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Teaching and learning human-computer interaction (HCI): Current and emerging practices

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Published in
Frontiers in Computer Science

ISSN 1664-8714
ISBN 978-2-83251-905-9
DOI 10.3389/978-2-83251-905-9

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Teaching and learning human-computer interaction (HCI): Current and emerging practices

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Citation
Girouard, A., Joshi, A., Kang, J., MacDonald, C. M., St-Cyr, O., Slegers, K., Kharrufa, A., Saltiveri, T. G., eds. (2023). *Teaching and learning human-computer interaction (HCI): Current and emerging practices*. Lausanne: Frontiers Media SA. doi: 10.3389/978-2-83251-905-9

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frontiers | Frontiers in Computer Science

TYPE Editorial
PUBLISHED 18 April 2023
DOI 10.3389/fcomp.2023.1188680

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OPEN ACCESS

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RECEIVED 17 March 2023
ACCEPTED 29 March 2023
PUBLISHED 18 April 2023

CITATION
MacDonald CM, Girouard A, Granollers T, Joshi A, Kang J, Kharrufa A, Slegers K and St-Cyr O (2023) Editorial: Teaching and learning human–computer interaction (HCI): current and emerging practices.
Front. Comput. Sci. 5:1188680.
doi: 10.3389/fcomp.2023.1188680

Editorial: Teaching and learning human–computer interaction (HCI): current and emerging practices

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KEYWORDS

education, human-computer interaction (HCI), teaching and learning, design education, pedagogy

Editorial on the Research Topic
Teaching and learning human–computer interaction (HCI): current and emerging practices

Human–computer interaction (HCI) is the academic discipline dedicated to understanding how humans interact with technology. Since technologies play such a prominent role in our daily lives, ensuring that they are designed to reflect the full spectrum of human abilities, skills, and experiences is more important than ever. Between higher education HCI courses and degrees and practitioner-oriented UX training programs, there are more opportunities than ever to teach and learn HCI, but HCI can be taught from various disciplinary perspectives at different academic levels, in different modalities, and in different institutional contexts. Therefore, for educators, what does it mean to teach HCI? For students, what are the most impactful and effective ways to learn HCI?

To help answer these questions, over the past several years, we have been developing an international community of practice focused on HCI education. This work began in 2011 when the Association for Computing Machinery (ACM) Special Interest Group on Computer—Human Interaction (SIGCHI) Executive Committee sponsored a research project about the future of HCI education worldwide (Churchill et al., 2013, 2016). After hearing from hundreds of international HCI scholars and educators, Churchill et al. (2013, 2016) noticed a recurring theme: The need for both a place to share HCI teaching materials and a platform to discuss HCI pedagogical approaches. Inspired by these results, St-Cyr et al. (2018) organized a workshop at CHI in 2018 to begin developing an HCI education community of practice (St-Cyr et al., 2018), which soon transformed into the EduCHI symposium which has been held annually since 2019 as part of the ACM CHI conference (St-Cyr et al., 2019, 2020; MacDonald et al., 2021, 2022). A related effort was a special HCI issue of the EngageCSEdu repository of Open Educational Resources (OERs) published in 2022 (St-Cyr and MacDonald, 2022). This Research Topic further extends this work by providing a dedicated platform for educators to investigate, analyze, and critique current and emerging best practices for teaching HCI from a global and interdisciplinary perspective. To that end, this topic includes 10 published articles from 30 contributing authors representing eight different countries on four continents and from various academic disciplines, including computer science and information technology, digital media, information science, interaction design, industrial design, architecture, and communication studies.

The first group of contributions to the Research Topic discussed different pedagogical approaches to engage students and deepen their understanding of HCI concepts, skills, and methods. Kang et al. conducted a scoping review of the past 20 years of HCI education literature to identify 12 types of experiential learning strategies, including applied research projects, industry/community projects, hands-on activities, role-plays, and interactive workshops. They found evidence that these techniques offer a range of benefits to students, such as enhancing their technical knowledge, acquiring soft skills, and increasing their job marketability. Gamboa and Ljungblad discussed the benefits of using a community-based studio approach in a master-level UX design course to teach "designerly ways of knowing" and helped students learn how to manage the chaos and ambiguity of design projects in a supportive, peer-led environment. Alenljung et al. evaluated a bachelor-level UX design program inspired by the apprenticeship model and featuring situated and embodied teaching practices that emphasized guided participation, realistic, work-like settings, and multiple opportunities for reflection. While the findings were specific to their program, other academics can learn from this experience, both in terms of the contents of the curriculum and as a method to evaluate a curriculum. De Wet explored various emergency remote teaching methods to keep students engaged in the HCI class that was forced to be taught entirely online due to COVID-19.

The second group of contributions examined various methods to incorporate ethical principles and values into HCI education. Nunes Vilaza and Bækgaard discussed the benefits and challenges of using five normative principles to teach engineering students how to make ethical UX design decisions and called for a much stronger emphasis on moral philosophy education in engineering. Sin et al. presented a series of case studies where instructors implemented the Digital Design Marginalization (DDM) framework in seven different contexts, showing its potential value to improve design pedagogy by helping students become more thoughtful and inclusive designers. Eriksson et al. described 28 inspirational suggestions for teaching HCI students how to incorporate values into their work in all five phases of the design process. In a similar vein, Fernandez used a quadrant learning activity to familiarize students with the concepts of instrumentalism and technological determinism and help them become more aware of their personal beliefs and values as they relate to human–technology interaction.

The third and final group of contributions focused on teaching HCI skills to different types of student populations. On the one hand, Grace et al. discussed the benefits of using student-led learning and pair programming to teach coding to interaction design students. On the other hand, Lewis and Sturdee explored pedagogical approaches to teach sketching to computer science and HCI students, many of whom were uncomfortable with the technique and needed to be convinced of its value as an ideation and exploration method.

Author contributions

CM drafted the editorial. KS, AK, AJ, and OS-C contributed to the draft. All authors approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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frontiers in Computer Science

CURRICULUM, INSTRUCTION, AND PEDAGOGY
published: 21 December 2021
doi: 10.3389/fcomp.2021.793466

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Teaching Human-Computer Interaction Modules—And Then Came COVID-19

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In teaching Human-Computer Interaction at university level, it has always been beneficial to explain the related theory and engage students in a practical way, whether individually or in groups. And then came COVID-19. Face-to-face classes were replaced by emergency remote teaching methods. Students became student numbers in cyber space. The danger became real to convert back to the traditional way of presenting lectures, namely a lecturer doing all the talking and the students being the passive audience. This paper describes how the author had to adapt and innovate in terms of teaching Human-Computer Interaction modules to university students in a practical way during the COVID-19 pandemic. Frequent online quizzes, audio messages, online group discussion, smaller topic-dedicated practical activities, and webinars encouraging student participation, were employed. Instead of having access to eye-tracking technology in a usability laboratory, students had to innovate for usability evaluation assignments by employing observation, think-aloud protocols, and performance and self-reported metrics as data gathering methods. The laboratory had to be replaced by COVID-compliant places of residence. The outcomes of adapting previously-used teaching methods and inventing new ways to encourage student participation, were surprisingly positive. An additional advantage was that many of these methods turned out to be so successful that their application could be continued and extended to post-pandemic times for a blended learning approach to further enrich Human-Computer Interaction teaching.

Keywords: human-computer interaction, COVID-19, practical HCI teaching, practical HCI learning, emergency remote teaching, HCI, HCI teaching

OPEN ACCESS

Edited by:
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Specialty section:
This article was submitted to Digital Education, a section of the journal Frontiers in Computer Science

Received: *12 October 2021*
Accepted: *25 November 2021*
Published: *21 December 2021*

Citation:
De Wet L (2021) Teaching Human-Computer Interaction Modules—And Then Came COVID-19. Front. Comput. Sci. 3:793466. doi: 10.3389/fcomp.2021.793466

INTRODUCTION

According to the Stirling Institute of Australia (2018), although learning styles differ, practical learning is the one type of learning that benefits most students. An improved skills set, increased understanding, the creation of a deeper impact and better knowledge retention are but a few of the advantages of practice-based learning.

In teaching Human-Computer Interaction (HCI) at university level, it has always been beneficial to explain the related theory in a practical way, as well as to engage students in this practical application, whether individually or in groups. According to Churchill et al. (2013), the relationship between theory and practice when teaching HCI is an issue that has often been raised. Although a solid theoretical basis is needed, hands-on projects and practical experience are considered important. Oleson mentions in Bits and Behavior (2020) that although interaction design is hard to teach and hard to learn, these students should ideally come out of these classes with enough proficiency to avoid common pitfalls in the software that they design. This proficiency could be enhanced by approaches to assist students to practically apply theoretical knowledge. Examples of these approaches include the student-use of mobile devices in class where they could reinforce their understanding of certain principles or topics with a hands-on approach, class quizzes, incorporating videos in lectures, as well as encouraging group discussions.

During the author's teaching career, the practical application of knowledge when teaching HCI also extended to students conducting usability evaluations in a usability laboratory on campus. Here they had access to specialized technology, such as eye-tracking. The benefits of this practical approach have been numerous, including better understanding of the theory, better results, enthusiasm towards the module, as well as frequent "light bulb moments".

And then came COVID-19. Face-to-face classes were replaced overnight by emergency remote teaching (ERT) methods. Students became student numbers in cyber space. Using the mobile devices and the usability laboratory on campus was not possible any more. Instead of making use of eye-tracking technology, students had to revert to only using observation, think-aloud protocols, performance and self-reported metrics as data gathering methods in their usability evaluation assignments. The usability laboratory had to be replaced by COVID-compliant places of residence. The danger became real to convert back to the traditional way of presenting lectures, namely a lecturer doing all the talking and the students being the passive audience.

Higher Education Institutions (HEIs) across the globe faced multiple challenges due to the pandemic. Various studies have been performed recently to investigate these challenges—faced by both staff and students. Examples include the Global Survey of College and University Leadership from the International Association of University Presidents and Santander Universidades (O'Malley, 2020), a study undertaken in Norway (Langford & Damsa, 2020), another in Cyprus (Souleles et al., 2021), and a study at the University of the West Indies (Thurab-Nkhosi et al., 2021). Although most of these studies identified access to technology and the maintenance of academic standards as challenges, faculty training in ERT was highlighted as a serious need. With such training (or professional development in this area) not generally being part of an academic's pre Covid-19 armor, many an academic had to adapt and innovate almost overnight as a result of the pandemic.

This curriculum instructions pedagogy (CIP) paper describes how the author had to adapt and innovate in terms of teaching Human-Computer Interaction modules to university students in a practical way during the COVID-19 pandemic. The paper is organised in the following way: the pedagogical foundation is first addressed by defining HCI and presenting an overview of the two HCI modules discussed in this paper. This includes a brief glimpse of the differences between before and amidst COVID-19. Then the learning environment is discussed by explaining the South African COVID-19 context and the teaching setting and methods. This involves the methods employed during the COVID-19 pandemic to adapt learning materials and communications methods, to teach theory classes, and to handle practical assignments and assessments. The paper is concluded with insight into the practical applications and lessons learnt during this trying, but unique experience.

In the rest of the paper the term "author" and will sometimes be replaced by the term "lecturer" in those instances where the context is that of teaching HCI.

PEDAGOGICAL FOUNDATION

Human-Computer Interaction

Sharp et al. (2019) describes Human-Computer Interaction (HCI) as the study of computer systems from the user's point of view. It falls under the umbrella term of Interaction Design. While HCI has a narrower focus on the design and usability of computing systems, the scope of interaction design is broader, concerned with theory, research and practice of designing the user experience for all manner of technologies, systems, and products.

Human-Computer Interaction Modules

In the tertiary institution where the author is lecturing, HCI is taught as both a second year and Honours level module in the Department of Computer Science and Informatics. The author is responsible for teaching both of these modules.

Learning Objectives and Outcomes

The aim of the second year module is to introduce students to the fundamental and exciting discipline of HCI in order to understand the designs that people need, to distinguish between poorly and well-designed user interfaces, and to learn the basics of usability testing. The students are, therefore, introduced to topics like usability, the user experience (UX), design principles, conceptualization, cognitive and emotional aspects, interface and screen design choices, and patterns for prototyping. They are briefly introduced to data gathering and the evaluation of prototypes and final products.

Therefore, after successful completion of the module, it is expected that the second year students will:

- Display knowledge of the basic principles of Interaction Design
- Identify usability goals and user experience goals for proposed interactive systems
- Redesign poorly designed user interfaces
- Distinguish between and select appropriate interface types
- Determine user needs and convert them into requirements in order to ensure that the interactive product helps the user to perform his/her tasks in an effective, efficient, and enjoyable manner
- Display and apply knowledge on the evaluation of a user interface (interactive product) in terms of usability.

On Honours level, the focus is mainly on usability engineering and evaluation. In this case, the students need to be able to do the following after completion of the module:

- Explain the issues involved in the evaluation of interactive systems
- Identify the different types of metrics used in evaluating the user experience
- Plan and design a usability study
- Conduct a usability study, making use of the usability laboratory and its equipment in the department (if access to campus is possible).

For both these modules it is crucial that the students learn how to apply in practice the theoretical principles.

Pre-COVID-19

Pre-COVID-19, modules were presented in face-to-face mode at our tertiary institution. Although aspects of blended learning were incorporated on a small scale, it was more the exception than the rule.

Undergraduate theory classes were presented on campus twice or three times a week, while a 3-h practical took place in one of the computer laboratories. IPads were incorporated as part of the theory classes where students could participate in class by means of online quizzes, or by doing individual or group activities to practice the taught skills. This method had the additional advantage of providing the lecturer with immediate feedback to see whether the students are on board or not. Periodical practical assignments included the evaluation of existing systems according to usability and user experience goals, identifying various interaction and interface types in existing systems, and improving badly designed screens or questionnaires by applying navigational and screen design patterns.

The Honours students attended one 2-h contact session on campus per week, while practical assignments could be done in their own time by making use of the departmental or the usability laboratory. These students were expected to plan and perform a full-fledged usability evaluation in the usability laboratory, recruiting real users, and using various technologies, including the eye tracker.

Amidst COVID-19

As we received the email on March 18, 2020 that the university will be locked down basically with immediate effect, both staff and students were totally unprepared for what lied ahead. The government announced that all post school training institutions would have an early recess, starting that day, to minimise risk of COVID-19 to all its staff and students. As the national lockdown was declared to last for 3 weeks, the general idea was that we would be able to return to campus after 3 weeks. The author left campus with her laptop, a few files and (fortunately) remembered to grab the Honours text book (the module that she was teaching at the time). Little was she to know that staff and students would only be able to fully return to campus in the following year.

This was the start of lecturing staff's exposure to the ERT environment. The recess period was to be used to adapt all plans, schedules, and learning materials from face-to-face to "online" mode, as well as to comply with newly developed University and Faculty contingency and catch-up plans. The university's Division for Teaching and Learning immediately started to compose material concerning the extended use of the learning management system (LMS) that were applicable and useful to both staff and students. They also started presenting online workshops to assist staff in how to apply this well-organized digital learning platform (ispring, 2021), especially in terms of the LMS functions that have seldom been used before.

LEARNING ENVIRONMENT

In order to understand the challenges of adapting lecturing procedures, lecturing practices and learning materials to emergency remote mode while preserving quality of teaching, is it important to understand the learning environment of South African students during COVID-19.

South African COVID-19 Context

With the university relevant to this paper being situated in the central province of the country, many of its students come from rural areas. Being a residential university, these students reside either on campus in university residences, or in student housing in nearby suburbs. With the national lockdown, these students had to return home. Having to study from home implied for some the reality of living in an area that has not yet received access to electricity. Additionally, it was during this time that the national energy provider, Eskom, incorporated frequent national load shedding periods as a result of not being able to supply in the country's energy demands.

If access to the Internet was possible, the bandwidth was often not adequate for a student's needs. With data costs and financial difficulties that many students and their families experienced, internet access was problematic. The majority of students generally make use of computer laboratories on campus to do their practical assignments. A large number of them do not own their own computers or laptops, therefore, with moving back home even computer access was not a given.

In order to attempt to address these issues, the university launched a campaign to obtain laptops that could be lent to students to work on during the lockdown period. First of all, all the students needed to be contacted in order to determine the need for computers. Then they were required to supply their physical addresses where couriers could deliver the laptops and sign agreements. However, the negative COVID-19 economic implications caused a shortage of computer components in the country. All these aspects delayed the process considerably.

To address the issue of inadequate bandwidth and data, negotiations by Universities South Africa with national mobile provides were undertaken. Eventually an agreement was reached that allowed for a selection of academic websites to be zero-rated, including the LMS used by our university. This implied that they were exempted from data fees by the four major mobile providers in the country. This also addressed the communications problem, as emails sent and received via the LMS would be free of charge. However, one has to bear in mind that all these provisions were not yet in place by the time the classes resumed after the recess. They all realized over time.

Teaching Setting and Methods

The Coronavirus caused a shift that forced the adoption of new ways of teaching and learning on both instructors and learners (Kristen et al., 2021). This gave way to emergency remote education that is referred to as ERT, or emergency remote learning (ERL). On the Educause Review (2020) website, (Hodges et al., 2020) define ERT as "a temporary shift of instructional delivery to an alternate delivery mode due to crisis circumstances". It involves the use of "fully remote teaching solutions for instruction or education that would otherwise be delivered face-to-face or as blended or hybrid courses and that will return to that format once the crisis or emergency has abated". Both positive and negative aspects of ERT and ERL have been reported. The positives include that students learnt new skills through associated in-class technology, more freedom for breaks and learning at a slower pace, better problem solving and more family time. In contrast, the negatives include the stifling of learning effectiveness by technical issues, isolation that can have a negative effect on mental health, and increased responsibility at home (Beekman, 2021).

In comparison to ERT and ERL, online teaching allows for community building among students and with the lecturer, and provide opportunities for learners to engage with learning material through practice, repetition, real-world context and feedback. Online learning also provides a safe environment for all leaners, thus addressing accessibility (Schlesselman, 2020).

ERT required that learning material, as well as communication methods, be adapted to cater for low bandwidth. Lecturers also had to provide for a variety of (often new) ways to present content. Theory classes had to be presented online, while alternative measures had to be devised to ensure that students still had the opportunity to be taught how to apply the theory in a practical way. Lastly, assessments had to be re-invented and re-designed.

Each of these aspects will now be discussed in terms of the second year and Honours HCI modules presented by the author. As many of the principles applied were applicable to both modules, a distinction will only be made when appropriate.

Learning Material and Communication

One of the first tasks was to adapt PowerPoint slides. Many students did not have their text books with them, therefore the slides had to be extended to additionally serve as study guides. To ensure that students with access to low bandwidth would still be able to access the slides, all unnecessary aesthetics, e.g. images, had to be removed. Images that were deemed necessary, had to be compressed. In a practical module like HCI, this posed a challenge, as many of the explanations provided previously were done with the aid of images or sketches. Heading and text typeface sizes in slides also had to be reduced. After all these issues were addressed, the slides were compressed and converted to pdf-files.

In order to ensure that students were not left in the dark, especially in the beginning of the lockdown period where a lot of uncertainty prevailed, communication with students had to be taken to a next level. The author started by preparing an audio message where the plans and procedures for the semester were explained. Students were also assured of continuous support, of which weekly audio messages and schedules being made available each Monday morning before 09:00, formed an integral part. Email communication and lecturer announcements took place from within the LMS. A WhatsApp group was created for the class, where urgent messages could be posted.

Theory Classes

Theory classes were presented once a week via webinars held from within the LMS. This is where the challenge of class participation and practical applications became tricky. IPads could no longer be used in class. Neither could face-to-face group activities.

To compensate for the loss of in-class quizzes, compulsory weekly quizzes were set up in the LMS. These quizzes mainly focused on the theoretical part of the work and tested whether students were following and understood the basics.

To additionally encourage class participation, the lecturer sporadically made use of online polls during these online classes. The students had to indicate if they agreed with a certain statement (yes/no response), or they were provided with a multiple choice question that they immediately had to answer. The poll responses were displayed in real time, which meant that the students could rate or compare their answers to those given by the rest of class. After closing the poll, the lecturer then discussed the responses.

Face-to-face in-class group activities were replaced by smaller group discussions during the online classes. A question or statement was posed by the lecturer who subsequently divided the class into smaller groups. The groups were instructed to each appoint a spokesperson for feedback afterwards. While these groups broke away for the discussions, the lecturer was able to "visit" each of these groups in turn to get insight into their discussions. After a predetermined time period, the class was again united and some of the groups were asked to provide feedback. Having a spokesperson appointed by the groups really helped and motivated participation. It seemed to be a confidence booster, as the lecturer's past experience was that when a question was posed to the whole class, nobody often responded.

Practical Assignments

Due to the connectivity challenges that some of the students faced, deadlines for completing assignments had to be extended.

The second year HCI students had to complete four assignments during the semester that were intended to teach them to apply theory into practice. These included an assignment where a badly designed website had to be selected and evaluated based on the conformance (or not) to usability goals, user experience goals and design principles. To address data gathering, a badly-designed questionnaire had to be redesigned by adhering to good questionnaire design principles. For screen design, an assignment consisting of various screens (websites and mobile screens) were presented to students where they had to either identify or apply navigation, general layout, mobile layout or visual design patterns, or apply them. The final assignment required them to suggest various evaluation strategies for scenarios presented. These assignments were released to the students via the LMS, generally providing space for answering the questions on the question paper itself. They then had to upload their answers via the LMS as well before the due date.

Pre-COVID-19, the Honours HCI students were required to complete a large semester assignment that involved the planning and conducting of a usability study where real users had to perform tasks on the system in question in our Department's usability laboratory. The use of the eye-tracker in the laboratory was compulsory. However, with the COVID-19 restrictions the students were firstly not able to get access to campus (and therefore to the laboratory), nor were they allowed to approach prospective test participants. A re-invention of the semester assignments was necessary.

The assignment was changed to require students to plan the usability test without incorporating the eye-tracker. The usability evaluation had to be performed in their place of residence (with adhering to all the COVID-19 sanitary requirements) and they had to use the people around them who they had access to, as test participants. As far as data gathering methods were concerned, they had to rely only on observation, the think-aloud or retrospective think-aloud protocol, and asking users (questionnaires and interviews). The lecturer acted as expert to conduct expert evaluations. The assignment was broken down into modules with interim deadlines. The students were then able to send their work-in-progress to the lecturer before each due date and would receive initial feedback on the part of the work done. This served as quality control, but also as a motivational factor for students to keep their momentum going as far as assignment progress was concerned.

Performance metrics (task success, time on task, number of errors, and efficiency), self-reported metrics (various types of questionnaires and interviews) and issue-based metrics could be incorporated in the usability tests, as no special equipment was necessary to do this. Students were also required to combine metric results in order to obtain a single usability score (Tullis and Albert, 2013)

Assessments

During these times, the university followed a "no student left behind" policy. This entailed that no assessments where marks counted towards the semester or final mark, were to take place during the first 6 weeks of lock down. This allowed students time to address connectivity and computer problems. This policy also required lecturers to provide longer time periods for answering or submitting assessments, as well as to provide multiple assessment opportunities for those who missed tests and assessment deadlines due to sickness, family trauma, or even load shedding. It placed quite an additional work load on staff, as it could involve the provision of up to three additional tests or examination papers.

Major semester assessments had to be prepared online, which posed new challenges due to the fact that students now had access to all their study material during tests. To counteract, the tests were transformed to an assignment format, and the type of questions posed were mostly focused on the application of knowledge. Case studies were used to sketch scenarios to which solutions needed to be found.

As mentioned by Adedoyin and Soykan (2020), summative assessments during ERT bring along the challenge of eliminating cheating and plagiarism, which was addressed by the author by requiring the students to submit their assignments through Turnitin (turnitin, n.d.), a plagiarism checker integrated with the LMS used by the university.

CONCLUSION

Practical Implications

Adapting the lecturing of HCI modules at tertiary level had practical implications. Firstly, class attendance at our university is compulsory. During the pandemic, class attendance (for online real-time classes) tended to be poor. This came despite the fact that the online classes presented in the LMS allowed for attendance lists to be pulled after class. As very little control existed over class attendance with all the possible problems that students could potentially experience (i.e., connectivity, illness, hospitalization, load shedding), some students made use of this opportunity not to attend classes. However, as classes were recorded and these recording links being available to students, one could not ultimately determine whether students did in fact attend these classes offline.

Communication with students needed a conscious effort. It needed to take place regularly and in such a way that students would never be unsure of what was expected of them. Collaboration among students increased. It seemed to be easier for them to communicate electronically with co-students compared to face-to-face communication. The discussion board in the LMS provided a useful platform for this collaboration to take place.

The author needed to stand back and consider HCI from a new perspective. It required creativity and innovation to keep classes interesting, practical, and to adapt assignments and assessments to ensure practical application, all while attempting to adhere to the expected standard of teaching.

As far as the student results were concerned, the second year average stayed similar compared to previous years, but the average of the Honours students increased with 3%. This was quite a heartwarming realization amidst the extremely trying circumstances. And as far as all the students who did their part were concerned, nobody was, indeed, left behind.

Lessons Learnt

In retrospect, very important lessons were learnt through this COVID-19 teaching experience. These lessons include realizing the importance of communication with students and collaboration among students, the importance of good and extensive planning of a module, the advantages of presenting the same content in multiple ways, and the advantages of blended learning. In terms of the students themselves, the experience provided insight into the real-life circumstances of students at home and those aspects that one often takes for granted, like access to electricity, computers, and the internet, which are not always a given. The author was also reminded of the privilege of being on campus to gain access to all its facilities, for both staff and students.

Contributions

This paper described the experiences and insights gained while teaching HCI during the COVID-19 pandemic. Despite the fact that face-to-face teaching might in future again become a generally applied mode of teaching (post-COVID-19), blended learning can assist HCI lecturers in providing opportunities to expose students to the same content in different ways. Incorporating compulsory online quizzes as a way to ensure that students prepare before attending a class, for example, could serve as student motivation and ultimately, better results. This is in line with the findings of Adedoyin and Soykan (2020). Additionally, incorporating audio messages, online group discussions, smaller topic-dedicated practical activities and webinars, can improve student participation.

HCI students can be encouraged to be innovative in conducting usability evaluations as part of practical assignments, especially in a third-world context where access to top-of-the range technology is not a given. Instead of incorporating, for example, eye-tracking technology in a usability study, valid evaluation results can also be obtained by employing observation, think-aloud protocols, and performance and self-reported metrics as data gathering methods. As the laboratory had to be replaced by COVID-compliant places of residence, it showed that usability evaluation could be performed in a variety of alternative locations, as long as the evaluators adhere to the basics of setting up a controlled environment.

Although challenging, these experiences pathed the way to being perceptible to possibilities for innovative teaching strategies in future.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article. Further inquiries can be directed to LdeW (DWetL@ufs.ac.za).

AUTHOR CONTRIBUTIONS

As I am the only author of this paper, my contribution was 100%. LdW.

ACKNOWLEDGMENTS

The author would like to thank the Centre of Teaching and Learning at the tertiary institution for their efforts in assisting staff and students during the pandemic. A specific expression of gratitude to Jani van der Merwe, a senior officer and learning designer of the LMS, for all her unprecedented help and guidance through difficult times.

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Conflict of Interest: The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Computer Science

CURRICULUM, INSTRUCTION, AND PEDAGOGY
published: 23 December 2021
doi: 10.3389/fcomp.2021.771731

Teaching Students How to Frame Human-Computer Interactions Using Instrumentalism, Technological Determinism, and a Quadrant Learning Activity

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OPEN ACCESS

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Specialty section:
This article was submitted to Digital Education, a section of the journal Frontiers in Computer Science

Received: *07 September 2021*
Accepted: *23 November 2021*
Published: *23 December 2021*

Citation:
Fernandez L (2021) Teaching Students How to Frame Human-Computer Interactions Using Instrumentalism, Technological Determinism, and a Quadrant Learning Activity. Front. Comput. Sci. 3:771731. doi: 10.3389/fcomp.2021.771731

This paper describes an innovative learning activity for educating students about human-computer interaction. The goal of this learning activity is to familiarize students with the way instrumentalists on the one hand, and technological determinists on the other, conceive of human-technology interaction, and to assess which theory students favor. This paper describes and evaluates the efficacy of this learning activity and presents preliminary data on student responses. It also establishes a framework for understanding how students initially perceive human-technology interaction and how that understanding can be used to personalize and improve their learning. Instrumentalists believe that technology can be understood simply as a tool or neutral instrument that humans use to achieve their own ends. In contrast, technological determinists believe that technology is not fully under human control, that it has some degree of autonomy, and that it has its own ends. Exposing students to these two theories of human-technological interaction provides five benefits: First, the competing theories deepen students' ability to describe how technology and humans interact. Second, they provide an ethical framework that students can use to describe how technology and humans *should* interact. Third, they provide students with a vocabulary that they can use to talk about human freedom and how the design of computing technology may constrain or expand that freedom. Fourth, by challenging students to articulate what theory they favor, the learning is personalized. Fifth, because the learning activity challenges students to express their personal beliefs about how humans and technology interact, the learning activity can help instructors develop a clearer understanding of those beliefs and whether they reinforce what Erin Cech has identified as a culture of depoliticization and disengagement in engineering culture.

Keywords: Instrumentalism, technological Determinism, HCI, personalized Education, Freedom, Autonomy, Utopianism, UX

INTRODUCTION

One of the primary global accrediting bodies for schools of computing is the Accreditation Board for Engineering and Technology, or "ABET" for short. Schools of computing that are interested in satisfying ABET accreditation are required to include in their curricula material that encourages students to reflect on the "Local and global impacts of computing solutions on individuals, organizations, and society." (ABET, 2021) To survey these impacts, students can be exposed to a variety of case studies that illustrate computing's discrete and granular effects as well as its more systemic and widespread consequences. (Baecker and Ronald, 2019; Fiesler et al., 2020)

While empirical case studies go a long way towards fulfilling ABET's "impact" requirements, these efforts can be supplemented and contextualized by asking students to consider a more general and fundamental question about the relationship that humans have with technology. In its simplest formulation, the question can be posed as follows: "Are we in control of our technology? Or is technology controlling us?" While this question may seem abstract and philosophical, in reality it is central to ABET's mandate to examine the way computing impacts us; if we're in control of our technology then we should be able to control those influences and channel them in ways that are aligned with humanly defined ends. On the other hand, if we aren't in control of technology, then those effects may be more ambiguous.

This article describes a teaching technique that can help students develop more theoretically rigorous understandings of the way that technology and humans interact. It also provides empirical evidence of how undergraduates (and aspiring engineers in particular) initially model these interactions. Finally, it outlines further research that could be pursued to deepen our understanding of how aspiring engineers originally understand technology-human interaction and how their models may evolve as they proceed through their college studies.

INSTRUMENTALISM VERSUS TECHNOLOGICAL DETERMINISM

Instrumentalism and technological determinism are two theoretical frameworks for conceptualizing how technology and humans interact. The following section briefly outlines their differences:

Instrumentalism

Instrumentalists uphold what is sometimes referred to in long hand as the "instrumentalist philosophy of technology." But for semantic convenience, in discussions about technology, this philosophy is usually simply referred to as "instrumentalism." Proponents of instrumentalism maintain that technology is in essence just a means to an end. When viewed this way, technology is merely a tool or instrument that people use to carry out humanly defined ends. Instead of having any inherent goals or biases of its own, technology is seen as essentially neutral; it can be used for good or bad purposes depending on the intention and goals of whomever is using it.

An instrumentalist understanding of technology conforms with many "common sense" assumptions. Since technology is inanimate, and doesn't have a will of its own, it seems almost self-evident to many students that it can't have its own ends, its own biases, or its own politics. Langdon Winner summarized this perspective: "We all know that people have politics, not things." (Winner, 1980) In an address to undergraduates at the University of Tokyo the philosopher of technology Andrew Feenberg described this perspective succinctly:

In the modern context technologyappears as purely instrumental, as value free. Itis merely a means serving subjective goals we choose as we wish. For modern common sense, means and ends are independent of each other. Here is a crude example. In America we say "Guns don't kill people, people kill people." Guns are a means which is independent of the ends brought to them by the user, whether it be to rob a bank or to enforce the law. Technology, we say, is neutral, meaning that it has no preference as between the various possible uses to which it can be put. This is the instrumentalist philosophy of technology that is a kind of spontaneous product of our civilization, assumed unreflectively by most people. (Feenberg, 2003), (The Instrumental Theory of Technology Is Perhaps Most Classically Stated in Martin Heidegger's Essay "The Question Concerning Technology". See Heidegger, Martin, 2013; David, 2021)

Technological Determinism

There is more than a grain of truth in the way instrumentalists describe the interaction between humans and technology. But there are other narratives, or, more aptly, stories, that depict human-technology interaction differently. For example, in the original *Terminator* movie, humanity is depicted to be at war with autonomous machines that are intent on annihilating the human species. (Trailer to the Movie, 2021) Similarly, in Stanley Kubrik's movie *2001: A Space Odyssey*, a computer aboard a space ship murders some of the astronauts on board and attempts to wrest control of the ship from its human occupants. (Oliver, 9000) These Hollywood depictions of autonomous technology are some of the most extreme representations of what scholars call "technological determinism." In these guises, technology ceases to be an instrument that humans control; instead, it becomes an agent in its own right, pursuing its own ends and determining the future in ways that are often at odds with human ones.

Most scholars dismiss simple technological determinism because it is as reductive and as simplistic as instrumentalism. Where instrumentalism only acknowledges humans as agents, extreme forms of technological determinism attribute much greater agency to technology. Yet even if serious scholarship avoids extreme forms of technological determinism, that doesn't mean that there aren't "softer" and more plausible forms that accord to technology a partial role in driving historical change. For instance, in his book *Does Technology Drive History?* historian Leo Marx attempted to survey some of these softer, more nuanced forms of technological determinism. He argued that many students already find technological determinism plausible because they've been exposed to "lore" in which technology features prominently, sometimes to the point of obscuring human agency. This lore includes the introduction of the compass, which encouraged European exploration of the Americas, the cotton gin which made Southern plantations'

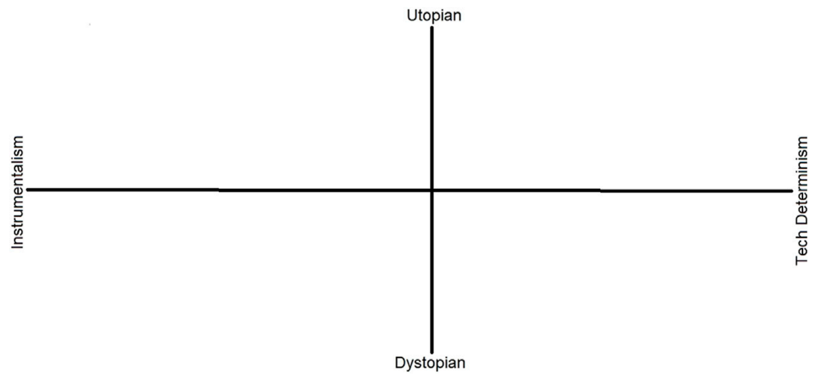

FIGURE 1 | The instrumentalism—technological determinism and utopian—dystopian quadrant.

economies profitable and more resistant to American abolitionist efforts, the Gutenberg printing press which sparked the Protestant Reformation, the car which ostensibly enabled the flight to suburbs, and the birth control pill which theoretically played a central role in sparking the sexual revolution in the 1960s. (Smith and Marx, 1994)

Since the publication of Marx's work in 1994, other technologies and books have emerged that also lend some credence to technological determinism. For example, the Silicon Valley tech evangelist Kevin Kelly, in his book *What Technology Wants,* argues that technology in the aggregate has developed its own "wants" and a momentum that humans are to some extent powerless to stop. To defend his thesis, Kelly speaks of the "technium" (his own neologism for the collection of all technologies) as having "tendencies. Leanings. Urges. Trajectories." These exhibit, in his view, some degree of "autonomy" and "independence." To illustrate his point Kelly speaks of a microchip industry which, following Moore's Law, "wants" to double it's processing speed every 18 months, and an encounter with a robot named "PR2" which is programmed to plug itself in:

If you stand in front of a PR2 while it is hungry, it won't hurt you. It will backtrack and go around the building any way it can to find a plug. It's not conscious, but standing between it and its power outlet, you can clearly feel it's want. (Kelly, 2011)

Finally, recent developments in computing also hint at some emergent deterministic and autonomous qualities in AI and machine learning. The most prominent of these was the development of Alpha Go which defeated the world Go champion using techniques that no human player had ever used or conceived of, and that no software developers could have coded on their own. (Oh et al., 2017)

THE QUADRANT—A USEFUL TOOL FOR INTERROGATING HUMAN-TECHNOLOGY INTERACTION

For students to understand the difference between instrumentalism and technological determinism, it is helpful to assign short excerpts from Leo Marx and Kevin Kelly or other tech theorists. But to drive the concepts home to my students, and to guarantee that they internalize their meaning, I also challenge my classes to develop their own opinions about how instrumental or deterministic their tools are, and how their answers to those questions may also inform their outlook on technology in general. To effect that outcome, the quadrant (**Figure 1**) is drawn on a white board or chalkboard:

As depicted, on the extreme left of the x axis is the label "instrumentalism," on the extreme right is the label "technological determinism." Having outlined the differences between these theories, students are then invited to place their name somewhere along the x axis to express how they think humans and technology interact. At the same time, students also consider the y axis which has the label "utopian" at the top and "dystopian" at the bottom. They are then invited to evaluate whether as a species we are moving toward a utopian or dystopian future and to express their hopes (or hopelessness) by moving their name up or down along the y axis.

In the classroom, the learning activity typically takes place over an entire class period. Students are polled in sequence. After each student commits to a position, their name is written in the appropriate place in the quadrant, and they are prompted to explain their choice. This usually sparks a round of Socratic questioning.

If students choose the top left quadrant, they are asked why they harbor instrumentalist views. Is it just a coincidence that they harbor instrumentalist views and are also optimistic? Or are instrumentalism and optimism mutually reinforcing? If so, why?

If, on the other hand, they choose the top right corner, what does that imply? Is it really possible to harbor utopian hopes if our destiny is controlled by technology rather than by humans? What are the prospects for human freedom when technology is relatively autonomous? Can utopia exist in a world where agency and freedom is more present in technology than in humans?

Analogous questions are sparked when students choose the remaining quadrants.

Students are also asked to consider how their choices may have been shaped by the world they grew up in. Do their choices reflect their firsthand encounters with technology? Or are they shaped by how the interaction of technology and humans is represented in literature, movies, or in other courses they have taken in college?

LEARNING OUTCOMES

In a comprehensive sense, the learning activity helps students to develop a deeper understanding of their relationship with tools and whether change occurs as a result of human agency or technology. And since they also have a chance to compare their views to those of their classmates, they gain a sense of the diversity of opinions on the subject.

There are other benefits as well:

The learning activity challenges students to tackle ethical questions. By default, the learning activity asks students to give a descriptive account of how humans interact with technology, and in particular, computing technology. But during the Socratic questioning, one can also ask the same questions prescriptively. For example, after a student has given an account of their choice, they are sometimes asked: "Ok, you claim that humans and technology interact this way. But should they act this way? Your choice reflects how you think the world works. But if you could choose, how do you think it should work?" Or along different lines: "Ok, you think that technology does have some autonomous qualities. But should it? In what circumstances might autonomous technology have a negative impact on human autonomy and/or human freedom?" (As Langdon Winner has pithily noted, 1978)

Finally, the learning activity also provides students with a framework that they can use to interpret subsequent readings that depict the interaction between humans and technology and the impact of technology on society. After each reading, students can be prompted to revisit the quadrant. Does the reading confirm or challenge the choice they made at the beginning of the semester? Revisiting the quadrant can also prompt students to read more critically. What sort of instrumental or tech determinist bias is revealed in the reading? And is the author optimistic or pessimistic about the future?

DATA COLLECTION, ANALYSIS OF STUDENT BELIEFS, AND FURTHER STUDY

Data Collection

The quadrant learning activity has been in use since 2012. In its initial rendering, only the x axis was used. (Fernandez and Matt, 2012) Since that date, the learning activity has been conducted in fifteen subsequent classes spanning nearly a decade with approximately 225 students. These classes were all seminar size classes with enrollments that generally ranged between ten and twenty students. Ten of these classes were in an introductory seminar titled "Engineering Culture." The vast majority of the students in this seminar have been engineering majors (or aspiring ones) who enroll in it to fulfill a social science general education requirement. The five other classes were interdisciplinary classes where significant amounts of time were spent exploring the impact of computing technology on Americans' emotions, culture, and society. All of the classes were taught at Weber State University except for one which was taught as a visiting faculty member at the University of Tübingen in Germany.

In six of the "Engineering Culture" classes and in one of the interdisciplinary classes, after the quadrant learning activity was completed, a picture of the quadrant was taken with all of the students' first names in the quadrant. This was done so that at the end of the semester the class could revisit their choices, and reflect on whether their opinions had changed in light of what they had learned earlier in the course.

Data Analysis and Student Beliefs

The data from these photographs have been anonymized and aggregated to create a quadrant (**Figure 2**) that contains 73 different student choices:

To further explain the above quadrant the bar graph (**Figure 3**) depicts how many students chose each quadrant as well as how many chose the center:

These graphs indicate that a majority of students harbored optimistic outlooks on the future. The optimists were split with a little more than half gravitating toward instrumentalism while the others were willing to entertain some deterministic qualities in technology. A minority harbored pessimistic beliefs, although in general the pessimism wasn't very acute. Most of these pessimists harbored at least some deterministic sentiments.

The data also show that instrumental optimism (i.e., the idea that humans purposefully and intentionally use technology for beneficent ends) was the most popular position. For aspiring engineers this choice is flattering since it accords power, agency, and virtue on engineers rather than on their tools. Meanwhile instrumental pessimism was the least popular choice, probably because at least some of the students associate it with a malevolent human nature that purposefully uses technology to effect evil outcomes. Instrumental pessimists don't have to believe in a malevolent human nature. But some students make this association by using the following logic: If we are in charge of our tools and we use them for reprehensible ends, then the only thing to blame is our selves rather than our tools. Ergo, we must be malevolent.

Some students chose the very center of the graph. Based on anecdotal feedback, those "centrists" can be separated into two groups. Some chose the very center because they hadn't developed an opinion. In contrast, others chose the middle because they didn't want to express a categorical position. This latter group vacillated; in their view some technologies behaved instrumentally while others were more deterministic.

As we shall see in the next section, these groupings can help illuminate important beliefs that computing students harbor. But it also fosters better teaching. We have known for a while that human computer interaction can be improved when the feelings and beliefs of users are better understood. The same thing can be said about instructor-student interaction. Those interactions can be improved when the dispositions of our students are more clearly comprehended.

During the fall 2021 semester, in addition to doing the quadrant exercise on a virtual white board (the class was taught via Zoom), a survey was distributed half-way through the semester to gather student feedback on the quadrant exercise. This survey was completed by 21 of the 24 students in the class.

When asked "Did the quadrant exercise change or clarify how you think humans relate to (or interact with) technology?" students responded in a variety of ways.

About six students explicitly reported that their views hadn't changed. As one student responded "I am still unchanged in my place on the graph" and another said "For me it has stayed the same." However, even when students didn't change their views, the exercise often helped them to see how their own views contrasted with others. For example, one student said "The quadrant exercise

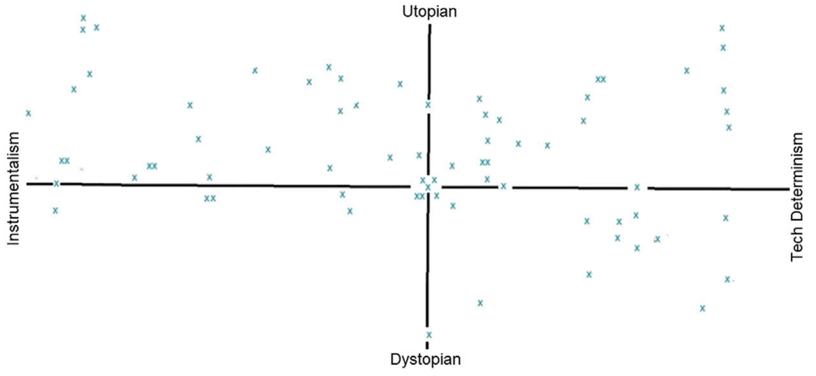

FIGURE 2 | Student choices in seven classes.

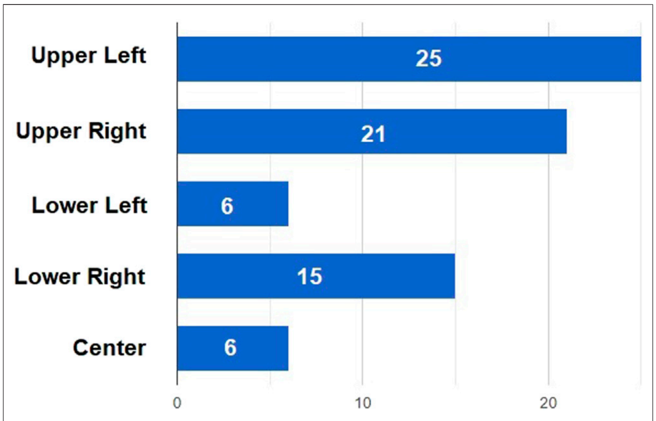

FIGURE 3 | Student choices presented as a bar graph.

didn't exactly change my views, but it helped me to find where my views really fit. It showed me that the way humans interact with technology is more of a broad spectrum than simply determinist or instrumentalist." This sentiment is much in keeping with what two others said "The quadrant exercise basically showed me how others think similar and opposing to me" and "It didn't really change my mind too much; however, it opened my mind to how others think about the subject."

However, even though a few students reported that they didn't shift positions, statistical evidence suggests that aggregate change occurred. The survey asked students to locate where they had positioned themselves at the beginning of the semester and where they now located themselves. Those responses were gathered with Likert style questions (**Figure 4**) and they indicate that while the was no shift in students' optimism or pessimism a notable shift from instrumentalism to determinism had occurred:

While the statistical evidence suggests that sentiments shifted from instrumentalism to determinism, there wasn't very much in the anecdotal feedback that explained or corroborated this change. Given that absence, the statistical shift might better be described as a shift from more extreme positions to more tempered ones—as one student put it "I would move myself closer to the middle." This moderation is probably the result of an emerging appreciation for other ways of describing human-technology interaction even if a student doesn't subscribe to that perspective themselves.

The final question in the survey asked "What might you change about the quadrant exercise?" Invariably students liked it. For example, one student called it "a great exercise that does what it is designed to do." Another noted "It honestly was good to talk about as it let us express our opinions and really discuss why we put ourselves there and how we perceived each side. I also feel like some people's opinions changed as they heard other people talk which is always nice." Students also noted that while the exercise was revealing, like any framework, it can't possibly comprehensively describe or model human-technology interaction. To that concern a few hoped that future exercises might include a "third axis."

The quadrant exercise is followed by a mid-term in which students are asked to write a paper on the following question:

Is technology just a tool? Is it neutral? Or does technology have politics, and more largely its own "wants?" Answer this question by consulting and quoting at least three of the readings in the course. In the latter part of your essay also discuss how your answer informs your own ethics of software engineering and the way you interface with technology.

The paper encourages the students to build on the quadrant exercise by developing and expressing a more concrete, nuanced, and qualitative understanding of how deterministic (or instrumental) *particular* technologies are in their own lives. The papers that the students write vary in quality. The most effective ones (whether defending instrumentalism or determinism) also clearly articulate the counterargument. Students who succeed best in this task exhibit one of the more important learning outcomes: the capacity to see how both instrumentalist and determinist perspectives shed light on human-computer interaction. Students responded positively to the overarching questions which the class posed and which were embedded in the quadrant exercise and midterm. Selected comments from student evaluations illustrate this. For example, one student said "I learned more about engineering politics and what comes with the occupation of engineering." Another noted "I like that this course is required to help young designers see more than just their work its ethical to teach someone how to engineer and also teach them about the consequences." And a third student noted that the class helped him see "The various

1.
At the beginning of the semester, where did you position yourself on the ***X (horizontal)*** axis?

Option	Text	Respondents 21 of 21 respondents Hits	Hit Graph
A	All the way to the left (hard instrumentalist)	1 (5%)	
B	Left of center (moderate instrumentalist)	8 (38%)	
C	In the center	4 (19%)	
D	Right of center (moderate technological determinist)	7 (33%)	
E	All the way to the right (hard technological determinist)	1 (5%)	
F	I don't recall where I placed myself	0 (0%)	

2.
Where do you now position yourself on the ***X (horizontal)*** axis?

Option	Text	Respondents 21 of 21 respondents Hits	Hit Graph
A	All the way to the left (hard instrumentalist)	0 (0%)	
B	Left of center (moderate instrumentalist)	5 (24%)	
C	In the center	5 (24%)	
D	Right of center (moderate technological determinist)	10 (48%)	
E	All the way to the right (hard technological determinist)	1 (5%)	

FIGURE 4 | Students' instrumentalist/determinist sentiments before and after 8 weeks.

situations in which technology can be seen as something else than just a tool. Helped me consider the two halves of the argument."

Limitations and Further Study

Most of the subjects in this data pool were aspiring engineers. But because no formal attempt was made to separate students by major, the data can't precisely indicate what engineering majors' sympathies are or whether they differ from other majors. However, in the future these distinctions could be clarified. By distributing an online questionnaire at the time of the quadrant learning activity, data could be formally collected that would record students' majors along with their relative sympathies for instrumentalism and technological determinism.

That data could be used to shed additional light on the nature of engineering culture and on the beliefs that engineering culture harbors. In particular, in the article *The (Mis)Framing of Social Justice: Why Ideologies of Depoliticization and Meritocracy Hinder Engineers' Ability to Think About Social Injustices*, Erin Cech argues that engineers are "depoliticized," and that engineering education is complicit in that depoliticization. (Cech and Lucena, 2013) Since instrumentalists tend to think of technology as neutral and without any inherent ends or politics, surveys that documented strong instrumentalist sympathies among engineering majors would tend to corroborate those findings. To gather the data, a survey with the following questions might be used:

1) Select your area of study:
Engineering
Art and Humanities
Social Sciences
Business
Education
Science

2) Using the slider, indicate how much you think interaction between humans and technology is described by instrumentalism or by technological determinism

Instrumentalism------------------<>------------------Technological Determinism

3) Using the slider, indicate how much you think the future will be utopian or dystopian.

Dystopian--------------------------<>----------------------Utopian

Note: With a bit of programming question 2 and 3 might be combined into a clickmap question that visually duplicates how the quadrant is presented on a whiteboard and how it is also used to record student responses.

To better understand what is informing students' choices on the *y* axis, one could also ask them to more clearly define what "utopian" and "dystopian" mean. Replacing the utopia *vs.* dystopia labels on the *y* axis with more specific words like freedom *vs.* enslavement, abundance vs. scarcity, or democracy vs. autocracy may yield different responses. Collecting and studying those responses may, in turn, further refine our understanding of our students hopes (and fears), and how those hopes relate to the visions of human-computer interaction they mapped on the *x* axis.

TEACHING RESOURCES

The quadrant learning activity can be conducted without assigning any supplementary reading. However, the discussion is enriched when students are presented with readings that outline the main differences between instrumentalism and technological determinism. Clips from movies can also further illustrate extreme representations of technological determinism. Mary Shelley's Frankenstein and associated modern commentary can also help students explore metaphorical aspects of instrumentalism and technological determinism. Here are some sources:

Readings on Technological Determinism

"Introduction" in Smith, Merritt Roe, and Leo Marx, eds. 1994. *Does Technology Drive History? The Dilemma of Technological Determinism*. Illustrated edition. Cambridge, Mass: The MIT Press. Pages ix-xv

"My Question" in Kelly, Kevin. 2011. *What Technology Wants*. Illustrated edition. London: Penguin Books. Pages 1–20

Readings on Technological Instrumentalism

"The Instrumental Theory of Technology" in Gunkel, David J. 2021. *How to Survive a Robot Invasion. 1st edition*. S.l.: Routledge. (about 3 pages in the Kindle edition)

Feenberg, Andrew. What is Philosophy of Technology? *Lecture to Komaba Undergraduates at the University of Tokyo*. (2003).

Readings that Contrast Instrumentalism and Technological Determinism

"Tools of the Mind" in Carr, Nicholas. *The Shallows: What the Internet Is Doing to Our Brains*. First Edition. New York: W. W. Norton & Company, 2010. Pages 39–57. See especially page 46

"Do Artifacts Have Politics?" in Winner, Langdon. *The Whale and the Reactor: A Search for Limits in an Age of High Technology*, Second Edition. Second edition. Chicago: University of Chicago Press, 2020.

Multi-Media

David Gunkel, *How To Survive The Robot Invasion*, https://mediaethicsinitiative.org/2018/04/04/robots-algorithms-and-digital-ethics-2/

The Terminator Movie Trailer, https://www.youtube.com/embed/ZAJr5cp01mI

2001: A Space Odyssey, Conversation between HAL and "Dave" the astronaut, https://youtu.be/HwBmPiOmEGQ

"We Are The Borg", https://youtu.be/AyenRCJ_4Ww

Classic Explorations of Instrumentalism and Technological Determinism in Literature

Shelley, Mary. *Frankenstein: Annotated for Scientists, Engineers, and Creators of All Kinds*. Edited by David H. Guston, Ed Finn, and Jason Scott Robert. Cambridge, MA, United States: MIT Press, 2017.

"Frankenstein's Problem" in Winner, Langdon. 1978. *Autonomous Technology: Technics-out-of-Control as a Theme in Political Thought.* 1st Edition. Cambridge, Mass.: The MIT Press, Pages 306-317

CONCLUSION

ABET encourages CS programs to teach students about the ways that computing technology impacts individuals, organizations and society at large. To understand those effects, and more largely, to understand how computing technology and humans interact as a result of those effects, it's helpful to work inductively from empirical case studies. However, that conventional approach can be productively supplemented by exposing students to more general theories about the way technology and humans interact. Two of these theories are instrumentalism and technological determinism. While those theories can be taught using textbook definitions, they are more productively presented through the use of a quadrant learning activity as delineated herein. As an ancillary benefit, the quadrant learning activity can encourage students to tackle ethical questions about human freedom and the circumstances in which that freedom is enlarged or constrained by technology (and computers in particular). It can also be employed as a formal research instrument that could shed more light on the culture and beliefs of aspiring engineers. These, in turn, can be leveraged to create better, more personalized teaching of HCI.

IRB NOTICE

The research described in this study has been categorized as "Exempt" by the Weber State University Institutional Review Board per Code of Federal Regulations 45 CFR 46, Subpart D.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Weber State University Institutional Review Board. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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Conflict of Interest: The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Computer Science

ORIGINAL RESEARCH
published: 22 February 2022
doi: 10.3389/fcomp.2022.830736

Teaching for Values in Human–Computer Interaction

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There is an increasing awareness of the importance of considering values in the design of technology. There are several research approaches focused on this, such as e.g., value-sensitive design, value-centred human–computer interaction (HCI), and value-led participatory design, just to mention a few. However, less attention has been given to developing educational materials for the role that values play in HCI, why hands-on teaching activities are insufficient, and especially teaching activities that cover the full design process. In this article, we claim that teaching for ethics and values in HCI is not only important in some parts of the design and development process, but equally important all through. We will demonstrate this by a unique collection of 28 challenges identified throughout the design process, accompanied by inspirational suggestions for teaching activities to tackle these challenges. The article is based on results from applying a modified pedagogical design pattern approach in the iterative development of an open educational resource containing teaching and assessment activities and pedagogical framework, and from pilot testing. Preliminary results from pilots of parts of the teaching activities indicate that student participants experience achieving knowledge about how to understand and act ethically on human values in design, and teachers experience an increased capacity to teach for values in design in relevant and innovative ways. Hopefully, this overview of challenges and inspirational teaching activities focused on values in the design of technology can be one way to provide teachers with inspiration to sensitize their students and make them better prepared to become responsible designers by learning how to address and work with values in HCI.

Keywords: values, ethics, HCI—human–computer interaction, teaching, design, technology

OPEN ACCESS

Edited by:
Karin Slegers, Zuyd University of Applied Sciences, Netherlands

Reviewed by:
Oscar Alvarado, KU Leuven, Belgium
Sonia Matos, Interactive Technologies Institute (ITI), Portugal
Christopher Frauenberger, Vienna University of Technology, Austria

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Specialty section:
This article was submitted to Human-Media Interaction, a section of the journal Frontiers in Computer Science

Received: 07 December 2021
Accepted: 17 January 2022
Published: 22 February 2022

Citation:
Eriksson E, Nilsson EM, Hansen A-M and Bekker T (2022) Teaching for Values in Human–Computer Interaction. Front. Comput. Sci. 4:830736. doi: 10.3389/fcomp.2022.830736

1. INTRODUCTION

We are witnessing an increased focus on the role that ethics and values play in the design of technologies. In the field of human–computer interaction (HCI) there have been several workshops (Waycott et al., 2017; Pillai et al., 2021), keynotes (Antle, 2017), panels (Fiesler et al., 2018; Frauenberger et al., 2019; Hendry et al., 2020), research papers on teaching practices (Fiesler et al., 2018; Frauenberger and Purgathofer, 2019; Nilsson et al., 2020), and research papers (Friedman, 1996; Cockton, 2004; Miller et al., 2007; Yarosh et al., 2011) focusing on this (just to mention a few examples), in addition to the development of professional codes of ethics in various organizations (e.g., ACM, 2018; IEEE, 2020). However, there is less attention to sharing concrete teaching resources for addressing the topic of ethics and values in design, and for creating conditions for students to grow into responsible designers of future technologies. Many methods from areas such as e.g., value-sensitive design (VSD) (Friedman and Hendry, 2019) are developed for research and development purposes, rather than for teaching. The VSD community has generated a rich body of literature on value conceptualizations, methodological papers, and projects, but methodological guidance is largely missing, especially for researchers new to VSD, and there is a need to lower the entrance barrier (Winkler and Spiekermann, 2018). In addition to that, many HCI courses are built up around the various phases of the design process, with or without a design project, often tackling various forms of design problems. Design problems are often referred to as wicked problems, described as "[a] class of social system problems which are ill-formulated, where the information is confusing, where there are so many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing" (Buchanan, 1992). However, while much resources on ethics and values in design has a focus on either the consequences of the design, or the planning and early phases of the design process, there are less resources in the later phases such as implementation and evaluation.

In a recent cross-European research project, we set out to fill these identified gaps: insufficient concrete teaching resources for teaching for ethics and values in design, and especially teaching resources addressing all parts of the design process. Partners from four Universities in three different countries have collaborated in order to iteratively develop a pedagogical framework and an open educational resource including 28 teaching activities and 12 assessment activities (VASE, 2021). We have applied a modified pedagogical design pattern approach (Goodyear, 2005; Laurillard, 2012), based on principles of systematization, sharing, and adaptability.

The contribution of this article is a unique collection of 28 identified challenges related to ethics and values in HCI that can occur throughout the design process, and accompanied by just as many inspirational suggestions for teaching activities for how to teach students how to tackle them. The teaching activities have so far been tested by more than 1,563 students involving 50 teachers at six universities in four different countries.

2. BACKGROUND

There are various classifications of human values, such as those defined by, e.g., Rokeach (1973), Schwartz (2012), or in value-sensitive design (Friedman and Kahn Jr, 2003). In this work, we do not lean toward one or the other model, but rather define what we mean by values in relation to teaching for values in design.

2.1. What Do We Mean With Values?

Values play an important role in design but there are many different ways to consider values, and a literature review of values in design will encounter many of these different notions of value. When teaching students about values in design we need to disentangle these different notions and consider how different methods can be taught for each of the relevant notions. We distinguish three different axes that may be relevant.

2.1.1. Axis 1: Value or Values

As several authors have pointed out (e.g., Andersen and Cox, 2018; Bekker et al., 2019), there is a difference between the meaning of the word "value" and the word "values." "Value" often refers to the worth of something, whereas "values" refers to what is important in life. The objective view of "having value" can be linked to an economic view of value, and the subjective view of "being of value" can be linked to a sociological view of value. Concepts and definitions of value in the context of innovation have thus been explored in economy, psychology, sociology, and ecology (Ouden, 2012). This use of the word "value" is closely connected to how "value" was initially used by Cockton (2006), and which was later renamed to "worth," meaning what a technology brings to its end-users. In this report, we are interested in values as what is important in people's lives. What we mean by this, is that we aim to teach students to take responsibility for their own values, and how their designs can support or undermine other stakeholders' values (where other stakeholders can be defined in the broadest sense, such as end users, society, but also e.g., nature).

2.1.2. Axis 2: Focus on the Process or the Product

In the design context, values can be connected to either the product of design or the process of design contributing to values or expressing values. The notion that values can be embodied in design, as expressed by Friedman and Kahn Jr (2003) relates to the product's values, while the notion of empowerment, which forms the basis of participator design (PD), also relates to the process' values. Of course, values also underlie the ethical framework for doing design and research in general, making sure that stakeholders are treated with respect.

2.1.3. Axis 3: Focus on Designers' Value(s) or Stakeholders' Value(s)

Finally, we can consider values from the perspective of the designers and/or from the perspective of the stakeholders. As Ouden (2012) has pointed out, stakeholders may exist on many different levels, from users, to organizations, the ecosystem, and society. To be sensitive to values, designers need to be aware of their own values, as well as the values of all stakeholders. Thereafter, they need to make decisions about potential value conflicts between and within stakeholders.

2.2. Teaching for Values in Design

Values are inherent in technologies (Verbeek, 2011), and "technology affects values regardless of whether the designer has any explicit intention to do so" (Knowles and Davis, 2017, p. 62). In other words, designers—knowingly and unknowingly—both embed values into their designs and affect values through their designs (Friedman and Kahn Jr, 2003). It is, then, important that designers are aware of the role and implications of values in design. We therefore argue that the topic of values in design should be addressed in all educational programs related to HCI.

While various approaches exist to practicing and researching values in design (see, e.g., Cockton, 2006; Belman et al., 2009; Iversen and Leong, 2012; Friedman and Hendry, 2019; Nissenbaum, 2021b), there are only few examples of how to teach students about values in design (Frauenberger and Purgathofer, 2019; Barendregt et al., 2020; Nilsson et al., 2020; Nissenbaum, 2021a, for recent overviews see Fiesler et al., 2020; Hendry et al., 2020).

A number of other articles have reported on teaching design approaches from various related sub-fields of HCI, such as tangible and embedded interaction design (Martin and Roehr, 2010), interaction design and children (Eriksson and Torgersson, 2014), digital craft (Nitsche et al., 2014), interaction design with a focus on sensor-based interaction (Brynskov et al., 2012), participatory design (Hecht and Maass, 2008; Christiansson et al., 2018), ethnography in human–computer interaction (Weinberg and Stephen, 2002), and interaction design by research through design (Hansen and Halskov, 2018). We have also seen a need for more discussions around teaching various strands of design of technologies, such as in child–computer interaction (Van Mechelen et al., 2020) and in participatory design (Hecht and Maass, 2008), to name a few.

In the broader field of HCI, several authors have also called for initiatives to address ethics in design. (Lilley and Lofthouse, 2010) set out to develop teaching material which will help foster responsibility in design students by encouraging deeper reflection on the social, environmental, and ethical implications of design for sustainable behavior. Similarly, (Frauenberger and Purgathofer, 2019; Nilsson et al., 2020) are developing teaching materials for educating responsible designers. To both describe current trends in computing ethics coursework and to provide guidance for further ethics inclusion in computing, Fiesler et al. present an in-depth qualitative analysis of syllabi from university technology ethics courses (Fiesler et al., 2020). Finally, Pillai et al. (2021) recently argued that beyond defining ethics, an ethics curriculum must enable practitioners to reflect and allow consideration of intended and unintended consequences of the technologies they create from the ground up, rather than as a fix or an afterthought (Pillai et al., 2021). In a recent workshop, they therefore aim to build upon existing practices and knowledge of ethics in HCI and enrich ethics curriculum (Pillai et al., 2021). While these initiatives mainly focus on taking responsibility for the effects of the technology that is being developed (which we think is indeed also very important), there are insufficient resources for also considering the design process.

Several approaches have been inspired by Nelson and Stolterman design judgement as the key element in the design process (Nelson, 2003) and what Vickers (1965) named appreciative judgement. Design judgement is a competence that is not based on formal rules, but rather on the accumulation of the experienced consequences of choices made in complex situations (Nelson, 2003). While appreciative judgement is the capacity to understand a situation through the discernment of what is to be considered as the background and foreground in a design situation (Vickers, 1965).

Le Dantec and Do (2009) drew upon Nelson and Stolterman's taxonomy of design judgments (Nelson, 2003) to ensure taking designers' values into account besides that of the participants'. They did this by analyzing verbal exchanges from a design meeting, however, they do not provide any hints for how to, on a practical level, support for the emergence of values. Similar to Ludvigsen et al. (2004), Le Dantec et al. (2009) describe how they elicit values through interviewing people using artifacts, in order to provide physical instantiations of values. These methods based on verbal exchanges and interviews can mediate an initial elicitation of values, however, there is no description of how they continuously refine/negotiate values throughout the design process.

In values-led participatory design (PD), Iversen et al. (2010) address a concern for values in PD as a specific kind of design judgment, which they term as appreciative judgment of values, and that this judgment usually occurs in a dialogical process of emergence, development, and grounding of values. This represents the full cycle of a values—led PD inquiry: from the process of early analysis to the development of the final product. However, practical guidance is mainly focused on the emergence of values in the beginning of the design process (Iversen and Leong, 2012).

The Values in Design (VID) Council, Nissenbaum (2021b), proposes a process containing three steps: to discover the values relevant to the project, the translation of those values into specific design features, and finally to systematically verify that the values' content of what is created matches the intentions. This has been applied in and documented from a course on Values Embodied in Computer and Information Systems (Nissenbaum, 2021a). This course is mainly a two parts reading course: first, the students read about the social, political and moral dimensions of technology in general, and secondly the students focus more on information and communications technology specifically.

The Values at Play curriculum (Belman et al., 2009), is meant to be incorporated in any game design course as a 4-week module. Students participate in four activities, one for each week, with accompanying readings. Some specific tools or activities used during the 4 weeks are the Grow-A-Game cards activity (Belman et al., 2011), preparing a video clip of a game in which values are at play, creating a prototype of a game, and play-testing and critiquing the games.

The Design Challenge Based Learning (DCBL) approach was developed by Blevis (2010), who was frustrated by the lack of studio-based learning approaches for design students at universities. According to Blevis (2010) "the core idea of DCBL is to present designers with humanity- and life-centered issues-based design research and design-concept challenges in the arena of HCI [...]" (p. 2). In this sense, it is not a design approach, but rather a pedagogical paradigm. However, one of the pillars is that "[i]t is an issues-and values-first paradigm" (Blevis, 2010) so therefore it is of some interest for this report. In DCBL, students work on individual, collaborative, and competitive activities involving public presentation and critique; they receive implicit rather than explicit inclusion of rigorous concepts in the service of motivated, design challenge goals; and linked pairs of research and concept projects prompt the students to practice, ensuring that their concepts follow from research insights and that their research insights lead to concepts. Although DCBL could be an interesting approach to define projects for students to work on, it does not explicitly explain to students why values are important, or how they can deal with different values of different stakeholders.

A recent example of making ethics and values more easily accessible and integrated into the design process is the design tool: The Moral-IT Deck and Moral-IT Impact Assessment Board (Urquhart and Craigon, 2021). The Moral-IT Deck is a set of physical cards that prompt reflection on normative aspects of technology development. Coupled with our Moral-IT Impact Assessment Board, they help technology designers to reflect on how to address emerging ethical risks and implement appropriate safeguards. The cards and board enable designers to reflect on challenges and consequences posed by their system and plan how to act in response (Urquhart and Craigon, 2021).

One example of a collection of concrete teaching activities for values in design is developed by Hendry (2020), which is a pedagogical resource containing four tech policy instructional case studies. The case studies are planned to be delivered as a 110-min class, but intended to be revised for different pedagogical settings and goals. The educational resource is based on methods from value sensitive design (Friedman and Hendry, 2019), and especially the following methods: Direct and indirect stakeholder analysis, Value source analysis, Co-evolution of technology and social structure, and Value scenarios. However, although this is a great resource for position students to consider the deeply interactional processes of human values and technology, they do not cover the full design process.

This article focuses on teaching for situated ethics and values in the technology design process as well as in designs. As such, we hope to ease entrance barriers to the field, as has been called for Winkler and Spiekermann (2018). Through this, we hope to provide other teachers of HCI courses with teaching material to sensitize their students and make them better prepared to become responsible designers by learning how to address and work with values in design.

2.2.1. Consequences of Insufficient Education in Values

There are many examples of the consequences that HCI and technology design have been suffering, which might partly be due to the difficulties in obtaining consensus about ethical imperatives (Anderson, 1992), but may also be due to an insufficient education in ethics and values. One classic example is by Winner, of the low bridges "designed" by Robert Moses to deny low-income people to travel to the beaches by bus (Winner, 1999). Another example is how until recently, due to a light-skin bias embedded in color film stock emulsions and digital camera design, the rendering of non-Caucasian skin tones was highly deficient (Roth, 2009; Caswell, 2021). A more recent example is how some big data algorithms are increasingly used in ways can lead to decisions that harm the poor, reinforce racism, and amplify inequality (Neil, 2016). We see these examples of how design and engineering professionals play an important role in the shaping of society, but without always being explicitly aware of this (e.g., Facebook's CEO Mark Zuckerberg who brought a technology to life without being fully aware of the major societal consequences of its use). Of course, it is not a naïve hope that an increased focus on ethics and values in education lead to technologies without any negative consequences, but we still aim toward students thinking more carefully about values and consequences—all through the design process.

3. METHODS

Through a period of 3 years, we have iteratively developed, piloted, evaluated, and re-iterated a total of 28 teaching activities and 12 assessment activities (VASE, 2021). However, the focus in this article is on the challenges throughout the design process where such teaching activities could be applicable, why it will not present or go further into details of the teaching activities, and not touch upon the assessment activities. The teaching activities have been tested, in isolation or in combination, by a total of 1,563 students involving 50 teachers in six universities in four different countries (Sweden, Denmark, Netherlands, and Turkey). The educations have ranged from first year bachelor in e.g., digital design and teacher education, to master level in e.g., experience economy and interaction design. The pilot tests have ranged in various ways in everything from a guest lecture to a full course on values in design, however the full range of teaching activities have not been tested as one full program. The teaching activities have been piloted and formative evaluated primarily in order to inform re-design and improvement. The formative evaluation was not systematically applied, but the teachers constructive comments and suggestions have been implemented in iterated versions of the activities. In some cases, and as part of the respective universities final evaluation of a course where one or several activities have been piloted, students have been asked to answer some variation of the following question: "To what extent do you experience achieving knowledge about how to understand and act ethically on human values in design?" However, this has not been done systematically, and we have rather relied on the experiences from the teachers and examiners in the partnering universities.

In the development of pedagogical framework, identification of challenges in the design process, and in developing activities, we have used a modified version of the pedagogical design pattern approach (Goodyear, 2005; Laurillard, 2012). The method has been applied in pattern mining workshops, in order to elicit existing best practice from teachers and from related work found through desk research. It has further been applied in that we have developed a specific template for teaching activities, which is separated from assessment activities, and which is based on the SOLO taxonomy for defining intended learning outcomes and objectives (Biggs, 1982), and has a focus on describing every step in the activity in detail. The template is complemented with teaching materials, such as suggested literature, worksheets, and presentation slides (VASE, 2021).

There are many different more or less established models of the design process which all contain a number of various phases (e.g., Jones, 1992; Maguire, 2001; Council, 2004; IDEOU, 2021). In this article, we have divided our work following five phases: Values theory, Research, Synthesis, Ideation, and Evaluation, and developed teaching activities accordingly in order to fit each phase. The last four design phases are inspired by Maguire (2001), while we have created the first so called meta-design phase, values

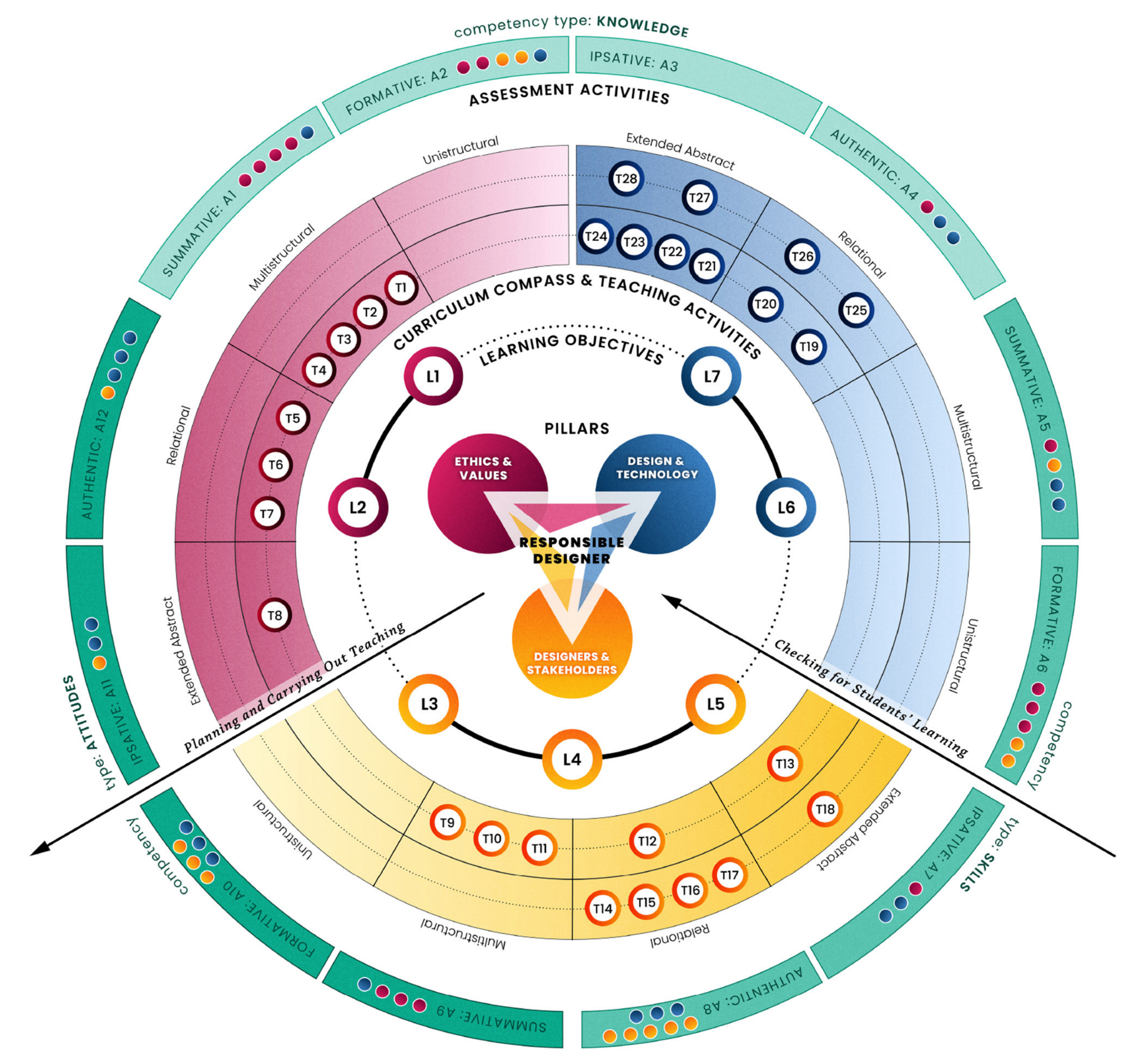

FIGURE 1 | The pedagogical framework. See VASE (2021) for more details.

theory, as a foundation for the activities in the following phases to emphasize the importance of gaining theoretical base knowledge of different approaches and frameworks for ethics and values in the design of technology.

The 28 identified challenges as presented in this article, and the accompanying inspirational teaching activities spread over the whole design process, is part of a pedagogical framework, which will be briefly introduced in the next section. For a detailed presentation of the pedagogical framework and the full collection of teaching and assessment activities see VASE (2021).

4. THE PEDAGOGICAL FRAMEWORK

The pedagogical framework, see **Figure 1** consists of five dimensions:

- Pillars: three core competency pillars for educating responsible designers—Ethics and Values, Designers and Stakeholders, and Technology and Design,
- Learning objectives: seven overarching learning objectives that guide teachers when teaching for values in design,

TABLE 1 | Overview of the teaching activities related to the design phase values theory in the pedagogical framework on teaching for values in design.

Pillar	Phase	Teaching activity
(I) Ethics and values	Values theory	T1. Introduction to values in design
		T2. Introduction to ethics in design
		T3. Introduction to cultures and values in design
		T4. Design with and for certain philosophies
		T5. Manifestos on values and ethics
		T6. Values manifested in products, system and services
		T7. Values clustering for developing students' value vocabularies
		T8. Understanding values changing over time

- Curriculum compass: the curriculum compass contains 20 learning outcomes based on the SOLO taxonomy which outline progression in learning design for values,
- Teaching activities: 28 teaching activities that expand, concretize, and integrate learning outcomes in step-by-step activities,
- Assessment activities: 12 assessment activities that are connected to relevant teaching activities to support teachers in checking whether the teaching activities' learning outcomes were achieved by the students.

We have formulated three main pillars for teaching for values in design. The three pillars aim to cover what we consider the main knowledge and skills for becoming a responsible designer: the theoretical background, a focus on different stakeholder needs, as well as the skills to actively engage with technology and values in the design process. Each of the pillars cover one or two design phases:

Values Theory—Pillar 1: Ethics and Values

The Ethics and Values pillar cover the meta-design phase values theory. It explains the underlying theoretical foundations that students need in order to take ethics and values into account, both in their methods and in their design process, as well as in taking responsibility for their end product or service. The overarching learning objectives are:

- Recognize and describe different values.
- Critically reflect on how values are manifested in design.

Research and Synthesis—Pillar 2: Designers and Stakeholders

The Designers and Stakeholders pillar cover the design phases research and synthesis. It addresses methods and processes for students to ethically engage with different stakeholders and their values, acknowledging that they themselves are stakeholders too. The overarching learning objectives are:

- Identify and describe direct and indirect stakeholders of a design.
- Elicit stakeholder values.
- Identify possible tensions between different stakeholder values and imagine how to mediate these tensions in a design.

Ideation and Evaluation—Pillar 3: Technology and Design

The Technology and Design pillar cover the design phases ideation and evaluation. It addresses methods and processes that allow students to practically design and evaluate products and services with values in mind. The overarching learning objectives are:

- Integrate values into the design process.
- Analyse and critically reflect on the impact of a design (draft) and its manifested values in context.

In the rest of this article, we will focus on the challenges we have identified throughout the design process where teaching about the role of ethics and values in HCI in regards to both process and product is highly relevant. These challenges will be accompanied by brief inspirational suggestions for teaching activities.

5. TEACHING VALUES FOR DESIGN THROUGHOUT THE DESIGN PROCESS

In this section, we will walk through the design process divided into the five phases: Values theory, Research, Synthesis, Ideation, and Evaluation. For each phase, a number of identified challenges related to ethics and values in design as well as arguments for the importance of teaching for values in HCI will be provided and illustrated through 28 inspirational suggestions for teaching activities.

5.1. Phase 1: Values Theory

This meta-design phase is important for students who are about to start designing with values. Through teaching activities in this phase, students gain theoretical base knowledge of different approaches and frameworks for ethics and values in design. Building on this theoretical understanding, the students will be able to carry out the activities in the following phases more effectively. An overview of the teaching activities for this phase is in **Table 1**.

5.1.1. Introduction to Values in Design

While students in HCI are often introduced to different design approaches, such as Agile, User-Centered, Critical, or Participatory Design, they often have the notion that design is value-neutral. This prohibits them from taking a reflective and active stance toward values in present and future design projects. Furthermore, even if students recognize the role that values play in design, they usually lack the knowledge to think about this issue and identify possible approaches to address values during the design process. This lack of knowledge may make them fall short when being confronted with or working with values in design projects. In an "Introduction to values in design" teaching activity, students gain knowledge about the role of values in design, and are briefly introduced to some design approaches that take values into account. The Value-Sensitive Design approach is explained in more detail, specifying the three types of investigation commonly found in VSD: conceptual investigations, empirical investigations, and technological investigations. Recommended reading for this activity: Friedman et al. (2009).

5.1.2. Introduction to Ethics in Design

The design of technology is not neutral, and the designer is always accountable. Therefore it is vital, in order to become responsible designers, to understand both the various moral traditions, the formal ethical rules and regulations, as well as adopting a reflective stance to applying ethics in the design practice. This can be achieved through an "Introduction to ethics" activity. Students need to understand how their designs are intentional, how they are products of inscriptions by designers, and what the implications are with regards to stakeholder moral, will, and agency—both in the product and in the process. Recommended reading for this activity: Frauenberger et al. (2016).

5.1.3. Introduction to Cultures and Values in Design

In the books *The Patterning Instinct* (Lent, 2017) and *The Geography of Thought* (Nisbett, 2003) the authors argue that humans will not be able to solve today's environmental problems if they do not combine human knowledge systems from the West, the East, and indigenous cultures. The different knowledge systems or "ways of seeing" present very different ways of understanding values and virtues. Contemporary designers and engineers are educated in university institutions that build on scientific traditions that mainly come out of the Western knowledge systems. Thus, it is important to look beyond the Western knowledge systems and the values that they represent and look into other cultures' value systems.

The "Introduction to cultures and values in design" teaching activity introduces students to alternative value systems as they are covered in and Somé (1999), Nisbett (2003), Ani (2017), Lent (2017) through a lecture. Through this lecture, students get an introduction to a broader perspective on values than the one offered by Western cultures. Students become aware of how they might look into value systems alternative to the one offered by Western cultures. The lecture is followed by a seminar where students discuss the differences between the value systems that they are introduced to. The students end with producing a combined list of values offered by the West and alternative value systems, and some research questions that open up for further research on values in other cultures.

5.1.4. Design With and for Certain Philosophies

As claimed by Verbeek (2006), engineers are "doing 'ethics by other means': they materialize morality," which also applies to designers. The challenge that students often face is either: (1) an insufficient awareness of the ethical dimension of their designs, e.g., the design of social platforms like Facebook and Instagram are pushing teenagers to perfection and collecting likes from everyone, since all their peers seem to be flawless and liked, or (2) a lack of competency to be able to relate ethics and esthetics in their designs. e.g., how can one design the public space in such a way that it is inviting the 1.5 m COVID-19 distance, while respecting the autonomy and creativity of people?

By ethics, we mean the moral principles of conduct governing an individual or a group. By esthetics, we mean the appreciation of the beautiful and its effects. It is fairly hard to design, making abstract values "experienceable" when engaging with a product, system, or service. Not being able to identify, describe, apply, and reflect on the underlying values and ethics of products, systems, and services and the relation with esthetics, might lead to all kinds of unintended consequences of designs in use: users feeling frustrated, belittled, not able to express themselves, endangering themselves or others, etc. It might unintendedly push certain values, where others might be societally preferred or beneficial, as also shown with the example of the impact of social media on teenagers. The outcome of the "Design with and for certain philosophies" teaching activity helps students to understand, experience, and reflect on the relation between esthetics and ethics. This teaching activity offers a fairly explicit way of using ethical frameworks, students will start to understand the underlying relations, thus having handles to design and generalize their reflection on ethics and values to other design projects.

5.1.5. Manifestos on Values and Ethics

When writing their own design manifesto, students often focus on what they themselves believe in, meaning that they pay little attention to what others believe in. However, in order to take a position and avoid intolerance toward those who hold different opinions from oneself, it is important to be aware of diverse viewpoints and to learn not only to agree but also to disagree with others in a constructive manner. In the "Manifestos on values and ethics" teaching activity, the students will gain this understanding by reading several inspiring and thought-provoking examples of manifestos from multiple fields and discussing their individual stances. Examples of manifestos for inspiration can be found here: Backspace (2021), Designmanifestos (2021), and Ethical (2021), etc.

5.1.6. Values Manifested in Products, System and Services

While new products, systems, or services are often promoted as adding value to people's lives, such statements might also veil the philosophical, theoretical, political, and cultural influences on a particular design (Friedman and Hendry, 2019). If students don't engage in a critical reflection on how values are manifested in products, systems, or services they may not understand how these embedded values might have an impact on the way we think, our lifestyles, and our culture. In other words: how products, systems, and services "speak" to us and shape our everyday lives and mindsets. This teaching activity provides students with some examples of existing products where the underlying motivations and contextual influences behind the designs are brought up for discussion. Students learn to find the underlying values that are embedded in a product, system, or service. This teaching activity trains students in noticing what kinds of cultural and philosophical influences are behind a product, system, or service. When students have done some analysis, they might be able to come up with research questions that address the philosophical, theoretical, political, and cultural influences that shape contemporary products.

5.1.7. Values Clustering for Developing Students' Value Vocabularies

When working with values in design, students sometimes lack a nuanced and elaborate vocabulary for communicating about values. This creates the risk of a narrow understanding of what values in design imply and how to work with and talk about values in a holistic and multifaceted way. By expanding our value vocabulary, we might also gain a more nuanced understanding of the values we are working with—in effect creating better products, systems, or services. If students lack a nuanced value vocabulary, values run the risk of becoming one-dimensional buzzwords with no depth or situated meaning. In the activity, the students are introduced to relevant thesauruses, dictionaries, value vocabularies (such as the HUValue Tool Kheirandish et al., 2019 or Schwartz Theory of basic values Schwartz, 2012) and other materials that might help them broaden and deepen their vocabulary for, and understanding of, a certain value.

5.1.8. Understanding Values Changing Over Time

Students often focus on integrating a predefined set of values identified during the early stages of design. They often assume that these values will remain stable in the later stages of the design life-cycle during widespread adoption and use. However, values can change over time. Value changes can occur either due to social developments (e.g., French Revolution that overthrew the monarchy) or induced by technology (e.g., contraceptives which have had an effect on sexual morality). New values may emerge in society (e.g., emergence of feminist values), the priority of values for a specific technological design may change during its use (e.g., increased emphasis on sustainability over efficiency), and the meanings or interpretations of the same value may change over time (e.g., how privacy is understood in the age of the Internet). The "Understanding values changing over time" activity will encourage students to situate their designs within a broader socio-historical context, to become aware of value changes, and in turn lead students to design products, systems and services that can better adapt to changing conditions. Readings and example of a multi-lifespan timeline, see Yoo et al. (2016) and van de Poel (2018).

5.2. Phase 2: Research

In this phase, relevant information is gathered around the initial design brief. This includes information regarding direct and indirect stakeholders, their values, and the relationships and tensions between them. The values of the designers (students) themselves are also analyzed and reflected upon. The teaching activities related to the design phase research are listed in **Table 2**.

TABLE 2 | Overview of the teaching activities related to the design process phase Research in the pedagogical framework on teaching for values in design.

Pillar	Phase	Teaching activity
(II) Designers and stakeholders	Research	
		T9. Individual designer's values identification and hierarchy
		T10. Design team's values identification and hierarchy
		T11. Design team's value statement manifesto
		T12. Listing stakeholders and their values
		T13. Stakeholder values elicitation
		T14. Mapping stakeholder value landscapes
		T15. Project values identification

5.2.1. Individual Designer'S Values Identification and Hierarchy

Design work is often based on a collaborative effort of a group of designers. While students are often introduced to design methods for involving other people in the design (e.g., interviews or focus groups), these methods do not necessarily address or relate to other people's values, and they also do not focus on the values of the project members themselves. The "Individual designer's values identification and hierarchy" teaching activity supports students in becoming able to understand and explain their own underlying values, that their values are different from other students' values, to adapt to other students' values, and explain that values have an impact on the design of products, systems and services. In the activity, show the students a collection of values for inspiration, such as e.g., the HuValue Wheel (Kheirandish et al., 2019) or Schwartz Theory of Basic Values (Schwartz, 2012). The students are asked to formulate their own values and how they might shape them as responsible designers and impact their HCI practice, but also ask the students to describe how their individual values interact with and position them in relation to the values of other students or stakeholders.

5.2.2. Listing Stakeholders and Their Values

Students often focus only on the end-users and overlook others, who do not necessarily interact directly with the technology, but are still implicated by the technology nonetheless. Students often lack a broader perspective on people and the social context in which products, systems, or services will be integrated. In particular, the roles of non-targeted users such as adversaries and indirect stakeholders such as bystanders are often overlooked by the designer. If students only think of people in terms of users, they might end up focusing on immediate tasks and short-term goals without considering the ripple effect of their design that might cause unforeseen consequences in a long run. Students may end up unintentionally creating products, systems, or services that do more harm than benefit for some people. Through this activity, students will become able to identify a diverse range of direct and indirect stakeholders, and discuss their different roles and values implicated in products, systems, or services. This understanding is materialized in a list of Direct and indirect stakeholders, and their values, which enables discussion and reflection between teacher and the groups about the impact and ripple effects of a specific product, system, or service. In the activity, ask the students to read a text that describes the concepts of direct and indirect stakeholders, e.g., Section 6 in: Friedman et al. (2013) or chapter 2 in Friedman and Hendry (2019). The students are asked to understand the diversity of possible stakeholders, and show that they can reflect on the possible consequences of considering diverse stakeholders in their project.

5.2.3. Stakeholders Values Elicitation

While students are usually introduced to methods for the elicitation of design requirements from diverse stakeholders, these methods do not necessarily address the stakeholders' underlying values. This teaching activity helps students to plan and perform elicitation activities with stakeholders that address values, and to analyse the results. In the teaching activity the students practice the skills to plan and perform interviews with diverse stakeholders to elicit their values related to a specific product, system, or service, or to a set of similar products, systems, or services. The activity is based on the Socratic questioning structure (Robinson, 2017), and the repertory grid and the laddering technique (Kelly, 1991) where the stakeholders are asked about their appreciation of one or more products, systems, or services. This is done by structuring the answers from the interviewees on three levels: attributes (e.g., "light," "hexagonal shape," or "soft texture"), functions (e.g., "simple to use," "not expensive"), and values (e.g., "control," "ownership," or "comfort").

By doing so, the students gain a deeper understanding of how values relate to consequences and attributes. The teaching activity could also be used as an evaluation method to understand whether a designed product, system, or service fulfills the goal to support certain values according to the stakeholders. In this case, the students should have identified and described the intended values of the design before performing this activity. At the end of the activity, they will compare their intended values with the values as experienced by the stakeholders.

5.2.4. Mapping Value Landscapes

In contemporary society, we are facing complex challenges that can no longer be addressed by individual designers or design teams. Addressing challenges such as sustainability, the energy transition, and obesity requires a multi-stakeholder approach. When working on such challenges, students should be aware of and understand all the direct and indirect related stakeholders that might have stake or influence the challenge, even though they might not be able to actually run a multi-stakeholder project and meet all these stakeholders. Hence, students require competencies to explore the broader perspective on people and the societal context in which products, systems, or services will be integrated. In case students lack these competencies, they might not consider the ripple effect of their designs, which could have unforeseen consequences, such as excluding specific user groups. Moreover, with such complex issues, there is a fair chance their design solution will be experienced as rather naïve, or their design will never end up in practice, if they ignore the multi-stakeholder perspective.

In order to gain such a broader perspective on people and the societal context, they can create a stakeholder value landscape. A value landscape visualizes the (key) stakeholders and beneficiaries related to the challenge/topic at hand, as well as the key values that they hold and share and how they differ between the different stakeholders. The stakeholder value landscape aims at showing basic values, which Schwartz calls those trans-situational goals that guide people to live their lives (Schwartz, 2012), but it also shows other meaningful and valuable relations stakeholders have, both intangible (e.g., needs, feelings, expressions), tangible (goods and services), financial (money), or in the form of information.

Creating stakeholder value landscapes can be done in various ways, depending on the topic at hand, the intended outcome and the availability to meet stakeholders. A very well known example is the "value flow model" by Ouden den and Brankaert (2013), although they put less emphasis on basic values. There are many more (expressive) forms of value landscapes that can be made to explore the challenge. See the provided slides for various examples. The mapping is best done after having done the initial research phase so students can have some understanding about the stakeholders involved.

5.2.5. Project Values Identification

Becoming aware of the underlying project values at the beginning of a project—even before the idea sketching phase begins—is just as important as identifying the problem situation or design opening that students are designing for. Upon entering the second half of the first diamond in the Double Diamond design process model (Design council, 2021), students review their user research data through for example an affinity diagram (Interaction design Foundation, 2021) and identify four underlying project values. In this analysis phase, most experienced designers might have a gut feeling what the underlying project values are. However, this teaching activity makes it very explicit by enabling a design team to anchor what they identify as the four main project values in their empirical research.

The four project values should be regarded as provisional, and can serve as material for discussion throughout the design project. For example in a dialogue with stakeholders, where the student group later can introduce stakeholders to the project values, and negotiate the project values through an iterative process. Furthermore, the project values might serve as triggers for a discussion with stakeholders how to deal with value tensions, and how to concretely manifest the project values in a product, system, or service.

5.2.6. Value-Based Reformulation of the Design Draft

To our experience, students have a hard time critiquing design briefs and maps (e.g., value landscape map, mindmapping), as well as assessing the values in a design brief they receive. They tend to take what is explicit for granted and to ignore the untoned. A design brief is defined here as the formulated demands and expectations of the project provider, e.g., the client.

This activity teaches students to work with toned and untoned values in a design brief. By "toned" values, we mean values that are explicitly mentioned in the design brief (such as the available resources of each stakeholder involved in the project). By "untoned" values, we mean values that are not explicitly mentioned in the design brief, yet that are implied; taking them into account may impact the project (such as power relations among stakeholders). The aim is not to broaden the design brief, but to make better informed decisions on which values to take into account in the design process.

The teaching activity is performed after the Mapping value landscapes teaching activity, which results in a direct and indirect stakeholder analysis and a value landscape map, that is, the relations, objectives, ethical stances of stakeholders involved in the design project. The students analyse the value landscape map, which enables them to characterize untoned relations, and may lead to an evaluation and adaptation of some aspects of the design brief.

Example: Original design challenge: how to connect small and medium sized enterprises (SMEs) and expatriated partners. Through combining a value landscape map with reflections on all the relations that are not described in the previous description, the new design challenge can then for instance develop into: how can the region and a big company support local SMEs to find and hire new staff among expatriated partners.

5.2.7. The Game Changer

Designers and developers need to take responsibility and create products, systems and services that lead to positive environmental and social change. Nudging (Thaler, 2008) can be a way of creating change through a product, system, or service because nudging encourages people to act differently in ways that promote positive changes, sometimes in very unconscious ways, because of how salient qualities and features might influence behaviors. However, when designing for change, designers may tend to focus on designing for stakeholders who are already ready to become change agents. There might even be a tendency to design for some stereotypes in that regard. For example, when producing stereotypes around vegans and view them as "natural" change makers, when it comes to environmental issues.

Not everyone might be inspired to use new products, systems, or services that contribute to change. Simply because they are not motivated, and cannot associate themselves with being change makers. For example, why would a person who is into bodybuilding start to eat less meat, because it is good for the environment? Especially if the consensus within the bodybuilding environment is that protein contributes to building muscles, and that meat contains a lot of protein. However, what if a new design, or the way that a product, system, or service is introduced, could change a consensus within a specific group of stakeholders? An example of this is given in the video The Game Changers[1] where bodybuilders are convinced to switch to a plant-based diet. This is an interesting example of how visual language, combined with celebrity presence and expert knowledge might convince a group of stakeholders to change both convictions and their resulting behaviors. It basically changes the game for them. In this teaching activity, students will identify a stakeholder group, who they do not immediately recognize as the "natural" users of their product, system, and service.

Based on empirical research on a specific stakeholder group, students create personas (see Grudin and Pruitt, 2002, and Guan et al., 2021) that could be part of this "radical," but potential new stakeholder group. Students will then imagine how their product, system, or service might create new ways of being and acting in the world from the point of view of the stakeholder. When imagining this, students will judge what kind of visual material and storytelling might be the most convincing in relation to the selected stakeholder(s).

Finally, when students have created visual material, e.g., a video, that works like a commercial for their product, system, or service, they will have an ethical reflection on how they argue for the change that their product, system, or service might create in the stakeholder's life.

[1](2019). The Game Changers Official Trailer (Video File).

TABLE 3 | Overview of the teaching activities related to the design process phase Synthesis in the pedagogical framework on teaching for values in design.

Pillar	Phase	Teaching activity
(II) Designers and stakeholders	Synthesis	T16. Value-based reformulation of the design draft
		T18. Constructing value based design requirements
		T17. The game changer

5.3. Phase 3: Synthesis

In this phase, research findings are clustered. Insights evolve and potential areas of opportunity are identified. Students build the foundation to frame and specify the initial design brief. The teaching activities related to the design phase research are listed in **Table 3**.

5.3.1. Design Team'S Value Identification and Hierarchy

If students are only able to take into consideration and orient themselves on the basis of their own individual value sets rather than a team's shared value hierarchy, they run the risk of creating value tensions or conflicts within the team, the team's design process and, subsequently, the final design.

This teaching activity helps students working in groups or teams to establish a common ground with shared and prioritized values. Furthermore, it helps students sort, hierarchize, and interconnect values into a value hierarchy for the group, where some values are in the foreground (primary values) and other values are in the background (secondary values). The value hierarchy is materialized in the Designers' Value Hierarchy Map enabling discussion and reflection between students in the design team—as well as between teacher(s) and the groups—or group and stakeholders—about how their values come together with stakeholders, design contexts, etc. If students are not able to identify and arrange a shared and prioritized value hierarchy within their group or design team, they might end up with a design that is created based on a patchwork of more or less conflicting and unprioritized individual values, rather than a product integrating and expressing values in a prioritized and harmonious ways. When students have established a shared and prioritized Designers' Value Hierarchy Map, they are subsequently better able to negotiate, work with and integrate indirect and direct stakeholder values.

Generally, the Designers' Value Hierarchy Map, is to be constructed before the group or the design team begins communicating and negotiating with stakeholders, in order for the design team to give stakeholders a clear and solid impression of the design team's values.

5.3.2. Design Team'S Value Statements Manifesto

Even if students as a group have established their values, they often find it challenging to know how to turn them into actionable principles for the group or design team in a design process and project. This activity helps students construct a shared value manifesto with design principles constituting the design team's design position and orientation in the design process. Furthermore, it helps students combine and classify their manifesto-like design principles into a unified value statement manifesto for communicating their attitude and approach to design as a design team. This helps the group or design team negotiate with stakeholders and make decisions in the design process.

The group's value statements are materialized on the Value statement workshop cards provided and in the Design team's value statement manifesto, enabling discussion and reflection between students in the design team—as well as between teacher(s) and student teams—or student teams, and stakeholders—about how their value-oriented attitude and approach is acted out in the design process with stakeholders, design contexts, etc. If students are not able to formulate how they want to integrate or act on their values in the design process or project, they run the risk of creating design conflicts or paralysis within the team, the team's design process and the final design product, system, or service. Here, the students need a shared design stance or argument in the form of a designers' value statements manifesto to guide their work.

When students have formulated shared and actionable value statements, they are subsequently able to engage in reflective value-oriented design arguments that can guide their design work with stakeholders. Generally, a Design team's value statements manifesto is to be constructed before the group or design team begins communicating and negotiating with stakeholders, in order for the design team to give stakeholders a clear and solid impression of the design team's design principles and approach.

5.3.3. Constructing Value-Based Design Requirements

As values are general in nature it can be hard for students to make them concrete and incorporate them into design work. In this activity the students will learn how to analyse the identified project values and construct specific design requirements, which play an important role in guiding a design process. The teaching activity is an adaptation of a method originally developed by van de Poel (2013).

In the teaching activity, the students formulate a value hierarchy consisting of three levels: (1) the project value (identified in a previous teaching activity), (2) the design objectives, and (3) the specific design requirements. By constructing a value hierarchy, the identified project values are systematically translated into design requirements, and the value judgments involved become explicit, debatable, and transparent. Value judgment is defined here as the designer's opinion about whether something is good or bad, right or wrong. Making these judgments explicit allows for critical reflection upon the translations made, and enables the debate among the stakeholders involved. Moreover, a value hierarchy may be helpful in pinpointing exactly where there is disagreement about the specification of values in design. A value hierarchy makes design choices, and especially the implied value judgments, more transparent to other stakeholders, which is important because design usually impacts on others besides the designers.

TABLE 4 | Overview of the 28 teaching activities in the VASE pedagogical framework on teaching for values in design.

Pillar	Phase	Teaching activity
III) Technology and design	Ideation	T19. Visualizing values in design with mood boards
		T20. Understanding value tensions
		T21. Identifying and resolving value tensions
		T22. Exploring values through extreme worlds
		T23. Re-designing for different cultures
		T24. Envisioning future scenarios
		T25. Contextualizing values through reflection in action

5.4. Phase 4: Ideation

In this phase, students generate value-sensitive ideas based on their re-framed design brief through different ideation activities. Moreover, students choose ideas to produce in the form of prototypes. The teaching activities related to the design phase research are listed in **Table 4**.

5.4.1. Visualizing Values in Design With Mood Boards

The underlying values in products, systems, or services are manifested in use through e.g., their visual appearance, the symbolic language associated with them, or the different elements that they consist of. The underlying values may encourage and discourage people to act in certain ways when they interact with a product, system, or service.

A prerequisite for this teaching activity is that students work on a project and have already identified their project values. During the activity, the students are challenged to express the values and the intentions of their product, system, or service through visual means in order to support the prototyping process.

It is important that the students are able to reflect upon how they might integrate, embody, and manifest values in their design. If students are not able to find ways of embodying values in a prototype, the values behind the product, system, or service might not be obvious to the direct and indirect stakeholders.

Thus, in this teaching activity the students use a mood board as a prerequisite for a prototyping process to reflect upon how they would like their design to "speak" to different users and how their products, systems and services influence user behaviors and lifestyles. The visual representations of values are collected in mood boards (a visual presentation or a collage that communicates a concept or an idea) that inspire further development of prototypes.

5.4.2. Understanding Value Tensions

Value tensions occur when different stakeholders have different values or value priorities, causing them to dislike elements of a product, system, or service that other stakeholders do like. To be able to design the product, system, or service in such a way that it is as much in line with all stakeholders' values as possible, the designer first needs to identify the value tensions.

It can be difficult for students to do this, because it requires an in-depth consideration of (the manifestation of values in) various design elements. As guidance in the process, this teaching activity provides an introduction to the Value Dams and Flows method (Miller et al., 2007), which is a method for identifying value tensions. By exploring what value tensions are, how the Value Dams and Flows method works, and taking the first steps toward working with this method, students will be equipped to identify value tensions in the future.

5.4.3. Identifying and Resolving Value Tensions

Value tensions occur when different stakeholders have different values or value priorities, leading them to dislike elements of a product, system, or service that other stakeholders do like.

To be able to design the product, system, or service in such a way that it is as much in line with all stakeholders' values as possible, the designer first needs to identify the value tensions. The designer can then consider how these tensions can be resolved, i.e., how to design for one value that is important to some stakeholders, without sacrificing another value that is important to other stakeholders. This is necessary to ensure that all stakeholders will appropriate the product, system, or service.

It can be difficult for students to identify value tensions, because (1) it requires stakeholder input about many different (potential) elements of the design, and (2) it requires a criterion for when conflicting stakeholder preferences are important enough to be considered a value tension. The Value Dams and Flows method (Miller et al., 2007) offers guidelines for this process. By applying the Value Dams and Flows method, students will be equipped to identify value tensions within their own project, and consider how these tensions could be resolved in their design.

5.4.4. Exploring Values Through Extreme Worlds

Most students are unintentionally including many implicit values into their designs. It seems hard to step out of one's world and question things that seem so natural and generally accepted, such as for example, considering autism as a disorder. But also the values underlying more everyday situations, for example when interacting with interactive devices like smartphones and tablets, often seem determined by unquestioned boundaries of values related to hedonism, achievement, and power.

Designing for extreme worlds is a technique that opens up new perspectives and possibilities by not taking commonly accepted starting points for granted, and questioning the status quo. This can be done by (1) changing paradigms and norms, e.g., designing for extreme worldviews (e.g., Design a PDA for a world where dementia is blessing; van Dijk and Hummels, 2017), or (2) by focusing on different people to design for, e.g., designing for extreme characters (e.g., Design a PDA for a drugsdealer; Djajadiningrat et al., 2000).

– Extreme worldviews strongly deviate from prototypical and socially accepted ways of living, and are for now imaginary and speculative, such as a world where everyone has dementia, a world where the average age is 150 years old, or a world where people live in hibernation 9 months per year. This way, conflicting values which we might take for granted can be questioned through designing in this world (van Dijk and Hummels, 2017). – Extreme characters are the opposite of prototypical characters from a target group, which often remain emotionally shallow during the design process. Instead, extreme characters have exaggerated emotional attitudes and character traits, such as a drug dealer, the pope or a 3-time Olympic triathlon champion. This way, character traits can be exposed which can be antisocial or in conflict with a person's status, thus questioning personal values we might take for granted (Djajadiningrat et al., 2000).

On the one hand, this teaching activity can support opening up the design space and the creation of new ideas, and on the other hand it can support the awareness, reflection on and discussion of implicit values in design. Working with extreme worldviews and characters helps to reflect on and discuss implicit assumptions of new design ideas and concepts, by opening up new design spaces that trigger imagination and new views on values. It stimulates reflection on implicit values, questioning of trodden paths, as well as out-of-the-box ideation.

5.4.5. Envisioning Future Scenarios

When focusing on users and user experiences, students may approach their own or others' designs from a single, narrow perspective without realizing its potential impact on a broader society. Evidently, designs can have widespread consequences and long term effects on various stakeholders beyond the stakeholders initially imagined, both in positive and negative ways.

If students lack an understanding of the broad impact and long term effects of their designs, they run the risk of inadvertently causing more harm than good in society.

For this teaching activity, envisioning prompts are used as a tool for developing future scenarios to analyse and explain a use or user situation based on four criteria (stakeholders, time, values, pervasiveness). Each envisioning prompt will draw students' attention to a particular socio-technical issue that is important yet easily overlooked (e.g., diverse geographics, political realities, obsolescence).

The teaching activity builds on the Envisioning Cards (Friedman and Hendry, 2012a) developed by the Value Sensitive Design Research Lab at the Information School at the University of Washington. However, since these cards are not freely available, the main concepts are explained without requiring purchase of the cards.

5.4.6. Contextualizing Values Through Reflection-In-Action

In our experience, students seldom consider the act of making as a means for reflection, but rather as a way to demonstrate their ideas or concepts (which mostly takes place later in the design process). This teaching activity brings them to realize other uses of their design skills in the design process, namely reflecting-in-action on values engaged in the designs (output) and in designing (activity).

This exercise focuses on "making for exploration," which is characterized by ambiguity and a lack of predetermined planning (Frens and Hengeveld, 2013), i.e., with no expected plan and result planned before starting making. Such making supports the designer to engage in a reflective dialogue with the material in order to ideate and reflect, and may therefore lead to reflection-in-action on values engaged in the design project.

In this teaching activity, the students are introduced to a value-based perspective (e.g., oppositions such as individualism vs. collectivism) or a worldview (for example, cognitive embodiment), and through making, the students reflect on the values and value stances addressed by the aforementioned value-based perspective. Instead of working toward an end product the focus in this activity is on the reflection-in-action.

5.4.7. Public Evaluation of Values in Design

Often students do not have the opportunity to present their designs at open events or public exhibitions and explain or argue for their design to a wider audience. When students do not get the opportunity to receive, integrate, and adapt feedback on their designs from a wider audience they might lack a broader value-check and validation of their values in design. By inviting external audiences to engage with and evaluate the values of the design, students are able to evaluate how successfully their products, systems, or services embody and communicate the intended values in a meaningful and appropriate way. And, subsequently, how successfully they themselves are in acting as responsible, value-sensitive designers.

This teaching activity supports students in presenting their products, systems, or services at open events or public exhibitions to external audiences. The exhibition focuses on students' explanation, exemplification, and substantiation of their designs' values and value sensitivity in order for them to interpret and integrate audience feedback into their designs. This gives students the opportunity to adapt their designs based on the feedback they received so they become more value-sensitive before presenting them to a client or direct stakeholders.

5.5. Phase 5: Evaluation

In this phase, students test their prototypes with a focus on values. The values are embodied in the prototypes, and, one by one, they are investigated together with stakeholders and reflected upon in order to improve the design solutions. The teaching activities related to the design phase research are listed in **Table 5**.

TABLE 5 | Overview of the teaching activities related to the design phase evaluation in the pedagogical framework on teaching for values in design.

Pillar	Phase	Teaching activity
(III) Technology and design	Evaluation	T26. Evaluating values in design with stakeholders
		T27. Public examination of values in design
		T28. Design after evaluation of prototype

5.5.1. Re-designing Concepts for Different Cultures

Many designers are often not aware of the implicit culture-related values they incorporate into their designs. Semantic meaning related to color, forms, people, relations, etc. can be culturally specific and relate to social norms within a specific culture. Not being aware of these values can lead to embarrassing situations. For example, the translation of a Dutch Dick Bruna children's book about "Betje Big" (Poppy Pig) to Turkish (Betje Big'in, Dogum Günü) changed the connotation completely, since the pig is considered unclean in Turkey.

We are moving toward a global multicultural world, which is asking designers to be more aware of cultural values and norms. Researchers like Geert Hofstede, a Dutch organizational psychologist renowned in the field of intercultural studies, developed culture and organization-related frameworks (e.g., Hofstede, 2010). These frameworks provide a starting point, but are not immediately transferable to a design. They do not say, e.g., whether colors and materials have the same connotation all over the world. That might require exploration and engagement with people from this culture during the design process.

This teaching activity supports students in getting an understanding of the role of esthetics in their designs, regarding the appearance and interaction in relation to different cultural connotations. Through learning about and designing for different cultures than their own and having their designs evaluated by people from another culture, students are sensitized to these often implicit cultural values, and supported to include them more consciously in their design process.

Overall, this activity supports students becoming aware of and more competent in addressing the complexity of values and the situatedness of values given a certain culture or setting.

5.5.2. Evaluating Values in Design With Stakeholders

When designing products, systems, or services, it is important that students invite stakeholders to evaluate and reflect together with them about whether their designs managed to integrate and express the intended and desired values. That is, students need to engage the stakeholders as a gauge to see whether they managed to act as responsible designers and successfully consider values in design. If students do not present their designs to stakeholders they will lack validation of their value-sensitivity as well as the value-sensitivity of their designs.

Through evaluating values in design together with stakeholders, students go full circle by returning to their values, stakeholder values, the values of the design context and the values of the design project. In doing so, they reason, judge, and reflect on whether values were appropriately and attentively embedded in the product, system, or service.

Overall, the teaching activity provides students with arguments for the suitability and value sensitivity of their designs, allowing them to judge if there is alignment between the values identified at the beginning of the design process and the values the stakeholders experience in the product, system, or service.

For this teaching activity, students and stakeholders meet in a workshop where the product, system, or service is presented, tested, and discussed in order to evaluate values in design.

5.5.3. Design After Evaluation of Prototype

A product, system, or service is never fully finished, in the sense that it needs iterative or incremental design and development after it has been appropriated into the use contexts that it was directed toward. At the end of a design process, when students are evaluating the reception and impacts of their designs in use, they can perform this activity as part of the evaluation phase.

To maintain the students' critical perspectives on the impacts of their product, system, or service, and the values that it generates in real-world/real-life contexts, students should reflect upon the results of the stakeholder evaluations of their prototypes and how they might differ from the original visions behind a design.

Additionally, students will predict a few potential impacts of their product, system, or service on the contexts in which it is deployed. They will set up criteria for how they might evaluate the impacts of their product, system, or service, and how different stakeholders have appropriated it to fit their user contexts.

The students bring the prototypes to the use contexts and bodystorm (Oulasvirta et al., 2003), or do contextual inquiries (Beyer and Holtzblatt, 1999; Holtzblatt et al., 2005) with their prototypes in the different use contexts in order to evaluate them together with a selection of stakeholders.

The students will also discuss which parts of their product, system, or service that might need to be changed or modified later on, based on the different appropriations that they might discover in the evaluation phase.

The teaching activity ends with a proposal for how the students might follow up on the development of their product, system, or service after it has been used for a while. In other words: how they might assess future use patterns and their consequences.

6. DISCUSSION

Most approaches in related work on ethics and values in design and HCI deal with values rather than value, which goes in line with our intention to make designers aware of the influence of their designs, take responsibility, and be able to reflectively address the role that values play in design. However, values and value are not completely disparate concepts. Therefore, it may be necessary to explain to students what the connection between value/worth and values could be, especially in the context of working with businesses. For the collection of teaching activities presented here, we mainly focus on values and how these may also relate to ethics and morals.

Also, most approaches found in related work focus on the values in the product rather than the process. However, Values-led PD also focuses on values during the process (Iversen and Leong, 2012). This is not surprising since stakeholders are closely involved in the process of PD. However, whenever working directly with stakeholders in other approaches, it may also be useful to consider values (and even value) in the process. While we do think it can be useful in many educational programs to consider approaches that focus on values in the process, such as (values-led) PD.

There is a split between approaches that focus mainly on understanding and accommodating for stakeholders' values, and those that focus more on understanding and expressing designers' values. To provide students with a full understanding of what it means to address values in design, we argue that we need to incorporate both.

While Values at Play (Nissenbaum, 2021a) and Value-sensitive design (Friedman and Hendry, 2019) have been taught to students, Values-led PD (Iversen and Leong, 2012) and Worth-centered Design (Cockton, 2006) have mainly been used only by experienced designers, even though we are aware that they have introduced it in some courses. However, we have not been able to find any articles describing how to teach these approaches in detail.

When teaching students about values in design, it may be useful to determine whether one wants to work with a certain set of values, such as those defined by Rokeach (1973) and Schwartz (2012), or whether one wants to leave the concept of values more open. Here, we do not think we should adhere to a certain framework of values. Rather, we suggest making students aware of the different frameworks. Furthermore, it can be important to decide whether one wants to delve deeper in the different kinds of values and how they may or may not relate to morals and ethics. In Value-sensitive design (Friedman and Hendry, 2019) for example, the focus is mainly on values that have moral implications, rather than on all possible values.

6.1. How to Apply Teaching for Values in HCI in Practice

The collection of 28 identified challenges throughout the design process and the suggested inspirational teaching activities presented above, are extensive. We are aware of that it is difficult to implement all of this in one single course, and that is not the intention either. We would rather see this as an inspirational educational resource, where it is possible to pick and choose what is needed, and what fits into the existing curriculum. There are many considerations to take when planning to teach about values in HCI and design that will influence how the course will be set-up. Such considerations include:

- Who are they following. For example: design students, engineers, social scientists, computer scientists.
- Length of learning activity, course. For example: introductory workshop, 8 week course.
- Level of knowledge of the students in relation to values and/or design: beginner or more advanced.
- Attitude and intention of the course (vision): ranging from providing knowledge to indicating the role of activism (active or pro-active).
- The dimensions of knowledge, skills, and attitude that need to be taught (competences, and through lines), e.g., Awareness activities pointing out that values are a part of design, Investigating diverse (own and stakeholders) values Designing

for (diverse) values, Evaluating values, Coverage of different design phases, and teaching a balance between knowledge, skills, and attitude.

The collection of design challenges and accompanied inspirational suggestions for teaching activities can be used in several different ways, some of them described below:

Select specific stand-alone activities

Teachers can explore the overarching learning objectives for each activity and select those that are the most relevant to their discipline, curriculum, or course. The learning objectives are described in broad terms, while the teaching activities connected to each of the learning objectives execute them in concrete ways.

Create in-depth learning pathways

Teachers can combine concrete teaching activities that move students from a simple (unistructural) to a complex (extended abstract) level of understanding of values in design within a specific pillar in accordance with the SOLO taxonomy (Biggs, 2003). Each of the three pillars represent core areas of teaching for values in the design of technology connected to specific design process phases. Integrating learning pathways in teaching allows students to build deeper knowledge, skills, and attitudes progressively to acquire a desired set of competencies within a specific pillar.

Give students a broad foundation

Teachers can combine concrete activities across all three pillars and design phases that create a broad foundation for students to become more responsible designers. Creating a broad foundation within a certain level of understanding allows students to develop a more holistic approach to values in the design of technology in relation to a select level of competence.

Whatever way is chosen to apply teaching for values in the design of technology, it is important for teachers to adapt and appropriate the teaching activities (as described more in detail in the open educational resource, VASE, 2021) to fit their specific educational context (Hendry, 2020; Nilsson et al., 2020).

6.2. Consequences of Teaching for Values in Design

In a recent study, an adapted version of the teaching activity Envisioning future scenarios was used in order to identify the large-scale effects of teaching values in design (Kok et al., 2021). One traditional scenario was developed (Rosson and Carroll, 2002), and two value scenarios (Nathan et al., 2008), using prompts divided into four envisioning topics: direct and indirect stakeholders, time, values, and pervasiveness (Friedman and Hendry, 2012b). While the traditional scenario mostly considers the obvious and desirable consequences of teaching values in design for direct stakeholders, the value scenarios reveals less obvious, unintended, concrete, and long-term effects, both good and bad. It demonstrates that individual classroom outcomes are not the only important consequences one's teaching may have (on students nor on society). Rather, the way education shapes students continues to play out beyond the classroom and throughout their professional lives. Envisioning can helped clarify in what ways students as well as indirect stakeholders could be affected by teaching, and can therefore be an effective tool to use when planning teaching. However, we are aware of that over time, the political significance of educational approaches will change, and that we can never envision and imagine the full implications of our teaching or educational designs (Winner, 1999; Tromp et al., 2011; Kok et al., 2021).

Results from piloting one or several of the 28 teaching activities, indicate that teachers involved in the pilots experience professional development within teaching for values in design, a qualitative update of the design curriculum, and increased capacity to teach for values in design in relevant and innovative ways. The participating students have reported that they experience achieving knowledge about how to understand and act ethically on human values in design. From the initial trial period of evaluating pilots through questionnaires, we have seven responses from teachers. In those responses, over 70% indicate the highest relevance possible regarding the question "To what extent was this material relevant to you?," and 86% indicate high on the question "To what extent do you experience increased capacity to teach value sensitive design in relevant and innovative ways?". From the initial trial period of using the student evaluation questionnaire, we learned that 90% out 30 students indicate high to the question "I have learned something about working with values in design that I consider valuable for my professional development". However, we soon decided not to provide a separate evaluation questionnaire for each activity, but instead add one question to the respective universities mandatory course evaluation forms. In one example with 35 students, 78% answer very great or significant outcome to the question: "To what extent do you experience achieving knowledge about how to understand and act ethically on human values in design?" For shorter interventions, such as a guest lecture in a university that was not a partner of the project, an exit ticket was provided asking the students to list three things they have learned during the lecture. The answer to this was e.g., values, design values, and ethics. So, in that sense, early results indicate that we have achieved what we set out to do, to educate more responsible designers. However, not all teaching activities have been through this evaluation, and the activities have so far only been tested in a limited number of educational contexts, why more work is waiting ahead, such as large-scale testing in other educational contexts and cultures with non-Western value systems. We further acknowledge that values are of course but one angle on teaching how to become a responsible designer—many other angles exist.

A final limitation to this work is that in the identified challenges, we outline students' approaches through our unique perspective as teachers in higher education. This is due to that we have used a modified version of the pedagogical design pattern approach (Goodyear, 2005; Laurillard, 2012), in order to elicit existing best practice from teachers and from related work found through desk research. Other approaches could have been applied in order to incorporate the students perspective better, such as a collaborative approach to the design of learning goals and teaching materials. Active participation of stakeholders is the basis of Participatory Design (Simonsen and Robertson, 2012), and could have been applied by e.g., to introduce the students to values and ethics in HCI and ask what they believe a responsible designer of technology is, and what a responsible designer needs to know and should be able to do. Acknowledging that involving students in the assessment process is a key attribute for students' motivation to learn (Falchikov, 2004), we leave this collaborative approach as a suggestion for future work.

7. CONCLUSION

In this article, we have argued for the value of teaching for values throughout the whole design process, as a mean to educated more responsible designers of technology. We have identified insufficient hands-on teaching activities throughout the design process, and especially in the later parts of the process. In this article, we argue for the importance of teaching for values throughout the design process, by identifying a unique collection of 28 challenges accompanied by inspirational suggestions for teaching activities tackling these challenges related to values and ethics in HCI. Participants in various types of pilots of the suggested inspirational teaching activities experience achieving knowledge about how to understand and act ethically on human values in design (student perspective), and increased capacity to teach for values in design in relevant and innovative ways (teacher perspective). However, it can be discussed whether we have covered all parts of the design process. For instance, we have less teaching activities in the phases synthesis and evaluation than in values theories, research, and ideation. This does not mean that we consider these less important, but rather that it has been more difficult to design activities for these phases. We see this collection of challenges related to ethics and values throughout the design process and the inspirational teaching activities as a first start to educate more responsible designers of technology, and invite members of the HCI community to test, critique, and complement this work.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

FUNDING

The research is co-funded by Erasmus+ programme of the European Union, Grant number 2018-1-SE01-KA203-039072.

ACKNOWLEDGMENTS

The authors thank the participating partners, students, teachers, and researchers.

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frontiers in Computer Science

SYSTEMATIC REVIEW
published: 03 March 2022
doi: 10.3389/fcomp.2022.812907

Experiential Learning to Teach User Experience in Higher Education in Past 20 Years: A Scoping Review

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Experiential learning is an effective method to teach User Experience (UX) to Human-Computer Interaction (HCI) students. Despite its popularity, there seems to be no comprehensive overview on (1) the current use of experiential learning in UX education at universities and (2) student learning outcomes and benefits resulting from the use of experiential learning. Hence, we conducted a scoping review to provide such overview. We analyzed 45 articles published from 2000 to 2021 and we found 12 types of experiential learning employed by HCI educators: applied research project, industry/community research project, hands-on activity, role-play, interactive workshops, guest speakers, in-house work placement, internship, flipped classroom, field project, lab, and design hackathon, from most to least frequent. Twenty-six articles reported student learning outcomes and benefits: (1) enhanced UX technical knowledge, (2) applied textbook knowledge into practice, (3) acquired soft skills, (4) student satisfaction, (5) increased awareness of user diversity, and (6) increased job marketability. Overall, we advance current HCI teaching practices by providing HCI educators with a list of experiential learning types that they can adopt in their classes to teach UX.

Keywords: user experience, higher education, experiential learning, human computer interaction, scoping review

OPEN ACCESS

Edited by:
Gerrit C. Van Der Veer, University of Twente, Netherlands

Reviewed by:
Styliani Kleanthous, Open University of Cyprus, Cyprus
Sandra Sanchez-Gordon, Escuela Politécnica Nacional, Ecuador

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Specialty section:
This article was submitted to Human-Media Interaction, a section of the journal Frontiers in Computer Science

Received: *10 November 2021*
Accepted: *26 January 2022*
Published: *03 March 2022*

Citation:
Kang J, Roestel NME and Girouard A (2022) Experiential Learning to Teach User Experience in Higher Education in Past 20 Years: A Scoping Review. Front. Comput. Sci. 4:812907. doi: 10.3389/fcomp.2022.812907

INTRODUCTION

Human-Computer Interaction (HCI) students typically learn about user experience (UX) during their studies. The field of HCI focuses on the design, implementation, evaluation of interaction systems that support human activity (Hewett et al., 1992) and thus it trains students on a wide range of UX topics, from accessibility to user-centered design and software development. HCI students should be able to create systems that provide the best possible interaction for intended users (Hewett et al., 1992; ACM, 2020).

There is a growing interest among HCI educators to adopt experiential learning as a pedagogical approach. For instance, out of 16 papers submitted to the Teachable Moment track at EduCHI from 2019 to 2021, a symposium to discuss HCI education, 8 papers (50%) have presented new class activities that involved experiential learning.

The shift in higher education toward experiential learning makes sense against empirical evidence that suggests its superiority in fostering academic *and* workforce skills (Hamer, 2000; Sánchez et al., 2019). The power of experiential learning to successfully prepare students to be work-ready cannot be overstated. Many HCI students pursue UX industry after graduation (Rosala and Krause, 2019; Girouard and Kang, 2021) and yet employers question whether new graduates of computing disciplines are work-ready (Brechner, 2003; Radermacher and Walia, 2013). Hence, adopting experiential learning as a pedagogical method is a must, not an option.

To date, HCI educators' efforts to advance HCI pedagogy can be classified in two ways: *what* topics should be taught and *how* should HCI topics be taught. The former identifies new HCI topics and curriculum that should to be taught to students in response to rapid technology advancement (Churchill et al., 2013; Musabirov et al., 2019); the latter focuses on proposing a new way of teaching HCI topics by providing a case of their individual pedagogical approach (Talone et al., 2017; Roldan et al., 2020; Lallemand, 2021). Our current work falls under the latter but we take a different approach. We offer a comprehensive overview of the types of experiential learning that have been used to teach UX (vs. focusing on an individual pedagogical approach).

Specifically, we asked two research questions. **RQ1:** What types of experiential learning have been employed by HCI educators to teach UX? and **RQ2:** What student learning outcomes and benefits have been reported, if provided? To address these questions, we conducted a scoping review of published articles from 2000 to 2021 ($N = 45$). In our analysis, we found 12 types of experiential learning and we also identified five student learning outcomes and benefits among the articles that have evaluated the effectiveness of their pedagogical approach.

Our contributions, which center on advancing the current practices of teaching UX concepts, skills, and methods, are the following:

- We trigger a critical reflection on the appropriateness of the UX teaching practice for past 20 years, potentially identifying if new types of experiential learning should be adopted.
- We provide a list of experiential learning types that can be used to teach UX in higher education. This overview empowers HCI educators to design and adopt techniques that match their goals and constraints.
- We offer insights on UX learning assessment methods that have been employed by HCI educators. This information identifies if any improvements are needed with the current assessment practice.

In this paper, we define HCI expansively to encompass computing and related disciplines that specifically focus on understanding the impact of ubiquitous computing on individuals. These disciplines include computer science, information technology, design, and psychology (Hewett et al., 1992).

Benefits and Types of Experiential Learning

Drawing from Kolb (1984), there are four major principles in experiential learning:

- Expose students to new experience. These experiences can be any hands-on activity to new information.
- Guide students to reflect on new experience. This guided reflection helps students to connect new experience to prior understanding.
- Encourage students to abstract new knowledge from reflection.
- Help students apply the new knowledge with a new practice set.

There are many types of experiential learning (hereafter, EL types). Most popular EL types are case study, work placement, lab, and role-play (Gittings et al., 2020). Benefits of experiential learning are well-documented and these benefits include increased technical knowledge and higher comprehension of a course content, higher student satisfaction and obtainment of employment at graduation (Gittings et al., 2020).

The hands-on aspect underlies all EL types and thus students can develop the same skills from participating in any of the EL types. But they may develop those skills at a greater depth from participating in more immersive EL types than less immersive EL types. This is because immersive EL types place students in touch with the real world and certain skills such as leadership and teamwork are learned better in a working situation than in class (Barr and McNeilly, 2002).

Experiential Learning to Teach UX in HCI

In this paper, we define UX to refer to all aspects of a person's experience—emotion, behavior, and cognition—while interacting with computing systems (Hassenzahl and Tractinsky, 2006). HCI students master several competencies to achieve a high quality UX of a given computing system; these competencies center on HCI foundation (e.g., accessibility, user-centered design, human-centered software development), user testing (e.g., prototyping, evaluation techniques), statistical methods, and content strategy (Hewett et al., 1992; ACM, 2020).

HCI students have a great interest in pursuing UX careers (Yargin et al., 2018; Rosala and Krause, 2019). Yet, they feel and are ill-equipped to pursue UX careers (Gonzalez et al., 2014). Feeling and being unprepared for the UX industry can explain the surging adoption of experiential learning in HCI education since experiential learning can teach students professional skills (Talone et al., 2017).

Also, CS undergraduate students perceive HCI as too easy and common-sense (Edwards et al., 2006), which may contribute to their reluctance to adopt a user-centered approach in software development. Experiential learning can engage students and thus it is paramount to understand what EL types are available to HCI educators, so that they can adopt and use the technique in their UX teaching.

To date, there seems to be no comprehensive overview that shows different EL types employed by HCI educators to teach UX. A review—be it scoping or systematic—of experiential learning is done to improve curriculum and class delivery and ultimately the effectiveness of teaching (Gittings et al., 2020). We sought out to conduct a scoping review to assess and organize the available body of literature on UX education (Arksey and O'Malley, 2005). We posed the following research questions:

- **Research Question 1 (RQ1)**: What types of experiential learning have been employed by HCI educators to teach UX in higher education?
- **Research Question 2 (RQ2)**: What student learning outcomes and benefits have been reported?

TABLE 1 | Key terms and their alternative terms.

"Experiential learning"	"User experience"	"Higher education"
"active learning", "student-centered learning", "learning by doing", "cooperative learning", "problem-based learning", Kolb*	UX*, usability, user*, "accessibility", "web analytics", "user research", "interaction design", "visual design", "content strategy", "information architecture", HCI, "human-computer interaction"	"tertiary education", universit*

METHODS

We followed PRISMA's guideline for a scoping review (PRISMA, 2021). The first and second authors conducted the review. We used a web-based review tool called Covidence to facilitate the process of initial paper screening [Veritas Health Information, (2014)] and Excel for final paper screening process.

Database Selection

Given the interdisciplinary nature of HCI, we employed both computing-specific and non-computing-specific databases to capture as many relevant papers as possible. We used two databases—IEEE Xplore and ACM Digital Library—that specifically support computing research and another database—Scopus—that supports multidisciplinary research.

Search String Development

Our search string consisted of the three main key terms (i.e., experiential learning, user experience, and higher education) and their corresponding alternative terms (**Table 1**; for each column, the first row presents the key term). These key terms were determined based on our RQs and prior work on experiential learning (Gittings et al., 2020). For the term "user experience," we developed alternative terms based on seven knowledge branches of UX: information architecture, visual design, interaction design, user research, accessibility, content strategy, and web analytics [usability.gov, (n.d.); Tiwalolu, 2018]. We used the Boolean operator AND to separate the terms in each column; we used OR to connect alternative terms; we used an asterisk (*) to search for variations of word stems; we used a quotation ("") to get an exact match of that term. We searched for terms in title, abstracts, and keywords.

Inclusion/Exclusion Criteria

We only included articles that met all the following criteria:

1. The article must be published between 2000 and 2021. We chose this publication range because we see an upsurge of academic work on UX being published from 2000 (Lallemand et al., 2015).
2. The article must describe a pedagogical approach (e.g., course, workshop) that teaches skills and knowledge that fall within the seven UX branches defined above.
3. The article must address a pedagogical approach dedicated to undergraduate or graduate students in university.
4. The article must be peer-reviewed. It can be published in a journal or peer-reviewed proceedings of a conference. For conference proceedings, the article can be in any forms, including Gray literature (e.g., work-in-progress papers, extended abstracts). Gray literature is scholarly work that falls outside of typical peer-reviewed, full research articles [New York Academy of Medicine, 2009]. There is lack of research on experiential learning in HCI (Lee et al., 2019; Lima et al., 2021). By extending our search to include Gray literature, we are covering large and diverse sources of evidence, with the goal of providing a comprehensive overview on UX pedagogy. This inclusion practice of Gray literature aligns with recommended scoping review guidelines (Scherer and Saldanha, 2019; Sucharew and Macaluso, 2019).
5. The article must be a full text. Its entire textual content should be available in the database.
6. The article must be written in English.

Additional Search for Articles

We searched for additional articles by doing backward reference list checking. We examined references in the articles that we have already found from three databases. We also checked for relevant articles by using the "cited by" function in Google scholar. Lastly, we checked for articles available articles in EduCHI website; this symposium has specific paper track dedicated for sharing new HCI pedagogical approaches. The whole search was conducted for 1 week in July 2021.

Article Screening Results

We found a total of 1,128 articles from three databases and manual search process (**Figure 1**). We uploaded the full text of these papers on Covidence. Then the first and second authors reviewed each article on Covidence. Each of us marked the paper with Yes, Maybe, or No based on the following decision criteria:

- Yes: the title, abstract, and/or keywords refer to the three main key search terms (i.e., experiential learning, user experience, and higher education).
- Maybe: the title, abstract, and/or keywords refer to two of the three main key search terms.
- No: not the title and/or abstract may include a reference to one of the main key search terms, but the terms have no relationship with one another.

In this initial screening, we disagreed on 236 papers and the disagreement mainly arose because a paper's abstract, title, and/or keywords did not give clear indication of which UX knowledge and skills were being addressed. The discrepancy was resolved through discussion and reading the full text of a paper.

After resolving the disagreement, we had a total of 226 papers that were eligible for final paper screening process. In this final screening process, each reviewer independently checked the article against the inclusion criteria. We coded the article as the following:

- Yes, in which the paper satisfies all the criteria.
- No, in which the paper satisfies all the criteria.

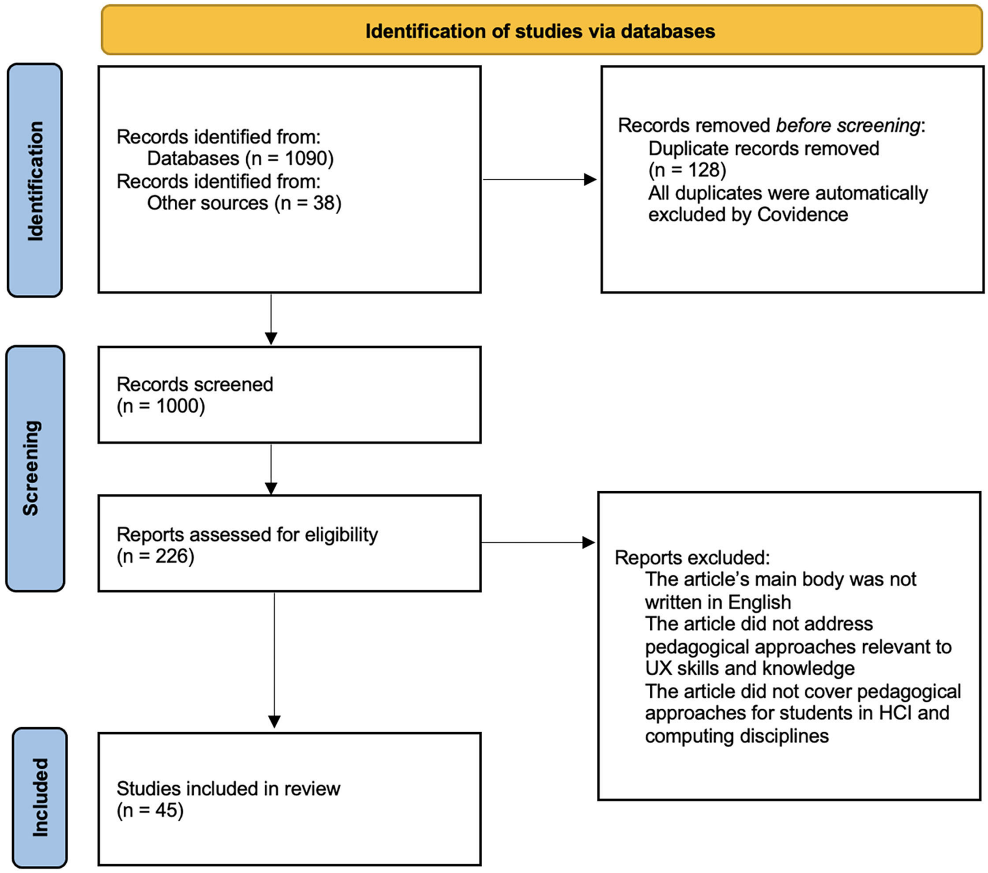

FIGURE 1 | A flow diagram illustrating the article screening process.

We disagreed on 11 articles, which mainly arose due to our mismatched understandings of what disciplines fall under HCI. We resolved the disagreement *via* discussion. We had a total of 45 articles eligible for data analysis.

ARTICLE BIBLIOGRAPHY PROFILE

Thirty-seven articles were full research articles, 3 short research articles, 4 symposium articles, and 1 extended abstract. Articles described pedagogical approaches that were based in USA ($n = 21$), European countries ($n = 8$; Germany, Switzerland, Austria, Denmark, Netherlands, Greece, United Kingdom), Canada ($n = 5$), India ($n = 3$), and others ($n = 8$; Chile, Turkey, China, Indonesia, Mexico, Egypt, Australia, Colombia). Articles were published/presented in 30 unique journals and conferences (**Table 2**). Thirty-seven articles were published/presented in international conferences and eight papers were published in journals.

Articles described pedagogical approaches offered to students in the related department, school, or faculty of Information Technology ($n = 7$), CS and Software Engineering ($n = 20$), Design and Industrial Design ($n = 6$), Computer Graphics Technology ($n = 1$), and UX ($n = 1$). Three articles said their students came from various STEM fields; seven articles did not clearly indicate the discipline of students, but the authors were from the department of Information Science, CS, and Engineering. Articles were published in the years of 2005–2021 (**Figure 2**).

RESULTS

We analyzed each article by summarizing its key information relevant to our RQs: the author, publication year, publication venue, EL type, student benefits and assessment method, and student discipline. We used prior work to identify major EL types described in each article (Gittings et al., 2020). Under this section, we report a comprehensive summary of the reviewed articles, which is a recommended practice (Arksey and O'Malley, 2005), and then we offer a critical overview in relation to the UX education literature in Discussion.

RQ1: Types of Experiential Learning

Thirty-one articles described pedagogical approaches for undergraduate students, ten articles described pedagogical approaches for graduate students, and four articles described

TABLE 2 | A list of journals and conference venues.

Venue Name	n
SIGCSE Technical Symposium on Computer Science Education	6
EduCHI: Annual Symposium on HCI Education	4
International Conference on Computers and Accessibility (ASSETS)	3
International Conference of Design, User Experience, and Usability	2
Annual Conference on Information Technology Education	2
Transactions on Computing Education (TOCE)	2
International Conference on Software Engineering: Software Engineering Education and Training	2
Conference on Human Factors in Computing Systems (CHI)	2
World Engineering Education Forum	1
International Conference on the Foundations of Digital Games	1
International Conference on Interfaces and HCI	1
International Journal of Human-Computer Interaction	1
International Journal of Research on Service-Learning and Community Engagement	1
Journal of Usability Studies	1
International Professional Communication Conference	1
Health Informatics Journal	1
Association of Information Science and Technology	1
IFIP Conference on HCI (INTERACT)	1
Interaccion: International Conference on HCI	1
Designing Interactive Systems Conference (DIS)	1
Australasian Computing Education Conference	1
Journal of Engineering Education Transformations	1
International Conference on MOOCs, Innovation, and Technology in Education	1
Koli Calling International Conference on Computing Education Research	1
Participatory Design Conference	1
APCHIUX: Asia Pacific Symposium of HCI and UX Design	1
Frontiers in Education Conference (FIE)	1
Western Canadian Conference on Computing Education	1
International Conference on Teaching, Assessment, and Learning for Engineering (TALE)	1
Informatics	1

pedagogical approaches for both graduate and undergraduate students. In the last category, the pedagogical approach either allowed for enrolment of graduate and undergraduate students or it was specifically designed to promote collaboration between graduate and undergraduate students.

We identified 12 EL types and we describe each in detail. **Table 3** lists the first authors of all articles. We assigned each article a random number to improve readability of other tables. See **Tables 4–7** for an overview of EL types that have been employed to teach UX in the past.

We treated each EL type appeared in a given article as a unique count and the frequency of all EL types does not add up to a total number of articles because some articles describe more than one EL type (i.e., articles that presented more than one EL type).

Applied Research Project (*n* = 24)

In 24 articles, students were involved in an applied research project. In this project, students were expected to produce minimally functional prototypes or a research report with recommendations. In 17 articles, students worked with industry and community partners or involved end-users. Students or instructors decided on a research topic (vs. industry and community partners). When external partners or end-users were involved, students involved them to a limited degree (either when they conducted usability evaluation or gathering user requirements) and they initiated the initial contact with external partners and end-users.

For instance, in Holzer et al. (2018), students created a prototype that can nudge sustainable campus behaviors and they conducted interviews with potential users only during the design ideation stage. In Zhao et al. (2020), students contacted a person with a disability and they involved the person either to gather user requirements or to conduct usability testing of their design targeted to address accessibility issues.

In three articles, students conducted usability testing with other students. For instance, in Santana-Mancilla et al. (2019), graduate students conducted usability testing of their interactive videogame devices with other teams in class.

In the remaining four articles, end-users were not involved. Notably, Satterfield and Fabri (2017) described an interesting way of "involving" end-users. Their students designed an educational game meant to facilitate social interaction between children without and with autism. Students gathered user requirements by observing preselected YouTube videos to understand children's behaviors.

In 20 articles, an applied research project occurred in a semester-long course (lasting up to 15 weeks). Among these articles, Patil et al.'s (2016) course for CS undergraduate students in India lasted over 4 months. In one article, this EL type occurred in a short course that lasted 2 weeks (Lazem, 2019). Lastly, in three other articles, this EL type occurred in a curriculum.

We found notable variations within this EL type. First, in Koutsabasis and Vosinakis (2012), students engaged in design and research activities, shared ideas, and presented their multi-touch interactive table or kiosk prototypes in the virtual world, which was specifically created for the course. Second, some instructors adopted innovative ways to cultivate design thinking in students, for instance, by having to students co-designed with people with and without disabilities (Shinohara et al., 2016) or by having students to team up a student with disability (Zhao et al., 2020).

Industry/Community Research Project (*n* = 14)

In 14 articles, students participated in an industry/community research project. The hallmarks of industry/community research project included: (1) students engaged in intimate collaboration with industry and community partners, starting from project topic inception to iterative design process and final prototype and research report presentation, (2) students sought out to address external partners' needs, and (3) students provided recommendations and prototypes to partners in exchange of learning experience (i.e., monetary compensation was not

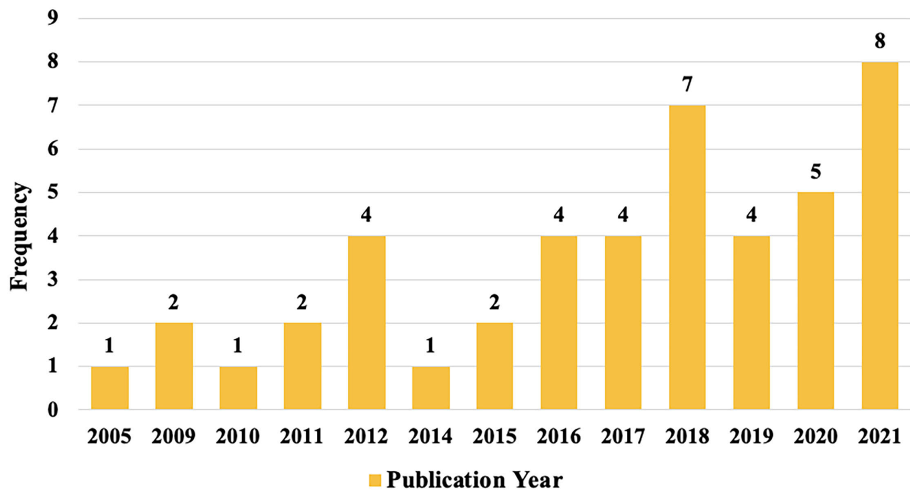

FIGURE 2 | A range of publication years of all articles.

TABLE 3 | The authors of all articles in the review and their corresponding reference number.

Ref #	References	Ref #	References
1	Talone et al. (2017)	24	Girouard and Kang (2021)
2	Robinson and Hall (2018)	25	Lazar (2011)
3	Hui (2020)	26	MacDonald and Rozaklis (2017)
4	Péraire (2019)	27	Xin et al. (2018)
5	Byers et al. (2021)	28	Kabakova et al. (2021)
6	Lallemand (2021)	29	Zhao et al. (2020)
7	Brown and Pastel (2009)	30	Vorvoreanu et al. (2017)
8	Krusche et al. (2018)	31	Yargin et al. (2018)
9	El-Glaly et al. (2020)	32	Shinohara et al. (2016)
10	Konstantinidis et al. (2021)	33	Poor et al. (2012)
11	Koutsabasis and Vosinakis (2012)	34	Harrison (2005)
12	Lazem (2019)	35	Shalamova (2016)
13	Kang et al. (2021)	36	Satterfield and Fabri (2017)
14	Hardy et al. (2018)	37	Patil et al. (2016)
15	Patricia (2011)	38	Nair (2020)
16	Maher et al. (2015)	39	Motschnig et al. (2016)
17	Solano (2017)	40	Chaffin and Barnes (2010)
18	Santana-Mancilla et al. (2019)	41	Roldan et al. (2021)
19	Waller et al. (2009)	42	Holzer et al. (2018)
20	Wang (2012)	43	Leshed (2019)
21	Santoso and Sari (2015)	44	Shinge et al. (2021)
22	Mohan et al. (2012)	45	Neyem et al. (2014)
23	Christiansson et al. (2018)	–	–

involved). Students designed various interactive systems for their external partners, ranging from serious game applications (Konstantinidis et al., 2021) to a study aid for seniors who study the citizenship exam (Robinson and Hall, 2018) and a mobile recycling application (Leshed, 2019).

In nine articles, students worked on an industry/community research project in a semester-long course (lasting up to 13 weeks). Notably, in Nair (2020), their course in India lasted from 2 weeks to 6 months. In other two articles, students were enrolled in a short course (lasting 4 days) (Xin et al., 2018; Konstantinidis et al., 2021).

We found several variations within this EL type, first regarding the delivery group. In Konstantinidis et al. (2021) and Nair (2020), their courses were offered to international students and

TABLE 4 | A list of EL types.

EL Type	Description	n*
Applied research project	Students conduct a real-world project without external partners, but they can involve partners if they wish.	24
Industry/community research project	Students collaborate on a project with industry and community partners in the exchange of their learning experience.	14
Hands-on activity	Students are presented with real-world scenarios in a classroom or an outside-of-classroom setting.	3
Role-play	Students assume a particular role and perform its associated responsibility to complete a task.	2
Interactive workshop	Experts are invited to provide interactive learning experience or students can also lead a workshop.	3
Guest speakers	Guest speakers who are not instructors share their expertise with students.	2
In-house work placement	Students spend time doing real work through university and receive payment *via* university account.	1
Internship	Student spend time doing real work for a real business in their relevant field.	1
Flipped classroom	Students watch video lectures outside of class and engage with real-world scenarios in a classroom setting.	2
Field project	Students make a field visit to industry practitioners outside of classroom setting.	1
Lab	Students engage in practical application of skills within a classroom setting.	1
Design hackathon	Students engage in a project with industry partners over a short period of time.	1
Combined practice	Industry/community research project and role-play	
	Flipped classroom, applied research project, field trip, and guest speakers	
	Industry/community research project and interactive workshop	
	Applied research project, industry/community research project, and design hackathon	
	Applied research project and industry/community research project	
	Internship, interactive workshop, and guest speakers	

**We treated each EL type appeared in a given article as a unique count and the frequency of all EL types does not add up to a total number of articles. Some articles describe more than one EL type (i.e., articles that presented more than one EL type).*

other university researchers in addition to their students in the department of engineering. Second, in Vorvoreanu et al. (2017), their experiential studio invited students of all levels—freshmen, sophomore, and junior—to work on an industry-sponsored partners (i.e., cross-cohort teamwork).

Second, in certain courses, students who worked with local communities worked on projects that were more socially driven. In Shinge et al. (2021), students designed a new digital method of teaching to improve elementary school children's poor performance across basic subjects. In Nair (2020), students provided technology remedies for pressing issues such as sanitation, potable water and nutrition faced in village communities in India.

This EL type also occurred in an independent training program. Kang et al. (2021) described a training program called the Research and Education in Accessibility, Design and Innovation (READi). Students concurrently pursued their home degree program while participating in these programs. They worked with community partners for 8 months and they provide tangible insights to partners' accessibility issues.

Regardless of whether students were embedded in a semester-long course, a short course, a curriculum, or an independent training program, students performed all or some of the following key UX activities that closely follow the real-world UX project lifespan: (1) requirement gathering (e.g., stakeholder identification and interviews, stakeholder map, persona); (2) design (e.g., iterative prototyping), (3) usability evaluation (e.g., focus group, experiment, affinity mapping, user journey, accessibility evaluation), and (4) implementation (e.g., prototype and presentation to clients).

Hands-on Activity ($n = 3$)

This EL type provided students with real-world scenarios and challenges. In Hui (2020), students identified four real-world design challenges and, in teams, provided solution to each challenge. Students also conducted heuristic evaluation on one of the prototypes created from a design challenge. Lallemand (2021) presented three creative hands-on activities to teach students about research methods. One notable activity is called a Self-Exploration of Methods Booklet. The booklet presents a real user study that employed UX methods (e.g., AttrakDiff scale, Geneva Emotion Wheel) to evaluate design concepts. Students participate in the study as if they are a real study participant and then they critically evaluate each method.

Role-Play ($n = 2$)

In this EL type, students performed a certain role and its corresponding responsibilities to complete a task. Krusche et al. (2018) introduced "software theater" in which undergraduate students role-played as actors of the screenplay and they played out how end-users would use the new product and services in the real world. In Robinson and Hall (2018) agile development methods class, students formed a scrum team and took on roles as SCRUM Master, Product Owner, UI Designer, Tester, or other roles essential in scrum and they carried out an industry/community research project.

Interactive Workshop ($n = 3$)

Interactive workshops invited students to lead a class or participate in hands-on activities. In Leshed's (2019) advanced HCI course, students were the drivers of the class; they planned and led a workshop on a given topic. Students were encouraged to be creative with the pedagogical method for the workshop, such as craft exercises, field trips, performing arts, and cooking.

In two independent training programs—READi (Kang et al., 2021) and Collaborative Leaning of Usability Experiences (CLUE) (Girouard and Kang, 2021)—accessibility and UX experts from industry and academia delivered a workshop and students participated in hands-on activities to learn about relevant topics, including web and document accessibility;

TABLE 5 | A list of EL type and respective reference.

Ref #	Student level	Format	Central Topics Taught	Duration	EL type
1	U	Outside-of-class lab activity	UX research, design, and evaluation	Not indicated	In-house work placement
2	U (3rd and 4th)	Course	Rapid prototyping, project management, teamwork	Semester	Industry/community research project, and role-play
3	U (3rd and 4th)	Course**	HCI theories; HCI research, design, evaluation	Semester	Industry/community research project, hands-on activity
4	G (Master's)	Course	Requirements engineering, interaction design	Semester	Flipped classroom, applied research project, field project, and guest speakers
5	G	Course	Inclusive design	Semester	Applied research project
6	U (2nd and 3rd)	Course	User evaluation methods	Semester	Hands-on activity
7	U and G	Course	HCI research, design, evaluation	Semester	Applied research project
8	U	Course*	Software design and development	Semester	Role-play
9	U (1st and 2nd)	Lab	Accessibility	20–60 min per activity	Lab
10	U	Short course	User-centered design	4 days	Industry/community research project
11	G (Master's)	Course	HCI research, design, evaluation	Semester	Applied research project
12	U	Short course	HCI research, design, evaluation	2 weeks	Applied research project
13	G (Master's and Doctoral)	Training program	Accessibility, HCI design, research, and evaluation	1–4 years	Industry/community research project and interactive workshops
14	U	Curriculum	Design thinking	3 years	Design hackathon, applied research project, industry/community research project
15	U	Course	HCI research, design, evaluation	Semester	Industry/community research project
16	U and G	Course*	HCI research, design, evaluation	Semester	Flipped classroom
17	U	Course	HCI research, design, evaluation	Semester	Applied research project

*U, undergraduate students; G, graduate students; Format, the context in which a given pedagogical approach took place; Duration, the length of a given pedagogical approach; *articles have applied a given EL type in various courses; **articles that have used different EL types in the same course in different year.*

design thinking; and assistive and adaptive technologies, entrepreneurship, and interpersonal skills.

Guest Speakers ($n = 2$)

Two articles invited guest speakers to bring the real world to the classroom and offer students an outside perspective. Girouard and Kang (2021) stated CLUE regularly hosted guest speakers to talk about their recent HCI and UX research projects. Similarly, Péraire (2019) invited a guest speaker on interaction design in industry.

Flipped Classroom ($n = 2$)

In a flipped classroom, students watched video lectures outside of class and they dedicated in-class time on interactive group learning activities. Instructors created video lectures or pulled them from web sources, such as YouTube and Coursera. In the beginning of class, instructors used online quiz and spent 15–30 min to check students understanding.

As an example, in Maher et al.'s (2015) class, students engaged in class activities designed to improve UX competencies. When learning about needfinding, one or two students in a group developed a persona and they role-played as a user while other students in the group prepared interview questions and conducted an interview with "the user."

Internship ($n = 1$)

An internship was observed in one article that introduced the CLUE training program (Girouard and Kang, 2021). Students in CLUE undertook paid UX Internships. They worked with leading UX experts from industry and government for 8-month (part-time) or 4-months (full-time). Students took on various roles, such as UX architect, Design Researcher, Human Factors Researcher, UI Designer, UX Programmer, and Business Intelligence Analyst.

Lab ($n = 1$)

El-Glaly et al. (2020) created online accessibility lab activities that can be embedded in various computing classes. Each lab activity addresses five topics: (1) deaf/hard of hearing, (3) color blindness, (3) blindness, (4) dexterity issues, and (5) cognitive impairment. Students go through each lab with and without an emulation feature meant to simulate a given accessibility condition.

In-house Work Placement ($n = 1$)

Talone et al. (2017) described a UX lab that is led by a faculty mentor. Undergraduate students in the department of Information work as a part-time, paid UX consultant under the mentorship of the faculty mentor and graduate students who are experienced in HCI and UX. They work with local companies (often software developers) and offer various UX

TABLE 6 | A list of EL type and respective reference.

Ref #	Student level	Format	Central topics taught	Duration	EL type
18	U (3rd and 4th)	Course	HCI research, design, evaluation	Semester	Applied research project
19	U	Curriculum	Accessibility, software design and development	4 years	Applied research project
20	U (1st and 2nd)	Course	Web design, accessibility	Semester	Applied research project
21	U (3rd and 4th)	Course	HCI research, design, evaluation	Semester	Applied research project
22	U (3rd and 4th)	Curriculum	Software design and development	2 years	Applied research project and industry/community research project
23	U (1st and 2nd)	Course	Co-design and participatory method	Semester	Applied research project
24	G (Master's and Doctoral)	Training program	UX	2–4 years	Internship, guest speakers, and interactive workshops
25	U	Course*	HCI research, design, evaluation	Semester	Industry/community research project
26	G (Master's)	Course*	UX research, design, evaluation	Semester	Industry/community research project
27	G (Master's)	Short course	UX research, design, evaluation	4 days; project spanned over 45 days	Industry/community research project
28	G (Master's)	Course*	UX research, design, evaluation	Semester	Industry/community research project
29	U (2nd and 3rd)	Course	HCI research, design, evaluation; accessibility	Semester	Applied research project
30	U (all)	Studio	UX research, design, evaluation	Semester	Industry/community research project
31	G	Course	UX research, design, evaluation	Semester	Applied research project
32	U	Course	Design thinking	Semester	Applied research project
33	U (2nd and 3rd)	Course	Accessibility engineering, UI, usability	Semester	Applied research project
34	U	Course	Web design, accessibility	Semester	Applied research project
35	U (1st and 2nd)	Course	UX theory, engineering, designing thinking	Semester	Hands-on activity

*U, undergraduate students; G, graduate students; Format, the context in which a given pedagogical approach took place; Duration, the length of a given pedagogical approach; *articles have applied a given EL type in various courses.*

TABLE 7 | A list of EL type and respective reference.

Ref #	Student level	Format	Central topics taught	Duration	EL type
36	U (3rd and 4th)	Course	Inclusive design and research	Semester	Applied research project
37	U (3rd and 4th)	Course	UX research, design, evaluation	Semester	Applied research project
38	U (3rd and 4th)	Course	Human-centered design and research	Semester	Industry/community research project
39	U (2nd and 3rd)	Course	User-centered design, usability, UI	Semester	Applied research project
40	U and G (3rd and 4th)	Course	Software design and development	Semester	Applied research project
41	G (Master's)	Course	Human-centered design and research	Semester	Applied research project
42	U (3rd and 4th)	Course	Design thinking	Semester	Applied research project
43	U and G (3rd and 4th and Master's)	Course	HCI research, design, evaluation	Semester	Interactive workshop
44	U (1st and 2nd)	Course	Human-centered design and research	Semester	Industry/community research project
45	U (3rd and 4th)	Course	Software design and development	Semester	Industry/community research project

U, undergraduate students; G, graduate students; Format, the context in which a given pedagogical approach took place; Duration, the length of a given pedagogical approach.

services that fall under three areas: user testing, user research, and design evaluation.

Design Hackathon ($n = 1$)

Hardy et al. (2018) incorporated a 2-day design hackathon called Design Sprint. Students of all levels worked with startups and companies to develop a solution for their needs. Students engaged in four design processes—user gathering requirements, ideate, develop, and test prototypes. In the end, students prepared a 3-min pitch of their prototype to judges evaluated based on creativity, best use of technology, and best problem-solving approach.

Field Project ($n = 1$)

This EL type nudged students to visit industry practitioners in their working environment. Péraire (2019) asked students in teams to interview two real industry practitioners from Silicon Valley companies working on the same product. One practitioner has to be in requirements (e.g., Product Manager, Product Owner) and one practitioner had to assume user experience (e.g., Interaction Designer, Product Designer).

Combined Practice

In six articles, above-mentioned EL types occurred in combination: (1) industry/community research project and role-play (Robinson and Hall, 2018), (2) flipped classroom, applied research project, guest speakers, and field project (Péraire, 2019), (3) industry/community research project and interactive workshops (Kang et al., 2021), (4) applied research project, industry/community research project, and design hackathon (Hardy et al., 2018), (5) applied research project and industry/community research project (Mohan et al., 2012), and (6) internships, guest speakers, and interactive workshop (Girouard and Kang, 2021).

RQ2: Learning Outcomes

The authors of 26 articles provided student learning outcomes (**Tables 8–10**). From these articles, we extracted major cognitive and affective learning outcomes. Cognitive learning outcomes are students' gain on technical and conceptual knowledge on a given topic. Affective learning outcomes are students attitude toward an instructor, a course, or a learning environment (Wei et al., 2021). In addition, we extracted major students benefits that did not fall within the definition of cognitive and affective learning outcomes.

Most commonly used assessment methods were student final course evaluation ($n = 10$), pre- and post-survey ($n = 5$), student reflections ($n = 4$), combination ($n = 3$), student course work ($n = 2$), student exit interviews ($n = 1$), and student performance evaluation ($n = 1$).

A few studies are noteworthy in terms of the comprehensiveness of their assessment. El-Glaly et al. (2020) conducted an experiment to evaluate the effectiveness of their hands-on accessibility lab activities with a group of 276 students. In this study, there were three experimental conditions. Students in Group A did not go through the lab. Students in Group B went through the lab. Students in Group C went through the lab plus they received Supplementary Materials meant to cultivate empathy toward people with disability. Zhao et al. (2020) conducted a 4-year longitudinal study with a final sample size of 412 students. They assigned students to four different accessibility education interventions and recorded students' changes in knowledge from the start and the end of the course.

We identified 6 patterns across the reported learning outcomes (**Figure 3**). Note that most articles reported on several student learning outcomes and benefits fell under more than one pattern. Thus, some articles appear across several patterns.

First, students improved on UX technical knowledge ($n = 15$), including improved knowledge and skills on UX concepts (e.g., MacDonald and Rozaklis, 2017) and human-centered research and design (e.g., Vorvoreanu et al., 2017; Kabakova et al., 2021; Lallemand, 2021), increased knowledge on accessibility, assistive technologies, and accessible programing techniques (e.g., El-Glaly et al., 2020; Zhao et al., 2020) and improved programming skill (Chaffin and Barnes, 2010).

Second, students applied textbook knowledge to solve real-world challenges and valued the theory-practice link ($n = 10$). By

TABLE 8 | A list of learning outcomes and benefits reported in the articles.

Ref #	Student learning outcomes and benefits	Assessment method
1	Students improved their job marketability, improved ability to work in a professional setting, and acquired soft skills; they applied coursework to real-world project.	Student reflections
2	Students understood the importance of good teamwork, valued the learn-by-doing, and understood the complexities of working as a team.	Student reflections
3	Students realized real-world design challenge is complex to solve in practice and found the course interesting or relevant to real world applications.	Student final course evaluation
4	Students valued the learn-by-doing approach.	Student final course evaluation
5	Students gained professional experience and improved design and research skills.	Student reflections
6	Students learned about new research methods in a rapid and fun way; they liked applying textbook knowledge to solve real-world challenges; they liked creating the video on a chosen research method and learning from other groups' videos.	Student reflections
7	Undergraduate students valued the graduate student mentorship; graduate students learned about the UX evaluation process and the complexities involved in the UX process including, delays, and incomplete prototypes.	Student exit interviews
8	Students improved their demo management skills and found software theater creative, fun, dynamic, understandable, memorable, and engaging.	Student final course evaluation
9	Students who were in hands-on accessibility labs had more positive attitude toward creating accessible software and had higher quiz scores on accessibility topics than students who were not exposed to the labs.	Pre- and Post-Survey
10	Students enjoyed the course, they learned a lot, and they did not find the lecture difficult.	Student final course evaluation
12	Students were intellectually stimulated and learned new ideas and skills; they were satisfied with final course project and teamwork; they applied knowledge to practice.	Student final course evaluation
16	Students felt they learned more during and outside of class time compared to previous courses.	Student final course evaluation
18	Students learned the required HCI skills through the design and development of videogames; they had positive attitude toward using videogames for skill development in higher education, and they enjoyed learning using computer games.	Student final course evaluation

TABLE 9 | A list of learning outcomes and benefits reported in the articles.

Ref #	Student learning outcomes and benefits	Assessment method
21	Students valued authentic learning experience via applied research project and lecturer who shared their real-world UX experiences.	Student final course evaluation
24	Students were positively evaluated on dependability, self-reflectional capacity, team work, independence, and professionalism by UX internship mentors.	Student performance evaluation
26	Students improved on: their knowledge of UX concepts/methods, ability to create quality deliverables, ability to work in teams and with clients, ability to work within time/resource constraints, interest in UX, confidence in applying UX methods, and ability to manage the “messiness” of real-world projects. Students were satisfied with UX project participation. Students felt more prepared for UX employment and their experience made them more marketable to employers.	Pre- and Post-Survey
28	Students developed soft skills (e.g., project management, storytelling, empathy, collaboration) and UXD skills (i.e., communication with stakeholders, data management, domain knowledge, and comfort with ambiguity in face of wicked problems); they applied theory to real-world problems; they understood non-profit work; they showed a better understanding of own strengths/weakness. Students felt prepared for employment and developed a professional identity. Students valued user diversity and developed social network.	Student reflections and Student final course evaluation
29	Students showed greater consideration of individuals who use accessible technologies, greater awareness of assistive technologies, and greater technical knowledge of accessible programming techniques.	Pre- and Post-Survey
30	Students showed improvement on: defining human-centered design, collecting data from users, finding appropriate problems to solve, defending solutions to stakeholders, and creating compelling prototypes.	Pre- and Post-Survey
32	Students broadened their perception of accessibility (i.e., understood the implications and importance of inaccessibility in design and learned the etiquette of interaction with people with disabilities); they learned to balance functional and non-functional factors (e.g., aesthetics, safety) in a design for people with and without disabilities; they showed changed attitudes toward design for people with disability and embraced universal design.	Student coursework

TABLE 10 | A list of learning outcomes and benefits reported in the articles.

Ref #	Student learning outcomes and benefits	Assessment method
33	Students placed greater importance on broadening the range of technology users and greater importance on designing and building web interfaces. Students placed lower importance on evaluating usability, learning new technologies, using software development tools, insuring the privacy of user information, and designing and building user interface specifications.	Pre- and Post-Survey
37	Students showed high performance on major UX activities.	Student coursework
39	Students found the course very interesting and the course invited deeper involvement with the subject area.	Student final course evaluation
40	Students improved on their programming skills and showed increased knowledge of art concepts including creating animated sprites, tile sets, and GUI development. Students felt prepared for their long-term goal (e.g., grad school or game industry).	Student final course evaluation
41	Students understood the techniques and tips behind working with and engaging end-users	Student coursework, Student reflection, and student exit interviews
42	Students were satisfied with the course; they expanded their perspectives; they enjoyed collaboration and interdisciplinarity group work; they improved on feedback and presentation skills.	Student mid-course evaluation and Student final course evaluation

doing so, they realized the messiness of solving real world design challenge and evaluating prototypes. Third, students acquired soft skills ($n = 10$), including demo management skill (Krusche et al., 2018), time and resource management (MacDonald and Rozaklis, 2017), and storytelling and empathy (Kabakova et al., 2021). Students also valued the importance of good teamwork (Robinson and Hall, 2018) and enhanced interpersonal and communication skill with people with disabilities (Shinohara et al., 2016) and stakeholders (Gray et al., 2019).

Fourth, students became more aware of the needs of diverse end-users ($n = 5$). They showed positive attitude toward creating accessible software (El-Glaly et al., 2020) and understood the implications of inaccessibility (Shinohara et al., 2016). Fifth, students reported to become more marketable to employers, developed a professional identity, and feel prepared for their long-term career goals ($n = 4$) (MacDonald and Rozaklis, 2017; Talone et al., 2017; Kabakova et al., 2021).

Lastly, students expressed satisfaction toward various aspects of a given pedagogical approach ($n = 10$), including UX project participation (MacDonald and Rozaklis, 2017), graduate student mentorship (Brown and Pastel, 2009), and the use of videogames as a teaching tool (Santana-Mancilla et al., 2019).

DISCUSSION

Immersive and Non-immersive Experiential Learning

In response to the RQ1, the scoping review shows 12 EL types were used to teach UX in higher education. The review suggests five EL types are more immersive than others, mainly applied research project, industry/community research project, in-house

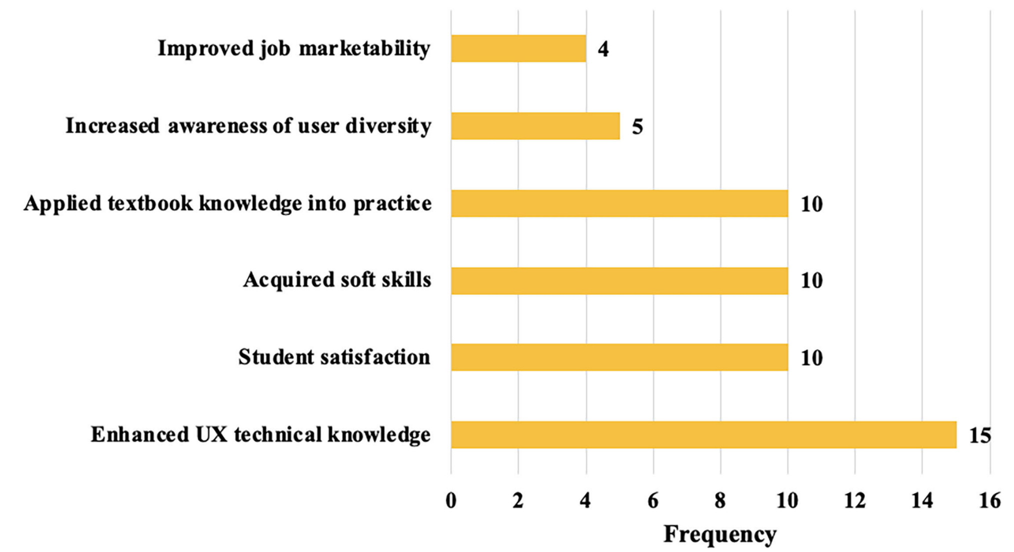

FIGURE 3 | A list of student learning outcomes and benefits from participating in EL.

work placement, internship, and design hackathon. In these immersive EL types, students interact with actual end-users and clients for a prolonged period of time, with the exception of a 2-day design hackathon.

Getto and Beecher (2016) proposed four components a student should go through to learn about UX. Orientation is when a student is introduced to basic UX principles. During the observation stage, a student observes experienced UX practitioners "in action" and ask them about what they did and why. During the practice and play stages, a student applies their UX knowledge to tackle real usability problems and putting their own spin on the methods.

In the current review, these four components were presented especially in UX internships and in-house work placement. In these two immersive EL types, students monitor closely their UX industry mentors (Girouard and Kang, 2021) and faculty advisor (Talone et al., 2017) (orientation and observation). They then practice and refine diverse UX skills with actual client projects, ranging from persona creation, user requirements, and A/B testing (practice and play).

These four components in immersive EL types may afford students with a unique set of learning outcomes and benefits. The current review shows three learning outcomes and benefits are mainly associated with immersive EL types: increased job marketability, increased awareness of user diversity, and development of certain soft skills, including learning etiquette of interacting with diverse user groups, handling messiness of real UX projects, and working under the constraints.

After participating in immersive EL types, students acquire a vital tangible outcome: a professional portfolio that showcases their UX projects to future employers. There is a discrepancy between the actual skills possessed by HCI graduates and the expected skills in these graduates by hiring managers and employers (Radermacher and Walia, 2013; Gonzalez et al., 2014). In general, employers are more attracted to new graduates with work experiences than graduate without the experiences (Chi and Gursoy, 2009).

By being able to showcase their UX proficiency via portfolio, students become more attractive candidates to employers. Relatedly, increased awareness of user diversity and soft skills related to user groups can only come from working with real end-users and clients, a core feature that is missed in non-immersive EL types.

However, we remain cautious in confidently mapping the relationship between immersive EL types and specific learning outcomes and benefits. The current review had a higher number of articles that focused on immersive EL types than non-immersive ones. This screwed representation can indicate the current gap in UX education literature and this highlights more efforts from the HCI community as a whole is needed to establish a pedagogy culture, so HCI educators are intrinsically motivated to share their UX pedagogy for all student levels.

Relationship Between Student Levels and Experiential Learning

For the articles that focused on undergraduate students, we did not observe the following EL types: field project, flipped classroom, internship, guest speakers, and interactive workshop. For the article that focused on graduate students and graduate and undergraduate students combined, we did not observe the following EL types: in-house work placement, lab, role-play, design hackathon, and hands-on activity. Are some EL types more suitable for graduate students over undergraduate students and vice versa?

Graduate and undergraduate students show differences on various skills, including critical thinking (Artino and Stephens, 2009) and task efficiency (Daun et al., 2015). Given this knowledge, interactive workshops, hands-on activity, lab, and flipped classroom might not be appropriate for lower-level undergraduate students. They require students to take control of their learning outside of class and students need to readily engage in discussion. Lower-level undergraduate students can lack training on those skills to benefit from those EL types. Hands-on activity and lab that were reviewed in the current scoping review is a great way to introduce foundational UX concepts to lower-level undergraduates but not for graduate students and upper-level undergraduate students.

Role-play and design hackathon can be useful for students of all levels. In the current review, role-play occurred in combination with industry/community research projects and having students to take on real a UX practitioner role can enhance the degree of student immersion. Design hackathon allows for peer learning opportunities where junior students learn from senior students.

Current Gaps in UX Education Literature

Need for Advanced Research Design, Analysis, and Report

In response to the RQ2, the current review identified six student learning outcomes and benefits from participating in experiential learning. The review also identified seven assessment methods, which are comparable to what other systematic reviews have found (Wei et al., 2021).

Most articles that examined student learning outcomes and benefits had smaller sample sizes compared to non-education related research studies published at a leading HCI conference. In the review, for studies that employed qualitative assessment methods, the mean of a sample size was 19 students (vs. the mean of a sample size was 55 participants in other studies). For studies that employed quantitative assessment methods, the mean of a sample size of 136 students (vs. the mean of a sample size was 224 participants in other studies) (Caine, 2016). Hence, all assessment methods, be it qualitative or quantitative, had lower sample sizes compared to the reported standard.

Having small sample size is understandable; most articles examined the short-term impact of their UX pedagogy with one group of students enrolled in their course for a semester. For qualitative assessment methods, a high sample size allows for the discovery of new themes centering on student learning outcomes and benefits. For quantitative assessment methods, a high sample size ensures researchers have a good statistical power to detect for potential differences between students enrolled in different educational intervention groups or potential differences in student learning outcomes in a pre- and post-survey study design. HCI educators can conduct a longitudinal and recruit multiple student groups across multiple semesters. This study design would allow for higher sample sizes.

We also note the lack of depth in final course evaluation questionnaires. These questionnaires either focused on course logistics or they were too simple (e.g., how much did you learn?). This lack of depth is understandable, given the focus was the description of their pedagogical approaches. In future, HCI educators can consider incorporating more comprehensive learning assessment methods as seen in El-Glaly et al. (2020) and Zhao et al. (2020).

Lastly, we highlight inadequate reporting practices; a few articles that did not report important study details, including student levels and the type and process of qualitative analysis employed, and a sample size. For instance, 27% of articles that provided learning assessment did not report on their sample size. Comprehensive reporting helps other researchers to map the relationships between study characteristics. Future work should report as many details of their UX pedagogy as possible.

Need to Understand the Effect of Different EL Types

The next step is to compare the long-term effects of different EL types and this comparison can determine which EL type is superior over another type. In this review, none of the articles experimentally compared different EL types. A few articles who provided rigorous student assessment were limited to comparing students in a control condition against students exposed to their UX pedagogy (e.g., El-Glaly et al., 2020). Zhao et al. (2020) compared the effect of variations of applied research projects and they found only the students who did not interact with end-users retained HCI knowledge after 2 years a course had finished. With the current review serving as a guideline, HCI educators can conduct longitudinal experiments and determine how different EL types compared to one another in UX knowledge attainment long-term.

Another relevant area of investigation is understanding the effect of combined EL types (vs. one EL type). In this review, 6 articles described how they offered a combination of different EL types. Scott et al. (2019) showed students who completed more than one EL type rated their writing skills higher and reported better quality of relationship with faculty than students who completed one EL type. Students who undergo combined EL types can continuously reinforce their UX knowledge over a long period of time. This area of investigation can assist HCI educators to strategically design their curriculum. Taking one EL type may not be sufficient to develop full UX competencies.

Practical Implications for HCI Educators

With 12 EL types identified in the review, we offer practical recommendations for HCI educators. HCI educators need to consider their own resources and constraints in implementing these immersive EL types. In all articles that have incorporated an industry/community research project, they have already established a partnership with local companies and organizations. In some cases, faculty have received an external funding to support an independent training program. For instance, Girouard and Kang (2021) mentioned that CLUE had initially established 33 industry and government partnerships to support students' UX internships.

One recommendation for starting partnerships is reaching out to UX professional associations and connect with willing partners. Getto and Beecher (2016) have recommended UX associations, such as Interaction Design Association (IxDA), the User Experience Professionals Association (UXPA), and the Information Architecture Institute.

When involving external partners is not feasible, having students to work on an applied research project can be an ideal approach. Some articles mentioned that it was students who reached out to target users and this student initiation can reduce the pressure off from the instructors. We also saw the use of YouTube videos to expose students to target users (Maher et al., 2015).

Study Limitations

There are two limitations. First, our review is limited to finding articles from three databases, mainly IEEE, ACM, and Scorpus. While these three are top databases in the fields of HCI and social science, there is a possibility of missed articles that discuss UX pedagogical approaches. In attempt to expand our pool of articles beyond these three databases, we conducted additional manual search *via* Google Scholar and backward reference checking. Moreover, our review is limited to articles published in English, which makes one wonder about other UX pedagogical approaches written in non-English languages.

Relatedly, threat to limited coverage is also raised by a possibility that HCI educators and researchers may not publish their work about their UX pedagogical approaches. That is, there could be more courses being taught than published papers about the course. Published work on any topics related to experiential learning is rarely seen at leading HCI conferences (e.g., CHI) (Lee et al., 2019; Lima et al., 2021). Many HCI scholars may not see publishing about teaching practices as a "hot" HCI area. If so, it would be important to consider how universities and the HCI community at large can change such perception.

Second, we want to acknowledge that some articles described a lecture component in their pedagogical approaches. A lecture can be highly experiential. But it was impossible to discern from reading the article whether the lecture component was experiential.

CONCLUSION

This paper reports on a scoping review that summarizes the types of experiential learning that have been employed to teach UX to undergraduate and graduate students. We also summarize key student learning outcomes and benefits from participating in EL types. From an initial set of 1,128 articles published from 2000 to retrieved from three databases, we analyzed 45 articles. We found 12 types of experiential learning: applied research project, industry/community research project, hands-on class activity, role-play, interactive workshops, guest speakers, in-house work placement, internship, flipped classroom, field project, lab, and design hackathon, from most to least frequent. We also reported on six student learning outcomes and benefits. We hope that our review serves as a useful source to HCI educators who plan on adopting experiential learning to teach UX.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary materials, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

JK and NR conducted a scoping review, data analysis, and interpretation. All authors conceptualized and designed the study, contributed to drafting the manuscript, manuscript revision, read, and approved the submitted version.

FUNDING

This work was supported and funded by the National Sciences and Engineering Research Council of Canada (NSERC) through the Collaborative Learning in Usability Experiences (CLUE) CREATE grant (2015-465639).

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Computer Science

CURRICULUM, INSTRUCTION, AND PEDAGOGY
published: 21 March 2022
doi: 10.3389/fcomp.2022.794400

The User Experience Design Program: Applying Situated and Embodied Cognition Together With Reflective Teaching

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The education of students to become competent user experience designers is a delicate matter as students need to obtain a multitude of knowledge, skills, and judgmental abilities. In this paper, our effort to manage this multiplicity in a bachelor's program in user experience design is shared along with our experiences and teaching practices influenced by theories of situated and embodied cognition together with reflective teaching. The program was followed up through interviews with eight alumni and a company representative that employs user experience designers. The results show that the program overall works well, although some of the identified issues need to be addressed in the future. The interpretation is that our program curricula and teaching practices are fruitful, which hopefully can contribute to thoughts and discussions for other teachers in the field of user experience design and human-computer interaction.

Keywords: situated cognition, embodied cognition, reflective teaching, user experience design, higher education, human-computer interaction

OPEN ACCESS

Edited by:
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Indian Institute of Technology Bombay, India

Reviewed by:
Venkatesh Rajamanickam,
Indian Institute of Technology Bombay, India
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Specialty section:
This article was submitted to Human-Media Interaction, a section of the journal Frontiers in Computer Science

Received: *13 October 2021*
Accepted: *08 February 2022*
Published: *21 March 2022*

Citation:
Alenljung B, Nalin K and Rambusch J (2022) The User Experience Design Program: Applying Situated and Embodied Cognition Together With Reflective Teaching. Front. Comput. Sci. 4:794400. doi: 10.3389/fcomp.2022.794400

INTRODUCTION

User experience (UX) designers need a wide range of knowledge, skills and judgmental abilities to be successful, for instance, knowledge about the user experience design (UXD) process and various UX methods and techniques, skills to perform investigations, evaluations, data analyses, along with how to stimulate creativity and innovation, and judgmental abilities to make ethical and societal considerations.[1] The issue of what an educational curricula for human-computer interaction (HCI) and UXD should embrace have comprehensively been in focus and discussed for many years not least by the SIGCHI education project (SIGCHI, 2014), the living HCI curriculum initiative (Churchill et al., 2013, 2014, 2016), and in workshops all over the globe (e.g., Peters et al., 2016; St-Cyr et al., 2019; MacDonald et al., 2021). It is clear that a program in UXD requires balancing multiple learning objectives; preparing future UX designers for a professional career as well as augmenting students' ability to pursue advanced level and graduate studies, which is discussed by, for example, Peer (2017).

[1]The occupational title UX designer is used in this paper, which reflects the name of the presented program and the type of work we prepare the students for. We are aware that UX designer is an industrial label and we acknowledge that the field of human-computer interaction is the academic realm of the program.

A wide range of work have been conducted in the community of HCI and UXD education. Some address pedagogical challenges on a course level (e.g., Karahasanović and Culén, 2021; Slavina and Gilbert, 2021), others focus on aspects related to the student population (e.g., Hui, 2020; Wong-Villacres et al., 2020), and some investigate the education landscape (e.g., Burgar, 2017; Khademi and Hui, 2020).

This paper contributes to the body of knowledge of education in HCI and UXD by sharing and reflecting on a 3-year UXD bachelor's program, offered at the University of Skövde in Sweden, regarding our efforts to address and balance multiple learning objectives. The purpose is to provide other teachers in the field inspiration and fuel for thoughts and discussions. In our case, the program curriculum and teaching practices are, in particular, influenced by situated and embodied cognition as well as reflective teaching (described in Section Theoretical Perspectives and Pedagogical Principles), which is an effect of the cognitive science origin of the program and the related research group's theoretical specialization in situated and embodied cognition (learning environment is explained in Section Learning Environment). In line with reflective teaching practice, we have followed up the program design by interviewing alumni and a company representative that employ UX designers (reported in Section Follow-Up). Based on this, practical implications and lessons learned are discussed (see Section Practical Implications and Lessons Learned).

THEORETICAL PERSPECTIVES AND PEDAGOGICAL PRINCIPLES

Situated and Embodied Cognition

Theories of situated and embodied cognition, as discussed and positioned in the cognitive science area, are not universally agreed upon and vary in content and specifics; however, they usually share an emphasis on the role of the body in cognition as well as the material and social-cultural setting or context in which an activity is carried out (Shapiro, 2014; Newen et al., 2018). Moreover, emphasis is placed on the interaction between brain, body, and the material and social environment where cognition is seen as something more than what happens inside the brain, in contrast to cognitivist theories on human cognition. Importantly, situated and embodied cognition should not simply be viewed as a specific type of human cognition that can be separated from non-situated and non-embodied cognition. Rather, it is a theoretical position that seeks to understand the very nature of human cognition.

Theories of situated and embodied cognition have led to an overall rethinking of learning theories and educational practices and research as well. There are a variety of perspectives and viewpoints on the issues of situated learning and knowledge appropriation, as researchers interested in the complexities of learning and human cognition have been active in a wide range of research fields (Lave and Wenger, 1991; Sawyer and Greeno, 2009; Yeoman and Wilson, 2019). Focus has often been on children's learning in school and community settings, and less on adult education in comparison; the focus here is on adults in a higher education setting (cf. e.g., Chiou, 2020). However, despite differences in approaches and foci, a common theme is that social interactions with other individuals and the active use of external structures in the environment are considered an important part of situated learning activities.

The social-cultural dimension frequently emphasized in situated perspectives on learning is drawing on a diverse range of historical ways of learning and teaching such as craft and trade apprenticeships. Lave and Wenger (1991) is one of the seminal sources for understanding the situated nature of learning, and as they point out, learning and work practice are indivisible from each other and the use of different kinds of apprenticeship reveal the distributed, social nature of learning and knowledge; i.e., concepts of apprenticeship capture how people, in communities of practice, learn by means of participation and guidance. From this perspective, successful learning activities occur in the context of real life, and should be reflected in the curriculum in educational settings.

An important characteristic of learning through participation and guidance is the use of tools; we humans are very proficient in using environmental properties as cognitive aids, such as note taking with pen and paper, and the last 20+ years have shown a substantial interest in finding out how different tools affect cognition and learning (e.g., Hutchins, 1995, a well-known and highly regarded book on this topic). There is also an important social dimension to tool use; even seemingly individual actions are social in nature where much of the interaction is indirect and mediated via different tools (Hutchins, 1995). Furthermore, other people, and their knowledge and experience can also be seen as social tools, which brings us back to the concept of apprenticeship and how people learn through guidance by others with more in-depth knowledge and skills (Susi, 2006). There is also an embodied dimension to learning activities as social exchange and tool use as embodied activities appear to be a necessary precursor condition for all forms of mental activity (Rambusch and Ziemke, 2005); for instance, the body appears to serve an important role in developing and understanding abstract concepts and knowledge (e.g., Kita et al., 2017), and also appears to facilitate creative work (e.g., Baber et al., 2019).

Reflective Thinking and Teaching

Our teaching practices are also characterized by reflective thinking and teaching, one of many pedagogical approaches in higher education, which concerns the practice of evaluating pedagogical experiences in systematic ways as a means to further develop future teaching (Ashwin et al., 2015). There are three personal characteristics in relation to reflective thinking; open mindedness, wholeheartedness, and responsibility (Dewey, 1933). A reflective thinker is an active, curious and critical listener, committed to the task at hand, and has to consider the consequences of a planned action. Thus, reflective thinking can be used to evaluate current beliefs and shed new light upon past experiences, which is essential in a higher education context. It requires continuous analyzes and evaluation of teaching practices to understand what is happening within the system in which the work is carried out (Ashwin et al., 2015).

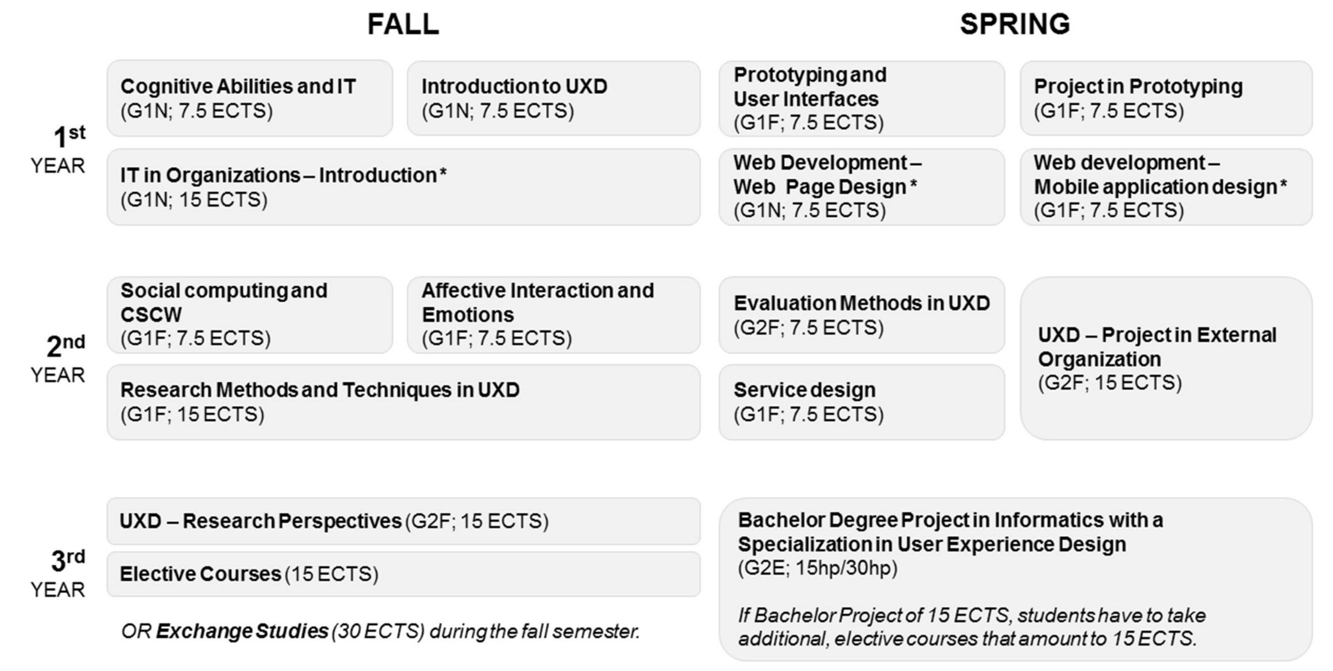

FIGURE 1 | Overview of courses in the UXD program. Most are program specific but three are supportive courses from other programs and are marked with *.

An important aspect of reflective teaching practices is the situatedness in time and in space, that is, they cannot be separated from the context in which they occur. Another facet of this context dependency is that reflective teaching practices are relational, i.e., relations are always involved in teaching, and the practices ought to focus on particular instances of relational interaction rather than general occurrences of transferring knowledge from sender to receiver(s). Therefore, teaching practices can be seen as interactions being both relational and situated, making mere routine teaching a problematic path to pursue as different people emphasize different aspects in their teaching, depending on their own background and interests as well as in relation to the students' various needs and learning preferences. In order to avoid this, constant and iterative questionings of everyday assumptions are needed.

LEARNING ENVIRONMENT

The UXD program is offered at the School of Informatics at University of Skövde in Sweden, leading to a degree of Bachelor of Science in informatics, 180 ECTS credits in total; 135 ECTS credits UXD specific courses including a required degree project of at least 15 ECTS credits, 30 ECTS credits supportive courses, and 15 ECTS credits elective courses (see **Figure 1**). ECTS stands for European Credit Transfer and Accumulation System, which is used as a tool in the higher education area of Europe to make students' academic qualifications comparable. Sixty ECTS credits equals a full year of study (European Commission).

The program started in 2013, replacing the Cognitive Science program (1993–2015), which specialized in human-computer interaction (HCI). Thus, the current UXD program is founded on a long educational tradition of Cognitive Science and HCI. Many of the lecturers are active researchers in and advocates of embodied and situated views on human cognition, which is why those theories constitutes a natural pedagogical basic view. Courses are given by a team of 14 lecturers, six male and eight female; the majority of them hold doctor of philosophy (PhD) degrees (eight persons of which one is associate professor). Each year, about 33 new students are enrolled (ca. 60% male, 40% female) and about 15 students pass the final year project (gender distribution approximately the same as the first-year students). Students dropping out before completing their education is a common issue for many undergraduate programs at the university, and reasons vary from student to student; some leave because of family or health issues, others lack a clear direction or change disciplines, and then we have students struggling financially or academically. It is not uncommon though for students who struggle academically to complete their studies at a slower pace.

Learning Objectives

As an educational program in Swedish higher education, the program curriculum is required to cover three categories of learning objectives specified in The Higher Education Ordinance (1993, p. 10) of Sweden: *knowledge and understanding*; *competence and skills*; and *judgement and approach*. These categories concern different aspects of education and both the theoretical and practical training included in these are addressed in the overall design of the UXD program. Each year, the primary objectives for the past year is summarized in a project course, allowing students to synthesize, demonstrate, and apply their knowledge and skills achieved so far.

Knowledge and Understanding

An important study objective in the **first year** is students' expressed knowledge and understanding of UXD basics and human cognition, and how UXD fits into a broader organizational context. Students also learn how to apply their knowledge in a practical UX setting, using essential concepts of user-centered design, such as user research, conceptual design, prototyping, and evaluation.

In the **second year**, one of the main objectives is for students to obtain theoretical knowledge relevant for UXD both as a vocational and an academic field, including social cognition and social interaction, situated and embodied cognition, as well as affective interaction design and emotion theories.

The **third year** provides a scientific outlook in terms of both historical background as well as current and future grand challenges in the field.

Competence and Skills

After the **first year**, the students should, in addition to theoretical knowledge and understanding, have necessary practical skills to do real UX work. Also, students should reach basic general academic competence and skills, primarily academic writing, reference management, oral presentations, and cooperating with others. The first-year assignments are mainly carried out as group work. The first-year wrapping up-project is done in house or in cooperation with smaller local companies and provides a clear timeframe within which specific and beforehand introduced milestones have to be met.

The **second-year** purpose is that the students should achieve UXD relevant methodological competence in a both vocational and academic sense, such as planning and carrying out empirical (research) studies as well as various forms of evaluations (e.g., cognitive walkthrough and UX testing). Students are, for instance, expected to take on more personal responsibility toward learning and independencies, and assignments are conducted in a mixture of individual work and teamwork. The second year ends with a project done in collaboration with an external organization acting as the students' client.

In the **third year**, the students work almost solely on their own and are to a large extent driving their own learning process. They are expected to identify research gaps and generate original research questions through problematization. The education ends with a degree project that most students do individually throughout the whole semester.

Judgment and Approach

During the **first year**, students are introduced to various reflective and self-reflective exercises and assignments, to cogitate upon their learning, and to spur new insights, such as that there seldom is only one right answer to a problem since human cognition and interactions with digital products are affected by a variety of factors, e.g., an activity's social and cultural context. The students are encouraged to go beyond their own point of views and assumptions, for instance, to take the user's perspective in the design process. A first introduction to ethical and societal considerations is also made.

Throughout the **second year**, reflection and self-reflection continues with an increased attention to the situated and embodied perspective on cognition, as well as ethical and societal considerations. The students are asked to consider, e.g., the influence of social media on social interactions and how information technology can aid or hinder cooperative work.

The objective of the **third year** is that the student should mature into an independent academic that is able to make well-thought through ethical and societal considerations and view their pursuits in a scientific context. The student should be able to put different aspects in relation and perspective.

Situated and Embodied Teaching Practices

The teaching practices borrow many cues from the concept of apprenticeship by providing students opportunities to explore and develop essential skills in real case scenarios. A scenario can be limited to an individual, minor assignment or span a whole course during which students work toward reaching specific milestones and goals. The students are guided and instructed, but the levels of lecturer involvement and student participation change over the years. In the first year, clear goals are set, detailed instructions are given and the students are made sure to stay within safe boundaries of potential answers and solutions to a problem. During the latter half of the second year, students are encouraged to set their own sub-goals and milestones toward an expected outcome (which can vary depending on the chosen path by the students). There is still a lot of guidance but the students are expected to increase individual and group responsibility during lectures, seminars, and supervision. In the third and final year, students take on an even more active and leading role in various learning situations whereas the lecturers mainly make sure discussions stay productive and on topic within the given guidelines, and provide feedback and suggestions during the final year project.

It follows from the apprenticeship concept that students also are provided opportunities to develop necessary skills in realistic settings, for instance, in the context of UX tests in the university's lab environment, or in cooperation with an external company where students meet company representatives who can act both as client and as a coach. Furthermore, it is important that the students not only read about various theories and concepts but that they also get the chance to grasp their inherent meaning. A key practice is therefore to let students participate in practical, hands-on exercises, activities, and assignments to let them experience what it is like, among other things, to interview user target groups, identify suitable UX goals based on the interview results, and see how difficult it is not to get lost in design details early in the process. Students also work with sketching, prototyping and basic HTML/CSS (which stands for HyperText Markup Language and Cascading Style Sheets that are used in web page design), individually and in groups; important tools are pen and paper, various crafting supplies, and various digital tools for prototyping and web design. To explore and understand the more theoretical concepts of, for instance, situated and embodied cognition, students are required to discuss and explain concepts and theories through real usage situations. Affective values in interaction design and their impact on the UX are explored, e.g., through object manipulation; students create a small set of objects that they must modify or design with various materials in mind, to change the object's affective features.

Reflective Thinking and Teaching

Reflection in terms of frequent evaluations and assessment is standard practice as evaluation of ongoing and past occurrences is essential in ensuring future events do not lead to loss of quality or direction.

On a program level, there are two types of formal program evaluations; one is performed once a year and one is carried out every sixth year. There are also informal follow-ups where feedback from students is given in dialogue with the program coordinator in program meetings once or twice per semester. In addition, there is a program council consisting of three UX designers with several years working experience in several companies. The program coordinator meets the council every 2 or 3 years, ensuring the curriculum is relevant and current, and comply with the needs of the UX community.

On a course level, formal questionnaire-based evaluations are conducted, which are automatically distributed to the students after a course ends. Course coordinators are required to reflect upon the evaluation results, including ratings and free text comments, in relation to the course's pre-defined learning objectives, and to provide suggestions for improvement. Course evaluations are primarily used for future course development, but, to some extent, they can also be used to ensure the expected course progression within the program.

On an everyday basis, many lecturers have developed a practice of addressing and discussing concerns regarding aspects that can be improved in future course editions, for instance, when lecturers receive repeated questions about the course curriculum or assignment instructions, or when students have difficulties achieving a certain learning objective associated with an assignment or exam. Having a dedicated space in the university's learning management system is one example of how lecturers keep track of suggested improvements.

FOLLOW-UP

Data Collection and Analysis

In order to get insight on how well the UXD program prepares the students for a working life as a UX designer a qualitative interview-based follow-up study with eight alumni and one company representative with experiences in recruiting UX designers was conducted.

The recruitment of interviewees was primarily intended to be made via a posting in the program's LinkedIn alumni group. However, only one of the alumni interviewees was recruited this way, due to lack of responses. The other seven participants were directly contacted by the program coordinator via email. The company representative was contacted by email as well. Four alumni were male, four female, as was the company representative. All but one alumnus work as UX designer. Graduation year for the alumni was one from each year 2016–2021, except 2020 when three alumni graduated. The emails scheduling the interview appointments contained information about the purpose and format of the interview, and that data was to be treated confidential.

The interviews were conducted individually and consisted of open-ended questions. The questions in the alumni interview guide covered participants' description of their tasks at work, to what extent and in what ways the program made them prepared or not for the job, and what they think should be added, removed, and kept in the program. Example *"If you think about the methods and practical experiences you gained from the program, what do you think about them in relation to your current work?"* The interview guide for the company representative followed the same structure, but was phrased in a slightly different manner, i.e., what competences and skills they expect from a newly graduated UX designer. Example: *"To what extent do you think a UX designer needs to know different methods and have practical experience? What kind of methods? What kind of practical experience?"*

Each interview began with informing the interviewees once more of the purpose, confidentiality, and what the results will be used for. Then they were asked for permission to record the interview to which all approved. A semi-structured interview guide was used. All questions were open-ended and a conversational interview style was established. All interviews were conducted via Zoom, and each lasted for about half an hour. All interviews were subsequently transcribed.

The data analysis started with coding of the alumni transcripts with predefined coding categories on two levels. The top-level categories were (a) knowledge and understanding, (b) competence and skills, (c) judgment and approach, and (d) others. The sub-level categories were (a) expressions of satisfaction, (b) expressions of dissatisfaction, and (c) neutral utterances. All quotations for a certain category were collected into separate topic memos, within which an inductive analysis was conducted where patterns emerged and were formed into a result. Thereafter the data in the company representative transcript was summarized.

Viewpoints From Alumni and Company Representative

The alumni's' overall view of the UXD program is that they are satisfied with it and that it made them prepared for a working life as a UX designer, but that there are aspects that need improvement.

Knowledge and Understanding

The alumni are pleased with having a solid understanding of UXD as a whole; the design process and basic concepts such as UX, usability, interaction and communication. They also find their knowledge of organizations and systems thinking valuable in their work. The program contains a breadth of related topics, e.g., social computing, that creates a wider beneficial understanding, even though they are not currently specifically working with them. Furthermore, they find their basic knowledge and understanding of cognitive abilities and related principles for design of user interfaces useful, not only for design tasks, but also as basis for explanations and arguments with, e.g., developers. Having fundamentals in programming is also of importance.

There is also knowledge that the alumni consider was lacking from their education, making them less prepared for their work. They miss content on how to handle the integration between agile development and the UX design process, how to work with UX in UX immature organizations, the handover phase between UX design and realization, as well as circular design. Moreover, the alumni regard it to be useful with a more in-depth knowledge and understanding of systems thinking, technical aspects, the stakeholder perspective as a complement to the user perspective, as well as different kinds of values, such as, business, customer, and societal value.

Furthermore, there was content that they found superfluous, in particular, affective computing and emotion theories, but also social computing and human-robot interaction.

The company representative emphasizes that a newly graduated UX designer is required to have deep knowledge and understanding of all the three fundamental parts of the UX design cycle: user research, design, and evaluation. The UX designer is also expected to have theoretical knowledge of human cognition and social psychology.

Competence and Skills

The alumni point out a range of competence and skills they obtained as students that are useful in their daily working life. They experience themselves as confident and comfortable in doing investigations, data collection as well as data analysis, with help of quantitative and qualitative research methods. Conducting UX evaluations, analytical and empirical, are also within their comfort zone. They are competent in sketching and using prototyping tools to conceptualize and do mock-ups. The alumni have basic front-end skills and can themselves manage design elements.

They have also obtained general skills that are valuable on a daily basis. The alumni find themselves to be well-trained to argue for their cause, motivate their suggestions, and convey their opinions. They possess the ability to work in groups, such as to cooperate and communicate, to “give and take”, as well as understand and meet the expectations of others. The alumni are able to specify problems, have the capability to go between whole and detail, and know how to find trustworthy sources of information. They are skilled in leading workshops and make presentations.

There are also competence and skills that the alumni considered should have been part of the program. Missing are project management including better understanding of different roles in an information technology project through experience of working in multi-professional teams, capability to handle the transition between the design process and the realization phase, how to manage and change UX work in UX immature organizations, as well as how to involve multiple stakeholders. The alumni thought that more skill training is needed regarding how to conduct workshops, prototyping and prototyping tools with less need for sketching techniques, to perform convincing presentations and argumentations, programming, and how to manage statistical methods for user data.

In addition, the alumni call for more practical experience in general and that the ability to build a portfolio could be improved. Another issue that was raised was that there is too little individual work, which can cause a lack of experience in relying on oneself to carry out UX tasks. Sometimes as a professional UX designer you have no other UX designers to collaborate with.

The company representative stressed that a recently graduated UX designer should be able to “bridge” the whole process, i.e., transform data into needs and requirements and attain a design based upon that so that the design is not freestanding. The UX designer is expected to have the ability to justify their work suggestions and design proposals, which is vital to achieve credibility. Furthermore, he/she is anticipated to have the competence and skills to conduct user research and UX evaluations, which also includes insights regarding bias. The ability to consider bias is an important example of competence that separates someone with an academic background from an autodidact person. The company representative also highlighted that in the future the UX designer should have competence to do data-driven analysis, e.g., Google analytics.

Judgment and Approach

The alumni have awareness of ethical and societal aspects that they have obtained from the program, such as, accessibility for all, data privacy issues, and that badly designed systems can create a poor working environment. They mentioned that there are ethical dilemmas that need to be considered. There was a call for more focus on accessibility for all. The company representative argued that as a UX designer, you need to be a “thinker” and not just a “doer”, where, e.g., the ethical perspective and accessibility for all is important. This is not easy for someone who is a junior, but if this is included well in the education, the new UX designer can feel more confident in questioning, according to the company representative.

The alumni view themselves as self-reflective and having awareness of the need to continue to develop and learn. The program increased their ability to receive feedback from others. However, the downside of self-reflection is that it creates uncertainty and doubt about one’s own ability. The company representative claimed that self-reflection is important and a natural part of the work and the UX designer role. An overview of the findings in the follow-up is presented in **Table 1**.

PRACTICAL IMPLICATIONS AND LESSONS LEARNED

Learning objectives in terms of *knowledge and understanding*, *competence and skills*, and *judgement and approach* are satisfactorily met throughout the program and, of course, the line between these three categories is an artificial one as they are closely linked to each other. The results show that students are well-prepared to work as UX designers and that the program mostly strikes the right balance between preparing students for practical UX work and augmenting students’

TABLE 1 | Overview of findings in the follow-up.

	KEEP	ADD	REMOVE
Knowledge and understanding	- UXD process - Basic concepts, e.g., UX, usability, interaction - Cognitive psychology and related user interface design principle - Organization theory - Systems thinking - Fundamentals in programming - Breadth of topics, e.g., social computing	- Integration between agile development and UXD - Working with UX in UX immature organizations - The handover phase between UX design and realization - Circular design - More systems thinking - More technical aspects - The stakeholder perspective - Business, customer, and societal value	- Affective computing - Emotion theories - Human-robot interaction
Competence and skills	- Qualitative data collection and analysis - Quantitative data collection and analysis - Empirical and analytical UX evaluation - Sketching and prototyping - Front-end skills - Argue and motivate - Group work - Problem specification - Move between whole and detail - Find trustworthy sources of information - Lead workshops - Make presentations	- Project management - Working in multi-professional teams - Handle transition between the design process and realization - Manage and change UX work in UX immature organizations - Involve multiple stakeholders - More training in conducting workshops - More prototyping tools - More argumentation and presentation - More programming - More statistical methods for user data - More practical experience in general - Ability to build portfolio - More individual work with UX tasks	- Less sketching
Judgment and approach	- Ethical and societal aspects, e.g., accessibility, data privacy, effects on working environment - Be a “thinker” not just a “doer” - Self-reflectiveness - Awareness of the need to continue to develop and learn - Ability to receive feedback	- More accessibility for all	- Uncertainty and doubt of one’s own ability caused by continuous self-reflection

academic achievements. The results are encouraging since a lot of our teaching practices draw inspiration from theories about the situated and embodied nature of human cognition and learning, which heavily emphasize the importance of guidance, participation and the use of external aids in learning activities. However, situated learning theories still mostly fail to address how socio-cultural processes transform into mental processes. Conceptions of apprenticeship and (guided) participation are largely based on ethnographic studies of learning and everyday activities which have repeatedly demonstrated how different schooling is from daily activities where those daily activities themselves give meaning and purpose to what is learned. This is one of the reasons why we take great care to situate various exercises and assignments in realistic, work-like settings. Reflective teaching is also a main thread running through our teaching practices as it calls for reflection and a focus on continually strengthening the various learning objectives. The reflective part is also something that has spilled over onto students’ learning activities as students repeatedly are required to reflect on their own learning and achievements, a necessary skill for a UX designer, as highlighted by the company representative in the interview.

However, it was no surprise that the alumni interviews revealed potential areas of improvements too. One of the main critiques was the program’s considerable focus on UX, which complicated students fitting in and finding their place in project teams with people having varying vocational and academic backgrounds; they know very little about taking the step from design to implementation. This is something we have been discussing and one suggestion is replacing the elective courses in the third year with a project course where students from various programs in informatics can meet and collaborate, thereby covering many of the various vocational roles and steps involved in a development project. Another critique addressed how the students are relatively unprepared for the varying level of UX maturity in companies and organizations, unless they choose to focus on this particular topic in their bachelor’s project. From this perspective, the program content represents an idealized point of view, how UXD “should be” rather than how it often turns out to be. It is a dilemma; on the one hand the students need to learn how it should be done for them to be able to inspire changes at an organizational level, on the other hand they ought to be prepared for whatever UX-related challenges that lie ahead. In this case, we settle for making students aware of challenges ahead rather than training them to handle these challenges. We will do this by re-balancing course content, high-lighting such challenges as part of for example ethical and societal considerations.

To conclude, to provide an education in which students can obtain knowledge, skills and judgmental abilities to become a well-prepared and attractive UX designer is not an easy endeavor. In this paper, we share our efforts concerning managing a multitude of learning objectives and our experiences and teaching practices that are influenced by situated and embodied cognition together with reflective teaching. Our interpretation based on the follow-up with alumni and a company representative employing UX designers is that our path is fruitful, both in terms of program curriculum, the pedagogical influences, and that doing this kind of follow-up gives valuable insights for improvements. Hopefully, this can contribute with inspiration and provide input for thoughts and discussions for others working with education in UXD and HCI.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because the data consist of interview transcripts, where there is a risk – although very small – that it can be traced back to an individual. Requests to access the datasets should be directed to beatrice.alenljung@his.se.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

BA, KN, and JR: conceptualization, methodology, data collection, writing—original draft preparation, and writing—review and editing. BA: data analysis. JR: visualization. All authors contributed to the article and approved the submitted version.

ACKNOWLEDGMENTS

We wish to thank the interviewees that have generously not only given us a piece of their time but also valuable information and insights that will feed into our unceasing effort to improve the UXD program.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Computer Science

BRIEF RESEARCH REPORT
published: 22 March 2022
doi: 10.3389/fcomp.2022.793879

Teaching User Experience Design Ethics to Engineering Students: Lessons Learned

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Contemporary dilemmas about the role and impact of digital technologies in society have motivated the inclusion of topics of computing ethics in university programmes. Many past works have investigated how different pedagogical approaches and tools can support learning and teaching such a subject. This brief research report contributes to these efforts by describing a pilot study examining how engineering students learn from and apply ethical principles when making design decisions for an introductory User Experience (UX) design project. After a short lecture, students were asked to design and evaluate the ethical implications of digital health intervention prototypes. This approach was evaluated through the thematic analysis of semi-instructed interviews conducted with 12 students, focused on the benefits and limitations of teaching ethics this way. Findings indicate that it can be very challenging to convey the importance of ethics to unaware and uninterested students, an observation that calls for a much stronger emphasis on moral philosophy education throughout engineering degrees. This paper finishes with a reflection on the hardships and possible ways forward for teaching and putting UX design ethics into practice. The lessons learned and described in this report aim to contribute to future pedagogical efforts to enable ethical thinking in computing education.

Keywords: ethics, digital education, user experience design, digital health, human-computer interaction

OPEN ACCESS

Edited by:
Anirudha Joshi,
Indian Institute of Technology Bombay, India

Reviewed by:
Philipp Marcel Scholl,
University of Freiburg, Germany
Girish Dalvi,
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Specialty section:
This article was submitted to Human-Media Interaction, a section of the journal Frontiers in Computer Science

Received: *12 October 2021*
Accepted: *23 February 2022*
Published: *22 March 2022*

Citation:
Vilaza GN and Bækgaard P (2022) Teaching User Experience Design Ethics to Engineering Students: Lessons Learned. Front. Comput. Sci. 4:793879. doi: 10.3389/fcomp.2022.793879

INTRODUCTION

Whilst computing systems have brought novel ways to work, communicate and play, the academic community is well aware of the emergent ethical concerns arising with the spread of digital innovations (Davis, 2020), especially in the context of digital health (Martinez-Martin and Kreitmair, 2018). The way such systems can persuade users' actions can be insensitive to vulnerable groups' autonomy (Ayobi, 2020). Language choices, technology literacy requirements and usability flaws can hinder broader access, going against social fairness (Costanza-Chock, 2020). Limited data sharing options can fail to recognize individuals' preference for privacy (Hutton et al., 2018), while lack of transparency can hide away limitations of digital interventions (Vilaza and McCashin, 2021).

As a consequence of the broader recognition of ethical issues, ethics education is currently deemed essential to forming future generations of designers and engineers (Skirpan et al., 2018; Hughes et al., 2020). For instance, experiential learning has been used to facilitate empathy-building toward accessibility issues (El-Glaly et al., 2020). A structured framework has been proposed to help students to identify and articulate harmful limitations of machine learning projects (Saltz et al., 2019). Science fiction has been applied as a medium to entice moral imagination regarding the drawbacks of artificial intelligence (Burton et al., 2018).

Despite a wide variety of theoretical frameworks for ethical thinking, applying pre-defined ethical principles to design work is among the most often adopted approaches in the industry and academia. The development of "ethics checklists" is an increasingly common practice among companies as means of attempting to alleviate the difficulty practitioners face when operationalising abstract principles (Madaio et al., 2020). Past research has also emphasized that lists of normative ethical principles are frequently applied in the critical evaluation of AI developments within health care (Morley et al., 2020). Intending to understand how students in a prototyping activity might apply this approach, we conducted a pilot study.

This paper advances this research record on ethics education by reporting on the results of the pilot study investigating how engineering students learn from and apply normative principles when making practical UX design choices for digital health prototypes. After a 1-week project part of an introductory course on UX design at a technical university, 12 students were interviewed and inquired about their experiences. The following sections describe: the methods used in this qualitative study, the interview findings, and the discussion of results. The study contributes to understanding the benefits and limitations of using normative principles to teach UX design ethics to engineering students in a project-based learning setting.

METHODS

This pilot study consisted of semi-structured interviews with the aim of understanding the learning experience of engineering students after being exposed to materials and an assignment about UX ethics. The study sought to investigate how the educational approach has facilitated learning of ethics and which challenges were experienced by the students in the process. The report of the educational evaluation conducted in this pilot study intends to not only advance research on this topic but also inform future educational approaches in the department.

Participants

The participants were students at a technical university in Denmark, enrolled in a 13-week course on UX Design. In terms of course structure, every week, there were 1-h lectures followed by 3 h of supervised group work in which students were given a design brief and asked to prepare a set of deliverables (business model canvas, user story maps, interactive prototypes, and report on prototype evaluation). Then, the students carried out an estimated amount of 4–5 h of independent work in groups before the next class. The goal of these short weekly projects was to prompt the students to learn how to ideate and materialize design concepts along the lines of the pedagogical approach of "project-based learning" (Kokotsaki et al., 2016).

In the 7th week of the course, the weekly project proposed to the students consisted of designing a prototype for a smartwatch application that could collect, visualize and share heart rate data between patients and doctors. In addition, the assignment included a written report on ethical considerations of the design concept and the prototype. In order to prepare the students for this assignment, there was a lecture given by one of the teaching assistants in which the students were given an introduction to the potential negative impacts of user interface design choices on users' well-being, autonomy and diverse access. This approach was then evaluated through this reported study.

Recruitment for the study occurred only after students submitted the weekly project deliverables, as participation was voluntary and completely independent from the course assignment. This measure was necessary so that the students work during the assignment would not be influenced by the interview study. A verbal announcement and a message in the class online forum invited the students to be part of an interview about their experience working in the UX design ethics part of the project assignment. In total, 12 students expressed interest. **Table 1** shows the participants' characteristics.

Materials

Before the study, all students of the class were exposed to learning materials about UX ethics. First, there was a lecture illustrating core ethical challenges. Then, the students were provided with two templates (Google forms online): a checklist for self-reflection or team discussions and a questionnaire to gather feedback from peers or potential users (see **Supplementary Materials**).

The lecture and the templates purposely emphasized a set of five normative principles: choice, transparency, inclusion, well-being and reciprocity (see **Figure 1**). This set of principles was inspired by the ethical framework of Nebeker et al. (2019) highlighting beneficence (providing end-users with direct health benefits), justice (enabling diverse and inclusive access) and respect for persons (not harming individual well-being, providing choices and being transparent) as essential ethical requirements for the digital health context. This framework facilitated the creation of learning materials that could concisely and soundly introduce the topic to the students.

Procedure

In order to build rapport and protect students from feeling that the participation in the study might compromise their grades, a teaching assistant conducted the interviews and confidentiality from the primary course instructor was guaranteed. As this pilot study was not planned nor conducted by the main course lecturer, which meant that some distance could be maintained, as the goal of the study responsible was learning from this experience and not judging teaching performance. Three interviews were conducted in person and four remotely (through a video call). Participants who belonged to the same working group in class were interviewed together. Interview questions were based on a semi-structured script.

Participants were explained that the goal of the interview is to improve how the activity is carried out in future classes and, for this reason, their honest feedback was very important. Participants were asked about their experiences, challenges and learnings, and were compensated with a voucher of 100 DKK. In

TABLE 1 | Study participants' characteristics.

ID	Group	Programme	Nationality	Gender
P1	1	Design and Innovation Engineering (MSc)	Danish	Female
P2	2	Human-Centered Artificial Intelligence (MSc)	Colombian	Female
P3	3	Industrial Engineering and Management (MSc)	Greek	Male
P4	4	Design and Innovation Engineering (MSc)	Spanish	Female
P5	4	Design and Innovation Engineering (MSc)	Spanish	Female
P6	5	Design and Innovation Engineering (MSc)	Danish	Male
P7	5	Design and Innovation Engineering (MSc)	Danish	Male
P8	5	Design and Innovation Engineering (MSc)	Danish	Male
P9	5	Exchange student	French	Male
P10	5	Exchange student	French	Male
P11	6	Human-Centered Artificial Intelligence (MSc)	Spanish	Female
P12	6	Software Engineering (BSc)	Danish	Female

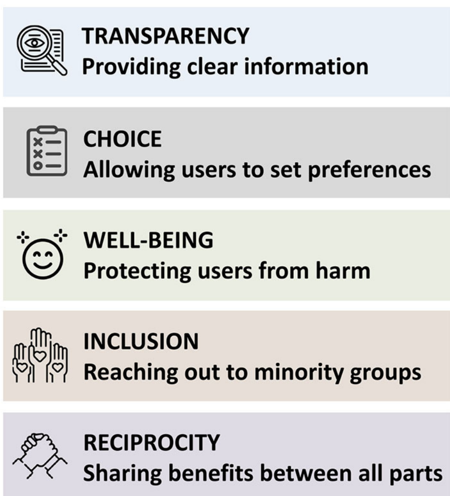

FIGURE 1 | Infographic illustrating the five normative principles emphasized to the students.

line with Danish research regulations, this study is not considered subject to formal ethical approval, yet the highest standard were adhered to including informed consent procedures and secure data storage following GDPR.

A Thematic Analysis was conducted by the first author, following the Braun and Clarke framework (Braun and Clarke, 2012); more specifically, it followed an inductive approach. The themes' descriptions and corresponding quotes were then used to report results as the narrative presented next.

RESULTS

The Approach Served to Raise Awareness and Interest

An important theme across the interviews was that ethics in design was perceived as a new topic not yet examined by many of the students until the course: "*It is the first time I hear about ethics in design*" (P2). Despite being a novelty, the educational materials were effective in bringing the topic to the students' attention: "*The lecture you gave raised some awareness. Since that lecture, ethics has been part of our work in the group*" (P1). Bringing this topic to class also changed some of the students' perspectives about technology design: "*We thought about ethics, but maybe not in a good way. We did the opposite with the previous courses. We thought: how can we be as evil as possible with this? How can we gather as much data? How can we blackmail the user the most? Now we think the opposite*" (P6). Despite being a novelty, most students were clearly interested in the topic: "*I have not thought about it, but as soon as I read it, I was like, okay, this is important, it is something that I really want to address because ethics is something that I care about*" (P11). Some also expressed an interest in learning more: "*I would like to see more about it because I am interested as a person*" (P3). Overall, these findings indicate that the educational approach was efficient in raising the students' awareness of the topic.

The Principles Helped to Identify Ethical Concerns

The interviews show that students understood how their prototypes could be designed to consider ethical aspects. In particular, issues of transparency and choice were often mentioned by the students as elements they have re-considered: "*We tried to add more things to the smartwatch regarding transparency and freedom of choice*" (P4). One of the students also mentioned adding more privacy settings to the design proposal: "*We were thinking that being able to know what you are showing and what you are not and having more settings, because, in the first app that we made, we did not have settings*" (P11). Harm to well-being was another concern tackled often by the students in their design process: "*The whole point is trying to make the users not feel bad if they have not done something they should have done. The notification could like tell them to go out for a walk without trying to make them feel bad and just try to stay positive*" (P10). In addition, when asked how they approached the evaluation of their prototypes, students reported that they used the templates as a guidance: "*Going through the checklists. It was quite informative, it made it quite clear the things we should be looking for*" (P1) and "*What we did was to use the templates, and that is how we learned how to do it. Without the templates we would not be able to know what to change*" (P5). The use of normative principles, therefore, appear helpful in helping to identify specific ethical issues.

Ethical Design Was a New Topic to Many Students

A lack of previous knowledge on ethics was raised by the students as a source of insecurity when making decisions: "*I feel hesitant, doubtful, concerned because I have never heard of the topic before. Of course, it is something important, but I never thought about it*" (P2). Missing specialized domain knowledge that could help to make ethical findings actionable was also an issue for some: "*We felt a lack of knowledge because in this particular case, we need a doctor to say what is more important. Maybe it could be nice to have more health information because we know it is something we should take into consideration but as we do not know the potential damage*" (P4). Similarly, one of the students felt unsure about how to attend to disabled users' needs: "*How to include the handicap? I think it is important, but I have no idea how. You must be the blind person to understand the blind person*" (P2). Another student did not know how blind users could use mobile apps: "*One of the comments that we kept getting when we were reviewing each other's solutions was that blind people would not be able to use this but are blind users even able to use apps?*" (P1). Such findings indicate that despite the ethics lecture, they may still need more info in the course to grasp the concepts.

Ethics Was Perceived as an Antagonist for Success for Some Students

In contrast with previous themes, a few students were not entirely convinced that ethics should be a priority to design: "*I think it was a good add on to the course, but I do not consider it being a high priority*" (P1). These students believed that ethical ideals could conflict with business growth: "*I think it is rather unrealistic to incorporate ethics in such a corporate area. How would you ask big corporations or developing companies to be more aware of ethics if it is clear that their primary concern is money?*" (P2). In particular, a student remarked how ethics could be a barrier to profit: "*Data is money, and all I ever wanted is to make money. So we need all the data even if you do not want to share it, that was our app's logic: money*" (P7). Aligned with this finding, a student stated that getting a high grade was, in fact, the primary motivation to engage with the subject: "*In the end, we were caring about a good grade, so I am not going to lie this was the reason behind*" (P3). Such negative views of ethics illustrate the resistance of a few students to consider the importance of the topic.

Group Members Had Conflicting Views at Times

As the students were working in a group, social dynamics played a role in how discussions were held, with many students stating it was sometimes difficult to reach agreements: "*We have been able to agree on many things, but we are a group of people who do not know each other very well so we do not always turn out super compatible. It is hard to say: "I think you should change all the work you just did*" (P12). Some also reported that their group members did not consider the topic important, leading to a conflict of interest: "*We were more interested in it than the others. It is not that they were against it, they just did not care*" (P12). As an attempt to handle disparate views, one of the students mentioned that when conflict arises regarding the ethical implications of a certain UX design choice, the group decides to ask for feedback from end-users or peers: "*The moment one has a question and asks the group, but we cannot agree in a few minutes, we decide to validate the concept with others*" (P5). This lack of alignment within teams is another challenge to teaching and learning ethics in design projects.

Time Pressure Was a Source of Frustration

The fast pace of the course and the requirement for weekly deliverables, where time on purpose becomes a scarce resource and thus forces the student to prioritize hard, were nevertheless barriers to deeper discussions: "*At that point, we were too busy and concerned with the next hand-in. We were just going to leave it because we did not have much time. We were not making great philosophical discussions about everything, but if we had a longer time frame, we could do it*" (P2). In order to be more efficient within the time frame, one of the students suggested that seeing more examples could help making faster decisions: "*Maybe we could see some examples of how to implement it more quickly*" (P3). Besides lack of time, some students wished they had started considering ethical aspects at the beginning of the project, not as an after-thought: "*It felt stressful and frustrating because it was late in the process, and I feel like that is something that should have come earlier*" (P11). Therefore, time management was a significant factor in deciding whether to engage in ethical reflections during the course.

DISCUSSION

The educational approach evaluated in this paper was effective in raising students' awareness, which is in itself a very favorable outcome for classroom activities about ethics (Skirpan et al., 2018; Saltz et al., 2019). Results show that the selected set of normative principles was a helpful structure for analysis, as the principles functioned as reference points guiding the students' creative process. A previous study evaluating a similar framework of ethical questions for machine learning also found that a list of ethical questions acted as a catalyst to students' debate (Saltz et al., 2019).

Findings also provide evidence that the students can make some ethical design decisions once instructed. Such reports of applying ethical thinking to the design of prototypes are not usual in the literature on ethics. An exception is perhaps a previous study that observed how students re-shaped their design concepts after experiencing the vulnerabilities of data collection and visualization firsthand (Shapiro et al., 2020). As the goal of ethics education in computing is to provoke change in future technological developments, ethical insights should lead to observable outcomes in the design process (Bauer et al., 2017; Barry et al., 2020).

Despite such supportive indicators, the study makes evident that students faced challenges. Even though disparate views can support debate and reflexivity, students could not perceive the group conflicts in such a positive light. Previous works have discussed that methods for "ethical mediation" are critical in decision-making so that arguments from conflicting views can be taken into account during team discussions (Gray and Chivukula, 2019), and our findings support the need to include that in the classroom. Past research has also highlighted that putting ethics in action is a demanding task, requiring an empathetic mindset, attentive to situational complexities (Munteanu et al., 2015; Frauenberger et al., 2017). Such a deep type of reflection can take time, and our observations indicate that it can be challenging to achieve more ethical design if time is too limited of a resource. Obstacles with group dynamics and time prioritization should still be used as pedagogical tools to prepare students for situations that may appear in their workplace, but course structures should consider including more concrete examples and tools to help students navigate the constraints of a design process more productively.

Findings also confirm previously discussed shortcomings of pre-defined checklist items and the limitation of atomistic normative frameworks. As previous research with employees working with artificial intelligence has argued, co-designing checklist items as a team is a more effective approach than providing professionals with pre-made broad guidelines (Madaio et al., 2020). However, checklists and normative principles may as well do not function as tools enabling more comprehensive ethical thinking, rather becoming manual tasks to be completed without genuine reflection. For this reason, if an approach based on lists of ethical principles is chosen, it is important to consider how to complement the method with other design inquiry methods, such as active stakeholder involvement and speculative prototyping (Friedman and Hendry, 2019).

Furthermore, results indicate that a one-time lecture and a prototyping assignment may not be sufficient to fill existing knowledge gaps. In fact, it has been argued that ethics education would greatly benefit from acknowledging the need to expose students to a diverse range of disciplines, skills and methodologies related to the topic throughout their studies (Raji et al., 2021). Aligned with such perspective, previous studies have proposed empathy-building tools and role-playing as ways to increase sensitivity to issues that are beyond a designers' lived experience, thus adding to their capacity to relate to their users (Matthews et al., 2014; Honary et al., 2018; Sas et al., 2020). The importance of empathy development is particularly relevant in the case of students who believe that technology should be "as evil as possible" (P6), as they might not have realized that, in the future, they might be victims of malicious technologies they built by refusing to act in solidarity with their users in the present.

Moreover, the analytical stance deployed by the students in this particular study is not the only way to engage with ethics. Active involvement of different stakeholders through participatory and emancipatory research methods are other options that can be used in UX education. An example is a study reporting on how the collaboration with communities and non-profit organizations was very effective in teaching students how to propose caring design concepts, more attuned to users' needs (Sabie and Parikh, 2019). Still, even though consulting others may be a way for students to seek different perspectives, it can also become a shortcut for making decisions without genuine reflection, which should not be the goal.

Regardless of the educational approach chosen, findings suggest that some misconceptions need to be addressed first if students are expected to produce concrete ethical designs in class. It is not easy to know exactly why some students seem to care less about ethics than others. However, a previous study on ethics education has found that students usually do not see themselves as political agents responsible for ethical work (Petelka et al., 2022). Previous works have brought to attention that engineering students may never come across topics of ethics during their education, which further complicates this problem (Saltz et al., 2019). The combination of standalone modules and the insertion of activities about the topic in multiple technical courses across secondary education programmes might prove to be the most effective approach in the long term, as advocated by previous research (Garrett et al., 2020). It is also fundamental to keep probing strategies for the challenging quest of turning indifferent students into caring ethical agents in their future careers.

Limitations and Future Work

This pilot study has methodological limitations. The fact that only students who volunteered to participate were recruited means that findings may not reflect the perspective of the whole class (sample bias). In addition, the empirical data comes from the students' reports of their experiences in retrospect, which can result in recall bias. Another limitation is that students had to share their views to one of the class tutors, which might have blocked the disclosure of opposing opinions despite our efforts to stay open to their feedback (acquiescence bias).

In order to complement and build upon the observations reported in this study, future work could consider the direct observation of students as they work on their projects and the discussion of the produced artifacts as additional empirical sources, as a way to evaluate the impact of the course based on the changes students bring into their processes. Further studies could also examine the preferences of students regarding different ethical frameworks, such as ethics of care. Finally, future research could consider more objective measures for the evaluation of pedagogical efforts, such as questionnaires and examinations.

CONCLUSION

This pilot study had the goal of learning from the experience of introducing students from a technical university to the concept of ethical UX design. Results were very insightful as they showed in practice the limitations and benefits of our approach. With the lessons learned through this study, we contribute to future pedagogical efforts to teaching ethics for UX design as the explicit statements from the students are powerful indicators of the challenges of teaching HCI ethics.

In summary, even though the educational materials could effectively raise awareness and guide some ethical decisions in the project-based learning setting, challenges remained. Some students seemed skeptical about the applicability of ethics in technology, and lack of interest was a significant barrier to a genuine engagement. Gaps in engineering education also became apparent as students reported feeling insecure with their knowledge on the topic. Students also claimed time pressure and group dynamics as obstacles to more profound reflections that could lead to user interface designs that respect human autonomy, promote well-being and broader access to digital innovation.

Such findings emphasize the need to expose students more often to a more diverse range of teaching methodologies, design skills and ethical philosophies throughout their engineering education. With the broader recognition of complex moral dilemmas by the media and digital technology consumers, ethics education has become imperative for future professionals and it consists of one of the most critical design aspects of digital health interventions. Efforts to include topics on computing ethics in teaching materials should be encouraged, and the way these materials are delivered should be mindful of the challenges discussed in this paper.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

GNV has planned and conducted the research and written most of the manuscript. PB has supervised the research and contributed with content to the manuscript. All authors contributed to the article and approved the submitted version.

FUNDING

We thank the Technical University of Denmark for funding recruitment and the Open Access publication costs.

ACKNOWLEDGMENTS

The author thanks the students who agreed to be part of the research and contributed to this study.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fcomp.2022.793879/full#supplementary-material

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frontiers | Frontiers in Computer Science

ORIGINAL RESEARCH
published: 01 April 2022
doi: 10.3389/fcomp.2022.826445

Curricula Design & Pedagogy for Sketching Within HCI & UX Education

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Sketching is recognised as an important tool in the journey of research and practical processes of Human Computer Interaction (HCI) and User Experience Design (UX). However, it is not always included in higher education curriculum, in which HCI and UX is often a single module in one year group amongst more "traditional" approaches in computer science. The benefits of sketching and visualisation practice can be used by students across the board in computing degrees, but especially so within HCI and UX, where novel approaches and ideation are valued and practiced. By the time learners leave higher education, they may or may not have engaged with this valuable skill. HCI has a lot in common with UX, and the two are commonly conflated to be the same thing, though despite this, there is not a focus on practical sketching and visualisation skills. In comparison, within the UX workplace environment, sketching is part of design thinking and vital for the structuring of ideas, storyboards, user journey maps and more. We focus on the incorporation and exploration of sketching as an educational tool, technique and output within HCI, and how this learning is given and received over a number of contexts. This paper outlines case studies where sketching has been included in both formal and informal learning with both undergraduate, postgraduate, and post education populations, and how this knowledge exchange has been both enhanced and changed by the recent compulsory move to online teaching during the COVID-19 pandemic. We discuss practice and learning in the context of four case studies: *Data-Sketching in a First Year Minor; Sketching in a 2nd Year HCI Cohort; Sketching as a Foundational Tool for MSc User Experience Design;* and, *Sketching in HCI for Peer-to-Peer Learning*. Further, we make recommendations for incorporating sketching practice and theory into both undergraduate and postgraduate university programs, as well as for peer-to-peer learning in both public and private contexts.

Keywords: sketching, user experience, design thinking, visual thinking, education

Edited by:
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Specialty section:
This article was submitted to Human-Media Interaction, a section of the journal Frontiers in Computer Science

Received: *30 November 2021*
Accepted: *23 February 2022*
Published: *01 April 2022*

Citation:
Lewis M and Sturdee M (2022) Curricula Design & Pedagogy for Sketching Within HCI & UX Education. Front. Comput. Sci. 4:826445. doi: 10.3389/fcomp.2022.826445

1. INTRODUCTION

Art and science are complementary fields (Andreasen, 2012), and embedding creative approaches into science education can enhance the learning experience, well-being, and support active and problem based learning. Within this remit, sketching is a key skill that underpins creativity, and therefore is core to such approaches, yet it remains under-utilised in courses that align with traditional science curricula.

Computer science as a field hosts many sub-disciplines, each with unique work patterns, processes, and group dynamics, which are also translated into the teaching within each sub-field. Computer scientists are technically skilled practitioners, however, they often do not possess skills or confidence for the ideation and design process, during stakeholder engagement, or for the subsequent dissemination of their findings. There is also the potential to improve research processes and systems, to make them more accessible, collaborative, and to gain insights. Could such positive change be enabled by embedding fundamental creative practices such as sketching into core interdisciplinary areas of computer science such as Human Computer Interaction (HCI) and User Experience (UX)?

Both HCI, and UX are complex, dynamic topics, which support the wider discipline of computing, complementing core standards, such as programming, development, and networking. These subjects are also inherently exploratory, diverse and interdisciplinary in their approaches to problem solving and development, and this variety lends itself to openness in pedagogy. This open approach to learning makes space for alternative skills to be embedded into curricula, and sketching is accessible, low cost, useful, and is a fundamentally human activity that we engage with from an early age. When entering higher education, and careers beyond this, most learners have specialised to the detriment of their creative and sketching skills, but these skills are not forgotten, they are simply underutilised. Revisiting these skills, and their associated benefits can create a rewarding educational experience, and equip our learners for their current or future workplace or research space.

Based on our experiences working at the many intersections of the arts and computer science, we investigate the existing and potential benefits of integrating sketching as a learning approach across HCI, UX, and within computer science. We do this *via* the exploration of four case studies where sketching has been integrated within existing course structures, or offered as a stand-alone activity. We discuss how sketching might be integrated into our existing course structures, its reception, best practice, and discuss the pedagogy which allows for its inclusion in an interdisciplinary computer science education.

Sketching as a fundamental creative process is presented as a method to support the breaking down of disciplinary silos, and changing attitudes toward creativity in HCI, UX, the wider field of computer science, within our own institutions and beyond. We, therefore, ask, what is the state of curricula design and pedagogy for sketching within HCI and UX education as a result of online and hybrid teaching practices? And further, how can other academics and practitioners learn from the experiences described and apply sketching pedagogy to their own teaching?

2. BACKGROUND

Creative practices such as sketching are often left behind at school when learners begin to narrow their focus to complement their future careers, and are becoming only a minor part of pre-university teaching, despite the advantages an arts education instils across curriculums (Hetland et al., 2015)—this is furthered by the STEAM initiative (UK), which tries to prepare school level students for "creative and analytical thinking" *via* incorporating the arts into STEM education. As an example of this in practice: literacy improved alongside artistic skills when students attended the *Learning Through Art* programme run by the Guggenheim, New York, in comparison to those who did not take up the opportunity (Kennedy, 2006). However, the UK education system (as an example) is set up to favor those subjects that are seen as "useful" or "employable," and the arts have suffered both historic and recent cuts in funding. Such cuts do not take into account the billions of pounds that the creative arts bring to our economy, or the cognitive benefits of arts education: *"The arts help our senses operate at their peak*[1]*."*

The rise of cross-disciplinary practices between the arts and sciences is a positive move into discovering truly blended practice, and incorporating the advantages of both fields into novel, impactful work (Wilson, 2002; Nakakoji et al., 2006; McCormack and d'Inverno, 2012). Brain studies have discovered links between art and other cognitive abilities (Cohn, 2012), and we find that highly talented artists and scientists do not differ, according to fMRI exploration of a neural basis for creativity (Andreasen, 2012)—therefore, the potential for overlap between the arts and sciences is well founded.

Artists of all genres embed themselves into works as diverse as neuroscience and astronomy, making scientific discoveries by utilising their outlook and skills (Diaz-Merced et al., 2011), and creativity has been identified as a positive influence throughout research and business spheres. Within the specific realm of computer science, creative practice has provided the impetus for digital artists to produce programmed exhibitive and investigative works (Wands, 2007; Kodama, 2008), supported the development of digital tools for creative practice (e.g., drawing tablets and applications) (Shneiderman, 2007; Frich et al., 2019), the development of Human Centred Design and User Centred Design (Norman, 1986), and influences a large body of research in Human Computer Interaction (HCI).

Creative arts activities such as sketching or visual note-taking can produce reflective imagery, and can help us solve problems (Roam, 2013), and the ability of hand-drawn sketching to capture thought, opinion, and show a record of events is well documented (Mendonça, 2016; Wallace et al., 2017). These types of visuals offer an organic, human response to stimuli, and have been shown to aid recall (Paepcke-Hjeltness et al., 2017), offer opportunities for reflection, analysis and feedback (Walny et al., 2011; Fernández-Fontecha et al., 2019), enhance learning and engagement (Paepcke-Hjeltness et al., 2017), and have additional cognitive benefits that can be lost as we move to using computers to make notes and plan our work as adults (Goldschmidt, 2017). There is also evidence that a considerable amount of creative scientific thought is worked out with "visuals" or externalizations of still vaguely formed ideas from the scientists' minds (Hadamard, 1954).

Embedding sketching into existing HCI and UX curricula is not straightforward—we cannot simply start teaching "creativity" and arts-based approaches without context. There may be

[1] www.ted.com/talks/sir_ken_robinson_changing_education_paradigms

resistance in learning supposedly "soft skills" alongside the practical applications of these facets of computer science, although there is ongoing evidence that such skills are valuable within the job market, as many computer scientists are expected to operate in multi-disciplinary teams, and be excellent communicators (Brown et al., 2009; Castro et al., 2018). Many graduates also may move out into non-degree based employment such as within graduate schemes, meaning a diversity of skills is even more valuable. (Bares et al., 2018) go as far to suggest that it is time for Computer Science to transcend itself as a field to become "*… a more universal, inclusive, engaging discipline*" and further one which is both relevant to, and "*incorporates and synthesizes*" other domains of knowledge. HCI and UX courses are a major part of this change, and offer an opportunity to explore, create, and think visually.

Post-education, such skills are still vital, but are "optional" in terms of their delivery and application, yet the uptake of professionals in both formal and informal sketching courses evidences that there are gaps in this knowledge that have persisted. Sketching is a persistent skill that crosses boundaries, knowledge and is global in its nature—manual sketching is still relevant in even the most technical of disciplines (Goldschmidt, 2017). Where sketching is such a natural fit to our discipline, it is important to do more to promote, discuss, and share best practices, with the aim of not only improving the pedagogy for HCI and UX, but potentially the wider field of computer science as well.

3. RATIONALE

This is a cross-sectional study where we present a snap-shot of learner groups at a given point in time, and during a time when a rapid evolution of teaching styles and technology was in play. Our intention in creating this work is to showcase a variety of approaches and techniques for teaching sketching as part of a wider HCI and UX education, based on our own experiences over the past 5–10 years of engagement in this area. We focus on case-studies to enable outside eyes on real-life scenarios, without the pretext of a user study or focused attention, and student work is shared with permission and attributed. The case studies are presented in order of educational experience, to show how delivery and impact varies across time, starting with first year undergraduates, then focusing on second year undergraduates, before moving to postgraduate and peer-to-peer learning in professional contexts. This allows us to compare groups and experiences in a reflective manner, and provide indicative guidelines for teachers to use within their own educational practice. Within each Case Study, we also provide direct comparisons between in-person and online/remote teaching for sketching, which was partially expedited by the pandemic, but has proven to be both a challenge and an opportunity for this kind of learning activity. Although we provide details of four case studies, we are also able to offer our feedback with background knowledge from both informal and professional settings, where sketching education has been either a volunteered or paid activity, at meet-ups, events and during invited talks and seminars. The following Case Study sections each provide details on course development, learning objectives, assessment, demographics, sketching pedagogy and feedback or resulting outcomes. We conclude this paper by reflecting upon lessons learned, and provide advice for those wishing to embed this valuable skill within their own teaching practice.

4. CASE STUDY #1: DATA-SKETCHING IN A FIRST YEAR MINOR

4.1. Course Development

This Case Study outlines the use of sketching within a course offered as part of an initiative aiming to make the benefits of computer science education available to learners studying any subject. Recent funding enabled the design of this as a brand new "minor" subject in Computer Science in 2019 (a course which runs alongside an individual's primary undergraduate degree program), with the aim that it is to be integrated into the main computer science degree during the next review of the accredited program. The overall minor is heavily HCI focused to show the range of possibilities when studying computer science. We examine the learning experiences where sketching was embedded in class and coursework activities for 1st year undergraduate students over a three week module covering information visualisation, documenting the process, results and challenges in teaching sketching within this context.

4.2. Learning Objectives and Assessment

The full minor course offers students a choice of "tracks" through a range of HCI focused modules, such as VR/AR, programming fundamentals, and physical computing, one of which is Information Visualisation. This particular module is aimed at examining and creating visual representations of digital material, such as social network diagrams, and the representation of personal data for communication. Specifically, the module explores the question of why we need to visualise data. Learners are asked to reflect on how we developed visualisations to communicate data with people, and what decisions are made by the programs we use today. Learners are also expected to be able to identify "successful" and "unsuccessful" attempts at communicating data visually, and discuss biases and limitations in visualisation.

Work was created during synchronous studio sessions (and during independent learning hours) and contributed toward a final assessed portfolio (80%) with the final output being a creative infographic outlining personal data collection and insights, and describing each learner's journey through information and visualisation. The remaining 20% of the course marks were given for engagement (10%) and a short online quiz (10%).

4.3. Course Demographic

Learners self-selected the minor as an accompaniment to their main degree course (non-computing focused), examples being Economics, English, History, and Maths. Only one learner in 2019 was studying an arts-focused subject (Design). From a full cohort of 71 (2019) and 76 (2020), 41 individuals chose the

Information Visualisation track in 2019, and 46 in 2020. The course was unusual in gender split being fairly even between those identifying as male, and female or non-binary, when compared to the full computer science cohort which ranges between 11–30% female or non-binary learners. Apart from the student on an arts course, students had little to no experience with sketching since before their exam subject choices which occurs in the UK around age 14.

4.4. Sketching Pedagogy

4.4.1. Structure and Schedule

The module was originally designed to be a blended learning environment (Osguthorpe and Graham, 2003) with a weekly studio session (2 h) where learners worked on their "table" with the idea that they would support each other during studios. The studio sessions primarily involved sketching with some hands-on "making" to describe both personal and broader data, as well as providing an opportunity to translate information into the digital domain. Video lectures were also provided to be watched asynchronously (up to 1 h a week in bite size chunks). There was also the expectation that learners would engage in independent study of around 10 h over the three week period. The weekly studios were split between the cohort to foster interpersonal relationship-building, with an average class size of 15. Learners were able to self select a "table" for in person sessions, but these were pre-allocated for online-only delivery. The studio sessions started with a task introduction and learners were given a selection of data sets to sketch, starting with a basic "social network" delivered in a table of names and numbers, and following on with housing types, and cars (2019 only). Following the studio session on data-sketching, students moved on to working with data physicalization, before returning to sketching to plan and outline their final portfolio piece which was an infographic of personal data, collected over the duration of the course.

4.4.2. Delivery of Sketching Pre-COVID Pandemic

Sketching in practice was core for the first week and the following independent learning hours. The blended learning environment meant that students had access to pre-recorded lectures which were designed to be accessed before the first studio. The first two lectures covered drawing hints and tips, including a "sketch your music task" where students reacted visually to a piece of music, and also comprised a short course covering sketchnoting, and commonly used icons, objects and figures (**Figure 1**). In the first studio, students were given a short demonstration of how to begin data sketching, using a large presentation screen connected to a Microsoft Surface. Pens, pencils and paper were supplied to ensure that materials availability was not a barrier to engagement. Teachers and teaching assistants then circulated and answered questions and gave hints as needed. The largest barrier to engagement was that students did not see why the data needed to be sketched, asking why they could not just feed the data into a machine to generate the desired result, however by the end of the session the students took away the knowledge of process—how we begin to design visualizations that become automated. Sketching underpins the design of visualizations and how the software maps the data to the visuals. Most students completed a full representation of the "social network" task during the in person session, with some also making a start on the houses or cars data set, which allowed for more creativity in the sketched representations (see **Figure 1** for an example of student work from this part of the course). Two students from the first cohort developed an alternative method of sketching the social network, encoding relationships into elements of a person's face or clothing. Several students found the full data set overwhelming to produce in one piece, and instead used small multiples (Tufte and Graves-Morris, 1983), describing each person's relationships in turn.

4.4.3. Development of a New Online Structure and Schedule

As the course had already been developed to be blended in its approach, the main difference in the delivery was that the studio format had to be rethought. Students no longer had the social experience of their "table," and the camaraderie of working together in person and comparing notes and sketches. Based on student feedback from the previous year, the sketching data sets were reduced from 3 to 2, to reflect the large number of learning hours needed to complete the tasks. The video lecture tasks which had previously been advised, but optional, were made compulsory to ensure that all students started the sketching studio with the same level of knowledge. Students were divided into "tables" using Microsoft Teams private (hidden) channels, with a general channel available for full class presentations at the beginning of each session, and more general sharing of work. Each channel was encouraged to chat and share their work in the channel directly to gather feedback from peers and teachers, and also in the general channel if the student felt confident. The demonstration was almost exactly the same as the in-person delivery, but delivered directly to student's computers rather than on a central screen. Unlike the in-person sessions, many students were reluctant to be the first to post an image, as they were concerned about their skill levels, however, once one person had posted then other students felt able to join in. This sharing also helped make connections between students, who largely worked on an individual basis for other tracks. Those students who felt unable to communicate to their group also made use of the private chat function in Teams to communicate directly with teaching staff if they had questions.

4.5. Results and Feedback

When making comparisons between the in-person and online only environment—for example, in demonstrating techniques and ideas, offering feedback, or sharing between groups—the largest difference was in sharing sketches within and between groups—although all students were encouraged to share within both their own channel and the "general" group. Feedback was made discrete by the availability of the private chat function, and students who posted their work publicly did so on the basis of sharing, rather than asking for feedback. Despite the less social set-up of the online-only module, the students appeared to enjoy the tasks more, perhaps because they did not have to worry about judgement as their images were private unless shared by choice.

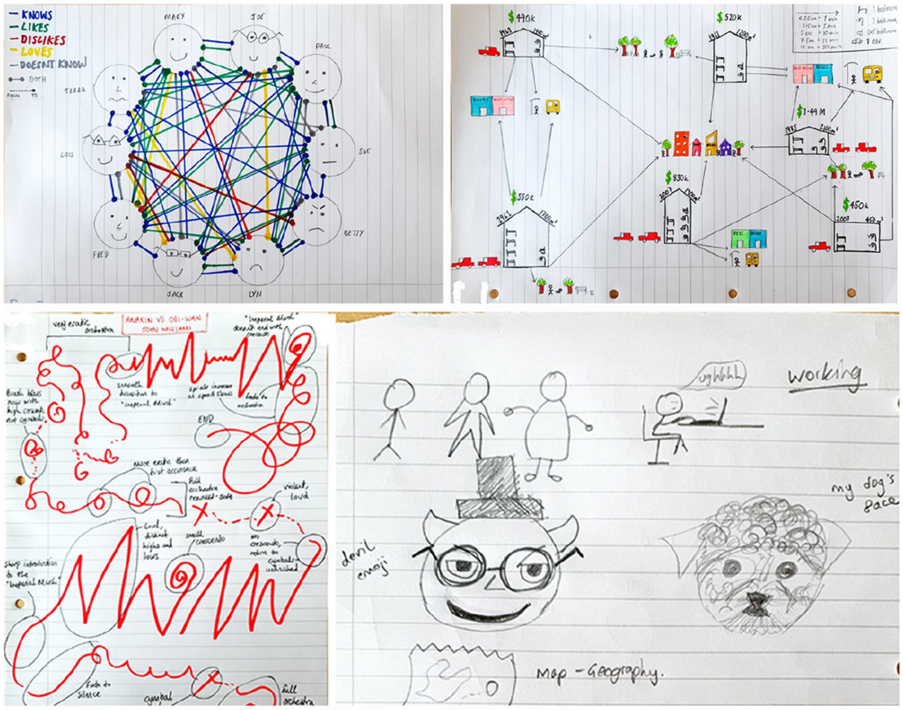

FIGURE 1 | From top-left to bottom-right, social network data-sketch, houses data-sketch, music visualization, emoji and figure practice. Reproduced with permission Oliver King, 2021.

For the in-person studios, any student could walk around and see what their peers were creating. Despite the minor differences between delivery, the second cohort were more engaged with the sketching content, spent more time drawing and the course feedback was more positive: First cohort: *"Very interactive and fun." "Learnt a lot of new skills"* (Standard university course ranking 3.71/5); Second cohort: *"Lots of fun doing sketching, provides a break from hard work while still learning. [The teacher] knows a lot about what she's teaching and can give examples for any situation."* (Standard university course ranking 4.18/5).

Sketching as a core activity was well received and most students engaged directly, however, for both cohorts, two students used digital tools rather than complete the tasks by hand (e.g., online diagramming rather than digital sketching with a stylus). The compulsory inclusion of data-sketches in the final portfolio meant that all students completed the task if they were able, in order to get the maximum marks for their work. Due to the course originally being implemented as blended learning, very few differences in transition and outcomes were noted apart from the final module feedback. One difference for the improved feedback between the first cohort and the second was that the explanation given for *why* sketching was important was made clearer, and the slightly reduced workload (one less data-set). As the students were from non-computer science subjects, the department was not able to get an update as to the learning journey and if the skills they learned were applied, but each student was given the opportunity to develop and apply their sketching skills in further study should they wish, and many of the final portfolio projects reflected the use of sketching and visualisation skills in application to their own interests and courses.

5. CASE STUDY #2: SKETCHING IN A 2ND YEAR HCI COHORT

5.1. Course Development

The Human Computer Interaction course is a full degree core cohort module that runs for the whole of the first term. In its current iteration it has been delivered in the same format for five years. The course is the first introduction that students have to human-centred computing and User Experience design processes and tools. Students are taught both theoretical and practical topics over a ten week period, comprising two hour-long lectures a week, and an hour]s practical workshop for six of those weeks. Students are expected to work in groups and commit additional learning hours alongside synchronous learning. The practical sessions offer hands-on design experience, implementation advice, and skills to evaluate interactive systems. The synchronous lectures explored human perception, UCD, and participatory design, to show how system design impacts external user behaviors, and explores the importance of accessibility in design.

5.2. Learning Objectives and Assessment

Students are expected to be able to integrate diverse information to form a comprehensive understanding of Human-Computer

Interaction; critically reflect on advancements in HCI and computer science as a wider field, and be able to leave the course having gained the abilities needed to work in modern design and development teams.

5.3. Course Demographic

In 2020, the second year undergraduate cohort comprised 276 students, enrolled either on a focused BSc Honours course in computer science, or a combined degree where computer science formed half of their modules. One student was completing a term in the UK as part of an exchange scheme. In 2021, the full cohort was 212 students, with two on exchange.

5.4. Sketching Pedagogy

5.4.1. Structure and Schedule

The change to online learning in the six months prior to the new university year meant that materials and structure had to be changed. All lectures that were previously delivered synchronously were now expected to be pre-recorded, for students to watch in their own time, or during the allocated session if preferred. The time slot given to the lectures was suggested to be used to replay the lectures, and then provide a short Q&A session. Lectures themselves were divided up into shorter chunks, similar to those provided in blended learning courses (see Case Study #1). The workshops had previously been 2 h in length, but the increased student numbers (up by nearly 100 on the previous year) and the online format meant that these were halved to ensure that students were not overwhelmed by screen time. The additional work needed for workshop tasks was allocated to independent learning hours (in group). Students were divided into groups of 5–6 for their coursework, to ensure that if there were non-engaged members, that sufficient students remained to not become overwhelmed by the workload, and any disruption taken into account when marking. A major change to the workshops and assessments was that a video prototype was no longer required—COVID-19 restrictions meant that students were unable to meet in person and film each other. To fill the gap in assessment, greater importance was given to sketching and storyboarding, with the students now required to produce sketches and finalised storyboards as one of the key marked coursework components (see **Figure 3**). To support the increased importance of sketching, students were offered a 1 h synchronous, hands-on lecture on beginner's sketching, in one of the regular lecture slots, alongside a pre-recorded lecture on sketching and storyboarding theory and examples (to be watched prior or after the hands-on session. A second, participatory sketching activity was also designed to demonstrate practical uses of sketching during ideation and prototyping.

5.4.2. Delivery of Sketching During COVID Pandemic

The synchronous sketching session was a 1 h live, hands-on sketch-a-long. All students were notified in advance of the session to prepare sketching materials (either pen/paper or tablet/stylus). Slides were used to structure the session, but these were not shown to students due to the limitations of the Microsoft Teams environment. The main window was set up to screen share a Microsoft Surface Go, and the meeting joined *via* an additional device (laptop and second screen—see **Figure 2**) in order to see what the students were seeing, view the slides, and also maintain the chat function to answer questions. The session covered basic sketching visual-vocabulary (e.g., people, actions, places, animals, and objects) and moved on to creating narratives and storyboards, which directly related to the coursework component. Students all used their own materials, but were given advance notice on what to have (paper, black pen, coloured pen, as a minimum). Prior to the session, students with accessibility needs were spoken to privately and alternatives and accommodations arranged (e.g., using a particular stylus and tablet, digital variations on sketching, embedding clip art and line drawing to create narratives). Of the full cohort of 276, 180 students joined and engaged with the synchronous session. Images were non-deliverable, but some students included items within their coursework appendix and evidenced style-guidelines and learning in their final storyboards—for example, in **Figure 3** the style of figure is taken from the live sketching session, and the use of highlighting and different viewpoints from the asynchronous lecture content.

FIGURE 2 | Sketching delivery set up: Microsoft Surface Go and stylus, Macbook Pro 13," Dell 20" monitor, mobile phone, table clamp for live hand-drawn view, pens, paper, desk lamp. Miriam Sturdee, 2021.

As the course progressed, students were expected to focus on theory and examinable information. To support knowledge formation, a co-sketching participatory activity was designed to enable students to apply their knowledge of good principles of design and accessibility (Nielsen, 1994). This activity was based upon one that we use in our peer-to-peer learning and called "HCI Improv" which combines user experience with ideation and design fiction (Sturdee and Lindley, 2019). During our usual peer-to-peer sessions (see Case Study #4 for an example) learners form teams and work on spontaneous prompts suggested by the full cohort, before ideating, diagramming and creating storyboards for a novel technology, use case, and user group. They then present these to the room. For the online set-up, the students provided the prompts, but the sketching was done live by the teacher, and students could advise on aspects of the technology and use case in real time using

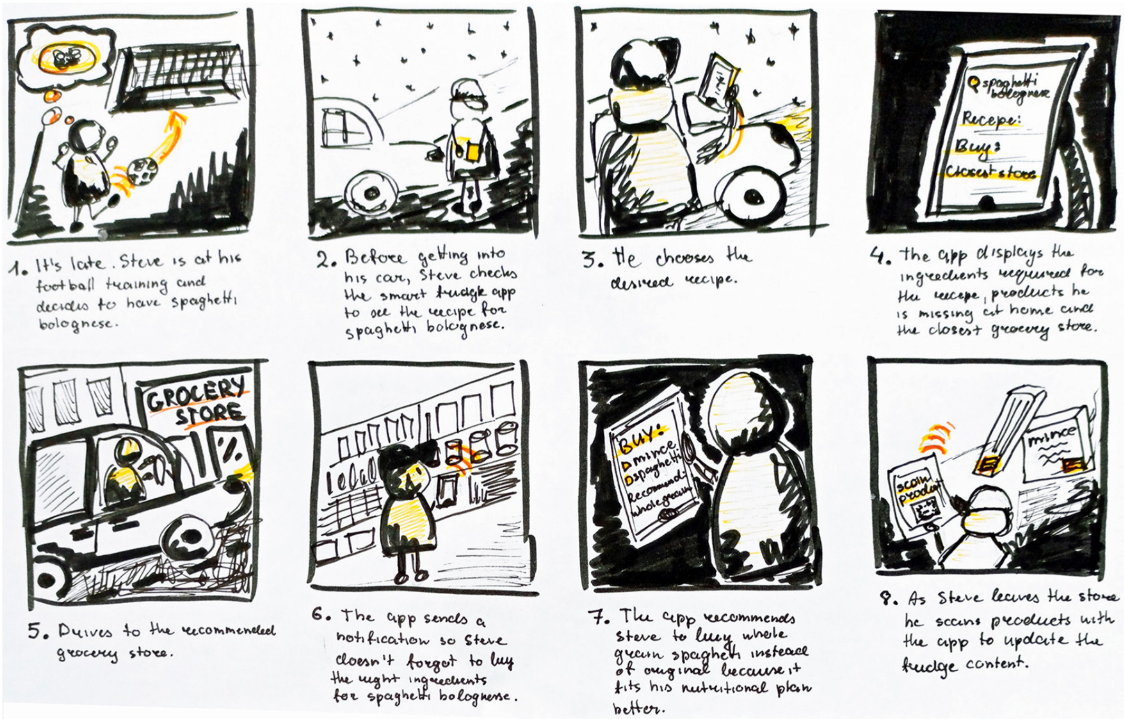

FIGURE 3 | Student storyboard for coursework component of 2nd year HCI, based on lecture and hands-on sketching session. Reproduced with permission Indre Aruodziute, 2020.

Microsoft Teams chat. This part of the lecture schedule was not designed to teach sketching, but to both show its value and instill practical knowledge of HCI and UX that had previously been delivered passively.

5.4.3. Development of a New In-person Structure and Schedule

With the return to synchronous, in-person teaching and workshops, the course had another overhaul, and was brought back in line with pre-COVID materials. The return to synchronous lectures meant that the videos were scrapped and the traditional format of slides and presentation to a theatre was brought back. Without the benefit of asynchronous learning, there was no longer the capacity for a full session on sketching. Basic skills were taught in a 10 min block at the end of the theory lecture, and then capitalised upon for another 10 min at the beginning of each of the seven workshops. In contrast to the online delivery, very few students brought materials with them, so were provided with basic pens and plain paper. To support the students in their sketching skills, a large part of the subsequent workshop was given over to detailed feedback to enable students to develop their style and content before the final storyboard components were created.

5.5. Results and Feedback

Following the online synchronous sketching lecture, several students reached out to state how much they enjoyed the content, and that they had not expected to have so much fun in a computer science lecture. The overall course feedback was positive, with HCI achieving an average score of 4.45/5 for the module, based on the standard university metric—this was the highest score the course had ever had, with a lot of feedback about the alternative activities and sketching skills. Although one student mentioned they thought that the "importance of sketching was overstated" compared to the bulk of the lecture and coursework material, it was also incorporated heavily into the open-book exams that were taken by students six months later, at which point it became clear why so much focus was on practical skills. Several students actively sought out opportunities to work as teaching assistants for the following year, based on their enjoyment of the course, and in particular, the sketching skills and applications.

In-person workshop take-up was extremely high due to HCI being the only fully in-person course offered to second year undergraduates in 2021. As a result, theatre occupancy was high and a large proportion of students engaged with the sketching and storyboarding theory. Despite the face-to-face context and presentation however, uptake for each in-person workshop was around 65% (around 18 students in each group) which was similar to the online delivery, but those who were not participating had a negative effect on the session, refusing to take part even with encouragement, and this meant the atmosphere was also less convivial. However, those that did complete the short sketching skills presentation also took all their sketches with them rather than leave them for recycling, which suggests they found value in the work. Several students who were particularly active also stayed to discuss their images and style after the session. Course feedback for the most recent cohort is not yet available but will be added before publication.

6. CASE STUDY #3: SKETCHING AS A FOUNDATIONAL TOOL FOR MSC USER EXPERIENCE DESIGN

6.1. Course Development

User Experience (UX) design postgraduate, accredited Master of Science, course started in the mid-2000s in the United Kingdom, with an overarching goal of equipping learners with the theory and practical skills to enter the UX profession in the UK and beyond, successful postgraduates have gained employment as UX designers, user researchers, and brand and product designers. The course has experienced exponential growth in the last 5 years due to the increased reliance and adoption of technology in everyday work and life. The module is one of five modules in the course lasting one academic year for full-time students and two years for part-time students. The module occurs in the second half of the academic year (winter term) for both pathways, lasting fifteen concurrent weeks. Traditionally, an in-person course, with weekly theoretical lectures and practical workshops, took an unprecedented shift to online learning and teaching in the winter of 2020, as a result of the COVID-19 pandemic and lockdown measures faced by UX education providers in the UK and around the world.

6.2. Learning Objectives and Assessment

The primary module learning objective is to introduce learners to design thinking, precisely the Stanford design thinking methodology[2] in the context of contemporary UX design. Students are asked to engage with the non-linear process with an aim to systematically extract, learn, and apply design thinking techniques to solve an in-class group work problem, a rendezvous smartphone application, and individual coursework, student chosen problem. The successful completion of the module means students are able to demonstrate research about their intended audience; analyse, both qualitative and quantitative, data to develop a number of grounded UX artefacts that define requirements, e.g., affinity diagrams, user personas, empathy maps, customer journey maps; creatively ideate and design modalities and interactive content that appeals, e.g., crazy 8 s, brainwriting, low-fidelity paper prototyping; to innovative and technically prototype a smartphone application with strong consideration and use of modern day practitioner principles, methods, and technologies to test the suitability of their intended user journey, and then to critically reflect on the design method, practice, and user experience whilst considering the strengths, limitations, and future work.

6.3. Course Demographic

In January 2021, seventy-eight postgraduate students from around the world were brought together to study a traditionally in-person course in an online capacity as a result of the UK Government enforced third national lockdown. The learners represented a variety of ages, skills, work and educational experiences, and knowledge. The majority joined having taken a direct path from related undergraduate studies with non-related work experience whilst others had multiple years of related-industry experience across multiple roles and levels who wanted to formalise their industry knowledge. Although, there were a few learners enrolled due to a desire to change industry and thus had limited experience in the space, e.g., illustrators, animators, architects, and social workers.

6.4. Sketching Pedagogy

6.4.1. Role and Delivery of Sketching Pre-COVID Pandemic

Sketching plays an important role in the module, especially in the areas that encourage the exploration and generation of knowledge, ideation and early prototyping; the early to mid phases of the methodology. The learners are asked to sketch alongside users to understand their past, current, and future experiences, e.g., current experience comic strips (Lewis et al., 2014); to define the users journey, challenges, requirements, and opportunities through the use of storyboards; by loosely sketching the problem and their potentialities from the perspective of others using a variety of ideation approaches, e.g., "rapid idea generation" and "day in the life of the problem[3]" pseudo-interactive low-fidelity paper prototypes (**Figure 4**) for evaluation with users supported by Marvel POP[4].

In traditional teaching and learning environments, pre COVID-19 pandemic, sketching took the form of in-person demonstrations followed by learner application through the use of electronic projectors using traditional, everyday, sketching tools: pencils, fineliner pens and markers on printer paper and or post-it notes (e.g., **Figure 5**) or using a whiteboard (e.g., **Figures 6**, **10** middle) in either a lecture theatre or computer laboratory setting. The students would be asked to "sketch-a-long" with the teacher, an established learn-by-doing approach that puts forward the idea that humans learn more when "doing" an activity (Schank, 1995). Throughout which the teacher used a think-aloud protocol to give students an opportunity to gather insight of the creator's thoughts, feelings, and decisions as they sketch, through which they can open dialogue with the teacher through questioning and discussion. Thus, it was determined that omitting sketching from the curricula would have a detrimental impact on the students successful engagement with the module.

6.4.2. Development of a New Online Structure and Schedule

As a result of the UK government online learning measures, the traditional in-person module structure and schedule was overhauled. The teacher's decision making process was supported by personal observations and experiences alongside learnings shared by the authors and the wider UX education community during previous lock-downs, these non-academically published mediums included blogs, social media (e.g., Twitter hashtag #onlineteaching), articles (e.g., Gewin, 2020), virtual department

[2]www.web.stanford.edu/~mshanks/MichaelShanks/files/509554.pdf

[3]www.nextgenpsf.co.uk/ngs-toolkit

[4]www.marvelapp.com/pop

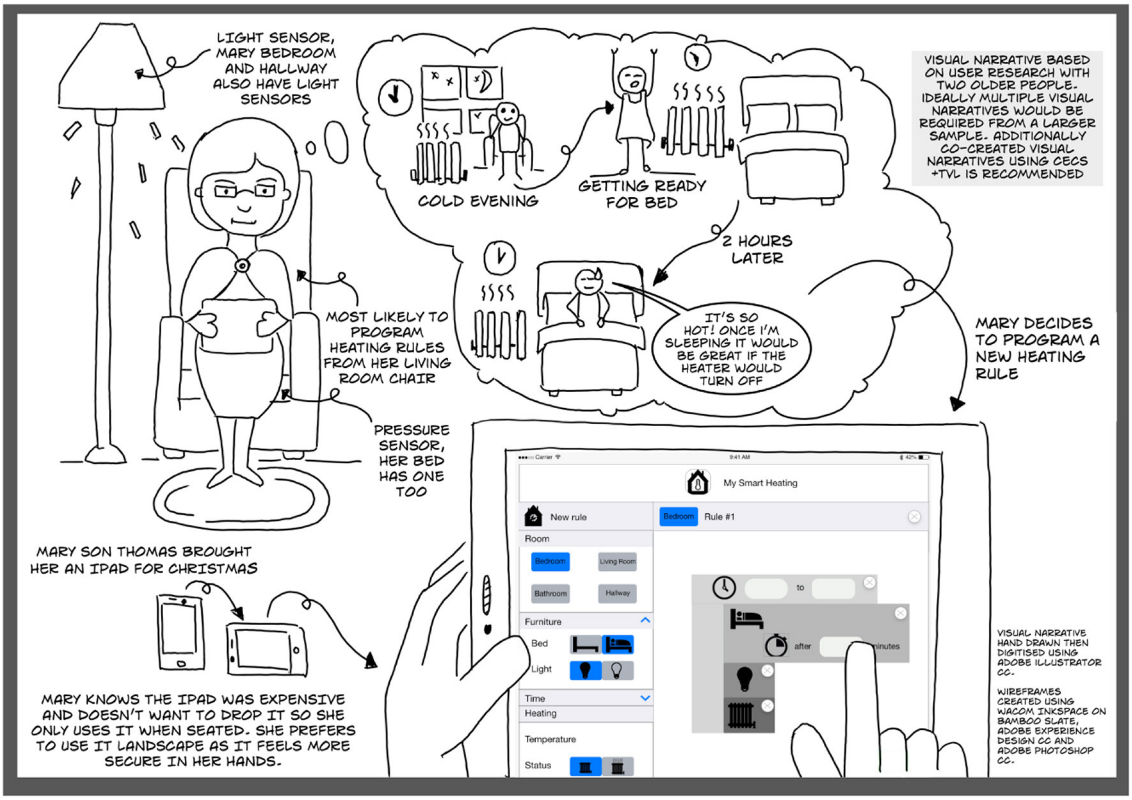

FIGURE 4 | Pre-COVID-19 exemplar of sketching in UX design: demonstrating contextual prototype vignette. Makayla Lewis, 2018.

FIGURE 5 | Pre-COVID-19 teaching sketching in UX design: demonstrating figure design using sharpie markers on paper. Makayla Lewis, 2018.

exchanges and coffee breaks and institution teacher training. The concluded that online module students would experience challenges that would impact their ability to learn sketching, would include, but were not limited to, passiveness; time management and discipline; learning environment control; isolation, anxiety, and depression; lack of motivation; and reduction in help seeking. In an attempt to overcome these the module structure and schedule was planned and delivered in a way that promoted technical and social presence, the module teaching team (the teacher supported by a teaching assistant, a previously successful module learner) actively and regularly engaged and encouraged presence. Although not a new concept, initially put forward by Mishra et al. (2020), Almendingen et al. (2021) and Parks-Stamm et al. (2017), it was fundamentally and logistically different from the teaching team prior module delivery.

Each week students were given a 2-h lecture, 1-h fireside chat with industry and academic researchers and practitioners, 1-h reading group with assigned industry and academic materials followed by a 3-hour workshop to apply their weekly learning to the in-class problem. Help seeking was presented to students in four formats: (1) 1-h group consultations at the beginning and ending of each week; (2) "frequently asked question" forum where students could put forward questions at one day or time for the team to answer during working hours; (3) and a mid-module review in the form of a student "show and tell;" and (4) student initiated 20-min 1:1 support sessions although this was rarely requested. Furthermore, optional extracurricular activities, curated by the teacher, were shared and regularly updated

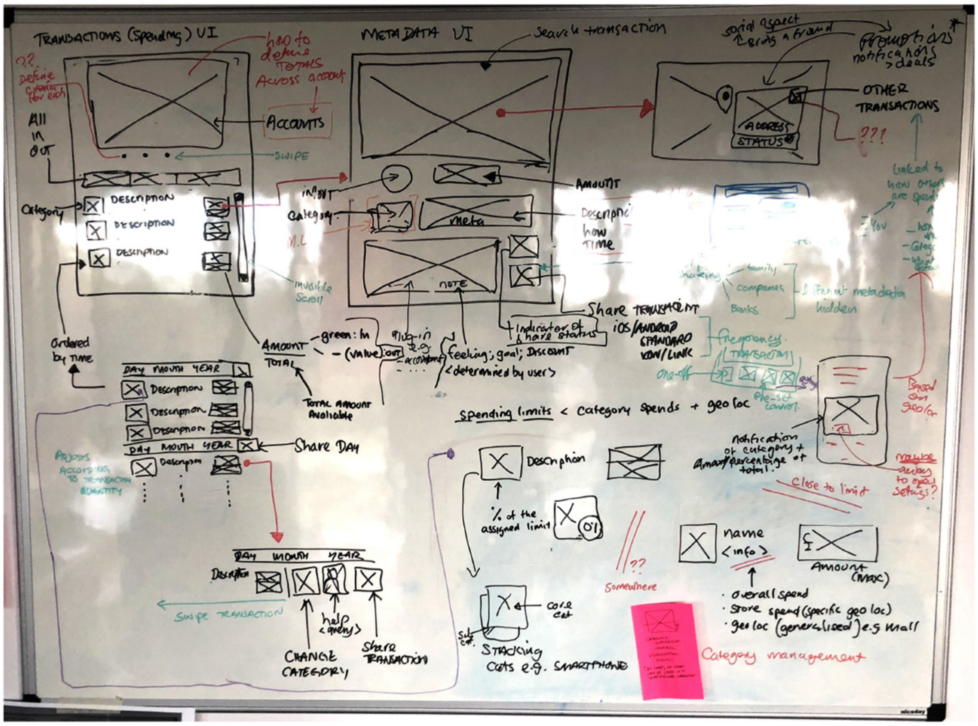

FIGURE 6 | Pre-COVID-19 exemplar sketching in UX design: demonstrating an ideation technique using a whiteboard. Makayla Lewis, 2019.

that included free, to support student accessibility, information to online UX community meetups, conferences, hacks, and coffee chats. The teacher made a point to attend extracurricular activities, greeting learners in virtual spaces, and engaging in UX community networking and discussions. Furthermore, similar to Case Study #2, the teacher consulted with students who identified as having accessibility needs prior to the commencement of the module and the module materials were adjusted accordingly.

To better support "presence," the students were divided into twenty teams where they were encouraged to collaborate inside and outside class hours. A systematic narrative approach was taken to teach and engage students in the content, every fortnight, for the duration of the module, was dedicated to a stage of the method whereby related concepts, theory, case studies, artefacts, demonstrations, and activities were put forward and practiced. Learners were asked to "show and tell" their in-class group work in the fourth week during timetabled workshops, present their empathise, define, and ideate phase of individual projects in week eight, present a poster of their completed in-class group work in week ten. Following the ten week teaching block, learners were given an additional five weeks to complete then submit their individual coursework.

6.4.3. Embedding Technology During COVID-19 Pandemic

The students were divided into twenty groups, between four to six members, using the People feature within Canvas, a course management system that supports online learning and teaching[5]. Each group was given a link to a private sub-channel within the module Microsoft Teams, a space for private conversations with a specific audience[6] where they were encouraged to collaborate, through chat and video, inside and outside class hours. It was believed providing the learners with a symbolically "hidden" online space allowed the teacher to separate the large cohort into smaller groups with an aim to promote a learning environment that is conducive to confidence and relationship building in a supportive peer environment[7], a space that would encourage exploration and experimentation with sketching. The author created a teaching space in a quiet, well lit, location of their home to minimise distractions during online teaching sessions (see **Figure 7**).

Sketching lectures were conducted synchronously through the use of multiple devices and applications. A laptop was connected to an external monitor to provide a large teaching space (**Figure 7**). The external monitor was restricted to Microsoft Teams, an online workshop offering chat, video conferencing, and software sharing; this allowed the teacher to monitor student engagement and interact through the use of an external microphone and webcam. A Wacom One drawing tablet[8] acted as the second monitor, this was screen shared with

[5]www.instructure.com/en-gb/canvas
[6]www.microsoft.com/en-gb/microsoft-teams/group-chat-software
[7]www.support.microsoft.com/en-us/office/overview-of-teams-and-channels
[8]www.wacom.com/en-gb/products/pen-displays/wacom-one

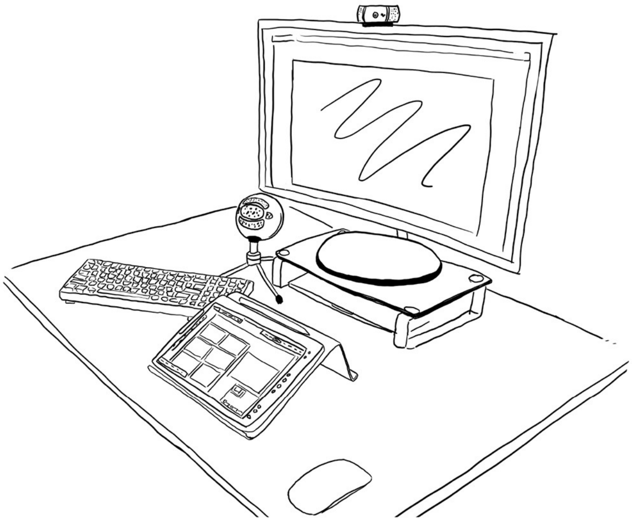

FIGURE 7 | Online learning sketching set up in a quiet, well lit, location: 27” monitor, external microphone, external webcam, external keyboard, external mouse, and Wacom Cintiq One with Pen on a laptop stand. Makayla Lewis, 2021.

the learners through Microsoft Teams. The purpose of the tablet was to synchronously demonstrate sketching skills and visually answer questions and comments. The digital sketching approach used differed from Case Study #2 as a result of the author's previous lockdown teaching experiences and through non-academically published mediums, discussed previously, that students often experienced difficulty with viewing traditional sketching demonstrations due to the presence and positioning of the teachers' hand. Miro, an online collaborative whiteboard, was used to deliver the sketching demonstration lectures. Miro boards permissions were set to *comment* meaning the visitors (learners) could view and add comments to any area of the board, Miro *timers* were also used to ensure the lecture remained on track, and Miro *timer music* provided ambience during individual learner activities.

Prior to each lecture a board template was created containing five core areas: (a) introduction to the lecture and the teacher, (b) reminder of core slides from that week's lecture, (c) a blank area for demonstration (**Figure 8**), (d) an exemplar area (e.g., **Figures 8**, **9**), and (e) upload area. Each sketching lecture began with a reminder of the lecture then sketch-a-long to build sketching skills, e.g., actions, faces, figures, emotion, scenes, etc., followed by a series of individual activities for application purposes. During the lecture students were encouraged to use Miro *comments* to ask questions by placing comments next to the relevant sketch or material (**Figure 9**, yellow speech bubbles). This helped the teacher to keep track of questions and their relevancy during synchronous demonstrations.

Toward the end of the lecture, the last 15 min, the Miro board elements were locked, permissions were set so that only the teacher could unlock the board. The learners were then reminded that the sketching lecture is a safe and supportive environment to share their creations. The Miro board permissions were then changed to *edit* allowing learners to upload their sketches to a predefined area of the board using their smartphone cameras and the Miro app. This allowed the teacher to view and provide feedback to students synchronously, it also offered the students to give constructive feedback to each other. Students who chose not to share their creations were asked to upload to their group Microsoft Teams private channel to obtain feedback from the teaching team and their group.

6.5. Results and Feedback

Upon comparison, the greatest differences between online and in-person teaching and learning that were observed by the author, were preparation, focus and attainment, and engagement. To ensure the teacher maintained control of the sketching lectures, precisely meeting learning objectives were met in a fun and interesting way, a considerable amount of time and planning was required, especially how technology would be used to support the sketching lectures. For example, the creation of the Miro boards were paramount, they needed to be easy to use, have logical structure, engaging, and support learner feedback and interaction. One Miro feature the author overlooked but learned quickly, 10 min into the first sketching lecture, was to use board permissions and element locking appropriately, *“If you give learners an sketching board for where you want them to engage in a specific way but give them access to all features and full permissions, what results is utter chaos, they will move areas and materials, sketching anywhere, upload photos of their sketching materials, their family pet in some instances, that are so large they take up most of everyone screen, and you will be flooded with Teams messages depicting confusion, frustration, and laughter followed by a flustered and panicked teacher.”* Planning is important, ensuring the teacher is adequately trained and practiced in the online synchronous hardware and applications they intend to use to deliver sketching lectures is crucial, this is because learners, when given the opportunity to be creative, will engage and push the boundaries in unexpected ways.

In relation to focus and attainment, the author witnessed an increase in “doing” amongst the students, precisely engaging with the content rather than only listening to it. Miro cursors, allow the teacher to show/hide collaborators' *cursors* on the board, allowed the author to see learners on the board, what they were most interested in, the links they were clicking thus allowing the author to adjust what was sketched and discussed, explore areas that were not being engaged with, and through the use of Miro *Bring everyone to me*, attention management feature that guides students to the teachers' location on the board, redirect student engagement and focus. Furthermore, through the use of Miro comments and emojis, the latter feature was an unexpected success amongst the students, the teacher was able to answer questions though comments left by students, reiterate content or re-draw a sketch when confusion was present as students would add sad emojis to specific areas of the board, they would use thumbs up emojis to vote on aspects of the board that were of most interest, and would use comments to support the teacher in answering questions.

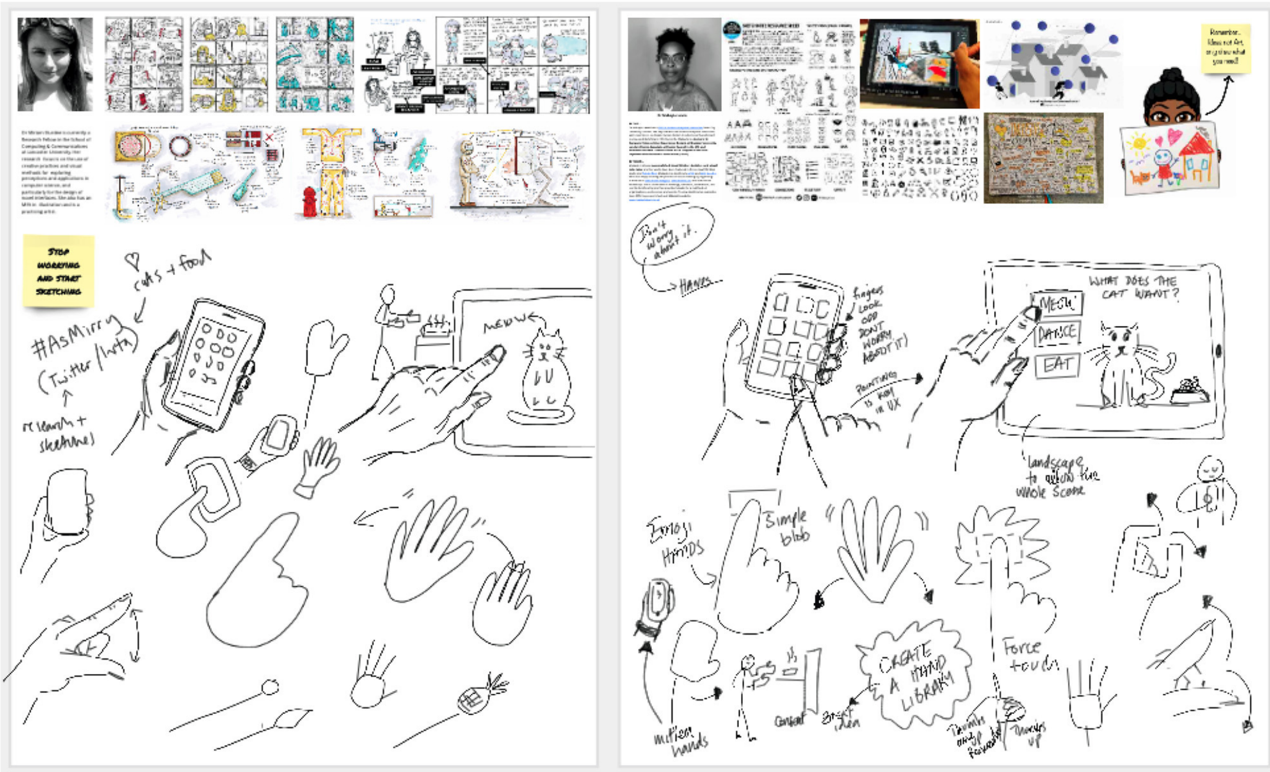

FIGURE 8 | Example interactive Miro board for demonstration of sketching devices, interactions, and gestures for storytelling and storyboarding lecture with a guest speaker. Makayla Lewis and Miriam Sturdee, 2021.

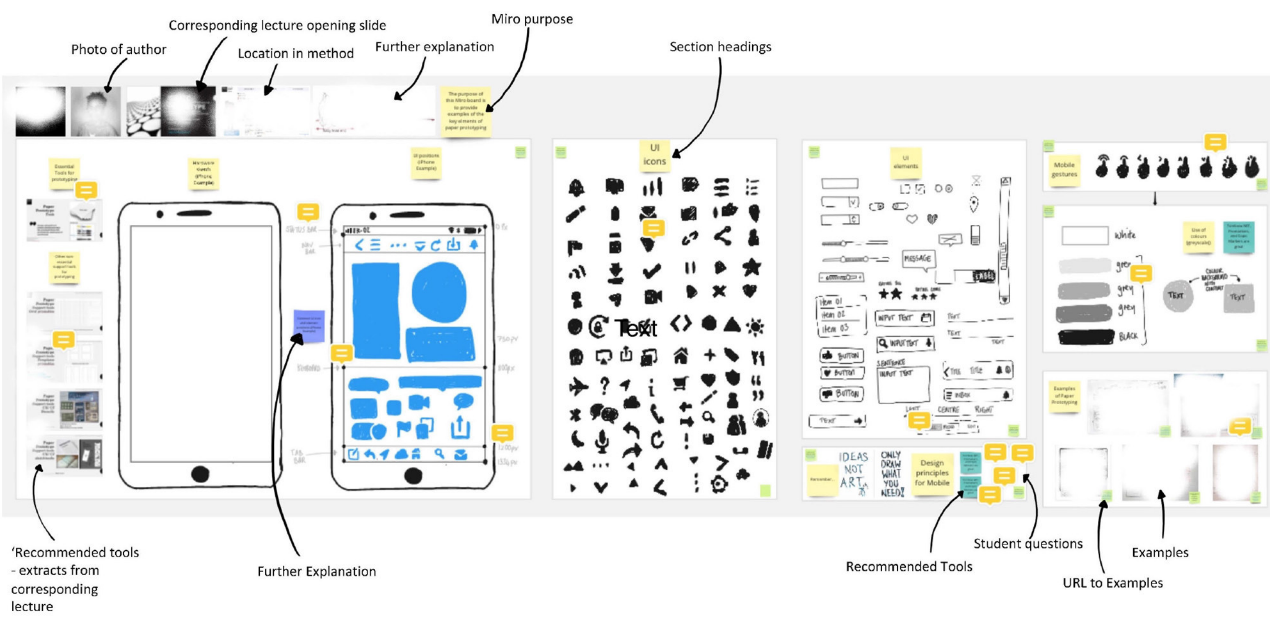

FIGURE 9 | Example interactive Miro board for demonstration of sketching components and icons for low-fidelity paper prototyping lecture. Makayla Lewis, 2021.

Student engagement was the most surprising outcome. At the beginning, the first week, they had a passive presence, both technological and social, during online lectures and workshops, however, by the end of the second week as a result of "presence" actioning of the teaching team they began to demonstrate greater presence in terms of attendance and engagement. This was especially evident in sketching related lectures, the author while preparing for the lectures, would see busy Miro boards (cursors whizzing around), Microsoft Teams video conferencing "start" notifications at least 5 min before the lecture with notable "pings" from the chat that regularly contained gifts depicting anticipation, sketching questions, and photographs of their sketching set up and previous practice. Students' technological and social presence remained high throughout the module, as a result the module received an overall ranking of 4.25/5, the standard university module ranking: 4.00/5, also a student noted in their module review, *"I am absolutely mesmerised by [ML] organisation and teaching technique. The module has been incredibly easy to follow and, if needed, going back to review the slides to answer any doubts is also easy to navigate. The [ML] has given us extensive reading material to reinforce what we're learning each week, alongside the Friday workshops which put our knowledge to practice. There have been times where it does feel somewhat overwhelming because of the amount of things we're learning, but the workshop helps calm that feeling by forcing us to process what we learned and put it to work."* Furthermore, the module saw an increase in the use of sketching in student coursework, previously when sketching was few and far between they were presented throughout in vast forms and to varying degrees, they were annotated and justified when they were not previously, the students demonstrated a greater understanding and application of sketching in UX which is hoped will remain as they commence employment.

7. CASE STUDY #4: SKETCHING IN HCI FOR PEER-TO-PEER LEARNING

7.1. Course Development and Learning Objectives

As discussed in case studies one to three, sketching is often overlooked in many applications and disciplines, it is often referred to as a "soft" skill and as such direction is often not provided in teaching and learning settings (universities and adult learning institutions). Although, it is proven that sketching can support students, researchers and practitioners in HCI to ideate, collaborate, document, and explore complex topics, themes, feelings, attitudes, opinions, and experiences of ourselves and others, e.g., code (Bergström and Blackwell, 2016), rapid prototyping (Cottam and Wray, 2009), algorithmic recognition (Johnson et al., 2012), and a digital representation (Igarashi et al., 2006).

In 2014, the authors observed that those wishing to learn and practice sketching in HCI had limited opportunity to do so in a fun, engaging, confident building and friendly sketching environment. The ongoing journey to provide this opportunity began at ACM NordiCHI 2014[9] continuing to 2021 at ACM CHI with a multitude of conferences, summer schools, events, meet-ups in-between, e.g.,[10, 11] (Lewis et al., 2018, 2019; Lewis and Sturdee, 2020, 2021), and (Sturdee and Lewis, 2020).

The overarching aim of the course is to be "hands-on," to foster a learning by doing approach as discussed in Case Studies #1, #2, and #3. The authors take the students from basic, hands-on sketching to practical research contexts, with opportunities for practice, feedback, and creative thinking. The key areas presented and demonstrated include: Warm-up "The Humble Line;" Icebreaker "Participant Portraits;" Exemplar Sketch Gallery; Visual Language; Applying Sketching in HCI Research & Practice; Without Words; Visual Narratives; Accessibility of Sketches; Digital sketching techniques; Design Fiction & Speculative Scenarios; Sketching with Participants; and Remote sketching techniques. Those who participate are asked to be open-minded and open to sketching exploration as a result, it is hoped, they will leave with the confidence to begin to employ sketching in their own HCI education, research, and practice.

7.2. Course Demographics

The course is directed toward academics (teachers and researchers), industry leaders, and practitioners, students, and early career researchers that have an interest in learning and or improving their sketching skills. Although, it is explicit that there are no prerequisites for attendance, i.e., novices, experts, and those with an interest are welcome to attend. Courses average 120 min in length with between 15 to 50 students, depending on the venue and the size of the event.

7.3. Sketching Pedagogy

7.3.1. Delivery of Sketching Pre-COVID Pandemic

The sketching in HCI courses took a traditional in-person workshop approach to learning and teaching, students were guided through theory and exemplars using PowerPoint presentations, this was intermingled with sketch-a-long demonstrations by the authors using digital projectors, flip-chart, and whiteboards (e.g., **Figure 10**). Followed by individual and group activities whereby the students would gather around a large table to sketch and discuss the activities or a discussion point provided by the teachers. Students were periodically asked to "show and tell," hold up their work, provide explanations and decisions with the aim of receiving constructive feedback from fellow students and the teachers (e.g., **Figures 11**, **12**).

Over the years, the courses were well received, the exit survey from CHI 2018: 23 of the 27 participants filled out the survey, and response was very positive: Course was worth the money: 6/7. Course should be offered again: 6.39/7. Course was well taught: 6.57/7. Helpful course material: 6.26/7. Overall, 17 agreed length was just right, 3 too short, and 3 too long.

[9] www.sketchinghci.wordpress.com/
[10] www.2021.hci.international/T04.html
[11] www.eventbrite.co.uk/e/uxpa-uk-sketching-ux-tickets-173628175547

FIGURE 10 | (Left) Makayla Lewis introducing participants to sketching storyboards on paper at CHI 2018 **(Middle)** Miriam Sturdee digitally sketching figure actions on a whiteboard at NordiCHI 2016 **(Right)** Exemplar of learners visual icon library wall using post-it notes at CHI 2018.

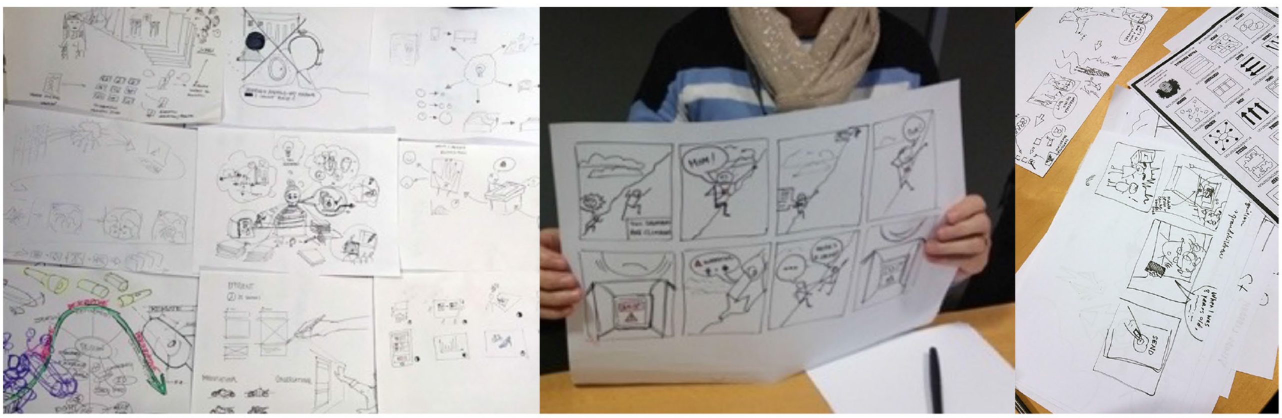

FIGURE 11 | Exemplar outputs from the Sketching in HCI workshop 2018, and courses at NordiCHI 2014, and CHI 2018.

7.3.2. Embedding Technology During COVID Pandemic

The COVID-19 pandemic meant that many HCI conferences in 2020 and 2021 were either postponed or moved to online only. As a result of the authors successfully transitioning from in-person to online only sketching lectures and workshops (see Case Studies #1, #2, and #3), they were enthused to continue teaching sketching in HCI to the wider community. Thus they successfully submitted to CHI 2021 and HCII 2021 where they conducted three courses with HCI students, practitioners, and researchers from around the world. The courses occurred at varied times (time zones), early hours of the morning, late afternoon, and late evening, with an aim of providing maximum community reach.

Similar to Case Studies #2, and #3, the authors conducted the sketching in HCI courses online, in English, synchronously, using a practiced sketching set up discussed in case study two and three (**Figures 2**, **7**). A digital sketching setup was taken to better support viewability, see Case Study #3, and to allow international audiences to follow and sketch-a-long directly *via* the Miro board if the video conferencing platform (Zoom, WebEx, and Microsoft Teams) were unclear, either due to student technical issues or low internet connectivity (bandwidth). As per Case Study #3, Miro was used to deliver the courses: *locks, timers, comments, emojis,* and *timer music* was used to support students' presence and engagement (e.g., see **Figure 12**).

The online synchronous courses, although different in delivery from the pre-COVID courses, had the same learning outcomes, demonstrations, sketch-a-long's and student activities, with one fundamental difference—two teachers—resulting in greater preparation for a successful delivery. This meant the development of an extensive Powerpoint, 126 slides, presentation of which 20% of the slides were visible to students, and the remaining being teachers timings and prompts. One author was responsible for the screen sharing of the Powerpoint, teachers took equal turns to present theory and exemplars, and video conferencing chat moderation whilst the other teachers was

FIGURE 12 | Example interactive Miro board from ACM CHI 2021. Makayla Lewis and Miriam Sturdee, 2021.

responsible for screen sharing sketching demonstrations, by both teachers, on the Miro board and moderation of Miro comments and emojis (see **Figure 12**). To further support the duel-delivery, the course's Miro board underwent alterations precisely in the area of supporting students flow:

- **Action colour key** *white* teachers sketch demonstration area; *yellow* teacher and student interaction area; *green* homework or break time activities area; *blue* Miro training and support; *orange* learner questions and comments and teacher feedback), and *black* arrows (to depict where to go next on the board);
- **Iconology** *camera* photograph your work, *upload* add your work to a specific area of the board, and *pencil* sketch a long.
- **Sketch upload** a *red* area was added to allow students to upload and resize their sketches without impacting others on the board.

These alterations were as a result of observed issues from joint lecture, sketching interactions and gestures, run by both authors as part of Case Study #3 (see **Figure 8**) and help to support a smooth, timely, and logical delivery of the courses (see **Figures 13**, **14** for exemplar outputs).

7.4. Results and Learner Feedback

Upon comparison, the greatest differences between online and in-person teaching and learning that were observed by the authors included, students fear of sharing images digitally especially in relation to peer judgement, in a space were community building is limited, meant they were less trusting and thus share their sketches; and students engaged less consistently perhaps due to demands of working from home or in distracting spaces, e.g., children and pets were often seen and heard and in some instances everyday household noises and external factors, such as deliveries, traffic, and planes, were present. Despite these observations, feedback from the students, *via* social media during and post courses, was positive, e.g., "Despite it being 4:30 in the morning here, having lots of fun at the #chi2021 course 'Let's Sketch! A Hands-on Introductory Course on Sketching in HCI' with the wonderful [author] and [author]," and *"Such fun sketching at virtual chi! I want more hands-on virtual workshops :) thanks for the cool course [author] and [author] #chi2021."*

Although, the online delivery was well received, the authors determined that in-person courses can be beneficial, it is easier to circulate the space and offer feedback and encouragement "in the minute;" humour during the course was important—the teachers tried to be fun and engaging but found "the room" is easier to read when in-person, students often had their webcams and microphones off thus receiving visual and auditory feedback was difficult. The authors found it much harder to cover the learning objectives, discovering that a three-quarter day sketching course would be far more draining, both physically and emotionally, online than in-person. However, online delivery setup allowed the authors to demonstrate and collaborate sketching simultaneously in the same Miro area, an aspect not possible when sketching using analogue tools. Furthermore, there is now permanent online record and textual feedback online meaning learners can revisit their work and the course in a way not possible in-person although some students were uncomfortable with this aspect thus deleted their shared sketches post course. Finally, the authors identified that online courses are cheaper to run and easier to meet and teach with

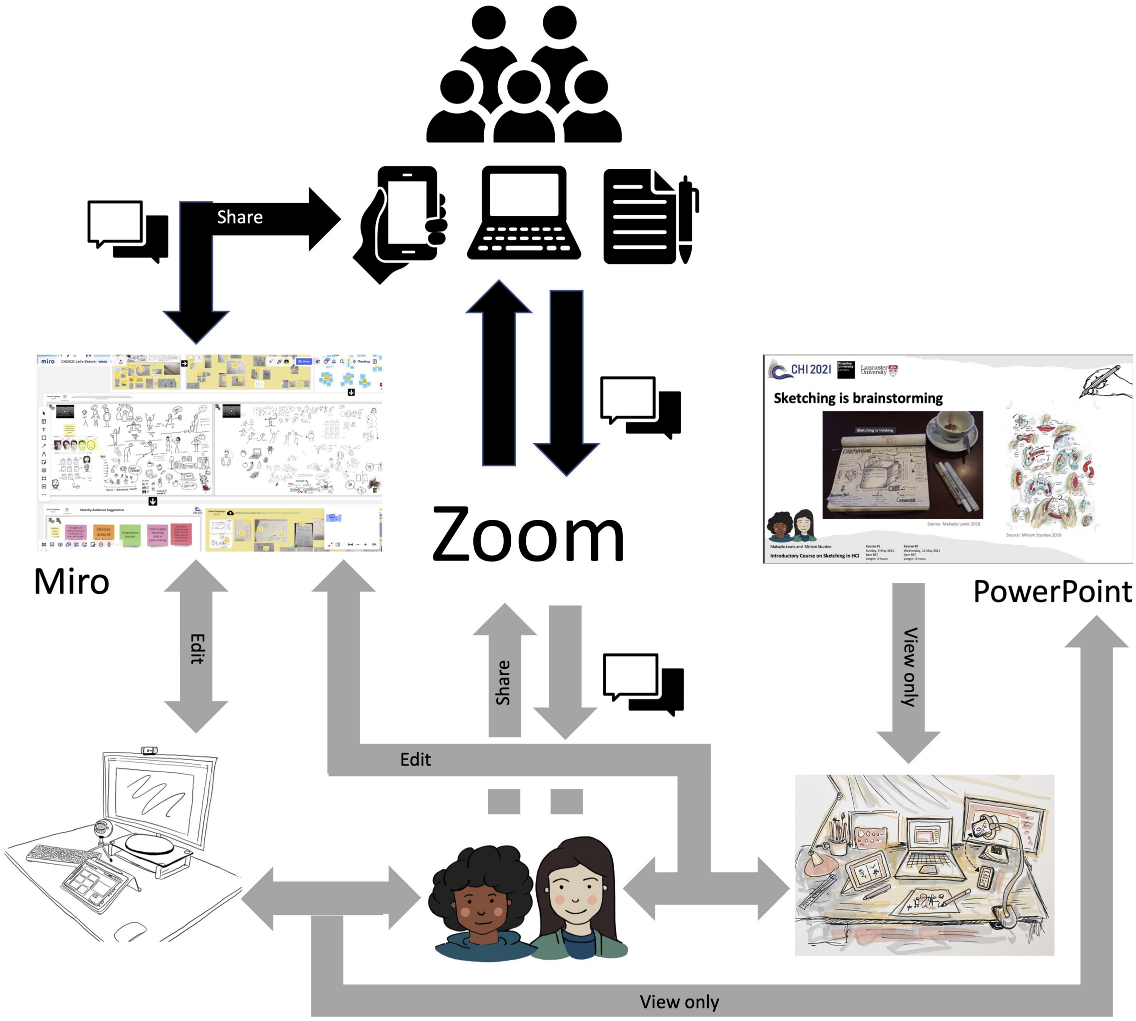

FIGURE 13 | ACM CHI 2021 delivery setup. Makayla Lewis and Miriam Sturdee, 2021.

students all over the world who might have not attended CHI previously due to its in-person format, thus community reach was the highest ever observed in the last six years.

8. REFLECTIONS

8.1. Motivations and Approaches

These case studies have provided four widely varying approaches to embedding and delivering sketching pedagogy within formal and informal HCI and UX education. Although Case Studies one and two embed sketching within a particular module to differing degrees (Case Study #1 is about 40% sketching based; Case Study #2 is about 10–15% sketching based) it is still an important part of learning outcomes. As learners specialise, as seen in the postgraduate (Case Study #3) and peer-to-peer courses (Case Study #4), there is more scope to embed further educational experiences.

We believe, through observation and literature, that undergraduate and postgraduate students, and to some extent, peer-to-peer learners in the space of HCI and UX have often not picked up a pen or pencil since school, yet find themselves in an degree course or industry that values the "soft skill" of sketching and visual communication. Those that have maintained an active interest in the arts are at an advantage in roles where creativity is valued, thus we find ourselves either teaching students who need to be educated as to WHY sketching is valuable, or learners who KNOW it is a valuable skill and are motivated to learn and refine it. Therefore our approaches to each of these groups differ.

Undergraduates in computer science have more recently "put down their pencils" and been funnelled down a particular learning route where they are told that they don't need to write, draw, or engage creatively. Part of the pedagogy for sketching in this demographic is explanation and demonstration of use—HOW is sketching used in industry, WHERE are the links to other modules in the course, WHY is it important in HCI and UX. Once you can instill the need for the skill, then the students are more willing to engage, this was seen for both the first and second year undergraduates. Removing barriers to sketching for

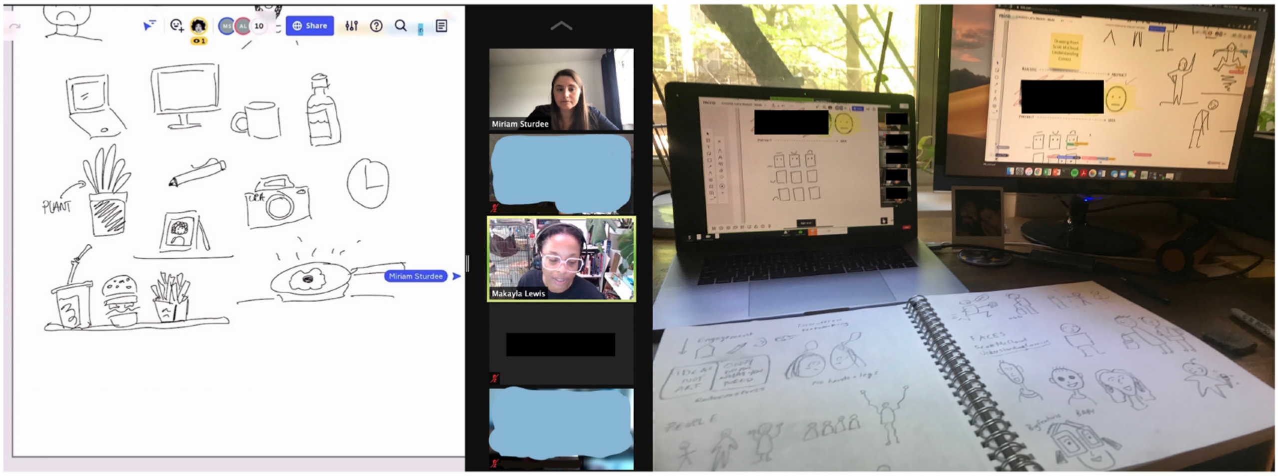

FIGURE 14 | (Left) ACM CHI 2021 delivery setup from student perspective. Andrés Lucero, 2021. **(Right)** ACM CHI 2021 delivery setup from student perspective. Maggie Jack, 2021.

this demographic is also vital—they will not have their own tools and these should be provided, they also are more afraid to share their work as they have been told they are not "artistic" at school, or have perceptions that only photo-realism and accuracy matter. The most important lesson here is to tell students to embrace their inner child and let go of preconceptions—leading by example is key here—if the teacher shows themselves to make mistakes, draw a skewed hand, laugh at themselves, they break down that most important barrier. A sketch, and the act of sketching, is not art, it is a fast, loose and creative method.

For postgraduate students in UX design (Case Study #3) the issues faced are similar to undergraduate students although more ingrained, these students often have a strong preconceived idea that analogue sketching is of limited value and as such should be kept to a minimum or skipped in favor of high-fidelity digital prototyping tools. For example, the author found it challenging to get students to engage in low-fidelity paper prototyping as there were preconceived notions that it was a waste of time and working directly in digital mid- and high-fidelity prototyping tools, such as Figma[12] and Adobe XD[13], as an initial step would be more appropriate. Students had to be convinced, through *practice* and *application*, that sketching as a visual medium that will allow them to develop their ideas through exploration and consideration of multiple designs and the examination of their pros and cons, it would support them to be quick and plentiful with their ideas without requiring much effort, time, or resources (Sturdee et al., 2018) and[14]. Through the integration of a halfway tool, Marvel POP, the author was able to support the students to begin the exploration of sketching, once their paper prototype became digitally clickable they were "sold" on the idea as they could see the many possibilities they had explored on scrap pieces of paper and post-it notes that littered their at home workspaces, and group Miro boards, thus were willing to explore, practice, and apply sketching to other areas of the design thinking process.

The peer-to-peer groups (Case Study #4) the authors approach differ largely from the undergraduate and postgraduate student groups in that they are highly motivated to engage with sketching, and have sought out the opportunity, often paying for the privilege. They are usually post-formal education or studying for their PhD (and sometimes postgraduate). Having been through years of formal education they are aware of their strengths and weaknesses, and are more willing to put their work in the public space (although this is more likely in the in-person setting). Those in industry (and usually research) have seen the benefits of sketching skills first hand and aim to add them to their skill-set to use proactively in their own work. That is not to say that they do not need to be told how to begin, and about relevant tasks and methodologies, and there is usually some resistance to starting small, but the use of ice breaker activities such as scribbling or "draw your neighbor" forces learners to make a start—overcoming the fear of the blank page. The authors sketch-a-long also provides a focus, and prevents learners from fixating on their own shortcomings (or lack of).

8.2. Accessibility in Sketching Pedagogy

We live in a world where there are one billion people with disabilities[15]. In the space of education, inclusive learning and teaching we seek to remove the barriers and challenges that create undue effort and separation of students and learners with disabilities, to enable all students and learners to participate in learning equally and independently. Furthermore, the UK Equality Act (2010)[16] requires teachers to ensure materials and resources produced for students are accessible. As teachers,

[12]www.figma.com/
[13]www.adobe.com/uk/products/xd.html
[14]www.interaction-design.org/literature/article/etch-a-sketch-how-to-use-sketching-in-user-experience-design
[15]www.un.org/development/desa/disabilities/resources/factsheet-on-persons-with-disabilities.html
[16]www.legislation.gov.uk/ukpga/2010/15/contents

we wanted students and learners to engage in the sketching knowledge we share easily and confidently. To do this we often deploy practices that support better engagement with our materials. Our sketching lectures, workshops, and courses are designed and delivered to be attended by, and accessible to, as many people as possible. We use plain text and clear speech which is simple to understand and in English. When teaching online, we also share imagery with appropriate Alt Text and color contrast. We clearly verbalise all sketching demonstrations, outline easy to follow tasks and timelines, and at an appropriate speed. When working online, we ask that conferences allow remote attendees to have access to conference platform closed captioning, and set up the virtual collaboration whiteboard (Miro) to allow for zoom in up to 300% without problems, and ensure that keyboard navigation is supported. Throughout the sessions we also provide opportunities for support, questions, and comments—regardless of in-person or online delivery.

As the sketching lectures, workshops, and courses have developed over multiple iterations, we have expanded our format to include a comprehensive section on sketching and accessibility. Writing Alt-text[17] for example, for students and learners, can present a barrier, a closed door some may put it, imagery that omits Alt Text mean learners who are unable to perceive imagery due to a disability, e.g., blind, visually impaired or a specific cognitive impairment, cannot obtain the benefits of such visual practices as their peers. Alt Text, alternative text, is an important practice all teachers should be aware of and well-rehearsed. We appreciate that Alt Text can be difficult to do well, and we take students and learners through the process of writing this for their own sketches. We also advise on the clarity of images, for example, when drawing arrows a "filled" arrowhead is easier for people to parse.

8.3. Future Approaches

Sketching needs time, space and reflection. One particular reflection (Case Study #1) noted how the quality and engagement for sketching went up when the time to complete tasks was extended, or the number of tasks was reduced, whereas the poor engagement in Case Study #2 was partially due to the short time slot allowed for sketching, and the difficulties of *sharing* and *being seen* for the in-person sessions. The online module and courses (Case Study #3 and #4) for peer-to-peer learning also became time and content constricted when they were moved to online, and content had to be adjusted significantly—however, it was not possible to reduce the time taken for the module or course without altering fundamental aspects of the learning—for example the visual vocabulary, or the accessibility. Despite this, the move to online-only teaching has been an opportunity as well as a challenge, and opened up sketching to a wider audience, and actually increased undergraduate and postgraduate student engagement.

For our own courses, allowing for increased time and space for sketching will be of the utmost importance so that our students and peer-to-peer learners get the most out of them. In particular, the online/remote approach should be streamlined for hands-on, creative teaching, and regular investigation and discovery of new online tools and potentials undertaken. The use of teaching assistants is valuable for in person settings, to encourage and support and maintain momentum, but online, the approach is often singular, and this means it is difficult to maintain live sketching, dialogue, administration, Miro management and slides at the same time without an elaborate set-up, or missing some aspects of the presentation. Existing video conferencing tools, e.g., Microsoft Teams, Zoom, and WebEx, have some remit to show a camera and slides and are beginning to implement a plug-in for popular collaboration tools, specifically Miro[18], but it is difficult to present fluidly. For user interface designers, there is an opportunity here, to further explore online conferencing software and hardware, such as OBS[19] and Elgato 10GAI9901 Stream Deck Mini[20], for sketching pedagogy which explicitly supports multiple outputs, inputs, interactions, and allows for resizing and placement of windows at desired points, this would support various video feeds, devices and maintain that face-to-face interaction that is so vital for our remote teaching.

As we move more to blended teaching and learning, often referred to as hybrid learning, embedding online technology into pedagogy for sketching re sketching theory and application in an in-person environment using a mixture of analogue and digital sketching tools. We encourage teachers in the area of sketching in HCI and UX to embrace visual whiteboards to structure and present their sessions and allow students to share and provide peer to peer feedback in a virtual space with the aim of improving their social presence in the classroom.

Finally, an additional potential method for addressing both confidence in sketching for all groups, and also motivating participation might be to embrace gamified approaches to teaching, such as Williford et al.'s *Persketchtivity* (Williford et al., 2016) or *ZenSketch* (Williford et al., 2019) where learners can "play" at line accuracy. Although this particular study used the game tool as an extracurricular activity, it could also be brought into the classroom. Game based approaches might have a particular appeal to the undergraduate demographic who are more likely to have the time and motivation for gaming.

8.4. Final Thoughts

Sketching is a valuable skill in HCI and UX especially when creating a foundational understanding and application, it requires different approaches to planning and delivery depending on the audience. Sketching in HCI and UX works well both in person and online, both approaches have advantages and disadvantages. Despite the advent of digital approaches as a result of COVID-19 pandemic and the ongoing move to blended/hybrid sketching pedagogy the fundamental skill and practice has always persisted and will continue to be as valuable today, as it will be tomorrow.

[17] www.webaim.org/techniques/alttext/

[18] www.miro.com/blog/miro-app-for-zoom/

[19] www.obsproject.com/

[20] www.elgato.com/en/stream-deck-mini

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

ETHICS STATEMENT

Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

FUNDING

The publication of this work was funded by the School of Computer Science and Mathematics at Kingston University London.

ACKNOWLEDGMENTS

We would like to thank our students and learners from our university modules and conference courses without which our exploration and learning would not have been possible. We would like to thank Oliver King, Indre Aruodziute, Andrés Lucero, and Maggie Jack for allowing us to include their original sketches and photographs in this paper. We would also like to thank course leaders and fellow HCI and UX colleagues for their support and advise in the delivery of these case studies.

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ORIGINAL RESEARCH
published: 02 May 2022
doi: 10.3389/fcomp.2022.793968

Designerly Ways of Knowing in HCI Education: A Case Study of a Peer Community-Based Studio

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Design methods and approaches are common within Human-Computer Interaction. And while design is recognized as a discipline with its own epistemology and pedagogy outside of HCI, there is a lot of work to be done in incorporating, facilitating, and developing designerly knowledge in HCI education. The abrupt shift toward distance education caused by COVID-19 surfaced the necessity for course design to purposely support online informal learning environments and facilitating tacit knowledge as previously prevalent in the design studio environment. Firstly, we present theory on design epistemology, related to "designerly ways of knowing" and the role of the studio in the learning process. Secondly, a case study presents the set up of a digital studio for a course in Designing User Experiences, with an emphasis on supporting a community-based studio. The empirical material includes an overview of the course set up and a thorough qualitative analysis of the feedback provided by a cohort of 48 students with diverse backgrounds. The course was conducted online and heavily based on the use of software such as Zoom and Miro. We conclude by offering a set of themes in three categories to be considered when designing community-based "designerly" courses within HCI. As future work, we suggest the Community-Based Designerly Scale to be used, adapted, and developed by teachers and students as a tool in their educational practice.

Keywords: design theory, design education, design epistemology, digital design studio, first-person perspectives, HCI education, peer community, design studio approach

OPEN ACCESS

Edited by:
Audrey Girouard,
Carleton University, Canada

Reviewed by:
Panayiotis Koutsabasis,
University of the Aegean, Greece
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Universidade Estadual Do Oeste do Paraná, Brazil
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Specialty section:
This article was submitted to Frontiers Human-Media Interaction, a section of the journal Frontiers in Computer Science

Received: *12 October 2021*
Accepted: *30 March 2022*
Published: *02 May 2022*

Citation:
Gamboa M and Ljungblad S (2022) Designerly Ways of Knowing in HCI Education: A Case Study of a Peer Community-Based Studio. Front. Comput. Sci. 4:793968. doi: 10.3389/fcomp.2022.793968

1. INTRODUCTION

Design knowledge within HCI has been widely discussed, both from an epistemological perspective (Stolterman, 2008; Harrison et al., 2011; Gaver, 2012; Svanæs, 2013), but also as a generally difficult topic to teach (Reimer and Douglas, 2003; Hoadley and Cox, 2008). Examples of studio based teaching in HCI are needed to inform decisions and inspire other educators to facilitate situated design knowledge. In this paper, we present a case study of a course in designing user experiences which included a variety of designerly online activities revealing the value of a peer community-based learning in design, grounded in the studio. We discuss how the course supported "designerly ways of knowing," and problematise how this is "a distinct 'designerly' form of activity that separates it from typical scientific and scholarly activities" (Cross, 1982).

This paper extends previous research on online studio-based teaching in HCI (Koutsabasis and Vosinakis, 2012; Vosinakis and Koutsabasis, 2013; Koutsabasis et al., 2018), by taking a stance in design epistemology theory. To this end, we use the concept of "designerly ways of knowing" as the theoretical framing to how design knowledge can be constructed in education, focusing on the exchange between peers. While managing expectations between clients and other stakeholders is vital in the design discipline, in this paper we put emphasis on supporting the development of a first-person and peer-based understanding of design through the use of the studio.

The set-up of the course is described thoroughly in this paper, and its strong connection to the notion of a design studio is reflected in the pedagogical activities. In our view, HCI cannot be taught without a transdisciplinary perspective—and therefore, heavily reliant on cooperation and community building which takes place in the design studio between peers. This instance of the course was taught mostly online and relied on a novel approach to the studio as a combination of digital platforms.

Stemming from the case study we present a set of themes, sorted into three categories to be considered when developing courses within HCI where designerly knowledge and a studio approach are strong components. The first category emphasizes how to encourage community-based design learning, the second on how activities can be designed to lead toward designerly ways of knowing, and the third proposes the possibility and advantage of a digitally extended studio.

Finally, we suggest the Community-Based Designerly Scale to be used, adapted, and developed by other instructors as a tool in their practice and discuss what designerly knowledge is, and how it should be tackled in their courses.

We find it worthwhile to share, report, and discuss the experiences the COVID-19 pandemic enforced in designerly HCI teaching. Despite the drastic changes and the eagerness to return to campus, there is much that will change in the aftermath of the pandemic, and many of the lessons learnt and pedagogical approaches used will remain. We have now the opportunity to reflect and develop upon how we are supporting the creation of long-lasting peer communities.

2. THEORY AND DESIGN EPISTEMOLOGY

In this section, we present the underpinnings that informed the design of the case study, as well as an introduction to designerly knowledge for those less familiar with it. Here, we explain why transdisciplinarity, community, tacit learning, and first-person perspectives are important topics in the research presented.

2.1. Designerly Ways of Knowing

This paper relies on understanding the intricacies connected with teaching students to work with "wicked problems" (Rittel and Webber, 1973), which are ill defined problems. Design links theory and practice, and bridges scientific and creative aspects to address ill-structured and open-ended problems (Hoadley and Cox, 2008). Archer (1979) defended the necessity of understanding "Design" as the third area of education, somewhere between sciences and humanities; defined as "Design with a capital D" which means, according to Cross (1982), "the collected experience of the material culture, and the collected body of experience, skill and understanding embodied in the arts of planning, inventing, making and doing". Cross (1982) explores the term "designerly ways of knowing" by placing design as a discipline of its own paired with a particular epistemology, noting that "we are certainly faced with the problem of being more articulate about what it means to be 'designerly' rather than to be 'scientific' or 'artistic'". We summarize his comparisons with the humanities and the sciences in **Table 1**.

TABLE 1 | A table based on the work of Cross (1982) roughly defining the differences between each of the disciplines, and setting design as its own discipline.

	Sciences	Humanities	Design
Phenomenon of study	The natural world	Human experience	The man-made world
Appropriate methods	Controlled experiment, classification, analysis	Analogy, metaphor, criticism, evaluation	Modeling, pattern-formation, synthesis
Values	Objectivity, rationality, neutrality, and a concern for "truth"	Subjectivity, imagination, commitment, and a concern for "justice"	Practicality, ingenuity, empathy, and a concern for "appropriateness"

Grounded on these distinctions, we argue for design as a transdisciplinary field.[1] Both Interaction Design and HCI are disciplines making use of computer science, cognitive science, social science, psychology, design, and others. This means that dealing with forms of knowledge from the sciences to the humanities is necessary. For a successful design project to be conducted, transdisciplinary education is needed to form an interaction designer.

2.2. Schön and Experience

Assuming that Design is a discipline on its own, the difficulties created by its combination of theory and practice must be tackled. Schön (1992) introduced the concept of "reflective practice," which puts emphasis on the reflective parts of practice-based work as a means for learning. Experience as a practitioner is not enough to extract knowledge, it is the reflection upon the experience and the ability to evaluate it that supports the development of skills. Hence, Schön identified two types of reflective practice: (a) reflection-on-action, and (b) reflection-in-action. The first relies on reflecting upon a past experience, on previous actions, and formulating what could have been done differently, expressing pros and cons. The second is based on reflecting on actions while executing them, and being able through knowledge of best practices to pick the correct process and path to follow. This second type of "reflective practice" is dependant on improvisation, but most of all on a critical approach to one's choices. His posture toward design epistemology was highly influential and included a strong stance

[1]Interdisciplinary: "coordination by higher-level concept," Transdisciplinary: "multilevel coordination of entire education/innovation system" (Jantsch, 1972).

on *technical knowledge* vs. *artistry*. Interestingly, many of his conclusions were derived from studying architectural design practice, where the need for a transdisciplinary approach is quite evident: a building can not be built without a combination of hedonic and pragmatic qualities, ranging from the facade to the construction. According to Schön, most institutions of higher learning did not target professional competence to the degree necessary to produce practitioners that could tackle improvisation; therefore, he suggested that technical rationalism should be replaced by an approach tightly connected to educating "reflective practitioners."

Schön influenced design education quite extensively in a manner that can be described as putting emphasis on the importance of experience, and how practice has major value to the creation of knowledge. What is important for this particular paper is the intention of considering reflection of practice as knowledge building as an attempt at turning tacit knowledge into explicit knowledge. It is noteworthy that Schön's perspective is centered on the designer as an individual, not as a part of a community.

2.3. From Experience to Phenomenology

If we agree that experience of practice has value, then it is not difficult to argue that applied interaction design is necessarily a transdisciplinary field. As systems become progressively complex, the need for specialized knowledge is increased. Therefore, to accomplish any design work, a transdisciplinary perspective is crucial as (a) part of the education of a designer, or (b) through transdisciplinary teams. What is important to note here is that alternative (a) is composed of an education varying from sciences to humanities, and design; meaning that each designer represents themselves a product of a transdisciplinary education. In that sense, their individual and first hand experience of the design process is important as a tool for design, and the ability to reflect upon their own practice and express their knowledge to others is essential. This particular type of knowledge, based on a first-person perspective, is what is an approach to research grounded in phenomenology (Merleau-Ponty et al., 1966). This understanding is connected to Merleau-Ponty's concept of the *lived body*. Svanæs (2013) connects this philosophy to HCI and embodiment, and explains the value of the designer's first person understanding of design artifacts as analysis but also during the design process. This philosophical stance puts emphasis on departing from the Cartesian body-mind dualism, and therefore also a departure from objectivity vs. subjectivity, rather an understanding of the body as a tool for empathy and modeling of the world (see **Table 1**). However, this departure has great influence in the epistemology of design and what is considered a contribution or acceptable knowledge. Other disciplines may not see upon these first-person expressions of tacit knowledge as worthy of "scientific research," and methodological conflict may surface. Validity comes up to discussion, and how we deal with ambiguity and rigor. As summarized by Svanæs (2013), "important contributors to the development of interpretive social science, such as Harold Garfikel, relied heavily on phenomenology for their theoretical framework, but the actual phenomenological insights did not originate from such research. This is as an indication that valuable theoretical contributions can result from reflections that do not originate from a 'scientific' basis of hard data. In the present context, the value of the theoretical contributions must be judged by their applicability to real problems, and by the extent to which they have explanatory power and provide inspirations for design. Others will have to make that judgement."

2.4. Tacit Learning: Extracting Intermediate Level Knowledge

One specific way of resolving the conflict of between design theory and practice is what is called *Intermediate Level Knowledge*. Within HCI and Interaction Design, there is a particular approach to research named *Research through Design* (RtD) (Gaver, 2012). Bardzell et al. (2015) suggest that not only the process of RtD can produce knowledge, but also the artifacts themselves. In their paper, they "investigate RtD in its relation to the production of knowledge; specifically, how design objects are knowledge producers both for those that encounter them and those that design them." (Bardzell et al., 2015). According to them, "knowledge is unfolded in objects," "knowledge is unfolded in the interpretation of objects," and "knowledge is unfolded in interpretative communities". The last point develops the value of being able to communicate this knowledge and how the format of the design knowledge is relevant to the possibility for communities with different backgrounds to extract valuable insight. This is yet again where tacit knowledge needs to be made explicit. One suggested way of achieving this is through annotated portfolios, which are a set of images of the design artifacts paired with reflections written by the designers (Gaver, 2012; Löwgren, 2013). Another example is strong concepts, which are abstractions of design instances (an instance can be compared to an artifact), amongst many other ways of framing knowledge within interaction design (Höök and Löwgren, 2012; Höök et al., 2015).

The expression of these qualities reinforces the value of "designerly ways of knowing" as transmissible knowledge. Historically, much of what is the evaluation of design work within HCI has been relying on methods with more or less validity (Bargas-Avila and Hornbæk, 2011). But perhaps many of these methods have been used to afford a false sense of objectivity which is serving the sciences more than the humanities: juggling the understanding of rigor is one of the harshest difficulties hindering the fluency of transdisciplinary work in academia.

2.5. The Studio as Community-Based Learning

The extensive investment and use of a Studio environment for design education is well known and widespread. The Studio is a feature spanning most design fields both in education and practice, and can be defined by: 'co-location', 'learning by doing', 'unrestricted timetable', 'integration' and 'mimicking practice' (Lawson and Dorst, 2009). Hence the Studio can be defined as a common space students can use at unrestricted times, which tries to approximate to design practice by doing, while integrating knowledge and expertise. The co-located aspect is particularly important as it puts the emphasis on peer relationships: "Students know that this is a place where things happen, where knowledge can be found and advice given, where like minds will meet and share reasonably common values. (...) Often the students will have far more contact with each other than directly with staff and may expect to exchange ideas extensively with their peers. In this sense the studio is a delightful example of the social community that was introduced so powerfully by the Bauhaus." (Lawson and Dorst, 2009, p.226). The tangibility of the design materials is relevant: "A design studio is creative, collaborative, and highly material, dominated by material objects" surfaces for sharing ideas and inspiration, and Post-it Notes, sketches, magazine scraps, models, and physical prototypes to make ideas visible and tangible. (...) The persistence of these images supports the design process, serving as collective memory and external cognition for the design teams." Blevis et al. (2008). Despite this, a relevant body of research has dedicated itself to support digital versions of the design studio, for example through wikis or collaborative construction environments (Laurillard, 2012, p.195-204). In this paper, we apply an approach based on replicating some of the core identifying values of community making in the design studio in a simple manner, which is accessible with off-the shelf software. But most importantly, we attempted to incorporate "designerly ways of knowing" into all aspects of the course design.

Lawson and Dorst (2009) offer a list of semantic differential adjectival scales based on workshops with students attending a design studio in architecture and a lab class in engineering as presented in **Figure 1**. They show a clear distinction between the two, and interestingly, a close connection between the studio teaching with with more emphasis on first person, student-led knowledge, as well as a more practical approach. The widest difference is seen exactly between episodic and semantic knowledge, which reinforces the positivism of experience, together with an integrative perspective relying on transdisciplinarity. The adjectives used in this scale served as a guide when designing educational activities in the case study presented.

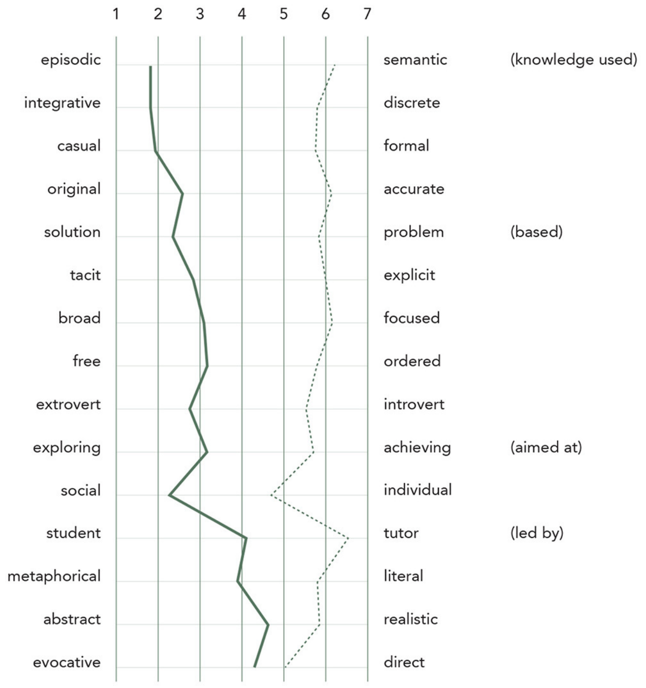

FIGURE 1 | The difference between a design studio (solid line) and an engineering lab class (dashed line) based on the work of Ismail bin Samsuddin (Lawson and Dorst, 2009, p.235). These semantic differentials informed the development of the case study and the proposed Community Based Designerly Scale presented in Section 6.1.

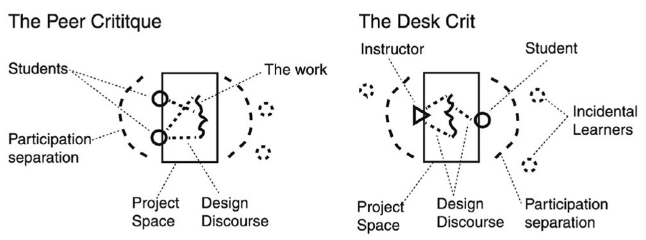

FIGURE 2 | An image from Hokanson (2012, p.78) showing to the left, a peer critique and to the right a desk crit with the instructor. It is relevant to note how the proximity to this event allows for incidental learners.

Crits (or critique sessions) are prevalent in Studio-based education which are supported by the possibility of having *ad-hoc* interactions in a share physical space (Schön, 1984). As noted by Hokanson (2012) (see **Figure 2**), the proximity of all the agents in this environment is paramount, where learning moments are created in a flexible and unpredictable way.

Crits and studio teaching are not new in HCI. For example, Reimer and Douglas (2003) describe a case study of teaching HCI design with the studio approach. However, our focus is on understanding and developing the peer community within the studio in HCI.

2.6. Design Epistemology in HCI

The relation between practice oriented design knowledge and research knowledge in HCI is problematic (Goodman et al., 2011; Gray et al., 2014). Design knowledge is typically misunderstood in research (Gaver, 2012) and not well translated into successful tools for practitioners (Goodman et al., 2011; Gray et al., 2014). Stolterman (2008) has even questioned if underlying principles in research are transferable to practice. He argues that HCI research does not properly understand and address HCI practice as a "unique activity of inquiry and action" and has a fundamental different view of techniques to address complex phenomena. Over the years, there has been a gradual acceptance in HCI toward work that describe reflective, first person perspectives, aesthetics and other alternative approaches to design. This suggests emerging epistemological changes within HCI, which also are relevant to consider when teaching HCI.

Epistemology is a field of study that reveals transdiciplinary differences within a research field, and competing paradigms (Guba and Lincoln, 1994). It addresses different ways of knowing, what is understood as valid knowledge, and how such knowledge is acquired in a specific context. Whereas, epistemology has a value judgement about what is valid knowledge in a specific context at a given time, comparative epistemology concerns to understand different viewpoints without value judgements. In any research field, mainstream frameworks emerged for the methodologies and approaches representing accepted knowledge within the field (Harrison et al., 2011). This is what Kuhn refers to as normal science: "... research firmly more past scientific achievements, achievements that some particular scientific community acknowledges for a time as supplying the foundation for its further practice" (Kuhn, 1996).

Research activities conducted in specific research paradigm, lead to assumptions that influence which type and form of knowledge is accepted: different types of evidence and argumentation explain and support a certain belief (Guba and Lincoln, 1994; Kaye, 2008). Research conducted outside of the mainstream framework may thus initially be dismissed as fringe activities (Harrison et al., 2011), which has been the case with reflective first-person perspectives, aesthetics, and other related approaches to design knowledge within HCI.

In 1993, Frayling wrote a famous piece about different approaches and contributions of design research (Frayling, 1993) and in the beginning of 2000, researchers more intensively began to articulate how design theory and critical design could take a more prominent role in the HCI field (Rogers, 2012). Rogers describes how this constituted a theoretical and contemporary turn toward design in HCI, leading to confusion of previously coherent aims and goals. Kutti argues that there is value in having several competing paradigms of inquiry in research where "each paradigm orients to a particular kind of research program, and admits different objects and activities into its mode of enquiry" (Kuutti and Bannon, 2014, p.3543).

This turn in HCI, also referred to as the third paradigm or wave of HCI, now incorporates "the notion that science does not have a single, objective viewpoint but may encompass a wide variety of viewpoints, even ones that may conflict" (Harrison et al., 2011, p.389). The third wave or paradigm shift has thus opened up for a more explicit focus on situated knowledge and values (e.g. reflective design, value sensitive design, phenomenology) (Bødker, 2006).

Hoadley and Cox (2008) describe how to teach design in HCI, and make prominent that design should be understood as a kind of expertise, where experts are unique and do not necessarily know the same thing in the same ways, but still understand some general ideas that all designers share. They also exemplify how to teach design through project courses, how design studios can support sharing problems and understanding of these.

3. DESIGNING USER EXPERIENCES: A CASE STUDY

In this section, we describe the content of the course which served as a case study, as well as details on the cohort of students and the method for data gathering.The main focus of this paper is on the online set-up of the course while maintaining a studio-based spirit. We leave therefore a more detailed description of the course content, pedagogy, and assessment strategy as out of scope. In this section we offer a short description of the course, but more details on the pedagogical groundings behind it can be found in Lundgren (2010)'s thesis. However, it is important to mention that this course focus on concept-driven (Stolterman and Wiberg, 2010) design explorations (Fallman, 2008) and a reflective research through design approach to open up a design space, complementing more user-centered and client-centered strategies. Instead, we prioritize the inclusion of fringe HCI research topics and programmes such as for example soma design (Höök et al., 2018), speculative design (Auger, 2013), and slow technology (Hallnäs and Redström, 2001; Odom et al., 2012). These fringe HCI research topics vary from year to year in the course, and we pick new ones according to the prevalent trends in academia, always encouraging a critical stance and the space for a personal engagement from the students.

The reason behind this choice is focused on complementing our student's "designerly ways of knowing" with approaches beyond user-centered design. We seek to build on their understanding of design epistemology, but also on the development of fringe theories as a valuable way of expanding design spaces. Therefore, in this course, we offer design activities that are strongly connected to the student's own personal lived experience. To support explorations and multiple perspectives, we have designed the course to encourage their own individual perspective to be valued and shared (e.g., through adding to lectures, seeing other groups working simultaneously, sharing their own links and interests).

3.1. Course Syllabus

Designing User Experiences (DUX) is a 7.5 ECTS master level course taught yearly at Chalmers University of Technology.

The duration of the course is 10 weeks distributed into 4 modules plus one individual project. Each year the 4 modules may incorporate different themes. According to the syllabus:

"After the course you should have a clear idea of some aesthetic ideals and how to design according to them, giving a valid design rationale. Designing interactive systems it often, but not always, about designing for efficiency. However, it is just as important to design the experience of use, as the functionality of the artifact in itself, although they are closely intertwined. Apart from designing for efficiency, we can also aim for playfulness, criticism, embodiment or various emotions (e.g., fear, joy, comfort), all of which create different user experiences. In this course we will look closer at different kinds of user experiences and discuss and practice how to design for them. Content includes, but is not limited to:

- What it means to design for a user experience.
- Common views and approaches toward designing user experiences.
- Analysis of possible user experiences provided by an interactive system or object.
- The connection between design objectives, design rationale and design decisions."

The course is organized as follows:

"The course features both practical and theoretical parts, as well as work in groups and individual work. Lectures and literature seminars give a theoretical foundation, which are immediately put into practice. The focus is on turning analysis and reflection into practical action. The focus is also on exchange of thoughts, feedback, designs, and ideas. Hence, the course requires active participation; participants will spend most of their study time at school, working in pairs or groups[2]."

In this particular instance of the course the modules covered the following themes: (1) UX foundations and Methods, (2) UX Essentials: Designing for Emotions and Persuasion, (3) Speculative Design and Critical Design, and finally (4) Embodied Design, Time, and Space. For the final individual project, the students could pick an idea themselves fitting either theme 3 or 4.

Each of the themes and activities, including the course evaluation, support a connection to the learning goals in the course, striving for constructive alignment (Biggs, 2014).

The schedule as presented to the students of the 2021 cohort is represented on **Table 2**.

3.2. Constructive Alignment in Learning Activities

The alignment between all of the activities in the course toward the learning goals stated in the syllabus is clarified to the students in the first introductory lecture. Each of the themes progresses from a set of curiosity triggering lectures, more in-depth analysis of literature, and an applied group exercise where the literature is put into use. Each theme ends with a crit session, where the students meet in the studio and provide peer feedback to one another, and the instructor gives closing remarks. Written feedback is provided to each group after the crit sessions. To assess the course, finally, the students must be able to find the threads connecting each of the elements of the course into one individual project with one-on-one tutoring, where they refer to literature and other design examples. The exercises in the course follow the guidelines offered by Baumann et al. (2007), and explicitly avoiding some of the pitfalls described such as: "Students expect didactic work instead of being expected to try things out themselves. Sometimes the students presume that the proper answers have to be found in the literature,rather than by their own investigations." and "Exercises to understand 'why' are most difficult. 'Why' knowledge refers to the ability to argue about why a specific skill or method will be appropriate or not." The details of the exercises and literature used are outside the scope of this paper, but the understanding of this constructive alignment is often mentioned by the students in Section 5.

3.3. Cohort

In 2021, 48 participated in most activities and out of those, 46 achieved a passing grade. Of the 48 students, 6 took it as a self-standing course, while the rest attended it as part of their masters in Interaction Design. The class of students from Interaction Design (42 students) started their education during the Covid-19 pandemic and had therefore only attended online courses together.

The educational background of the students was very diverse. The students held bachelor's degrees in cognitive science, product design, software engineering, psychology, informatics, computer science, industrial design, mechanical engineering, product development, and information technology.

3.4. Online Course Set-Up

The course was delivered online, with one instance of a local meeting. The platforms used were:

- Canvas[3]: a web-based learning management system, where the students had access to the official course information and documents. They also handed-in all of their exercises through this platform, and got written feedback on their exercises and final project by the teachers.
- Slack[4]: a communication platform supporting chat rooms, private channels, and direct messaging between the students. Slack was used as an informal fast communication channel for the students to use.
- Zoom[5]: a video-conferencing and chat tool used primarily as a communication platform for lectures, group work, crit sessions, and supervision.
- Miro[6]: an online whiteboard and collaboration platform adopted as the major innovation in the course, where students could interact with lectures, document their literature seminars, and effectively do most of their design and presentation work together. The platform was used as a shared space for supervision and feedback both by peers and teachers.

To tackle the issue of community-building, a novel strategy was adopted pivoted on three important points: (a) offering interactive lectures, (b) centring all the content of each course theme in one Miro board, and (c) creating an always-open Zoom room in combination with Slack. When the Covid-19 pandemic hit, the studio-based education we had been leading for a number of years was put to the test. In terms of the adjectival scales (Section 2.5), we were seeking a free, exploring, student-led, and casual access to the course's digital'space.

3.4.1. Interactive Lectures

Capitalizing on the combined use of Zoom and Miro, the lectures were held without sharing slides on the screen, but rather through sharing a Miro board where students could follow at their own pace, interact with, and add to the content. Furthermore, most lectures were conducted as a conversation between two teachers rather than a monolog. A screenshot of a lecture is shown in **Figure 3**.

3.4.2. Thematic Miro Boards

As described in Section 2.5, the physical environment of the design studio is naturally cluttered with material. The transition to online teaching ran the risk of creating an issue with overview of course material, where the

[2]The course is denominated DAT157 - Designing User Experiences and the syllabus can be publicly found online at https://student.portal.chalmers.se/en/chalmersstudies/courseinformation/Pages/SearchCourse.aspx.

[3]https://www.instructure.com/en-gb/canvas
[4]https://slack.com
[5]https://zoom.us
[6]https://miro.com

TABLE 2 | Table with the full schedule for the DUX course as conducted in 2021.

Mondays			Wednesdays			Topic
22/3	09.15–12.00	Course intro: – UX Foundations and Methods – Introduction of Exercise 1	24/3	09.15–12.00	Miro Talk: UX Foundations and Methods	UX Foundations and Methods
				13.15–16.00	Ex1: ASTEROID! SHAKE! (Supervision)	
29/3	09.15–12.00	Literature session 1 Debrief of Ex1.	31/3	09.15–12.00	Miro Talk: – Essentials: Designing for Emotions Persuasion – Introduction of Exercise 2	Essentials: Designing for Emotions and Influence
				13.15–14.00	Guest Lecture and Q&A	
				14.15–16.00	Ex2: Exhibiting Biosignals (Supervision)	
5/4	Easter Vacation / No teaching		7/4	Easter Vacation / No teaching		
12/4	09.15–12.00	Literature session 2	14/4	9.15–12.00	Ex2: Exhibiting Biosignals (Supervision)	
				13.15–17.00	Ex2 Crit Sessions	
19/4	09.15–12.00	Guest Lecture & Miro Talk: – Speculative Design and Critical Design – Introduction to Exercise 3	21/4	9.15–12.00	Literature session 3	Speculative Design and Critical Design
				13.15–16.00	Ex3: Spectacular Speculations (Supervision)	
26/4	09.15–12.00	Ex3: Spectacular Speculations (Supervision)	28/4	8.15–12.00	Ex3 Crit sessions	Embodied Design, Time, and Space
				13.15–15.00	Miro Talk: Embodied Design, Time, and Space	
				15.15–17.00	Ex4: Flower Power (Group Work)	
3/5	09.15–12.00	Literature Session 4	5/5	9.15–12.00	Ex4: Flower Power (Supervision at the Botanical Garden)	
				13.00–17.00	Ex4: Flower Power (Group Work)	
10/5	09.15–12.00	Ex4: Flower Power	12/5	8.15–12.00	Ex4 Crit sessions	Putting it all together: Individual Project work
				13.15–17.00	Individual Project Info Ideation and Idea Pitch	
17/5	09.15–12.00	Individual project (Supervision)	19/5	09.15–17.00	Individual project (Supervision)	
24/5	09.15–12.00	Individual project (Supervision)	26/5	09.15–17.00	Individual project (Supervision)	
30/5	18.00 Deadline for handing in Individual project, Individual Presentations all week from 31st of May to 4th of June					

fragmentation of tools used could lead into not as holistic or exploratory approach to the course content. The persistence of this material in the studio has two advantages: (a) allowing for work-in-progress to exist in common spaces invites early feedback, creating a more collaborative effect, prioritizing collaboration over individual work (b) it creates cross-contextual reminders to unrelated information, serving as inspiration and a source of serendipity and a potential trigger against homophily (Blevis et al., 2008; Reviglio, 2019). The digital solution actually offers an even broader overview and temporal perspective than the physical studio.

Figure 4 shows a screenshot of a Miro Board prepared for Theme 1: UX Foundations and Methods, while **Figure 5** represents the same board after the students interacted with it. To offer details and an example on how these themes are set up we have made this empty board available for consultation. The board can be accessed here.

3.4.3. Always-Open Zoom Room and Slack

To approach the 'unrestricted timetable' and mitigate some of the aspects of the lack of 'co-location'—which are some of the markers of a studio education as mentioned in Section 2.5—we decided to allow for an always-open Zoom Room which could be accessed and used by the students at any time. This room also had the same URL throughout the course, so that the way to its metaphoric door could be easily found. The Slack workspace included a specific channel for the course was used to communicate more immediate information and questions.

4. METHODOLOGY

The two following subsections describe how the data was gathered. The results presented in this paper are grounded on feedback provided by the students, and analyzed in a qualitative manner.

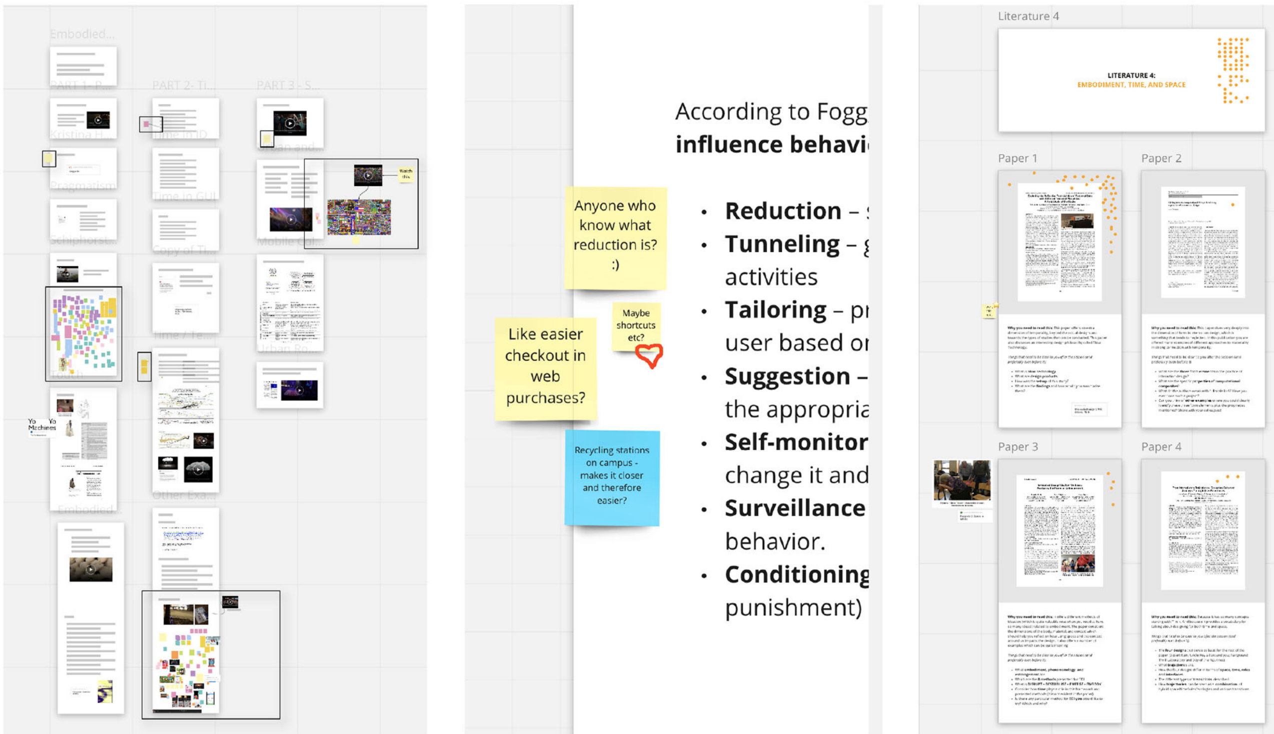

FIGURE 3 | Three screenshots from Miro boards. To the left, lecture slides with student input marked in black squares. In the middle, students helping one another figuring out some of the literature. To the right, a board showing the weekly literature with dot-voting, but also added information by the students.

4.1. Data Gathering Method

The approach to the analysis of the course is primarily qualitative. The sources of data collected were manifold and include the following feedback provided by the students:

1. The Miro boards filled in during literature seminars and exercises, and when prompted for lessons learned at the end of each module (420 digital sticky notes). Henceforth this data will be referred to as continuous feedback (CF).
2. A standardized University questionnaire filled in at the end of each course. It includes questions on the prerequisites necessary for the course, learning outcomes, course structure, literature, form of assessment, course administration, workload, working environment, overall impression, and interaction between teachers and students (19/48 response rate). This questionnaire will henceforth be called course evaluation questionnaire (EQ)
3. A voluntary questionnaire for the purpose of this paper, focused on evaluating to what degree students felt as a part of a community during the course and why, how their understanding of design knowledge changed, what their general experience was, what educational background they had, and what activities helped them learn the most and why (38/48 response rate). This questionnaire will henceforth be called research questionnaire (RQ)
4. During the standardized University course board meeting which happens after the results from the course evaluation questionnaire are published. This meeting is attended by the main examiner in the course, a representative of the student union, a programme responsible, a director of studies, and the 4 student representatives who attended the course. This meeting was documented through note-taking and will henceforth be called meeting notes (MN).

4.2. Analysis Method

Since most of the data gathered was qualitative, the methods used focused on identifying themes which could be translated into usable knowledge on how to consider community-based "designerly ways of knowing" for HCI teaching. The aim of this analysis was therefore to organize the high load of data into comprehensible chunks, triangulating the sources toward a thoroughly informed result. The primary method used was inductive thematic analysis, where very diverse data was organized by affinity creating clusters which were identified and named as themes (Braun and Clarke, 2006). The continuous feedback data was particularly helpful, and served as a grounds to identify the themes—the subsequent data was therefore analyzed after the themes which stemmed from it. This strategy proved appropriate, as the data from the questionnaires was somewhat dependant on the questions asked. In section 5 we present these results paired with images extracted from the course activities. The coding was done by one single coder, and the themes extracted are described in Section 5.

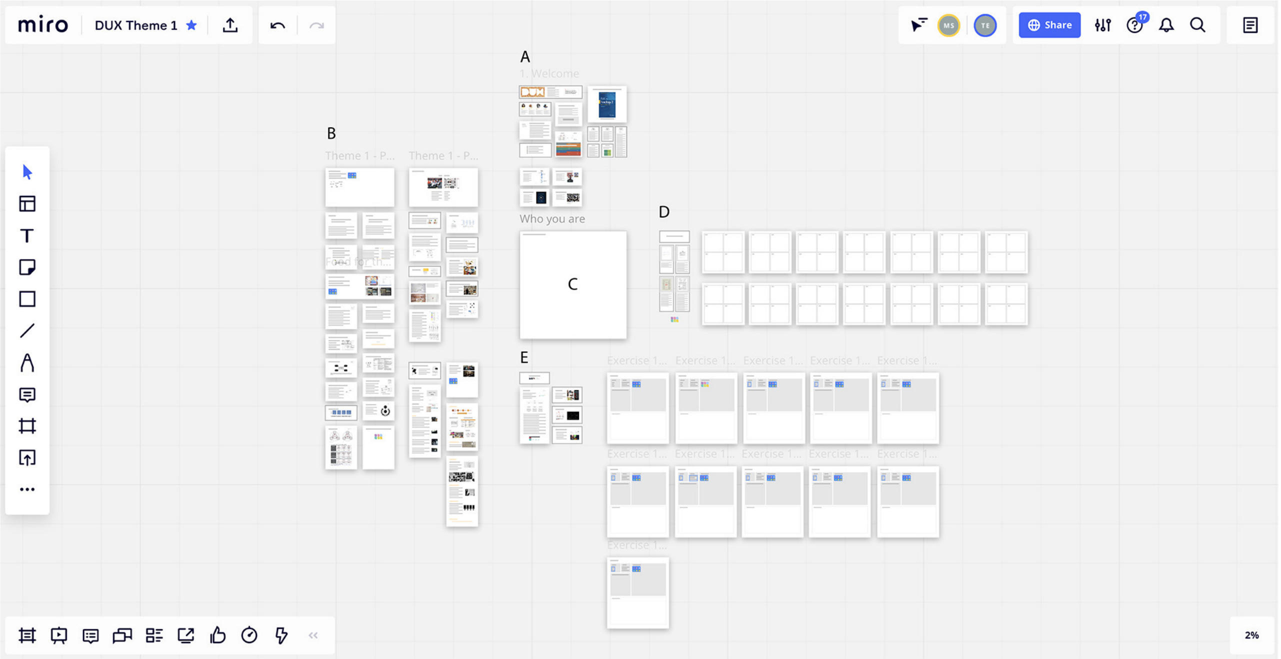

FIGURE 4 | A screenshot of an empty Miro board showing **(A)** on top, a number of slides introducing the course, **(B)** to the left, slides used as an introductory lecture, **(C)** an empty central slide where students can present themselves, **(D)** to the right, a set of empty boxes for literature seminar groups, and **(E)** toward the bottom, structured boxes with instructions for the exercise associated with the theme. We developed custom boards for each of the themes open to the students to edit and consult at any time throughout the course. The aim of this figure is not for the content to be readable, but rather to show the structure and general feeling of an empty board, particularly when compared to when the board is populated as seen in **Figure 5**.

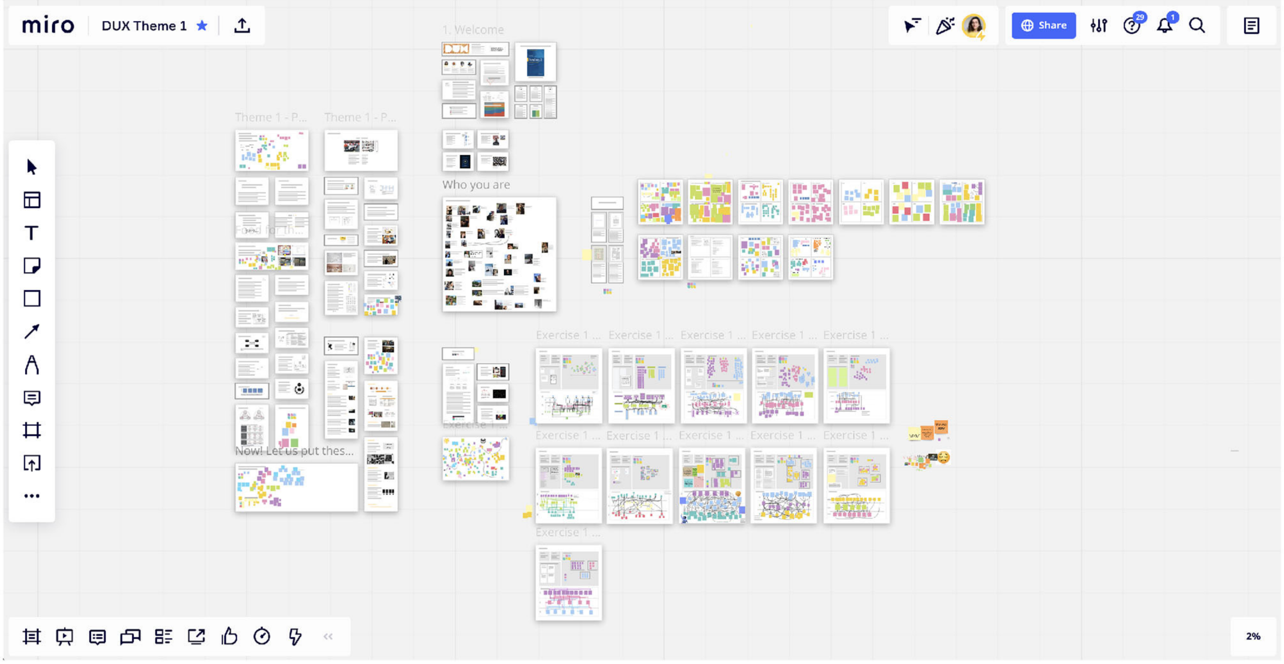

FIGURE 5 | Screenshot of a populated Miro board after the week in the course. Most of what is seen was added by the students. The aim of this figure is not for the content to be readable, but rather to show the structure and general feeling of an empty board, particularly when compared to when the board is empty as seen in **Figure 4**.

Each theme is presented including representative quotes for the most repeated or emphasized factors, but also include the fewer quotes representing an opposing opinion.

5. RESULTS

The results are reported under the following three categories, which include a set of themes:

1. Community-based design education: describes the role of informality, ephemeral groups, collective lectures, and field trips.
2. Teaching "designerly ways of knowing" in HCI: focuses on the need for acceptance of chaos in the work process, first person engagements and reflections, ambiguity, as well as the balance between collective crit sessions and space for the individual.
3. Digital platforms in the extended studio: describes how the digital platform supported openness of ongoing activities, emergent use, and appropriation.

These categories surfaced from the case study, and are pivoted on the most important factors of the course design as mentioned repeatedly by the students. At the end of each quote, a two letter source of the data is given as described in Section 4.1.

5.1. Community-Based Design Learning

"Designerly ways of knowing," as described in Section 2, puts a strong emphasis on experience and first-person impressions developed and reflected upon during the design process. However, to instigate a cooperative and transdisciplinary approach to the student's understanding of their own designerly posture, it is necessary to specify the components of community-building in the studio classroom. The following subsection presents themes to be considered when designing courses.

As a summary, we have found that:

- Informality and friendliness both in the platforms and in the communication with and amongst the students encouraged the community.
- Giving the students the opportunity to work in ephemeral diverse groups which last for shorter activities without their grade depending on the group work was helpful when creating a community.
- Allowing students to interact directly with the material in the lectures supported focus and collaboration.
- The field trip was an important experience which created focal points for the students to connect.

Finally, we also raise some of the hinders identified.

5.1.1. Informality in the Studio

Informal channels of communication was considered essential to support community building, even in periods where no group work happened. The use of the digital platform made evident how difficult it is to support *ad-hoc* discussions or meetings about other topics, such as everyday life, and simultaneously lifted how aware the students are of how the informality of the studio is valuable. Moreover, an open and recurrent synchronous encounter with other students (e.g. through the crit sessions and literature seminars) encouraged inter-personal exchanges:

> "By repetitively being forced to talk and discuss with you classmates it felt like being part of community. This since it felt like you could always ask your classmates as well as the teachers if you had any questions since it didn't feel to formal and strict." (RQ)

> "Discussions during seminars and the exercises made me feel it [as part of a community], but I miss the platform for being able to share the small everyday things to really feel the community." (RQ)

> "The thing that reduces the feeling of community is the work from home. It's harder to go naturally into doing activities outside of school together with people because of this." (RQ)

Friendliness appeared to play an important role, which became prominent when students reflected on the informal communication. Also, the sharing of work in Miro supported a sense of connectedness, making students aware of relevant peripheral activities (i.e., work in other groups) just as the physical studio would have done:

> "I enjoyed the course. A big difference was that the students and teachers were very friendly so the atmosphere was rather relaxed and everyone felt welcome." (RQ)

> "First of all the other students were very friendly. Secondly, using Miro and seeing the pointers of other people as well as their work helped me see that there were other people working so I didn't feel as alone. Third, I enjoyed the group work although I normally don't like it, however everyone I worked with was super nice and ambitious so it was an enjoyable experience." (RQ)

5.1.2. Ephemeral Groups

The students appreciated that the course set-up led them to work with many different people, in different contexts. It appeared to be essential that these group activities are not costly on an individual grade:

> "Also highly appreciate working in many different groups and talking to new people each literature seminar. In all of the group work I felt like my colleagues were highly ambitious even though it was just a pass or fail which was nice (...)" (RQ)

The random groups opened up for continued discussions when the individual work was introduced:

> "(...) getting randomized groups of multiple people gave me the chance to meet most of them and made it easier for me to communicate with them in the final project since I already worked with some of them." (RQ)

The set up and the dynamics of the course was described as helpful in keeping engagement:

> "The whole thing was so nicely put together. From the interactive lectures, to the groups switching each week. This was the most engaging course since remote started." (RQ)

Access to many different groups both during the literature seminars, the exercises, and the crit sessions was a considerable part of understanding and reflecting upon design:

> "All of the above [the course activities] made sense from a learning perspective and built on each other. (...) Exercises, colleagues and crit sessions. Because this was where the discussion and reflection was." (RQ)

From a transdisciplinary perspective, the fact that students got to know each other ahead of their individual project was relevant. A student with a background in computer science who had not previously attended design courses noted:

> "However the final hand in felt most stressful for me since I am not familiar enough with design methods, but feedback from students and the teachers gave me the boost I needed." (RQ)

5.1.3. Community-Building Lectures

One of the primary worries on the transition from campus to online was the difficulty preserving the collective experience of a lecture in the absence of physical proximity and encounters during the breaks. Many educators turned instead to asynchronous online lectures, which despite their advantages, have the great disadvantage of not contributing to the cohesiveness of the class. To compensate and support collective dialogue and exchange, all lectures were held in a combination of Zoom and Miro. The set-up is described in more detail in Section 3.4. Even if there are many strategies that can be used during lectures to activate the students, it appears that the space of the lecture in a digital room enhanced the experience making it worthwhile to consider the role of the community even in this context. As mentioned by many students, much of what was achieved relied on the digital platforms used, making clear the preserved value of a synchronous lecture:

> "I think Miro works out very well! the interaction makes you stay focused and you get more out of actually attending the lectures. On many other online lectures, it feels like you just might as well check the recording afterwards, but Miro adds a new dimension to taking part of the lecture in real-time." (CF)

Through the use of the digital platforms to support interactivity, the lectures gain a renewed value to being synchronously present:

> "Miro is a nice way of collaborating, makes the lectures more interactive." (CF)

> "To have the lectures on Miro instead of PowerPoint slides was a great way of keeping people focused and the fact that you always were two teachers talking to each other made it more welcome to ask questions or speak your mind." (EQ)

5.1.4. Field Trips

Due to the COVID-19 restrictions imposed by the government, a significant number of students were not located near campus and therefore most of the course was held online. However, we decided to organize a field trip where students and their groups were encouraged to go to the local Botanical Garden. Students in other cities were motivated to visit their own local gardens. This activity was embedded into an exercise where students were instructed to identify flora they liked, analyse their characteristics, and interpret them into ideation on the design of a domestic robot. This activity was highly appreciated and noted by many students: "Thank you also for letting us out into the real world." "Really nice to be able to visit the garden, meeting people from the course and just get away from the home. Great initiative!," "Leaving the apartment leads to a lot of fun ideas." "Really fun to get out and see people and get some fresh air." (CF).

Even weeks after this event, and when filling in the final course evaluations, the field trip was often mentioned as a definite experience in the course. It was often described from a first-person perspective, and also shed light on how a physical meeting was considered essential for social bonding:

> "And THANK your for the trip to the botanical garden!! It was so precious to meet everyone at least once." (EQ)

> "The visit to the Botanical Garden (...) really amplified the community feeling! While group exercises did go quite a ways to bond us, the in-person visit just about doubled the effect." (RQ)

5.1.5. Hinders to Community Building

While community-making is valuable in many ways, it also brings its dangers that should be considered. A big class, and already settled groups of student, was considered problematic for some, raising issues of exclusion.

> "What made me feel like I wasn't a part of a community was that it was a big class, and most students in the course knew each other before hand, so naturally that creates its own kind of bubble, especially when you only meet virtually." (RQ)

The majority of the students were Swedish and one student raised awareness of racial bias:

> "There's a racial bias when interacting with the other students. When you try to bring a different cultural and racial perspective, one faces skepticism. Being a non-Swede in this course made me feel like I had to work twice to make my arguments valid and heard, which in the end turned my experience exhausting and dreadful at times." (RQ)

5.2. Teaching "Designerly Ways of Knowing" in HCI

Beyond the value of community, we focus on understanding "designerly ways of knowing" for interdisciplinary groups of students in HCI. The case study lifted a number of important themes which are strongly related to the reflective activity of understanding design knowledge. Below, we present the themes stemming from the student data.

In short, we describe how:

- Utilizing the studio as a naturally chaotic environment lead into a collaborative attitude.
- Students were able to express their first-person personal engagement with the course material.
- Ambiguity is a key factor for understanding "Designerly Ways of Knowing" within HCI, and was recognized both when included in the course content, but also in the exercise descriptions.
- Crit sessions were a quintessential activity, as in designerly teaching, also in HCI.
- The individual students also needed the space for their own individual exercises and reflections, although there should be considerations on how isolated students may feel.

Furthermore, we present some hinders to "designerly ways of knowing" in the form of difficulties expressed by the students in managing workload.

5.2.1. Accepting Chaos

Designing is a volatile and ever-changing activity, involving a high degree of variables often resulting in rather chaotic working processes. However, during online teaching, the absence of the studio environment could have an impact on the students' acceptance of a chaos, and therefore, we aimed at using a common Miro board to support the visibility of the messiness in the learning activities. The approach to the course through the use of a common platform both enhanced and attenuated the feeling of chaos. Students were vocal on how Miro often behaved in unexpected ways but still noted that "working on Miro has mainly been okay, sometimes it gets messy and slow—but overall I think it has been good," "Miro didn't work very well for me personally, but I still prefer being able to see other people's progress!," while simultaneously encouraging to "keep it all over the place."

> "I prefer the structure of using documents or PowerPoint slides as it's easier follow and go back and find information. Miro is more chaos, but has the advantage of being a collaborative workspace." (CF)

> "Miro can seem all over the place sometimes but that is also what makes it interesting." (CF)

The empty templates aided in structuring the work for the students, but the shared Miro board gave an impression of chaos through overview of the class' efforts:

> "One thing I loved about Miro in this case is zooming out and seeing all the work we did - all the frustration and the product coming from it!We kept almost everything that we diverted from also so there is a lot crammed on the board!" (CF)

However, it was noted that the students appreciated the structured exercise boards (an example of an exercise board is seen on **Figure 6**), which kept them on track, showing that it may be worthwhile supporting design methods and processes amidst chaos:

> "I really love the setup of doing the assignments and literature sessions on Miro because it is very step-by-step and gives more ability to focus on the concepts and how to apply them rather than writing some huge and formal report." (CF)

5.2.2. First-Person Engagements

When asked on how their own understanding of themselves as designers had changed during the course, students recognized that design knowledge was not offered to them, but that rather relied heavily on their own perspective, and noted that:

> "With this course, there was not a lot of you need to learn x,y,z good luck! but more about understanding and discussing the knowledge." (RQ)

There was a very deep engagement from the perspective of their own individual involvement and personal growth:

> "I realized so much about myself, my capabilities, strengths and weaknesses I need to work on. (...) There's so much to learn within design knowledge, it feels like it's never ending - and I love that." (RQ)

> "I learned a lot about myself (poetic haha), about how I learn and how to use that knowledge." (RQ)

> "It opened up for a part of designs that I had not explored before, the things that are creating a "bad" experience but resulting in something good/important/..." (RQ)

Students reported achieving learning goals just by being engaged, reinforcing the value of experience as a means to create tacit knowledge:

> "Very practical course, which will probably help me remember the content better afterwards." (RQ)

> "My overall experience with the course have been really good. I feel like I've learnt a lot but it has 'just happened' meaning it doesn't feel like other courses were I have needed to study because I have to but instead in this course I have just been part of it and doing every step has meant that I learned a lot along the way." (RQ)

There were expressions of personal struggle being shared during continuous feedback (CF):

> "I hate this one [the exercise] most because of all the struggles but It's also most want to revisit as well. I want to try it again." (CF)

It may be important to note that the exercises themselves called to a personal engagement from the students and generated conclusions and inspiration that came from their own experience. Some of the exercises relied on changing their own personal rituals in the home to create a sense of "estrangement" (Wilde et al., 2017):

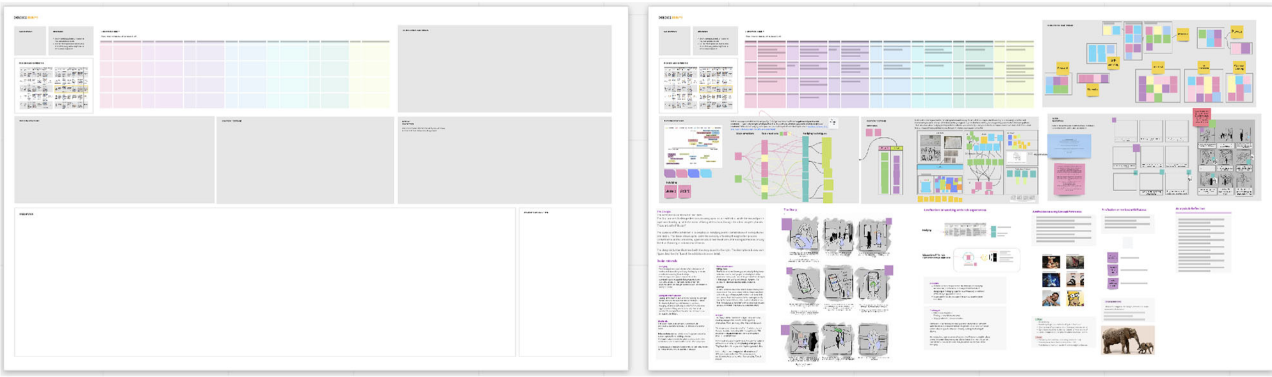

FIGURE 6 | Screenshot of a Miro board with an empty template for an exercise, and a filled exercise board by a group of students. The aim of this figure is to show the overall aspect of an exercise template, and visually contrast its empty state with a populated state. The content is therefore not readable.

> "Disruptive rituals are so good for getting insights. Who would have thought that drinking coffee with a spoon would make you more hot than usual." (CF)

5.2.3. Ambiguity as an Exercise

Ambiguity was presented in the course as a resource for design (Gaver et al., 2003; Boehner and Hancock, 2006). However, it was also embedded into the description of the exercises themselves. While some exercises had very strict given methodology, others were very open ended. Ultimately, the individual project allowed the students to approach the design with complete freedom, which many of them struggled with. Most students appreciated the stricter exercises rather than the more ambiguous open-ended ones, but some pointed out that:

> "Sometimes complex methodology gets in the way of productivity and creativity. Sometimes it would be easier to just think more freely to produce more clear ideas, as opposed to relying in the outcome of different methods." (CF)

More open exercises led into conflicting remarks:

> "I guess the open-endedness of this exercise really challenged us to think and be open-minded." (CF)

> "I actually liked that the instructions on the evaluation was not very strict. It forced us to actually think about what we wanted to get out from the users." (CF)

It was unclear for the students what the purpose of some of the instructions was, unable to see through the necessity of reasoning to make assignments clearer as part of the design process:

> "It was often hard to understand what we were supposed to do in the different exercises/project. The descriptions could be more clear." (EQ)

Of course, the level of instructional ambiguity led to mistakes being made, which was received by the students with varying levels of design maturity:

> "You learn from your mistakes, and having an assignment open for interpretation is good for realizing the mistakes you make, and next time you learn to ask for input." (MN)

> "Very nice assignments. I think that the outcome of some assignments (...) were a bit off because people still hadn't fully understood the concept and the assignment descriptions were sometimes a bit to open for interpretation." (EQ)

> "I think I learned the most from the individual project, but the exercises were a good warm-up for that. However, I feel that it could have been more obvious what was expected of us in (some of) the exercises, and that knowledge would have carried on to the final project as well." (RQ)

The inclusion of ambiguity as part of the design knowledge was well accepted by students with different backgrounds:

> "Being a first year student of the Master's Program in Interaction Design and Technologies, I'd argue it has been the most challenging yet interesting course so far, due to its fluffiness, and since I have a computer science background, which is so much flat in terms of feelings or emotions."

From a more applied perspective related to HCI, students gained an increased awareness of how difficult it is to tackle evaluating user experiences, and the understanding that they may gain within HCI is not always easy to approach. They remarked that "when evaluating UX, there is no method that is sufficient on its own. Preferably a combination of methods should be used," "UX is messy and we should try to embrace that. For example by picking methods/strategies accordingly" and that they should "embrace ambiguity in research" (CF):

> "I learned for example a lot of new methods to use in a design process and how important it is to research user experience in more ways than just how they experience the design when they have tried it once!" (RQ)

Furthermore, they gained a lot of understanding of the endless variables to be considered when designing within HCI:

> "UX depends on a lot of factors which I have not considered before, including temporal aspects (anticipation, momentary, episodic and cumulative) and context of use. Designing for and evaluating UX is thus far more complex and ambiguous than I previously fathomed. I have really only thought of the momentary or cumulative experience before and not considered how UX changes for the same user over time." (CF)

There were examples of a transdisciplinary understanding of design. For example, a student with a background in computer science came to terms with:

> "Sometimes it might be ok or even good to compromise some objectivity, if done consciously." (CF)

5.2.4. Crit Sessions in the Reflective Practice

Crit sessions were valued by most students, and recognized as a fundamental part of the course. When prompted to name which activities they learnt the most from, the exercises in combination with the crit sessions were often mentioned on top.

> "Crit sessions was good because you got a chance to see what other groups had done and hear the discussion around their design. And I learned from also commenting on other groups' design because than you started thinking about the literature and not only in terms of "this is cool" or "this is not so cool")." (RQ)

Students often mentioned a strategy used during the crit sessions, where a group of students were assigned the role of the 'bad cop' (the one that pointed out the possible improvements), while another group the role of the 'good cop'(the one that gave praise and noted the best in the design). The aim was the scaffold students to give honest feedback through role playing:

> "The bad cop good cop approach for the presentations was great because we learn from both criticizing and complementing." (CF)

> "Presentation feedback is usually just about what people find is nice and unclear - but good cop/bad cop provided the criticism part!" (CF)

> "The relaxed environment of the crit sessions is a great way to get both very nice and critical feedback.' (CF)

> "The crit sessions were so valuable! It teaches people to give and take feedback and to receive criticism and defend your design." (EQ)

It seems to be important to guarantee these sessions allow for enough time:

> "Really liked this Crit session, fewer groups seem like there is more time for deeper conversations." (CF)

Some students noted that it was difficult to assimilate some of the criticism given by the instructors, and felt at times like they were not willing to face it. However, they also noted:

> "Targeting the weaknesses in the design is a thing you appreciate as a student. It is much more helpful with critique, but of course some can be more sensitive to feedback than others and that is more personal. I think people have to think about - they will always get critique whatever they do." (MN)

The feedback given during these sessions had a clear impact in follow-up exercises, and even in the preparation of the individual project:

> "The biggest learning outcome for me was that you always need to be able to argue for your design choices - WHY did you decide this? Because in the midst of the design process you can easily steer off track when something gets difficult and start to design for 'just because'."

It may be important to note that being open to criticism may come from the side of the instructors as well:

> "They are [the teachers] always open for discussions, complaining, guiding and just chatting when it is needed. They consistently let students come with points, questions or notes. It feels like your opinion and voice is valued." (EQ)

5.2.5. Space for the Individual

The course finished in an individual project, which gave a lot of space for personal choice, but also individual reflection which would have not otherwise been possible:

> "I liked the fact that we had an individual project, everything in this master is organized around groups and I don't think we get the opportunity to explore our design skills deep enough. A mix of group-individual activities seem the best way to go." (RQ)

> "I think it was a very appropriate final assignment, makes sense for us to individually try to create an iteration of what we've been studying these couple of weeks."(EQ)

> "I learned so much about myself and what's my strengths and weaknesses by working on my own in the individual project." (RQ)

> "The individual project was where it all got connected, but I lost focus a bit because I wanted to include and explore so many things. I was not being realistic with my time - which also helped me learn a lot." (RQ)

Even the approaches to literature needed some individual space:

> "[The individual project] gave one last chance to revisit all the literature (that had already been worked through in a really good way with literature seminars) and it was good to be able to work around these articles in your own phase and manner."

Students learnt from their individual project, but also from observing and discussing with peers:

> "[Learnt most from] the individual project, but also being able to see other peoples' individual projects and following their line of thought."

However, working alone brought back some of the values of a community and different interpretations:

> "The individual project, how much it sucked to do it alone and how important it is to have a group or just a teammate to talk to, to get different perspectives." (RQ)

> "The only part where I felt very isolated was during the individual project, I found it very difficult to do it alone since it was harder to discuss your thoughts with others." (RQ)

And when alone, the lack of vulnerability exposed brought some risks in the form of anxiety.

5.2.6. Hinders to "Designerly Ways of Knowing": Workload

Because students were dealing with "wicked problems" (see Section 2.1), there was a big variance in how students perceived the time given for each task. As part of each exercise and project in the course, students were given an approximate number of hours they were expected to work. Students mentioned that "you forgot the time so you worked more than you expected," "time is difficult too manage because sometimes you are running out of time because you are curious to explore," and "the individual project was hard, but incredibly satisfying." (MN). In terms of workload however, it was noted that:

> "I think the workload was quite adaptable. Did you want to spend a lot of time on your assignments and in the individual project, you could, but you were able to pass even if you spent less time." (EQ)

> "I spent way way too much time on the final project, but it was my own fault because I went in too many directions. My fault not the course." (EQ)

> "I think it was difficult to know how much time and effort should be put into the different group exercises. Sometimes it was very time consuming and you weren't sure if it was worth it or not." (EQ)

In the evaluation questionnaire, the students were asked to rate the workload in the course related to the number of credits on a scale from 1 to 5. The mean was 3.79 and median 4, which indicates that the students thought the workload was a little too much:

> "The workload was heavy and I would have liked to have longer projects where you could work a bit more in depth, and have more time to reflect before going to the next theme." (RQ)

Many students reported that they found the course stressful due to this high workload, however some remarked that the course was "demanding but worth it!," "I think it was great yet very demanding," "it has been fun and a little stressful," but also:

> "I learnt A LOT. Even though the work load was in my opinion higher than the average course workload, I think it was totally worth it" (RQ)

Students without a background in design seemed to be more sensitive to this:

> "I'd argue it has been the most challenging yet interesting course so far, due to its fluffiness, and since I have a computer science background, which is so much flat in terms of feelings or emotions." (RQ)

While a student with a design background articulated their self-doubt in an ambiguous manner:

> "Intense! A lot of fun. (...) Experienced some performance anxiety since I among with many others felt that the expectations on our performance and dedication in the end of the course were high, but that's not necessarily a bad thing." (RQ)

However, when asked what to reduce in terms of workload, there was no agreement between students. While some wanted longer time for the individual projects by reducing the number of exercises, others appreciated the variety in exercises and themes:

> "A really fun course! Nice with several 'small'-projects, then you have the chance to explore many different ways of approaching design as well as decreasing the risk of becoming "fed up" with working with the same project for 8 weeks." (RQ)

All comments on what should be changed in the course actually suggested adding rather than removing any particular part, and when inquired on what could be removed, the student representatives had a difficult time letting go of any of the learning activities noting that: "I do not think this course should be watered down because of the high workload." (MN)

It may be worth considering the impact of the digital platforms on these hinders, specifically in terms of time management. The fact that the digital studio was open beyond the regular course hours may have led into an increased loss of sense of time, and encouraged more work than otherwise.

5.3. Digital Platforms in the Extended Studio

As discussed in Section 2.5, the studio is an important dimension of a design education. In the case study we present, the course was conducted as distance education, but many of the features of the physical studio were replicated through a number of strategies (see Section 3.4) and resulted in a collection of remarks related to the platforms themselves. We refer to the resulting hybrid studio as an extended studio, incorporating both physical and digital tools in the design activities. In this section we focus on how these digital platforms contributed to the community-based design learning.

The use of these digital platforms extends the reach of the peer community, and their application is of the utmost importance to properly support the exchange of knowledge and designerly posture in transdisciplinary contexts. The transparency and openness they support is conducive to a sharing environment, supporting co-creation and collective reflection.

This subsection presents the following themes:

- Openness is a primary characteristic of the design studio which can be enhanced by a digital platform.
- Relying on openness, the digital platforms clearly encouraged the students to appropriate the material and manipulate it, generating emergent behavior.
- A combination of the physical studio and the digital studio—what we call the extended studio—is a valuable future direction.

5.3.1. Openness

The fact that Miro, Zoom, and Slack were open at all times resulted in an approach to the spaces given which generated the possibility of feedback and discussion:

> "The use of Miro shortened the space between the students. It felt like we were always able to see what each other were doing, and ask others for feedback and giving them mine. I did maybe spend too much time on it, but it was a lot of fun! Another thing was having the Zoom room open, I often ended up meeting with other students there while waiting for feedback or discussing each others ideas. (. . .) It almost felt like being in a classroom." (RQ)

Allowing for communication between students even during lectures was noted upon, and seems to have contributed to a feeling of inclusion:

> "We we're all connecting on Miro, we could visually speak to each other directly and also collaborate on lectures and discussion, not just group exercises. (...) Everyone was very inclined to write in the open Slack channel for the whole course and prone to make everybody included, e.g., asking the whole class if they wanted to do focus groups etc. This was also very encouraged and supported by teachers." (RQ)

A clear example of openness is seen precisely during lectures, where students followed along the slides directly on Miro. Therefore, the students had the power to sabotage a lecture, but instead, they used the board as a space to input with their own suggestions, links, and information. Of course this level of maturity must have been pre-existing, but it is also revealed in the way many of the students could make sense of their own relationship to the digital platforms:

> "In the context of the pandemic, this gave me a great feeling of community. Given the natural lack of physical contact during the pandemic, feeling part of the class is hard to achieve. I thought that the Miro boards, together with the four group projects (where each project was done in a different group) was really good. The projects made you work with different people (thus making you feel part of both the smaller community of the group, but also the larger community of a class by seeing presentations and discussing). The Miro boards were very effective to emulating a class environment where everyone have their own space to work in at the same time as you and you are free to visit another area. In a hybrid style of teaching, I would say that Miro and group projects are great too keep that sense of community which is normally achieved physically." (RQ)

There was one noteworthy case where a student reported on gaining inspiration for her individual project on the activity she caught on the Miro board while working late hours (1 a.m.): this event was described in her hand-in as "comforting," "night owls connecting," and a feeling of "all in this together."

5.3.2. Emergent Use and Appropriation

The Miro boards, Slack, and Zoom room were introduced by the teaching team. However, during the course, the students adopted the digital platforms and adapted them to their own use (an emergent behavior usually called appropriation). Particularly during the individual project, the students used the open Zoom room as a platform to conduct focus groups with colleagues which were not mandatory. The organization of these workshops was entirely the suggestion and initiative of the students. Furthermore, a Miro board was created as an open resource for the individual projects as seen in **Figure 7**. In this figure, two boxes can be seen, A indicating the only content provided by the teachers, and B, a spontaneous collection labeled and constructed by the students as "Summary of the methods and frameworks from previous exercises. Check it when lost and feel free to add more!." The rest of the seen images is design material generated by the students themselves.

Students noted on their informal approach to the platforms, which was another clear sign of appropriation. Their humorous approach to communication between students was recurrent, and an actual contribution of the digital medium:

> "Being able to see other peoples work and leave little comments and memes on Miro increased this fun-factor in being a class that is beyond literature discussions and lectures." (RQ)

Another important note to take is that 4 months after the course was finished, some students still actively consulting the boards in the course, some of them even adding information to them.

5.3.3. The Extended Studio

Some of the observed advantages with the digital platforms showed a promising path ahead. When asked what could be of use for a hybrid physical-digital studio, students remark that literature sessions, for example "could work online"(MN). The reasons mentioned for its possible success have to do with the random groups created for these sessions. **Figure 8** shows a screenshot of a section of a board dedicated to a literature session. From a teaching perspective, this set-up also allowed for an easier way to check on all groups and answer questions, while facilitating a democratic and open approach to the literature chosen. It was also noted that the overview facilitated by the Miro

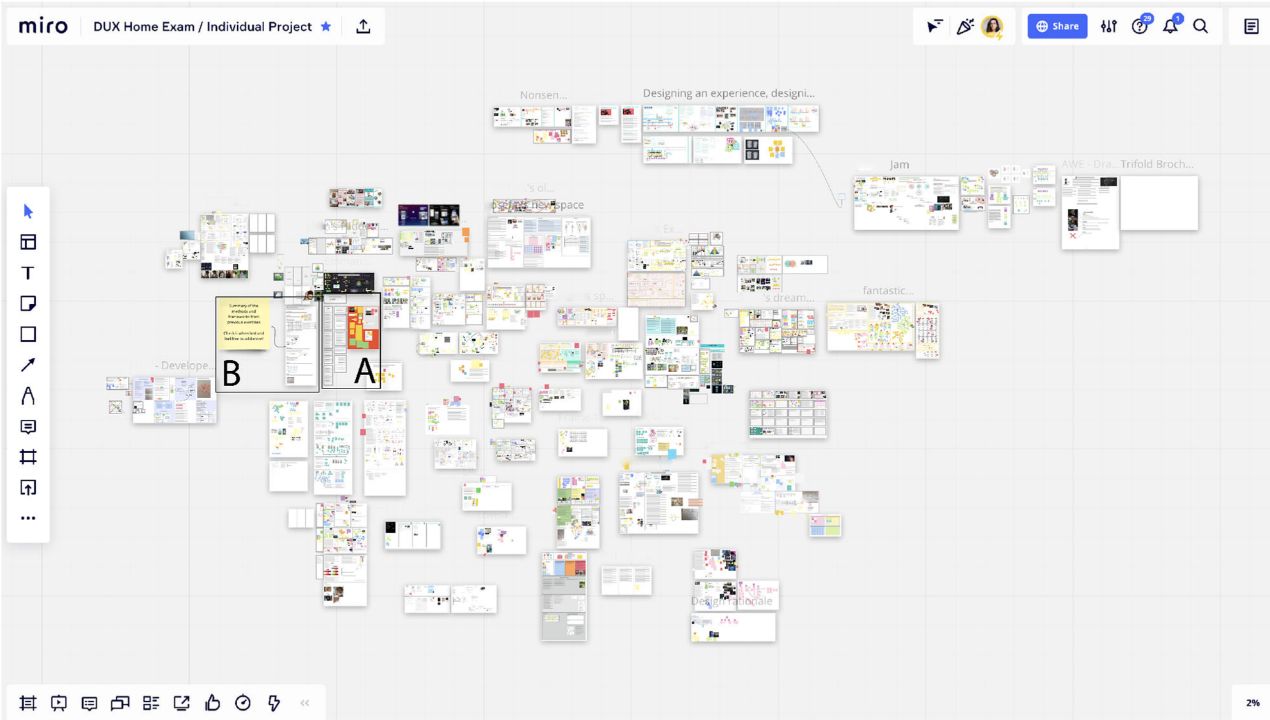

FIGURE 7 | Screenshot of a Miro board appropriated by the students when developing their Individual Projects. Two boxes can be seen marked with **(A)** the information given by the teacher and **(B)** a collection of methods and frameworks spontaneously generated by the students. The aim of this image is to give a visual impression of the content created by teachers and students, rather than provide readability. Some of the data is blurred or redacted for anonymity.

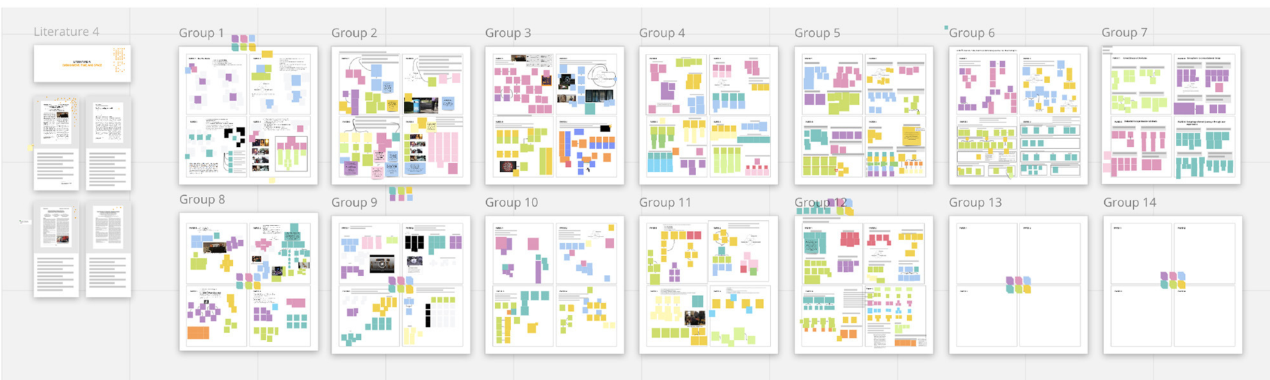

FIGURE 8 | A screenshot of the Miro board section dedicated to a literature session.To the left, the literature and respective dot voting (the students were prompted to vote on their favorite piece each week to facilitate the choice of literature for the next round of the course), and on the right a collection of boards filled by the students on each of the papers. Two empty group boards can also be seen.

board of all the information in each theme was helpful when tackling the exercises. On the capabilities of Miro it was also noted that:

"It enabled putting feedback to each other in a very easy way. We did not have to schedule, we did not have to book a time, now I have two minutes I wanna go look at something new, I will go look at Philip and give him some feedback. That also made it much more fun, you were much more engaged in your project and in other peoples projects because you could see what they were doing." (MN)

"The most helpful thing about this course was that the lectures, seminars, and exercises were executed on Miro! I loved that I could go back to the different boards under the project to get inspiration from both my groups but also other groups!" (RQ)

This reveals a promising application of these digital technologies even on-campus:

> "I think the Miro board would be a great to keep even though it would not be remote, so the different groups can still work on there even though they are together." (EQ)

6. DISCUSSION

The analysis of the data led to a split of the results into themes to consider to foster peer communities, important aspects to incorporate to facilitate designerly postures, and how digital platforms can be used to extend and develop the design studio.

The first set of themes are particularly important as they are usually not an explicit part of curricula—the tacit dimension of peer relationships is recognized, but it is not always embedded into the course activities. With our work, we offer four strategies that can easily be implemented in any HCI course: informality in the studio, ephemeral groups, community-building lectures, and field trips. However, when building communities we also expose issues of exclusion. This important hinder to community building is noted upon: for example, while ephemeral groups result in *ad-hoc* relationships between the students and encourages sharing, it also exposes the vulnerable students to more risk. We are confident the advantages out weight the risks but for each particular class, a risk analysis must be made and appropriate knowledge of the minorities in the cohort is to advantage in order to create a safe space for sharing.

The second set of themes focuses on incorporating "designerly ways of knowing" in HCI. These results show a set of themes strongly related to acknowledging facets that are also rarely formalized in curricula: they exemplify the relevance of ambiguity and chaos as well as the importance of many forms of reflective practice. These are difficult to express as goals, and are rather mirroring a process which may be impossible to formalize into goals to be assessed. Reflection and first-person engagement comes at a cost – the students showed signs of overworking. This hinder to designerly approaches is not unique, but worth reasoning about. It is a struggle which will likely continue in the professional life of the students, and tools to deal with 'wicked problems' and recognizing stopping point, and good enough solutions ought to be given as much attention as methods to move forward.

The last set of themes is a contribution transpiring from COVID-19. The sudden switch to distance education forced many to quickly adopt a number of platforms into their courses. Had this shift not happened, we had perhaps not experienced the advantages of the further digital extension of the design studio. These three themes are the legacy of a difficult year and will most certainly remain. It is important for the research community to share these experiences and consider what may be worth keeping back on campus.

The use case presented incorporated teaching strategies compatible with design as a specific epistemological field, as described by Cross (1982). This paper focuses on facilitating the development of "designerly ways of knowing" in HCI students, while putting an emphasis on an articulated and scaffolded combination of theory and practice. While never being introduced to the idea and theory of "reflective practice" (Schön, 1984) the students still exhibited the ability to be "reflective practitioners," craving even more time to be able to exercise their right to reflection (as described in Section 5.2.4). Schön's two types of reflective practice, on-action and in-action were well supported in the course through the more or less constant contact between peers. The digital studio was able to lead into an understanding of the value of critically questioning design decisions. This progressed from the crit sessions toward independent work, where the students were first asked to stop and reflect (reflection on action) to later be able to reflect while developing their individual designs (reflection in action). In part, this effect seems to stem from an acceptance of the first-person designerly stance, where the designer is in the center. During their individual project presentations the students were engaged with the task at hand in ambiguous but deeply personal ways, and were able to identify the surprising or unexpected effects the process had on their designs. As Schön mentions in an interview with John Bennett: "Designers need to be able to bridge this gap between the personal and the technical-to be able to work with the medium and to reflect on the surprises, and in the end to produce a design that works both for the designer and for the audience." (Winograd, 1996).

The articulations presented on their own perceptions of learning had a strong phenomenological grounding, where the students expressed how they learned about their own capabilities, and made use of their own experience (see Section5.2.2). However, transdisciplinary difficulties were never mentioned by the students. This result is surprising, given that they worked in many different groups, and the cohort included different backgrounds.

This paper builds on empirical material from the Miro boards, two questionnaires, and a board meeting. Thus, it did not focus on the work produced by the students in the course. Their final presentation and hand-in essentially took form as annotated portfolios (Löwgren, 2013), but consent was not gathered to use this material as part of the present research. As instructors, and by attending their final presentations, we gained an understanding of their designerly approach, but also noticed how the students showed difficulties expressing tacit knowledge. Overall, the empirical data collected had no mentions to the interpretative value of the student's own work, which was not surprising given students were never prompted to reflect specifically on their work as intermediate-level knowledge. To make students more aware of the value of their own designs is important future work—to not only acquire designerly knowledge (by doing and reflecting), but also learn concepts within design epistemology and recognizing the value of interpreting design artifacts (Bardzell et al., 2015). There may be a need to introduce students to these concepts from a meta-perspective, explicitly teaching them how to understand and recognize design knowledge in relationship to sciences, humanities, and arts. While the case study did not focus on design epistemology *per se*, but rather supported the students to do reflective practice as a community, we find that it may be worthwhile to include an agreement on what design knowledge is both for instructors and teachers. As a proposal on how to support this type of discussion, we suggest the Community-Base Designerly Scale on Section 6.1.

From a peer community perspective, it was clear that online set-up of the studio was successful (see Section 5.3. The students supported each other as a community, and the platform demanded openness and sharing of ongoing work, not only within groups. Students even reflected on how such a platform could be used for courses held on campus, as extended studio approaches. Their development as designers seemed to be closely connected to the unprompted reflections-in-action which surfaced by the transparency afforded by the digital tools.The set-up described was intended to allow keeping activities already planned, without needing to dramatically change them from the on-campus version of the course. The aim was to maintain a certain coherency between cohorts, however, as shown by the data, we have instead achieved rather innovative learning activities poised on the advantages of a unified approach to the online content. The overview allowed by the Miro boards was absent in the on-campus version of the course, and had an impressive impact on how the students considered the literature and lectures while working on their designs. The reflection-in-action was influenced by the improved accessibility of the theoretical overview.

HCI education is a living curriculum, and what is considered important as subjects, topics, types of interfaces, modalities and methods etc may vary between different institutions (Churchill et al., 2016). Churchill et al. (2016) suggests how specific design perspectives, cultural contexts, and knowledge traditions can be a resource for other teachers, supporting the development of the living curriculum. Studio based teaching has been understood as important problem-based approach when teaching HCI (Reimer and Douglas, 2003; Koutsabasis et al., 2018). As studio-based teaching can differ in complexity and application area (Vorvoreanu et al., 2017), case studies can support other teachers to learn and take inspiration in planning their teaching (e.g., Koutsabasis and Vosinakis, 2012; Koutsabasis et al., 2018). Previous research has described aspects of digital studio work and its role in HCI teaching (e.g., Koutsabasis and Vosinakis, 2012; Vosinakis and Koutsabasis, 2013). Vosinakis and Koutsabasis (2013) focus on the role of avatar representations in the platform OpenSimulator and describe collaborative creation of design materializations such as personas, flow charts and concept models on shared boards. Similar to what is presented in this paper, Vosinakis and Koutsabasis (2013) and Koutsabasis and Vosinakis (2012) describe how online shared workspaces can support progress tracking and feedback in crit sessions that are asynchronous, as well as brainstorming sessions that are synchronous. However, the case study in this paper focuses on the value of collaboration and spontaneous communication in-between groups of students as well as the potential role of epistemology in a studio approach, which previous studies did not address.

6.1. The Community-Based Designerly Scale as Future Work

We propose a scale (as seen in **Figure 9**) intended to support (a) instructors and students to engage in epistemological perspectives the development and (b) the discussion of designerly courses within HCI and act as a tool for a more transparent communication with the students, while simultaneously introducing concepts within design epistemology. Potentially, there could be benefits in exposing the students to a semantic differential as presented by Lawson and Dorst (2009), rather than just incorporating it in the course design. Taking a stance when designing the course on what values are important could be made evident to the students, which was not done explicitly in our case study. For example, the exercises were designed to be scaffolded by the methods and templates on the Miro board: they were not entirely structured nor completely free. By negotiating this distinction with the students at the start of the course, we could have hindered some misunderstandings on the exploratory nature of the exercises—meaning the students could deviate from the suggested structure, but should keep within the aims of the exercise.

We present a possible scale for community-based reflective practice within HCI education, based on a set of dichotomies to be considered when developing HCI teaching activities. The following scale can be included in the course content of designerly HCI courses and to be discussed together and openly with students at the beginning of the course. It can be used in a co-creative manner, where together with students, instructors are allowed to describe their course based on the proposed scale. This scale gathers inspiration from **Figure 1** and **Table 1**, combined with the themes described in the results section.

Although the scale needs to be evaluated and applied in the context suggested, it is a flexible tool which can be expanded even beyond academia. **Figure 9** shows an empty template to the left, but also two examples of how it can be filled in to the right. In this case, we used the scale to explore how different examiners would potentially describe their courses (see different lines) in comparison to one another. Below, we attempted to represent the current case study as placed somewhere in a span for each of the semantic differentials. As we see it, the scale is one step toward explicitly including the community in the planning and execution of courses, including students and teachers, but even potentially external actors.

6.2. Limitations

The current paper is grounded on a case study of one instance of a course conducted online, while still attempting to maintain many of the advantages of a studio-based teaching. Therefore, the intention of the study was neither to be reproducible nor generalized, but rather transferable. The data collected was mostly declarative in nature and "reflections on" the course after its completion, and would have definitely been better complemented from a designerly perspective if they had been generated in-action (Schön, 1984). The description of the results does include some notions of how the student's generally work developed. Unfortunately, consent was not gathered to

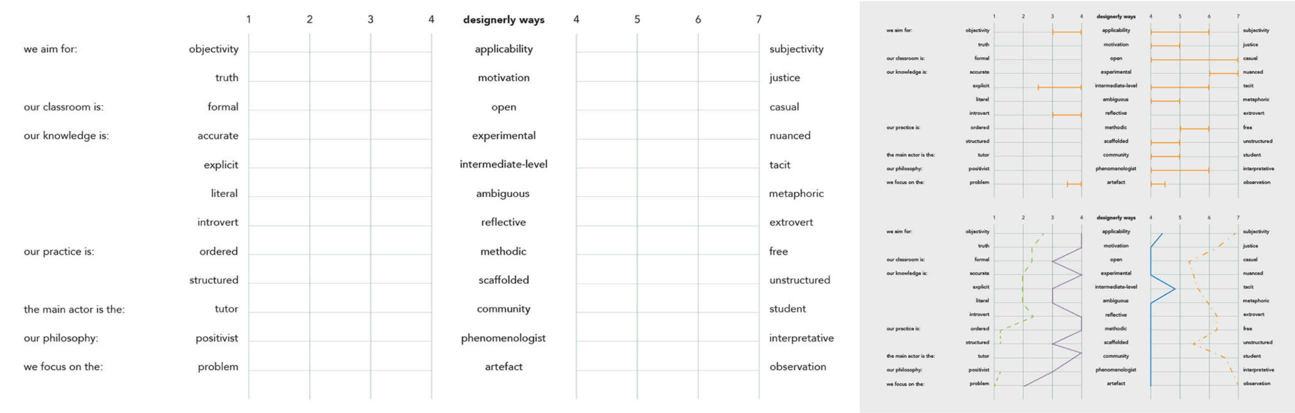

FIGURE 9 | To the left, the community-based designerly scale applied to HCI, where the differentials describe extremes representing different disciplines, with design discipline poised in the middle. This scale can be used both when designing courses, but also as a support for discussions between instructors and students on what type of knowledge and posture should or will be adopted in a course. To the right, an example of two possible ways to fill in the scale.

include the work in detail in the analyzed data, as the initial focus of the study was on the online tools as support for the development of a studio culture. In the next iteration of the course, consent will be gathered to analyse the work produced by the students, including also the use and evaluation of the proposed community-based designerly scale. We consider that the themes presented can inform the set-up of other courses intending to preserve and develop both peer community-based design learning strategies, as well as designerly ways of knowing and digital platforms in HCI courses. The themes presented in the results are expressed in a manner that allows for their application both online or on campus. In fact, this course has been run for at least 10 years on campus studio-based course, but never been described and analyzed in the holistic manner presented in this paper. The current set-up allowed for a more detailed study of the digital platform as a support to the studio. However, they are not definite and proven guidelines, rather issues to be considered and reflected upon by other teachers.

7. CONCLUSION

In this paper, we depart from the discussions and origins of design epistemology to describe "designerly ways of knowing" within HCI. The empirical work is a case study of the development and evaluation of the online set-up of a transdisciplinary design course in user experience (UX). The course is firmly grounded in first-person perspectives, community making strategies, and a studio approach. It was conducted primarily as an online course, and therefore, had extensive hinders in the creation of a physical studio-based community, which allowed for an understanding of the factors that contributed to its success.

We conclude by distilling the study case into a set of categories and themes to be considered when designing community-based "designerly" courses within HCI. This includes perspectives on the role of the community in design work, strategies for teaching "designerly ways of knowing," and the role of digital platforms in online studio-based teaching.

Finally, we discuss limitations of the case study and open up for future work. The case study was helpful and successful to reveal the value of an online community of HCI students, but less so at instigating a more general understanding of design knowledge within the cohort. We propose a community-based designerly scale to be used to discuss the characteristics of design knowledge in HCI courses. We consider this as a possible tool for supporting the discussion and negotiation of these epistemological underpinnings between students and instructors.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because of privacy regulations. Requests to access the datasets should be directed to corresponding author.

ETHICS STATEMENT

Ethical approval is not required for studies in Sweden which do not involve gathering sensitive and identifiable human data. The study is grounded on the evaluation of an activity, and not an intervention that was changed for research purposes, and therefore does not qualify for board approval. The participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

MG the first author in this article, is responsible for its outline, for the work in the case study, the analysis of the data and writing of the majority of the article. SL contributed with her knowledge of design epistemology and conducted extensive work which is incorporated in the Theory section, as well as supervised and guided the work in the remaining sections. Both authors contributed to the article and approved the submitted version.

FUNDING

This work was funded by the Wallenberg AI, Autonomous Systems and Software Program Humanities and Society (WASP-HS) funded by the Marianne and Marcus Wallenberg Foundation and the Marcus and Amalia Wallenberg Foundation.

ACKNOWLEDGMENTS

We acknowledge the effort and generosity of the students in the case study, their thoroughness in answering questionnaires and their openness to communication. MG also acknowledges the hard work and support provided by Sjoerd Hendriks when developing and implementing the course, as well as Sus Lyckvi for first implementing the course used for this study.

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ORIGINAL RESEARCH
published: 26 May 2022
doi: 10.3389/fcomp.2022.813889

An Open-Ended Blended Approach to Teaching Interaction Designers to Code

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This article reports on a three and a half year design-led project investigating the use of open-ended learning to teach programming to students of interaction design. Our hypothesis is that a more open-ended approach to teaching programming, characterized by both creativity and self-reflection, would improve learning outcomes among our cohort of aspiring HCI practitioners. The objective of our design-led action research was to determine how to effectively embed open-endedness, student-led teaching, and self-reflection into an online programming class. Each of these notions has been studied separately before, but there is a dearth of published work into their actual design and implementation in practice. In service of that objective we present our contribution in two parts: a qualitatively-derived understanding of student attitudes toward open-ended blended learning, as well as a matching set of design principles for future open-ended HCI education. The project was motivated by a search for better educational outcomes, both in terms of student coding self-efficacy and quantitative metrics of cohort performance (e.g., failure rates). The first year programming course within our interaction design-focussed Bachelors program has had the highest failure rate of any core unit for over a decade. Unfortunately, the COVID-19 pandemic confounded any year-to-year quantitative comparison of the learning efficacy of our successive prototypes. There is simply no way to fairly compare the experiences of pre-pandemic and pandemic-affected student cohorts. However, the experience of teaching this material in face-to-face, fully online, and hybrid modalities throughout the pandemic has aided our qualitative exploration of why open-ended learning helps some students but seems to harm others. Through three sets of student interviews, platform data, and insights gained from both the instructional and platform design process, we show that open-ended learning can empower students, but can also exacerbate fears and anxieties around inadequacy and failure. Through seven semesters of iterating on our designs, interviewing students and reflecting on our interventions, we've developed a set of classroom-validated design principles for teaching programming to HCI students without strong computational backgrounds.

Keywords: open-ended learning, student-led teaching, blended learning, interaction design, programming education, creative coding

OPEN ACCESS

Edited by:
Karin Slegers, Zuyd University of Applied Sciences, Netherlands

Reviewed by:
Jan de Wit, Tilburg University, Netherlands
Christos Troussas, University of West Attica, Greece

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Specialty section:
This article was submitted to Digital Education, a section of the journal Frontiers in Computer Science

Received: *12 November 2021*
Accepted: *12 April 2022*
Published: *26 May 2022*

Citation:
Grace K, Klaassens B, Bray L and Elton-Pym A (2022) An Open-Ended Blended Approach to Teaching Interaction Designers to Code. Front. Comput. Sci. 4:813889. doi: 10.3389/fcomp.2022.813889

1. INTRODUCTION

Programming skills are a critical part of any modern interaction designer's education. Computational thinking and digital prototyping skills, both of which require some level of programming proficiency, are increasingly important for designing all manner of products and services. In an era of cross-functional teams operating in demo-or-die environments, the notion of an exclusively human-focussed HCI practitioner seems ever more obsolete.

Despite this, a substantial fraction of the interaction design students in our undergraduate program, the longest-running HCI-focussed design course in Australia, consider programming to be one of their biggest struggles. This low coding self-efficacy (Ramalingam et al., 2004) is associated with students perceiving themselves as "not a coder", or "just not able to think that way". This paper synthesizes what we have learned from a 3-year project to redesign the introductory programming subject within our design degree.

Educating emerging practitioners of human-centered design to also be competent programmers is not straightforward: design and software development require very different metacognitive strategies, particularly in how they handle ambiguity and abstraction. Computational thinking teaches how to resolve ambiguity using hierarchies of abstraction (Wing, 2008). By contrast, design thinking teaches acceptance of ambiguity and how to instead value and work with multiple competing perspectives (Tversky, 2015). It's not a stretch to see how the students each discipline tends to attract would favor one approach but struggle with the other. The human-centered design aspects of an HCI education have classically been confronting to traditional STEM cohorts (Cooper, 1999), and the opposite is also true: the system-centered nature of programming is confronting to students of design.

To effectively educate modern HCI practitioners, therefore, means to produce graduates equally adept at both the human and the technical. To do so will require—perhaps fittingly—both technology-led and design-led innovations, but also a greater understanding of the student experience of such a program than we have today. To that aim, this paper reports on a 3 year design-led project to explore how to more effectively introduce interaction design, HCI and user experience design students to programming.

Our approach combined creative coding (i.e., programming as a creative medium) (Reas and Fry, 2006) with open-ended learning (i.e., giving students greater agency in shaping their learning trajectories) (Hannafin, 1995) and student-centered learning (i.e., letting students play an active role in teaching) (De Volder et al., 1985). Specifically, we wanted to frame programming skills around small open-ended "making" activities and then invite students to create these activities for their peers. Our hypothesis was that this would create an environment where the flexibility and expressive capacity of programming was emphasized, appealing to students of design. Furthermore, we needed this approach to scale to classes of up to 500 students and be teachable by staff with a wide range of expertise, so we adopted a blended learning approach—a far more niche choice in 2018 than it is today!

Our design-led methodology was necessitated by the well-known challenge of scaling educational innovations from the laboratory to the curriculum (Cohen and Ball, 2007). Evidence-based practices, particularly those of a technological nature, are notoriously difficult to implement (Klingner et al., 2013), facing obstacles from students, educators, administrators and policy-makers alike. As an alternative to tarring any of those stakeholders as particularly ornery, "design-based implementation" approaches (Penuel et al., 2011) have been adopted as a way to bring stakeholders into the process of deciding how, when and where educational innovations should be applied. Familiar to any practitioner of HCI, this approach amounts to applying human-centered design to the process of implementing educational innovations. This paper presents research in this tradition of design-led implementation of educational innovations, combining interface design, service design, and learning design into a multi-year collaboration between researchers and educators. Critically, that means this research thus does not propose or evaluate any original technological innovations, but instead contributes classroom-tested understanding and principles to guide future similar implementation challenges.

Driven by this approach we engaged in iterative prototyping, evaluation and refinement, deploying our first prototype in 2018, running our first full course using in 2019, and teaching 400+ students each year 2019–2021. Each year we took the best parts of what worked and refined them into a new version of our open-ended blended learning platform. In 2021 students submitted over 5,800 responses to our online "challenges," which are open-ended making-focused learning activities. The course has increased student satisfaction and been enthusiastically well-received by the 20+ teaching team.

The project also, by virtue of featuring a blended learning platform that was already deployed at scale in 2020, collected insights on how our students navigated the educational disruption of the COVID pandemic. At the university where this study was conducted this disruption was severe: one semester transitioned to remote learning in its fourth week, one semester was conducted entirely online, and a third semester was run "hybrid," with small (¡20 person) face-to-face classes for the (approximately half) students who were able to get to campus. In one sense this disruption has made it impossible to report on the year-on-year quantitative improvements in student satisfaction over the life of the project. However, it also offered an opportunity for us to expand our exploration of student attitudes to cover a broad range of contexts. Given this opportunity, our research contributions can be expressed as follows:

a) an understanding of how open-ended blended learning impacted the experience of designers learning programming, including their attitudes toward self-directed and student-led learning, derived from a rigorous qualitative meta-analysis, and

b) a set of classroom-validated design principles for effective open-ended programming education, particularly for cohorts without a strong computational background.

We reflect on each major revision of our "Creative Coding Challenges" platform (CCCs), its focus and goals, the way we evaluated its success, and the insights gained from it. We then provide a thematic meta-analysis of the 63 student interviews conducted over the life of the project. We then derive a set of recommendations for how to teach programming to designers in future.

2. BACKGROUND

Open-ended and student-led pedagogies are particularly applicable to teaching designers due to the existing prevalence of collaborative, project-based learning in design (Wang, 2010). Our blended learning focus was by necessity: a technology platform was needed to implement our ideas about student-led teaching at the scale our courses required. To explain how we arrived at these notions, we present the four research fields in which this project is situated: programming education, design education, open-ended learning, and blended learning.

2.1. Programming Education

Our 2018 prototype was inspired by another successful multi-year experiment in online peer learning for creative coding (Carvalho et al., 2014). The motivation behind that platform was to explore the peer learning aspects of learning programming in a web context (Carvalho and Saunders, 2018). Another key idea in both projects is that teaching creative coding is a more effective and accessible method compared to a traditional "plain" programming course.

It is well established that learning to program is very difficult (Gomes and Mendes, 2007), although directly saying as much to students has been shown to disadvantage students from underrepresented groups (Becker, 2021). Introducing students to algorithmic thinking and complex problem solving is a challenging task. Students must also simultaneously learn complex syntax with high levels of abstraction, in languages typically not designed to be a student's first language. Introductory programming courses typically aim to teach programming generally, but must by necessity focus on a single language, a confusing distinction for many students.

For educators, it is often difficult to personalize lessons due to large class sizes in introductory courses. Learning programming well-known to require significant individualized feedback based on each student's progress, which becomes challenging as classes and courses scale up (McBroom et al., 2020). There is also the challenge of students' coding self-efficacy, which is associated with prior exposure (and thus typically lower in non-CS cohorts) as well as being linked to programming course outcomes (Ramalingam et al., 2004). If coding self-efficacy is a high predictor of coding success, and many HCI and design students are not from the kind of backgrounds where they have had a high exposure to programming before attending university, how can we best improve it in our courses?

Difficulty learning programming is linked to a nexus of highly related motivational, interest, and identity factors (Jenkins, 2002). This is particularly common in the increasing number of contexts, like our own, where introductory programming is a core component of non-computer-science courses (Guzdial, 2003). For many students in these contexts, the completion of the subject may be seen as an inconvenient obstacle to completing their degree: they are less likely to exhibit the critical intrinsic motivation to learn that programming so benefits from. These issues are known to be especially prominent in non-white, non-male, non-cisgendered, non-heterosexual, and non-native English speaking students students, as well as students with disabilities (Peckham et al., 2007; Charleston et al., 2014; Kargarmoakhar et al., 2020).

"Creative coding" is a computing pedagogy that offers some solutions to these problems. In creative coding approaches, programming is presented as a medium for creative (often visual) expression (Reas and Fry, 2006), providing a simple means for highly abstract concepts to be represented visually. This can often lead to the "flow" of a complex program—a common sticking point for students—being clearer and more easy to manipulate. Many languages for creative coding are specifically designed for people without strong technical backgrounds, such as the Processing family of languages (Reas and Fry, 2007), which are designed for artists and educators. The visual and interactive nature of creative coding provides instant feedback to students on what their program is doing, as the code typically revolves around drawing to the screen. In addition to being more popular among certain groups of non-traditional programming students (Guzdial, 2003, 2009; Greenberg et al., 2012), creative approaches to code are perfect for our HCI audience: our students identify as designers, and this approach lets them see code as a medium for design.

2.2. Design Education

Design education finds its foundations in the "atelier" or master-and-apprentices model common in the fine arts until the late nineteenth century. In this educational model a well-known artist would coordinate a small group of assistants to produce creative works, with the assistants learning on the job and then, ideally, going off to start their own practices. This evolved into what is commonly known as the "studio model," the cornerstone of architectural and industrial design education. Studio-based teaching shifts the focus of the class toward the students, as autonomous and curious practitioners-in-training. Structuring learning in this way is supported by research into design cognition, such as the notion of "reflective practice" (Schön, 1979, 1987). The reflective practitioner is one who can think and re-think their plans while acting, and thus can respond to the uncertainty, uniqueness and conflict involved in the situations in which designers (and other professionals) practice. Important to Schön's argument is that the knowledge required to know how to act is learned through intentional and critical practice, i.e., the repeated act of placing one's self in a situation in which they are required to make design decisions. Studio-based education is the pedagogical formalization of that notion, with a focus on repeated learning-by-doing, interspersed with feedback and reflection. The goal of design studios is to building the critical and tacit knowledge required to become a reflective design practitioner (Kuhn, 2001).

In the last few decades studio-based education has found purchase beyond the traditional design domains where it was dominant throughout the twentieth century. Successful applications have been applied throughout STEM (Kuhn, 1998; Adams et al., 2003; Reimer and Douglas, 2003; Carvalho and Saunders, 2018), in part because of the expanding attention on design thinking as a general model for solving under-specified problems involving people (Cross, 2011). As the scope of human-centered design has expanded to include interactive products and services of all kinds, the design studio has followed, and now forms a core component of design programs with focusses as diverse as game design, medical device design, information visualization, and visual communication.

While there is much potential in this approach, the design studio model is uniquely ill-suited to the modern university context of ever-expanding classes and ever-shrinking teaching budgets. Design studios are extremely expensive in terms of face-to-face time, and require a high level of educator expertise, not just in the design domain in question but in the practice of studio teaching itself. It does not, at least in its original conceptualization, permit easy scaling nor lend itself to educational technologies. This paper reflects on how elements of the studio model that would be familiar to our students—open-ended learning, self-directed learning, and peer learning in particular—might be applied to teach programming in a scalable, blended way.

2.3. Open-Ended and Student-Led Teaching

Open-ended learning, which has its roots in constructivism, refers to "processes wherein the intents and purposes of the individual are uniquely established and pursued" (Hannafin, 1995). It involves individual students having autonomy in determining what to learn, and how they learn it. This definition is by necessity broad, as the very essence of this approach requires that there is not one correct way. Arguably the main difference between open-ended learning and more traditional directed methods, is that students are at the center of the learning process (Land and Hannafin, 1997).

Open-ended learning is based on premise that effective learning involves fitting new information together with what students already know (Bada and Olusegun, 2015). It is also related to the idea that learning is affected by context, as well as by students' beliefs and attitudes (Bereiter, 1994). This paradigm views teaching as a process that helps learners to create knowledge through interactive, engaging and authentic learning experiences. Taking inspiration from constructivist theories, Chickering and Gamson (1987) published ta well-known set of principles for effective open-ended learning environments in higher education. They included the encouragement of both student-student and teacher-student co-operation, active learning, prompt feedback, high expectations, and a respect for functional diversity.

These open-ended principles have been integral in drawing attention to good teaching and learning practices (Vaughan et al., 2013), although primarily they have been used in face-to-face contexts. In HCI education specifically, these principles have been manifested through studio-style teaching which emphasizes student autonomy, collaboration, creativity, curiosity, and student-led feedback (Reimer and Douglas, 2003). On the other hand, programming education tends to focus on learning transferable skills through various kinds of problem-solving (Carbone and Sheard, 2002; Rajaravivarma, 2005).

Open-ended learning has been adopted in programming education (Carbone and Sheard, 2002; Blikstein, 2011), typically with a focus on computer science and software engineering students. Collaboration is often a key part of open-ended learning, and existing research has sought ways both pedagogical (Emara et al., 2017) and technological (Troussas et al., 2020; Emara et al., 2021) to support and sustain collaboration amongst teams of open-ended learners. Computational approaches to analyzing and grouping students, however, have largely been studied in the context of tasks in STEM with clear right answers: assessing collaboration styles and assigning appropriate tasks in creative design contexts is significantly more challenging. We are not aware of significant research to date on how these open-ended methods can be applied when teaching programming to non-STEM audiences, such as to students of interaction design. Our design students have existing familiarities with open-ended and collaborative ways of learning, and it's possible that their expectations and outcomes will differ.

Student-led or peer learning is a closely related strain of experimental pedagogy to open-endedness. In student-led teaching, the design and/or conduct of some learning activities is given over to one or more students, who lead their peers in (usually collaborative) learning (De Volder et al., 1985). This has been shown to increase learner engagement and achievement in some settings (Casteel and Bridges, 2007), particularly when involving students from under-represented groups (Rohrbeck et al., 2003). Student-led teaching can be demanding (Robinson and Schaible, 1995), but it benefits both the student-teacher and the student-learners. The "protégé effect" is the common name for how teaching something forces thinking critically about one's own understanding of it (Chase et al., 2009). Peer learning can be considered an extension of active learning, in which learning-by-teaching is an extreme form of learning-by-doing.

It should be noted that open-ended, student-led and self-regulated approaches to learning are well known not to always work for all kinds of students all the time (Land, 2000). Students sometimes retain prior misconceptions, fail to sufficiently monitor and self-regulate, or engage only shallowly, without analysis or self-reflection. Land refers to this as the "metacognitive knowledge dilemma," the problem of monitoring learning in the absence of domain knowledge. It's a fundamental principle of constructivist approaches to learning that effective educators extend students' capability by framing new knowledge in ways compatible with those students' existing understanding (Vygotsky, 1930–1934/1978). From that perspective it is then unsurprising that removing the educator from the process can lead to worse outcomes for some students, particularly those who require more support. It has been recommended that open-ended learning environments, particularly those rich in content, incorporate organizing frameworks to help guide learners' metacognitive strategies and make their progress through the content explicit (Land, 2000).

2.4. Blended Learning

Blended learning is an innovative pedagogical approach to learning that seeks to use technology to improve the differentiation of instruction according to student needs and the facilitation of student interaction (Huynh et al., 2016). A common misconception with blended learning is that it is the transposition of physical classes transferred to a digital space. When misapplied, blended learning can leave students unengaged and isolated (Logan, 2015). According to Paniagua and Istance (2018), a blended learning environment utilizes technology to improve certain teaching and learning practices in order to focus more time on making the physical classroom more interactive, and the digital classroom more connected. Blended learning can make rapid, unscheduled shifts in the format of teaching (such as in response to public health orders instituted during a pandemic) simpler to facilitate (Nielsen, 2012).

Horn and Staker (2014) outline that in order for any learning environment to be effective, it must be student-centered. Student-centered learning is closely related to open-ended learning (see Section 2.3) and is defined as an instructional approach in which students influence the content, activities and pace of learning (Froyd and Simpson, 2008). This is consistent with constructivist approaches to learning, i.e., where students have the skills and opportunities to learn independently and from one another (Wilson and Lowry, 2000). Technologically facilitated flexibility in the time, place and pace of learning allows students more opportunities to influence the way their learning happens (Nassrallah et al., 2018).

Blended learning is often discussed in the context of facilitating active learning, learning activities that encourage students to "seek new information, organize it in a way that is meaningful, and have the chance to explain it to others" (Bransford et al., 2000). This form of instruction emphasizes interactions with peers and tutors, with a focus on applying knowledge and receiving rapid feedback (Freeman et al., 2014). Placing students at the center of learning promotes a learning environment that is more amenable to the metacognitive development necessary for students to become independent critical thinkers (Bransford et al., 2000). Critical thinking skills are crucial in the development of both successful programmers and designers (Jeong, 2017), making their encouragement central to quality HCI education.

3. MATERIALS AND METHODS

We present a reflective account of our iterative design process over the course of the project, supplemented by a summative thematic meta-analysis of the student experience as observed through over 60 interviews. The project consisted of three cycles of prototyping, evaluating and reflecting on our intervention, with each cycle yielding its own insights that may inform future projects. Education researchers might be most comfortable framing this iterative approach as action research (Armstrong, 2019), with each cycle being an opportunity to act with and then observe the students and teaching team. By contrast, HCI researchers might conceive of it as research-through-design (Zimmerman et al., 2007), with each cycle being an opportunity to iteratively refine and reflect on the intervention itself.

The truth, as with all interdisciplinary research, is likely in the middle somewhere—we contend that both apply equally here. To that end we describe our process as three iterative cycles (in the tradition of action research) of each of three processes: prototyping, evaluating, and reflecting, although (in the tradition of research-through-design) these are never as linear or separable as they might at-first seem. Each cycle contains one or more classroom-delivered prototypes, designed to build toward the project's goals, one or more periods of rich student-centered evaluation (typically thematic analysis of interviews and/or content analysis of platform data), and a series of reflections on the efficacy and implications of those prototypes and their analysis, in the tradition of reflective practice (Schön, 1979). Activities within each cycle typically occurred in parallel, and were undertaken by our interdisciplinary team of researchers and educators, including some graduate students who were both. Each cycle spanned approximately a year, or two semester-long iterations of our design programming course.

The design insights gained from each cycle of the project's life come from reflections of the educators, system designers and researchers—three groups that have significant overlap. Since 2018 the project has been the focal point for five undergraduate honors theses, each a 1-year interaction design project exploring and building on an aspect of the CCCs platform. All of those honors students have also been part of the teaching team, forming a unique coupling between teaching practice and research. HCI is one of the few domains where it's possible for there to be so much overlap between the developers of an educational technology, the front-line educators using it, and the researchers evaluating it. That integration was a significant strength for the CCCs project and one that we recommend that future HCI education innovations adopt.

The contributions presented in this paper are derived from a union of practice-based learnings (grounded in the experience of making and using the CCCs platform in the tradition of research-through-design) (Zimmerman et al., 2007), with ethnographic data (from a meta-analysis of over 60 interviews with students across the project's life). From these data we synthesize principles for how best to design for open-ended learning among HCI students in future.

3.1. Overview of the Creative Coding Challenges System

Running from 2018 to 2021, the CCCs project unfolded in three cycles: prototyping in 2018/19, adapting to an all-online environment in 2019/20, and finding a hybrid remote/face-to-face balance in 2020/21. Each cycle started with a set of goals, proceeded to design and development, in-class delivery, evaluation through interviews and platform data, and then reflection. The course is introductory programming in p5.js (McCarthy et al., 2015), taught to both graduate and undergraduate students in their first years of design programs.

The undergraduate course contained 250–400 students and ran once per year, while the graduate course is smaller (30–90 students) and ran every semester, for a total of over 1,250 students. Students approximately evenly split between Australian domestic and International students from all over the world, predominantly Asia. The undergraduate students were mostly (more than 95%) enrolled in an interaction design focused Bachelor's program, while the postgraduate students were enrolled in similarly-focused Masters or Postgraduate Diploma programs. Gender balance was approximately 55% female, 45% male, and <1% non-binary.

The initial design goal was a platform where students could both complete open-ended coding challenges as well as design and submit their own challenges for their peers to complete. Coding challenges were envisaged as extension exercises to help students apply their newly gained skills to creative problems of an appropriate skill level. Making new challenges was conducted as a form of self-directed learning in which we asked students to "create a challenge that would have helped you to learn something that you struggled with in the first 8 weeks of this course." We refer to this approach as "retrospective self-directed learning" (RSDL) and intended it as a way to trigger the protg effect and encourage mastery (Chase et al., 2009). Particularly high-quality student-authored challenges would be included in the platform in subsequent years in an asynchronous instance of student-led teaching. As originally envisioned, students would need to both complete and create challenges for grades in the course as part of an innovative social learning network (Carvalho and Saunders, 2018).

The first cycle of the project, detailed in Section 4.1, spanned 2018 and the first half of 2019. The team focussed on a user-centered approach to getting a minimal viable prototype (MVP) into classrooms, starting with technology probes (Hutchinson et al., 2003) and user interviews. The second cycle spanned the last half of 2019 and the first half of 2020, which would by necessity prove to be a turning point for the project (see Section 4.2). The UI was overhauled and a challenge recommender system developed, and then project pivoted to a platform for fully online learning in response to the COVID-19 pandemic and the closure of university campuses. The third cycle (see Section 4.3) expanded on the (somewhat rushed) transition to a fully online learning experience, exploring how to support remote learning through both formally assessed and informal peer learning experiences.

3.2. Thematic Meta-Analysis

We conducted interviews with staff and students as part of each of the three cycles of research, using thematic analysis to explore the impacts of our intervention. Each of these analyzes was contained within a particular research project, often led by an honors student, with its own specific aims, research objectives, and coding scheme. These varied qualitative perspectives all contributed to the iterative re-design of the CCCs platform, but we also wanted a broader and more unified perspective. At the conclusion of the project we conducted a meta-thematic analysis (Batdi, 2017) to explore the underlying student experience of blended open-ended learning in this context. To do this we revised, coalesced, and expanded the initial codes, sub-themes and themes from each of the studies conducted over the course of the project.

The goal of this meta-analysis (see Section 5 for the results) is to explore—independent of all the design revisions, new features, and pedagogical changes—the impact of open-ended and student-led learning on design students learning to program. The meta-analysis sits alongside the insights about open-ended learning that arose from the research-through-design process. The triangulation of multiple data sources, multiple collection methods, and multiple researchers (Campbell and Fiske, 1959) across the three research cycles, coupled with the process of the reflective meta-thematic analysis gives us a rich perspective on the complexity of student experiences (Banning, 2003).

4. ITERATIVE DESIGN OF THE CREATIVE CODING CHALLENGES SYSTEM

The Creative Coding Challenges platform was developed as a way to explore open-ended learning, blended learning, and student-led learning pedagogies in an HCI context. The platform's iterative design and development can be characterized as occurring in three cycles, each with its own goals, design revisions, and evaluations.

4.1. Cycle 1: Discovery and Prototyping

The initial (2018–mid 2019) phase of the CCCs project combined early probes into how the intervention could be structured with our first full-semester deployment. The initial probes in 2018 were accompanied by a process of stakeholder interviews exploring how students and teaching staff responded to open-ended, student-led, and blended learning. The first design and development cycle in early 2019 was focused on delivering an MVP for classroom use as quickly as possible. This was followed by another round of student interviews, this time to explore responses to the MVP. The broad findings of this cycle were that a) the challenge-based blended learning approach was valuable for extension material, b) asking students to create challenges was an effective learning activity, and c) offering students a choice of what extension challenges to complete was confusing, and tended to result in some students doing everything and the rest doing nothing.

Our student cohort was familiar with blended learning and creative coding approaches from the unit's existing learning activities, but we wanted to understand how they would respond to a more open-ended approach. Before developing a fully implemented platform, we first ran two small technology probes as part of our prototyping phase to validate our design concepts and obtain qualitative feedback from fifteen student interviews.

In the first probe, approximately 250 students used a simple web interface to complete three Javascript creative coding challenges in a single 2 h tutorial class. In this probe the challenges were conducted in order, with no branching or choice. The structure of challenges themselves would be familiar to anyone who has explored the web for software development tutorials: a blog-like rich media article with in-line editors in

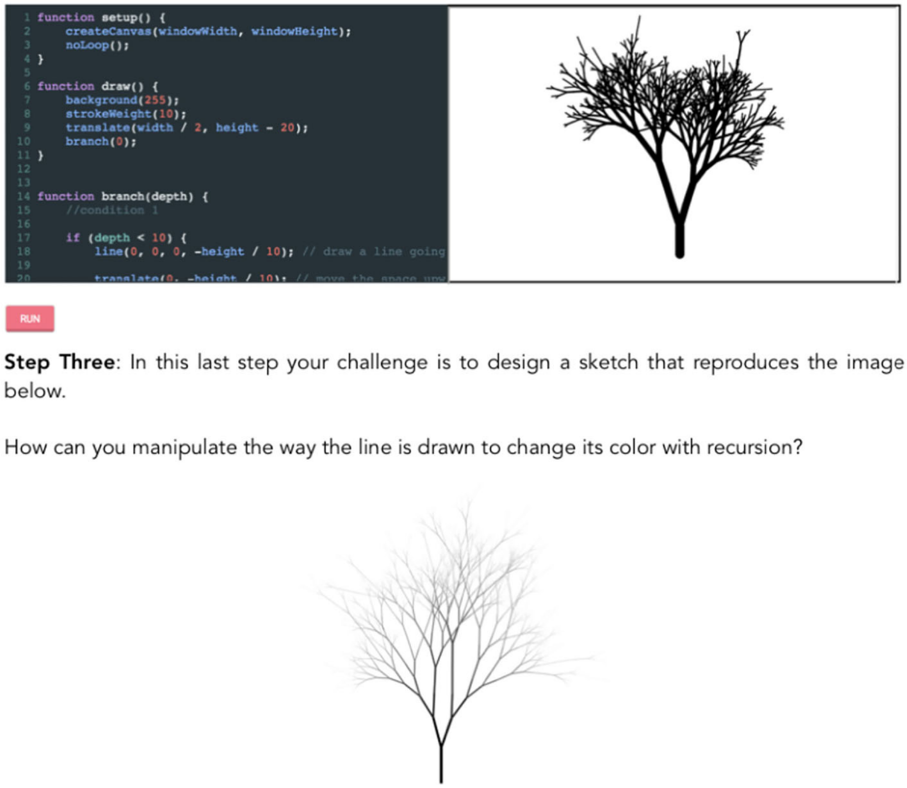

FIGURE 1 | An example challenge from our initial tech probes. Apart from minor advances to the editor (e.g., console access, stack traces) and some cosmetic updates, the structure of each challenge's page remained largely unchanged throughout the project.

which code could be written, saved, and run. See **Figure 1** for an example excerpt, in this case a challenge about learning recursion by drawing and styling a tree.

The second probe was conducted toward the end of the skills-focussed component of the class, before the pivot to project work for the final few weeks. In this probe the same cohort of 250 students were given choices as to which challenge to complete next. We employed a tree-like structure (seen in **Figure 2**) to show dependencies between challenges, ensuring that students would complete required prerequisites before moving on to more advanced concepts. Challenges were separated into a "trunk" of mandatory challenges with a branching series of optional "leaf" challenges for students to complete at their discretion.

Two rounds of semi-structured interviews were conducted, in order to evaluate these prototypes, one after each probe was used in-class. Student participation in the interviews was voluntary, conducted by researchers who were not in the face-to-face teaching team, and expressly disconnected from any suggestion that participation (or lack thereof) would impact grades. The first round focused on the challenges themselves, how they felt to do, what was fun, what wasn't, as well as how students searched for supplementary material to complement in-class activities. The second set of interviews (administered to a non-overlapping subset of students) focused on choice: how and why students chose to do the subset of challenges they completed. A speculative question concluded both sets of interviews, asking how the student would feel if a lot more of these challenges had been in the course, with the option to choose which ones to complete.

Students loved the challenges themselves, particularly the ones with clear multi-step instructions and well-crafted scaffolding. Opinions on open-ended learning were broadly positive but with some dissenters: perceived benefits included autonomy, more productive time with teaching staff, and increased engagement. Perceived disadvantages, however, included worries about whether their sub-set of challenges would be comprehensive, how much access to tutors they'd have if the course was heavily "blended," and how much motivation students would have to do anything that wasn't mandatory. Clearly just a taste of open-ended learning inspired both joy and fear.

We also implemented our first RSDL assessment, with 180 students in a follow-up course being asked to create a coding challenge that would have helped them learn a fundamental coding skill (like arrays or objects). Our hypothesis was that the protégé Effect would help solidify their knowledge, while simultaneously giving us a source of new, diverse content for our platform. The students performing this task had all participated in the two "probe" workshops in the prior semester. An additional round of (seven) interviews was conducted to

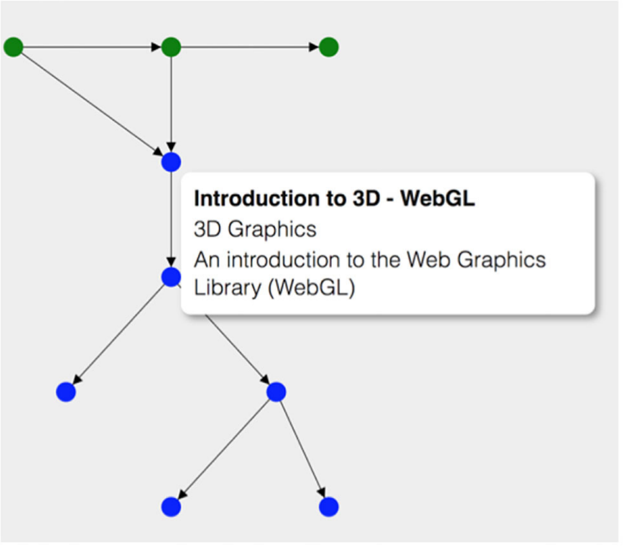

FIGURE 2 | The challenge "tree" used in the second 1-week technology probe that was the fore-runner for the CCCs platform. Mandatory challenges are in green, optional in blue.

explore the impact of this self-directed learning-by-teaching exercise. These questions focused on why students created the challenge they did, why they felt it would have helped them learn, and how they would feel if their work was used by other students.

The response among these (admittedly self-selecting for an interview) students was overwhelming positive, with the vast majority saying they'd created a challenge involving something they themselves had struggled to learn, that they had learnt more in creating it, and that they would feel positively about other students completing their challenge in the future. Of particular interest was the sense of "relatedness," or shared struggle: students making challenges felt that future students would "come from the same head space," or "understand [their] pain." However, the majority of the actual challenges produced by students were not of high quality, mostly lacking in appropriate scaffolding and/or being so disjointed from the course content that they could not have been used. Nevertheless, the benefit to their creators was apparent.

Following the success of these probes, we reflected on the feedback in the interviews to implement the first full version of the CCCs platform in the first semester of 2019. This first complete design had two main goals: to collect some survey data that could be used to improve the challenges, and to provide a whole semester of examples to the students creating challenges in the subsequent course. The branching "tree" interaction model was shelved for simplicity, with all challenges being presented as lists under each week, in approximately ascending order of complexity. After completing each challenge, students were asked to rate (on a five-point Likert scale) its level of difficulty and their level of enjoyment in completing it—this feedback let us quickly identify and revise challenges that were boring or too hard.

4.2. Cycle 2: From Blended to Online, Overnight

The second cycle spanned the last half of 2019 and the first half of 2020, which would by necessity prove to be a turning point for the project. The first goal of this cycle was to expand upon the MVP, both in terms of its interaction and educational design. A prototype educational recommender system was also deployed to assist students with their confusion about what challenge to do next. The second goal was to explore the quality of the student-created challenges and add our first batch of student-created content to the platform.

Interviews throughout the cycle evaluated student motivation to do challenges beyond the minimum required, finding (as hoped) that some students were intrinsically motivated to do additional creative coding tasks. However, other students were still struggling to find their footing, and a fraction of students were obsessively doing every possible challenge to ensure they didn't "miss out." At this time we started realizing that choice—the goal of our open-ended and challenge-based approach to the course—was a double edged sword, creating empowerment for some students but anxiety for others. Understanding the cause of this bifurcated experience and figuring out how to support choice positively became a major focus of the project.

The CCCs platform was deployed to around 95 students in the second half of 2019 with a fully re-worked user interface, which can be seen in **Figure 3**. This revision focused on bringing the interface to the professional standard expected by students familiar with the modern web—a task made possible by the fact that the teaching and research teams included professional interaction designers and web developers.

We also prototyped an educational recommender system (Bodily and Verbert, 2017) intended to provide support for those students having difficulty choosing which challenge to complete next. This used a hybrid knowledge-based and item-based recommendation approach (Ricci et al., 2011), combining data about students with data about challenges. The introduction of a recommender system brought aspects of guided learning models to our open-ended model, but it retained its open-ended nature as engaging with the recommendations was always voluntary. Metacognitively-aware personalisation is an established strategy in learner modeling (Bull and Kay, 2013), and has been applied in intelligent tutoring (Roll et al., 2007), and adaptive assessment (Krouska et al., 2018) in addition to content (Hidayah et al., 2018).

The logic for our recommendations, which appeared in a banner at the top of the UI, was as follows: If there was a mandatory challenge that had not been completed, the recommender would always suggest that first. This caught most of the disengaged or truly struggling students, who would be best served by engaging with something introductory (or, most likely, working on simpler exercises given out in class before tackling the challenges). If not, the system would use the number of challenges the student had completed as well as their average difficulty and enjoyment ratings to place the student into one of two categories: "striving," or "thriving."

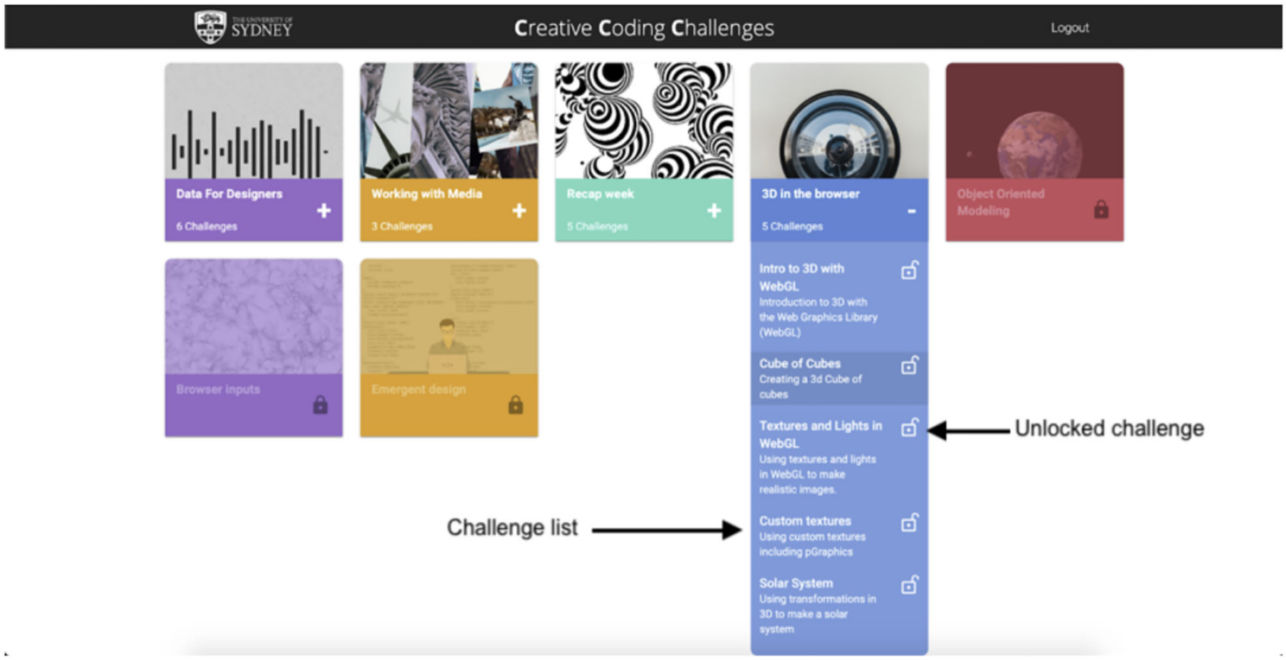

FIGURE 3 | The second version of the CCCs platform interface, showing challenges grouped into "modules," each corresponding to a week of the course.

"Striving" students, those who had rated challenges more difficult than average, were recommended challenges that contained topics that were precursors to those in their most recently completed challenge. A directed graph of programming topics and their dependencies was constructed from the challenge tags to support this. For example, understanding loops depends on understanding conditional statements, and understanding vector-based character movement depends on understanding both arrays and co-ordinate systems. By contrast, "thriving" students, or those who had rated challenges less difficult than average, were instead recommended challenges that similar students had enjoyed, a collaborative filtering approach based on the Singular Value Decomposition algorithm (Su and Khoshgoftaar, 2009). The goal was to try to empower those who felt that choice was an opportunity, while offering support to those who found choice anxiety-inducing.

12 students and six tutors were interviewed during this cycle, primarily to establish the effectiveness of the recommender system, but also (in the case of the students) to continue exploring how they choose challenges and what improvements they might want in the platform. A thematic analysis was conducted on both cohorts together, with ideas around progress, difficulties, communication and motivation emerging as important factors to both staff and students. The vast majority of students were positive about the CCCs platform and its challenges, for reasons that can be broadly characterized as a preference for active learning (Freeman et al., 2014). "Striving" students (we obtained permission to retrieve each interviewed student's record from the platform) worried that there were things they were missing, and often found challenges to not explain concepts in sufficient detail: they needed more basic learning material than the recommender could provide. "Thriving" students were more likely to view the recommendations positively, but found that there weren't enough truly open-ended challenges in the system yet, and so opportunities for truly serendipitous discovery were limited.

A significant fraction of students did not trust the recommendation system's ability to teach them what they would need to pass the unit, and didn't see how its suggestions would directly lead to improved grades. Interestingly, a number of students in both categories also wanted to re-do challenges as revision, which the team had explicitly excluded from recommendations. The recommender had helped start to address the gap between those empowered by and fearful of choice, but (and this attitude was prominent in both tutors and students) there was still clearly a need for structured, teacher-led learning. The challenges, even the mandatory ones, could only build on top of that.

Also during the second semester of 2019, the first class of students who had used the full CCCs platform completed the RSDL task in the follow-up course. In-class observation and informal discussion revealed that this cohort of students also found the learning-by-teaching component of the task helpful for reinforcing their knowledge. A small number of student submissions—six in total, out of almost 180 submissions—were judged to be of sufficient quality to be incorporated into the CCCs platform after significant editing. These challenges were labeled as "student contributed," and our intent was to continue iterating on this formula year-on-year. We planned to refine the recommender system, continue working on how to empower student choice without triggering anxiety, and to keep integrating exceptional student-contributed challenges.

It was at this point, however, that the COVID-19 pandemic forced the course entirely online, and the role of the CCCs platform—as well as the scope of this project—changed significantly. Instead of a platform for what were effectively "extension" exercises, CCCs had to become practically the whole course, supplemented only by pre-recorded lectures and video-conference tutorials. The notion of a "challenge" expanded overnight to cover all tutorial exercises, which ran counter to some of our findings but was the only feasible way to run the course during the crisis. In addition to its enormous impacts on the mode of delivery, it also had resourcing impacts, as in the rush to pivot online, further developing the recommender system was not feasible and that component of the project was shelved.

It was always our intention that the research questions would evolve as demanded by both the needs of the classroom and the capabilities of the technology. However, the unexpected pivot to fully-online learning caused our research to diverge to a degree that we could not previously imagined. We were no longer able to really assess (either qualitatively or quantitatively) whether our year-on-year refinements were delivering improvements to the student experience, because the contexts were now so inconsistent with each other that such comparisons were meaningless. COVID-19 also impacted the quantity and quality of available challenges: instead of refining our open-ended creative challenges and adding a few exceptional student contributions, we had to rapidly shift the entire course online. However, this offered a unique opportunity to study a different question: how could we design effective open-ended and student-led learning in a fully remote context?

4.3. Cycle 3: Pivot to the Protégé

The third cycle was all about consolidating the use the CCCs platform as the main focal-point of the course. We remained in remote-only mode for the second half of 2020 before returning to a hybrid model with some face-to-face classes in the first half of 2021. Throughout this cycle we focussed on further support for remote students in the form of pair programming for open-ended creative challenges, with very positive feedback. RSDL was also implemented within the programming subject itself, rather than as a component of the next semester's follow-on subject, to highly polarizing feedback.

Our experience rapidly pivoting online taught us that much more structure was needed for effective remote-only learning. To address that we abandoned the recommender system, which was at its best extending in-class learning, since we now had to focus on the course as whole. The "tree" structure from the first cycle was re-introduced in a new UI. Each week of the course starting with a pre-recorded lecture, then a tree of challenges, some introductory (and mandatory), and some more advanced, creative, and optional. This interface, which was used throughout the third cycle, can be seen in **Figure 4**.

By the second COVID-affected semester we had made the decision to pivot away from the notion that students could choose their own path through the challenges by branching out in directions that interested them. This "open-ended direction" approach proved both difficult to support in remote-only learning and difficult for students. As the platform now featured "challenges" for every tutorial exercise rather than just extension material, the ratio of mandatory-to-optional challenges increased substantially. With the role of the platform as a place for open-ended extension material no longer clear, the proportion of students perceiving the platform's open-endedness as anxiety-inducing increased. The open-ended tasks where students could choose how to solve a proscribed problem, however, were still among the highest-rated challenges on the platform. This suggested that the "no right answer so long as you make something intereting" task structure inspired by creative coding was still viable in remote learning contexts.

We also developed additional scaffolding for the RSDL task in the form of a walkthrough to help students create their own challenge. This approach framed the task as making a "puzzle," the solution to which required understanding something something about one of the concepts in the course (e.g., arrays, objects, nested loops, etc). This framing—which we had used internally for a number of the well-regarded challenges—was developed through a series of co-design workshops with students and then evaluated in focus groups after students had submitted. Student responses to the scaffolding were very positive, although still only a fraction of student-submitted were of sufficient quality to be included.

By 2021, with about half of our students back on campus, it was clear that students were experiencing significant anxieties during remote learning. A prominent source of student anxiety appeared to be how their emerging grasp of programming concepts compared to the course's expectations. This was true among both in-person and remote students, but stronger among those not coming to campus. To explore this we conducted 39 interviews exploring students' satisfaction with the platform and course as a whole, the latter to capture some of the sentiments around learning during the pandemic. The major findings were that students needed more connection, they needed more support, and they needed more motivation. It was clear that learning programming, which was an unfamiliar discipline for many of our design students, was an isolating experience.

To address these needs we developed a remote, creative-coding focussed version of the pair programming approach (Wiebe et al., 2003) and piloted it in several tutorials. The pilot was intended to add elements of peer learning (van Popta et al., 2017) to our unit, a familiar experience for design students used to working in creative teams. The goal was to introduce programming in pairs as a middle-point between the tutor-led walkthroughs of material and students working individually. This created a three-layer "I do it, then we do it together, then you do it yourself" approach based on the notion of gradual release of responsibility (Pearson and Gallagher, 1983). Students conducted these pair programming sessions remotely, completing creative coding challenges together using video-conferencing (Zoom) and a collaborative visual workspace (Miro) to structure their challenge responses.

Five interviews were conducted with students who participated in the pair programming pilot, with a thematic analysis revealing that the process had helped them overcome

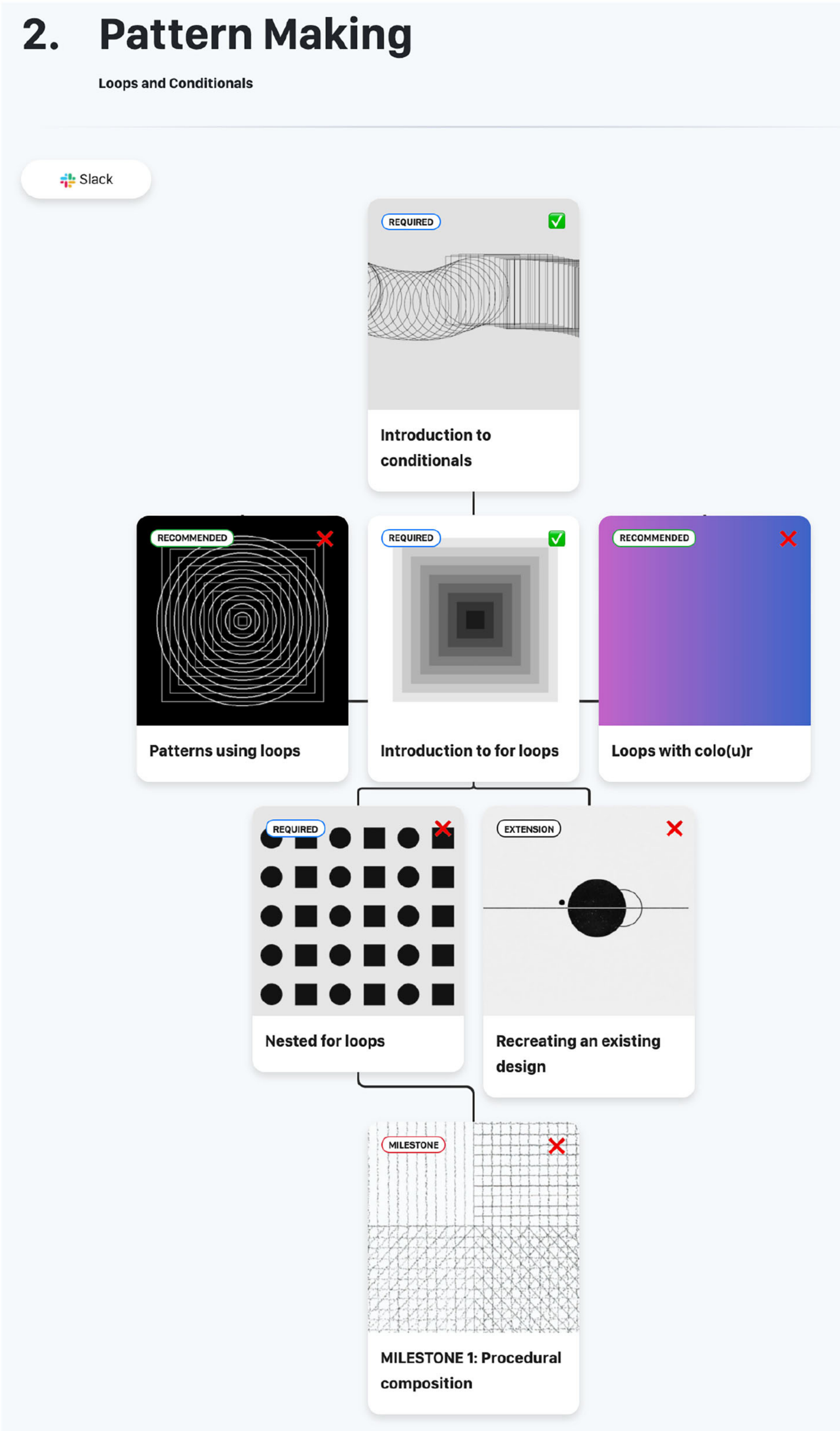

FIGURE 4 | The final UI used in the CCCs system, after the pivot to fully remote learning. By this point the notion of "challenges" had been expanded to cover all learning activities, not just open-ended extension material.

isolation, develop better coding self-efficacy, and be more pro-active with their learning. These social benefits of remote pair-programming were actually more universal among the interviewees than the benefits traditionally associated with the method (i.e., learning from each other and holding each other accountable). Most existing studies of pair programming were face-to-face, which suggests that an additional benefit of pair-programming for remote and isolated cohorts is the simple opportunity for much-needed socialization.

We also moved the RSDL task into the programming unit itself for the first time, with students in the last few weeks of the course creating a challenge that they personally would have benefitted from earlier in the course. Even though this exact assessment had been completed as a "refresher" in the first few weeks of the next semester's course for 3 years now, this particular version produced very different results.

The integrated RSDL task was the single most polarizing assessment any of our teaching or research teams had ever seen. Students either absolutely loved it, saying things like "I found it was a turning point in my learning where I actually could freely explore" or utterly hated the very idea of it, saying things like "in industry they pay us for our work, we don't pay them!." Five students were interviewed about their experiences with the RSDL task, with another seven offering anonymous feedback via a survey. One particularly negative group of responses exhibited the sentiment that students felt they were not getting their money's worth: they felt that asking them to teach was asking them to do our jobs for us. One hypothesis is that the student-led teaching exercise may have become a trigger point for broader student concerns about the value-for-money of remote education, particularly among students who also expected a more traditional mode of delivery.

In fact, the detractors of the "create a challenge" task were almost entirely remote students studying from overseas due to the ongoing pandemic, while the supporters of the task were almost all in the face-to-face tutorials. Language issues may have also played a part, as a portion of students appeared to misunderstand the task and produce a completed puzzle without any scaffolding or steps. Several of those students became hostile when they received poor marks for these submissions, asking why they should have to break their work into "baby steps" to help other, struggling learners. To speak freely for a moment: an actual flame-war broke out between supporters and detractors of the assessment on the class discussion board, complete with an ugly undercurrent of anti international-student sentiment. None of us had ever seen anything like it—and it underscores the challenge of effective open-ended learning in diverse student cohorts.

5. RESULTS

The thematic meta-analysis of interviews conducted throughout the life of our project revealed student attitudes toward open-ended blended creative coding fell into seven broad themes: *learning as a skill*, *learner technology*, *learner autonomy*, *social learning*, *learning support*, *content complexity*, and *learner struggles*.

5.1. Learning as a Skill

In tertiary education, particularly in HCI, a more student-centered approach to learning is encouraged. This means that instead of instilling knowledge into students, we as educators facilitate their learning by giving them the tools to develop their own learning strategy. **Table 1** shows the sub-themes that made up this theme. The CCC platform encouraged students to build their metacognitive learning skills through a more reflective and introspective approach, with students agreeing that the questionnaire at the end of each challenge allowed them to *"really reflect"* on how much they have improved. This reflection also allowed students to see the benefit of this subject outside the scope of semester, *"in this course I feel like I'm investing into learning a new skill."*

The ability to reflect on one's work also had an interesting impact on students' desire to push themselves, one student admitted that "*It was ok for me not to finish the advanced challenges*" because *"I know I pushed my limits and can see that it was my best attempt."* Students also acknowledged the difficulties faced working independently, *"I struggled a lot working through some of the assignment challenges by myself"*. But upon reflection, one student observed that *"I'm glad I struggled on my own... even though I felt so stressed during that time. It helped later, just because you knew you had to struggle for it"*. The initial difficulty of the challenges seemed to encourage students to develop their own protocol for solving them, with students being able to reflect and *"identify their own weaknesses"*, and prioritize accordingly.

5.2. Learner Technology

Unsurprisingly, the technology that facilitates learning for students significantly mediated their experiences, as reflected in our interviews (see **Table 2**). The CCC platform was initially designed to be used in partnership with physical tutorial classes, however, due to the COVID-19 pandemic, online learning resources were prioritized far more than originally planned. This resulted in pandemic-affected students describing the online tutorials and CCC platform as only *"somewhat interchangeable"*, with others describing how they *"couldn't get enough information from the [CCC] platform to do challenges by themselves"*. This physical/online learning disconnect was further exacerbated by some innate limitations of online learning whereby the restrictive nature of a virtual classroom *"doesn't allow [students] to feel comfortable asking questions"* with one student noting that they *"don't trust who they don't know - why would I want to talk to my peers or tutors if I haven't met them?"*.

This negativity was in stark contrast to our pre-COVID data collection, where students often expressed comfort seeking clarification or help, stating, *"I do not have an issue calling a tutor over or messaging on slack, I feel quite supported in that regard."* Despite these limitations and the challenges of pandemic-impacted semesters, students did discuss how motivating and impactful the CCC platform was. P5.js artworks are *"really inspiring"* for students, and immediate visual feedback *"drives [them] toward a goal"*. During scenarios where the challenge outcome was not clearly communicated, students expressed frustration, stating there's *"no answer for us to know what our goal*

TABLE 1 | Sub-themes within the "Learning as a Skill" theme.

Sub-theme	Example quotes
Learning Reflection	...you have to actually like to rate how you felt about that particular challenge and whether you liked it before you can move on. And I think it also has that kind of reflective aspect to it, which I guess most other courses don't really do. yeah well now that we're week 11 or 10 or whatever and now I look back to when it was week 2 and I'm like "you have no idea." I appreciate being able to reflect on my process, a motivator for sure.
Proactive Learner	I feel like, I'm glad I struggled on my own, even though, like, I feel so stressed during that time. Because it helped later, just because you knew you had to struggle for it, and you had to go really deep, maybe outside of traditional resources to understand how to solve the problem. In that time, I might have worked through it myself, maybe that's a good thing. But also, it's like, it's helpful to have that help as well.
Value of Learning by Doing	I really like how there's the structure, they introduce, you know, maybe a few features or a few functions and whatever, and then you put them into practice straight away. I like the way that the lectures are broken down into challenges like we're not sitting there looking to learn about theory, like we are doing something practical. I think that's how you learn.
Perceived Future Benefit	In this course I feel like I'm investing into learning a new skill. [Will you use programming after this semester for anything, not necessarily P5, but programming in general?] - Probably. I will...I think for certain I could use this one to design some interesting program for my career or university, so I probably will.
Student Workflows	So that's probably how I study, I identify my own weaknesses based on what I think the quiz will be about. It was a bit daunting at first, but then I started to make myself structure. So now I like drawing out a picture and I've chosen, like, I'm going to draw a sunflower for my final thing. And hopefully as time progresses, it's going to have interactive elements. It is just all about breaking down the elements.
Recognizing Own Competencies	Some of the challenges, I didn't finish them, but I felt good about it, I mean I didn't feel good but like I was relieved that I like it. It was okay for me to not finish "advanced" challenges cause honestly that was really hard for me. If I do my best, I do not care if I don't get a HD because I know I pushed my limits and can see that it was my best attempt, not everyone can get a HD.
Independent Learning	[on learning concepts] by ourselves maybe a little bit helpful is to make sure that everybody understood it It's like I need that hand holding. I need a basis because I feel like I can't build anything from scratch. But I think potentially for the weeks beyond week 6, week 7 when we're getting closer to like the stage now where we're building our own thing, potentially be good to maybe hide that prefilled text so that you can kind of have a go yourself at how you might build it from scratch.

is", and nothing for them to "go back and have a look" to see "how off they are".

TABLE 2 | Sub-themes within the "Learner Technology" theme.

Sub-theme	Example quotes
Disconnect Between Tutorial and Platform	I think the lecture content and the challenges are quite disjointed and don't really help each other. I think they can be incorporated better. I didn't have the knowledge to actually do that one and I accidentally missed the bit where he was explaining it in class, so I was just like, " shit. I guess I just have to submit the not finished one." I didn't get very far with that.
Online Learning Limitations	I just don't like speaking on calls, when there's a lot of people. That's just how I am quite an introverted person. Yeah, I don't find it comfortable to ask the questions. So I honestly just wouldn't ask. When I'm working on the challenge, I'm stuck. Like, I know there are people to ask, but there's 70 people in the one session, so I feel a little bit bad sometimes asking and also, I guess since we're in that zoom group, I can't really go to the person next to me and ask because there's no one there.
Creative/visual Code allows for Instant Feedback	I really liked the method where you can test your code and then you can immediately see the result. I find it helpful when I can visualize what the outcome will be, it is motivating!
What Students Need From Learner Platforms	I like the way that the lectures are broken down into challenges like we're not sitting there looking to learn about theory, like we are doing something practical. I think that's how you learn. If I like the picture I want to do the exercise. If the picture isn't attractive I feel less willing to do the exercise.
Platform Design	I know we have choice, but I still feel I need to follow the structure I think the content on the website (ccc platform) is too limited and maybe more examples would be better.

5.3. Learner Autonomy

Feelings of both autonomy and a lack thereof arose regularly in our interviews with students, as can be seen in **Table 3**. Students had a strong desire for different types of choices. Some students liked the ability to choose what they learnt, *"It's giving the student or myself autonomy and agency to kind of learn core foundational concepts that are essential across the whole unit"*. However, this wasn't a clear majority. When asked whether they felt they had a choice in what challenges they could complete, many students we interviewed expressed that they thought they *"were just required to do everything to do well"*.

Fear of failure was a prominent reason for students not feeling like they had any choice, mostly relating to the mid-semester exam: *"I'll get to the exam and with my luck, the random question will be the area that I didn't choose to learn more about"*. Other students instead appreciated the autonomy to choose how they complete the challenge, rather than what they learn. Students appreciated *"the opportunity to explore and do your own thing"*, noting that *"it's more personal driven, which I like. You get to come up with a design that you imagined, not what was given to you as a brief."*

TABLE 3 | Sub-themes within the "Learner Autonomy" theme.

Sub-theme	Example quotes
Desire for Choice	I like the freedom of choice. Like, you know, if you're not making us do everything, like some people just don't have time or, and some people just want to learn more, so it's up to them.
	It's giving the student or myself autonomy and agency to kind of a learn core foundational concepts that are essential across the whole unit
Inspiring Self-Directed Learning	It's good to have help with other people. But you also need to be challenged individually to go deeper.
	I don't think me and P3 really use the driver thing anyway, we just kind of did it on our own, and worked out how to collaborate and solve problems, all right.
Freedom to Explore	I also like the opportunity to explore and do your own thing, like the challenges in the first week. It's more personal driven, which I like. You get to come up with a design that you imagined, not what was given to you as a brief.
	This is the thing I've already got in mind that I want to do. I already know, I like to come into this class. I have all these ideas and I'm thinking how can I best use this class to realize these ideas? So I'm already gravitating toward things that I think are more relevant.
Feeling Comfortable Being Challenged	Challenging my own thinking around problems that I would have originally just disregarded, that I had solved in the first place.
	There are some things like, I feel like, I'm glad I struggled on my own, even though, like, I feel so stressful during that time. Because it helped later, just because you knew you had to struggle for it.
Satisfaction of Visible Progress	I also like the ability to kind of go back and look at what challenges you've done and haven't because you can't complete a challenge unless you've completed the previous one.
	I think it's just like that bit of representation that this is what we're focusing on now and you'll build up to be able to complete these future interactions, these features concepts, which I think is really encouraging.
Motivated by Marks	To be completely honest. I will only focus on what is testable on the exam
	Just because for me as a student, I want to optimize what will get me the most marks in my limited time. Um, and if I know that the criteria would be like looking at these elements and um, creating a novel idea and if the challenge is related directly back to that criteria, then I would prioritize them first.
Conquering Individual Goals	Well, you instantly fall in love with the challenge that you struggle with at first and then you conquer yourself.
	I think there's a sense of satisfaction in being able to, like solve problems
Sense of Accomplishment	My main motivation is to just get all the greens over here when I finished one challenge and I completed properly. Gives me like what motivation to go to the next one and finish that one too
	[the challenges] the reason why I think is enjoyable is that I am doing what I want to, during this challenge I can feel a kind of achievement or when I can, solve the problem myself.

5.4. Social Learning

Social factors played a big role in student attitudes toward open-ended learning (see **Table 4**). Feelings of isolation and detachment from peers predated the pandemic, seen in sentiments like *"Yeah, no, they [students] don't really help me. I don't know. I don't really know how to ask anyone. I haven't made that sort of connection with anyone yet"*. A fear of judgement by their peers was also present: *"I wouldn't ask a peer to help me cause I would be worried they are smarter than me"*. Students who completed the course during the pandemic definitely experienced enhanced feelings of isolation: *"Just naturally being virtual and away from people, you just don't feel as connected."* When we introduced pair programming to our virtual classroom, students acknowledged that there was a major improvement to learning, *"even just the practice of explaining, or pretending that you know what you're explaining catalyses learning"*.

Students also appreciated the support from their peers, and having someone there they can vent to: *"I think it was nice to, like, mutually support each other."* The online classroom also presented barriers to language accessibility, with some students feeling that *"the context of physical space and classrooms is very important to help us understand English"*. The ability to actively converse with peers also was hindered, with one student expressing a need for *"tutors to teach us how to ask questions"*, with students with English as a second language expressing that *"It's not a problem about listening, it's about talking"*.

5.5. Learning Support

A very prominent desire amongst students was additional learning support (see **Table 5**). This was often expressed through students vocalizing their concern over *"minimal revision opportunities"*. With some students agreeing that *"week to week when you come to class things progress based on what you've learned previously. And if you don't go back and revise and do it, you struggle."* This can be attributed to the issue of autonomy (see Section 5.3), with students feeling that open-ended learning makes it difficult to know what knowledge will be critical in future tasks. Students also expressed discomfort researching additional resources unless promoted or encouraged by the tutor, noting that tutors have a *"sense of authority"* and *"if it worked for the tutor then it should work for us."* This also caused some initial hesitancy with pair programming, with some students agreeing that *"sometimes with students, you can't be sure they are right. With tutors, it is their job, so you trust them more."* Regardless of when students completed the course (pre or during the pandemic), they expressed that access to tutors was something that they really craved: *"one-on-one time with the tutors is absolutely the most valuable thing. Right. But it's kind of limited to class time."*

5.6. Content Complexity

The perception that learning to code is inherently difficult was a common thread amongst the cohorts of students, as seen in **Table 6**). For some, that initial fear deterred them from the beginning: *"I was so nervous coming into this subject, and it just made my experience worse"*. For others, the pace of the course was stressful, with some students surprised that the *"difficulty*

TABLE 4 | Sub-themes within the "Social Learning" theme.

Sub-theme	Example quotes
Improvements to Communication	Some of the tutors' replies will be easy to understand and some tutors' answers will make us more confused. But in the grading standard, the definition of originality is very vague.
Effective Partner Matching	I think if we were on different levels in programming knowledge, that would be frustrating probably for both parties. I think it was nice to, like, mutually support each other.
Learning from Others	I think peer learning is really, really important. Because there's a lot of times where I'm pretty good at something. But others, I just need another perspective. And I can't always just do that in the classroom, because that's spent teaching us like the content and everything.
Encouragement from Peers	Even just the practice of explaining, or pretending that you know, what you're explaining catalyses learning. I am initially quite happy that I get to be mingling with other people, I think because of all the remote learning at the moment. It's nice, just any opportunity to kind of work with others.
Judgement by Others	I asked like on the second of [or] third week, one of the students in like, the explanation was just like, Oh, like how come you don't know this? And so I was like a little bit taken back by it. I feel like when they say ask the general chat in slack sometimes it might be stupid questions.
Willingness to Engage	if I had a question about what they were teaching in class, I would just act straight away. We can divide into groups and work together. I think that will be great for me and can help us. So some questions can be asked and answered.
Language Accessibility	questions to my tutors. But if tutors are explaining to me I can, I understand. It's not a problem about listening, it's about talking. If I just watch the CCC, I cannot code anything, well not anything, but a lot of things that I cannot understand including the english explanation.
Feeling Detached from Tutors/Peers	Just naturally being virtual and away from people, you just don't feel as connected. Yeah, no, they [students] don't really help me. I don't know. I don't really know how to ask anyone. I haven't made that sort of connection with anyone yet, because we only had 3 weeks together. So, it's been difficult.

TABLE 5 | Sub-themes within the "Learning Support" theme.

Sub-theme	Example quotes
Revision Opportunities	[cont.] - because I guess week to week when you come to class things progress based on what you've learned previously. And if you don't go back and revise and do it, you struggle. ("extra challenge" challenges) even if it's not compulsory, I like how it just helps you test your skills more
Resource Availability	[cont.] - If I don't get the idea of why this function works, I'm checking YouTube from the coding train. All students use that. I feel like I don't learn things very well. Right. Um, and I've been struggling to find resources that will help me to just practice.
Trouble Applying Tutorial Content	Ook, to be honest, I don't, I don't love the, um, creative challenges. Um, I don't, I have actually just not found them very useful, especially without guidance, especially out of the context of the classroom. Sometimes it's really exhausting because I can't figure out what to do.
Tutor Accessibility	The one-on-one time with the tutors is absolutely the most valuable thing. Right. But it's kind of limited to class time. But also with this online model, it's a little bit harder to access help. It pushes you toward self learning a bit more.
Desire for Credible/Reliable Sources	Whereas, like I like the sense of authority of you guys, I don't know, I assume you guys thought about the best way to give us this information. [on preference between help from tutors v students] I think teachers, because then you know as a fact that the answer is right.
Establishing Expectations	It'll always be a concern in the back of my head as to how much I'm supposed to learn to do well in the course. I just don't know what exactly the tutor wants and the rating is relatively subjective.
A Boost of Learning Support	[the platform green indicators] I think it's really helpful because it tells me which one I need to work on. So I think if that recommendation model can really guide students into focusing on what's really important, not just for assessments as well, but just in general, like as a designer or as a developer, like what are the core things you need to get right and what are you struggling with and filling in that gap. I think that'd be really good cause I think a lot of students kind of like give up really early with programming because they can't really get the basics. And if you don't get the basics you can't really get the bells and whistles.

increased so much", or that there was not a lot of time to "*reinforce your learning*". This unexpected difficulty was often the cause of students struggling to learn transferable skills, with one student noting that they "*get very confused as to how to apply different techniques*" and that they know "*how it is done, and how it is useful, but if you asked me to use it in a challenge I couldn't.*"

The rapid expansion of the platform's role in 2020 also created some issues around content quality. Students expressed that at times the challenges were verbose or overly complicated, "*why do you need that much text for a challenge that takes a couple of minutes?*". To at least one student the text descriptions that were intended as scaffolding added "*more anxiety than if they weren't there*". Conversely, students suggested that some of the harder challenges "*were not explained at all*", with students feeling like they were "*left in the dark*". Some challenges that were well-received pre-pandemic evoked these responses once the course switched to remote learning, suggesting that the levels of

TABLE 6 | Sub-themes within the "Content Complexity" theme.

Sub-theme	Example quotes
Unexpected Difficulty	[cont.] - the challenge, I mean, uh, in the beginning, in the beginning challenge is easy and uh, I can easily solve it, but the second challenge is just like, look, difficulty improved so much.
	I think it moves, uh, very quickly. Uh, I think all of the challenges are challenging, which makes them very interesting. Um, but I think it would be, um, you there's not a lot of time to reinforce your learning.
Knowledge Confirmation	I feel like we need a way to make sure that we understand, we know what we've been taught.
	Um, maybe the marks we give to each challenge and we can know which we didn't do well, so we can we really again, yeah. And I found that we usually need to ask for a resolution in Slack. Maybe you can after 1 week or something like that. Put the, say the answer. Maybe some of the solutions to each challenge.
Trouble Generalizing Concepts	Um, however, when I get the feedback on the code, sometimes I don't understand the thinking behind what I've done wrong, so I get the change in the code, but I've still gone, wow, I never would've thought of that. I don't know what to do. So I still feel a little bit like I'm not quite learning my own mistakes as much as I do one on one.
	I get very confused as to how to apply different techniques, such as the mapping. What does it mean? I see how it is done, and how it is useful, but if you asked me to use it in a challenge I couldn't.
Fundamental Difficulty of Computational Thinking	I think it depends on the challenge, how difficult it is because in the beginning I thought the basic class was very easy, so just out of class I wouldn't usually use the platform, but after weeks 4 and 5 the challenge became very difficult.
	Some of my friends are finding it a bit difficult, especially because it's the first time doing a programming related unit

scaffolding required for complex and open-ended content is very environmentally dependent.

5.7. Learner Struggles

Lastly, but expressing a critical component of the student experience, particularly among a portion of the cohort, were sentiments relating to the struggle of learning to program (see **Table 7**). In particular, catering for different learning styles presented itself as a major barrier. Some students struggled to adapt to the open-ended and student-led way of learning: *"how am I supposed to determine for myself when I have learnt or done enough to be confident?"* Some felt quite overwhelmed by the freedom: *"I think one of the biggest things for me is like, sometimes I'll get the answer, but I don't think I'm doing it right or in the right order."* A very interesting theme that came to light during the pandemic courses was the cultural learning differences. Students from outside of Australia stated that in previous semesters they could *"pick up the culture a lot quicker, which made it easier to adapt". When learning from their home country however, this was "a lot harder"*.

Open-ended learning was a big adjustment for some international students: *"coming from an Asian learning background, it's been ingrained that like everything that's presented to you is testable."* Other students, mostly those who came from HCI or design backgrounds appreciated open-ended learning, *"I think doing everything online, being forced to do everything online, made it a bit more transparent in different ways that we can learn."* Overall, and regardless of background, study fatigue played a big role in inducing anxiety amongst students, some stating that they *"had had enough"* and just submitted what they had because *"they were sick and tired of getting things wrong"*. Continuous practice seemed to be exhausting for students learning remotely, *"practicing is much harder than normal studying, my brain cannot copeâ"*.

6. DISCUSSION

As a research-through design project paired with a summative meta-evaluation, the findings arising from this research come in two parts: the meta-analysis of our student interviews, and the design insights arising from almost 4 years of iterative interaction design. Here we present both, starting with what we have learned from our students and then putting it all together into a set of recommendations for future open-ended learning in HCI contexts.

6.1. Understanding Student Attitudes Toward Open-Ended Blended Learning

As in any meta-analysis of a long-running project, student attitudes were extremely broad, covering the content, the delivery methods, the teaching team, their emotional responses, their learning needs, and more. Within the seven themes that we identified, however, is a common thread by which we intuit student attitudes toward open-ended learning can be understood: a tension between open-ended blended learning as a source of *empowerment*, and as a source of *anxiety*. Over and over, the same educational innovations produced both responses in different students, and through the lens of our meta-analysis we think we can begin to explain why.

The freedom to self-direct learning was appreciated by some students, and from our analysis we know that those students tended to be more motivated. While we don't know causality of that relationship (did motivation cause open-ended learning to be empowering, or did empowerment cause open-ended learning to be motivating?), we can leverage existing studies of learner motivation to make some educated guesses. The self-determination theory of motivation (SDT) (Deci and Ryan, 2012) is widely used in education contexts (Lavigne et al., 2007) and states that motivation requires autonomy (the capacity for impact), competence (the perception of ability, i.e., self-efficacy) and relatedness (the feeling of being in a community). Our open-ended creative coding model was designed, from the SDT perspective, to maximize autonomy, since it let their programs produce compelling and elaborate visual output that they could directly manipulate in code. Teaching during the pandemic highlighted the importance of relatedness (and its absence,

TABLE 7 | Sub-themes within the "Learner Struggles" theme.

Sub-theme	Example quotes
Start Paralysis	So most of the class I'm left with, like I don't know what I'm doing, or where to start. So that'd be sitting there doing nothing cause I didn't get the beginning part of it.
	Most people don't really understand what you're supposed to do with this challenge because it just shows a static image of what it's supposed to look like. They didn't understand that you loop over the circles and show a different position at each time. So that was kind of confusing
Different Learner Styles	I think doing everything online, being forced to do everything online, made it a bit more transparent in different ways that we can learn.
	Like, the tutors are great, but then to teach the knowledge that you have to someone else is very different for every student. Like, I learn better in different ways to other people.
Desire for more Engaging Instructions	The second one I had a bit more trouble with. I found that there was a lot of text dump up front, so there were lots of blocks of texts and like, I found that reading through that my brain just kind of mush and couldn't pass it quite that well.
	[cont.] - I think it's missing like a punch in, in its delivery. So, um, like summarizing it more might be applicable
Cultural Learning Differences	[If there were a lot more challenges available in CCCs, and you were able to choose which ones to do, specializing in different areas or techniques, how would you go about choosing?] - I think, like firstly, that would stress me out. Um, because like in my head, especially like coming from an Asian learning background, you've just had to- it's been ingrained that like everything that's presented to you is testable. And then I would feel like I would need you to go through all of that.
	Creative coding stressing the importance of solid practice is somehow not working for me. Practice does not necessarily equate to no-brain copying.
Lack of Confidence	P4 was sort of saying "it's okay. Like, I don't know what to do you, you can do it", whereas I feel like he had the ability to do it was probably a lack of confidence.
	I think one of the biggest things for me is like, sometimes I'll get the answer, but I don't think I'm doing it right or in the right order.
Fears Related to Failure	[on the platform] if I always fail at first, I, I don't want to begin yeah. I don't want to continue.
	[on the platform] So I think I like in order, um, like from some easy things to begin so I can get out of fear if I fail
Anxiety Over Open-Ended Platforms	I would just assume I would have to learn all of them. Because I'll get to the exam and with my luck, the random question will be the area that I didn't choose to learn more about. So I just assume I have to learn everything.
	I guess in lectures you just sit there and consume an hour's worth of information and then the tutorial, they just kind of regurgitate that information again and like you might do an activity that's almost unrelated to the lecture somewhat.
Insufficient Scaffolding in Open-Ended Tasks	There needs to be more detail and more step by step because this is the most useful for people who haven't understood code before.
	There are never enough guidelines
Study Fatigue	[On when to submit assignments] After I was done, honestly, I felt like it didn't really match the grading criteria, but one of the reasons is because I was sick of it and tired. I didn't really have enough energy to go further on
	The only thing I would say about the class time is that in the 3 h slot, like I feel like because it's so, I'm not, I haven't, I don't have background in programming, so I use so much cognitive power at the beginning that like I'm kind of, not bad, but like I'm a bit tired and foggy toward the end. And then generally toward the end is the more complicated part of what we're learning
Feeling Overwhelemed	So like I'm getting, falling further and further behind because I still don't understand a couple of weeks ago.
	I guess for me I didn't feel like I had a choice. Because I felt like we were just required to do everything to do well, if that makes sense.

isolation) on learning, and our peer learning exercises helped address this. But it was the third attribute, the perception of competence, that our analysis suggests drove the central tension between empowerment and anxiety.

We found that those students who knew where they stood, and who were comfortable being challenged, felt empowered. Those that were uncertain about their standing felt anxious, either because they were used to having "right" answers to judge their own performance, because they had a fear of failure, or because they felt they had to do everything because it might be "on the test." Choices created anxiety not because of the perceived difficulty of challenges themselves, but because they obscured traditional markers of progress or attainment that less-confident students rely on. A key takeaway from our project is that *open-ended learning can make it hard for students to understand where they are at relative to their peers or their instructors' expectations.*

The competency that we observed was not only in terms of prior programming skill: if that were the case, then perhaps our courses progressed too quickly, requiring prior exposure to succeed. Instead we saw a significant fraction of students talking in interviews about their metacognitive strategies for approaching the unit, and how those skills *in learning itself* were critical to success in our open-ended learning unit. Freedom to choose—and its inverse, the fear of not knowing where you stand—are dependent not only on your prior mastery of the material but on your mastery of your own learning. Student-driven learning requires students to lead, and many are not equipped to do so, particularly when forced into remote learning environments.

The desire to "know where I stand" was a powerful theme throughout all our cycles of interviews. Whether it related to the choice in open-ended learning or the isolation of being a remote student during the pandemic, students struggling with learning outside their comfort zone had significant fears of failure. This can be thought of as a kind of "hierarchy of needs" for learners. If progression in your degree is at stake, you're not going to focus on enriching experiences, or to put it another way: learning doesn't matter if don't think you're going to pass.

Our recommender system prototype was a key example of this dichotomy at work: from a content appropriateness perspective our recommender was very successful, suggesting challenges that would have helped students master concepts they were struggling with. However, many students—the exception being those who were confident in their performance—did not trust that the personalized content could help them meet course-wide objective standards: in that moment they were not primarily concerned with learning, but with meeting learning objectives! It's too easy to dismiss these "grades first" attitudes as reflective of students with extrinsic motivations, but SDT suggests that intrinsic motivation can only arise after those fears of failure are addressed. These issues are not insurmountable, we feel that good design—both of learning activities and platforms—can provide support to those who are not yet possessed of the necessary confidence, while still opening up choices to those who are.

The empowerment/anxiety dichotomy we discovered aligns with prior research in the domain of self-regulated learning (SRL), where a meta-review showed that metacognitive strategies, motivation and emotional regulation were three common themes across many SRL models (Panadero, 2017). Past studies of open-ended learning environments have demonstrated similar failure cases, including the resilience of prior misconceptions (Land and Hannafin, 1997) and the inability to deploy effective information retrieval strategies (Oliver and Hannafin, 2001). This suggests a complex self-reinforcing relationship between metacognition, motivation, and competence in open-ended learning. We suggest a possible connection to similar positive feedback loops observed in studies of learner self-efficacy (Schunk, 1995), which can be reinforced by authentic positive mastery experiences (i.e., "small wins").

Given the uneven efficacy of open-ended learning, particular when classes turned remote, we found ourselves pivoting over the course of the pandemic toward supporting our students to feel confident and capable. Open-ended choice motivated students with high self-efficacy, but created anxiety among those without. Creative coding, with its open-ended design tasks, helped some students reach the self-efficacy required for them to succeed by promoting the kind of highly visible "little wins" that contribute to the enactive mastery experiences that are so critical for effective open-ended learning (Land, 2000). Asking students to design educational activities for their peers helped yet more students—particularly those from design backgrounds who were used to thinking about human-centered design tasks—but alienated those unused to thinking in that way. It was pair programming during lockdown that was the most positively-received intervention in the project, perhaps because it offered a human touchpoint. Knowing that even a single other student was struggling with the same concepts seemed to provide a sense of relatedness absent in remote learning.

The seven themes that emerged from our meta-analysis are all tied to this central tension. Furthermore, our themes explore the relationship between the empowerment/anxiety dichotomy and complicating factors like remote learning and learners operating outside of their comfort ground (like designers learning to code). Our qualitative findings support both the overall positive efficacy of open-ended learning and its failure modes in students with insufficient metacognitive strategies and motivation. In the next section we present the implications of our findings in the form of three principles for designing effective open-ended programming activities for non-CS students.

6.2. Designing Effective Blended Programming Pedagogies for Designers

The three and a half year research-through-design process we followed for this project has yielded three design insights that we think are valuable for future open-ended learning projects in HCI, particularly for non-computing students.

Where possible, design open-endedness **within, not between** learning activities. We found that creative coding challenges, where students had to apply a particular technology to an open-ended problem, to be much more effective than offering choices of which activities to do. Students with low coding self-efficacy (even those who were getting reasonable grades) found the choice of activities anxiety-inducing, especially the notion of recommended-but-not-mandatory activities. Would content in those activities be tested in the exam? Would it be necessary for the final assignment? In all cases the answer was no—otherwise it would have been a mandatory exercise—but students did not trust that, possibly due to previous educational experiences where "everything could be on the test." Particularly when dealing with students early in their degrees, the use of mandatory activities containing open-ended problems added choice while largely avoiding this phenomenon. Examples of activities with embedded open-endedness include "create a visual composition using nested arrays" or "create a design that merges stylistic elements of these two stimulus images." Care must be taken when such activities are graded, that their open-ended nature is supported with clear grading rubrics, such that even a struggling student should know when they are "done."

Even **a single other student makes remote learning better**, allowing students of all ability levels to share their struggles and achievements. Pair programming is a well-known methodology in computing education and software development practice, but it seems particularly apt to an HCI and design context. Students of design are likely to be both proficient at and receptive to collaboration, and their positive response to our synchronous peer learning exercises suggests this translates to effective learning in pairs. Working in pairs, even on challenging tasks, was found to be more tolerable and less likely to trigger the anxiety and fear of failure we observed in students attempting our challenges alone. As proposed in the "Lightweight Teams" approach (MacNeil et al., 2016), students working together need not imply group projects that are worth a significant percentage of students' grades. We applied pair programming on in-class activities of little or no grade impact, and found that student motivation among participants in our pilot was very high. While the benefits we observed were likely magnified by the effect of the pandemic on students social lives more broadly, even outside of such extreme events many students suffer social isolation and a lack of support networks (Wu et al., 2015).

Student-led learning is human-centered design, or at least it can productively be framed as such to HCI students. Students in HCI and design degrees, especially professional degrees aimed at producing human-centered designers, are likely to respond positively to the idea of making something that helps someone else solve a problem. Where tasks can be framed as human-centered design, doing so may improve student self-efficacy. The major benefit we observed was for the student in the teaching role, confirming the "Protg effect" notion that one of the best ways to learn (or at least to master) something is to teach it. We used student-led teaching in an asynchronous and retrospective mode, with students being asked to make something that would have helped them learn, effectively designing for their past selves. Student-led teaching was also observed occurring naturally in the peer learning sessions, with (we hypothesize) similar effects.

7. LIMITATIONS OF THIS RESEARCH

Like all research-through-design, care must be taken when generalizing our findings, as they are the result of an iterative reflective practice attuned to a specific context, rather than an empirical attempt to observe population-wide facts (Zimmerman et al., 2007). Our findings should be read in the context they were generated, and the insights and design principles we draw from them are intended as suggestions for future practitioners and researchers, rather than conclusive objective truths.

Beyond the epistemological limitations, however, our study also has a number of specific scope limitations that bear mentioning. Our student population was drawn from a large Australian comprehensive research university, with about 60% of our students being Australian citizens and 40% international, primarily from Asia. The sociocultural expectations of our cohort may not align with those at other institutions worldwide. Furthermore, our course was delivered to first-year undergraduate and first-year coursework masters students, so both cohorts were in their first year of study, which may have had implications for their level of metacognitive development. Finally, this study overlapped with the second-worst pandemic in living memory, a period during which significant disruption to the tertiary education sector occurred, including border closures, stay-at-home orders and widespread layoffs in many of the industries where students work part-time. While irredeemable on a global scale, COVID-19 was a mixed blessing for this study, as while it prevented any year-over-year comparison of the efficacy of our approaches it did let us study our approaches in both blended and fully-remote contexts.

8. CONCLUSION

This project has been a unique opportunity to study the effects of different levels of technology-enhanced learning on open-ended learning pedagogies. Without the COVID-19 pandemic, we would have continued focussing on our platform to support open-ended learning a traditional face-to-face context. In that less-tragic timeline we would have likely designed both the interaction model and the learning activities of our intervention to minimize the anxiety felt by some students during open-ended learning. Instead we explored the notion of open-endedness in a much more broad set of educational contexts: face-to-face pre-pandemic, fully remote during the first wave, and hybrid after. With that exploration has come a rich understanding of the ways that open-ended learning can both empower and impair design students when they are learning to program.

At their most broad, our findings can be summarized as "open-ended learning helps some students some of the time," but to do so elides nuance. It's tempting to say that some students can "handle" freedom, while others are too focussed on their marks and grades to appreciate it, but this too is reductive: the real question is which students and why. Our findings suggest that at least one major cause for the anxiety that can arise from open-ended learning is a lack of understanding of one's own skills relative to expectations, leading to a fear of failure. Once that fear sets in, anything not directly and obviously connected to the exams or major assignments is likely to be discarded. This contrasts with the empowerment felt by the majority of the cohort when open-ended learning is successfully employed, but in order to be inclusive with our pedagogies these fears need to be addressed. We have outlined three design principles that might help do so, at least when teaching programming to design-focussed HCI students: adding open-endedness within rather than between activities, using pair programming, and appealing to students' human-centered design skills with student-led learning. These principles were derived from the iterative research-through design process we used during the CCCs project and codified through the meta-analysis of student attitudes conducted thereafter. We hope that they can help direct HCI educators in the critical task of teaching students from design backgrounds to program.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because our ethics approval prohibits sharing even de-identified interview transcripts outside of the research team. Requests to access the datasets should be directed to KG (kazjon.grace@sydney.edu.au).

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the University of Sydney Human Research Ethics Committee. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

AE-P developed the system and wrote the associated sections of the manuscript. BK performed the thematic meta-analysis and wrote the associated sections of the manuscript. LB co-ordinated the units into which our intervention was deployed and assisted with the writing of the manuscript. KG initiated the project, wrote the balance of the manuscript, and provided mentoring throughout. All authors contributed to the article and approved the submitted version.

FUNDING

We acknowledge the support, both financial and advisory, of the Education Innovation Team at the University of Sydney, particularly Dr Jessica Frawley. They were instrumental in the founding of the Creative Coding Challenges platform in 2018. The University of Sydney supported this research internally in several ways. The Deputy Vice Chancellor for Education supported the initiation of the project through a 2018 Strategic Education Innovation award. The School of Architecture, Design and Planning, where the authors work, supported this article's processing fees.

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frontiers | Frontiers in Computer Science

TYPE Original Research
PUBLISHED 27 July 2022
DOI 10.3389/fcomp.2022.822090

Check for updates

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Digital Education, a section of the journal Frontiers in Computer Science

RECEIVED 25 November 2021
ACCEPTED 07 July 2022
PUBLISHED 27 July 2022

CITATION
Sin J, Munteanu C, Nixon M, Pandeliev V, Tigwell GW, Shinohara K, Tang A and Szigeti S (2022) Uncovering inclusivity gaps in design pedagogy through the digital design marginalization framework. *Front. Comput. Sci.* 4:822090. doi: 10.3389/fcomp.2022.822090

Uncovering inclusivity gaps in design pedagogy through the digital design marginalization framework

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Designers play a key role in the design of inclusive and socially conscious interfaces. Thus, it is imperative for designers to be thoughtful of the ethical and social implications of design. However, gaps in the foundational training that designers receive (e.g., as university students) can negatively impact their ability to consider the social implications of their design practice. This can result in consequences such as digital marginalization, which, as defined by the Digital Design Marginalization (DDM) framework, is the "pushing away", whether intentional or not, of a defined group of users from a digital or online service or system, where the exclusion has additional, indirect, and long-lasting social consequences on that particular user group. Designers can contribute, even unintentionally, to digital marginalization through their design practices and the design choices they make. We argue that our role as educators includes ensuring not only that our design pedagogy is inclusive, but that the designers we train now are prepared to conduct their future design practice in a manner that is inclusive to all users. As such, we propose to use the Digital Design Marginalization as a lens to guide a reflection-based approach to identify gaps in our pedagogy that may lead to designers becoming ill-equipped to identify how their designs may lead to digital marginalization. Through seven case studies from our own teaching practice, we demonstrate the use of the DDM framework to guide marginalization-focused introspective reflections of curricula. These reflections through the DDM lens revealed gaps in our pedagogy with respect to providing future designers with training that enables them to consider the broader societal and individual implications of the design choices they will make in future practice. Based on our experience using the DDM framework, we then discuss in greater depth how reflection of social consequences of design pedagogy can be operationalized within institutions to reduce educational gaps that may be associated with design-mediated digital marginalization. Finally, we comment on avenues for further development of pedagogical reflection using DDM.

KEYWORDS

digital design marginalization, digital marginalization, inclusive design, design education, user experience design, HCI education, HCI pedagogy

Introduction

Essential services, such as personal finance, healthcare, social connectivity, and retail, are becoming increasingly–even exclusively–digital. Transitions to digital services risk leaving some users of these services behind. It is now more important than ever for interfaces and digital services to be designed and deployed in ways that factor their broader societal impact. Designers play a key role in users' access to and willingness to adopt digital services. This makes it imperative for designers to be thoughtful of the ethical and social implications of design and the impact of their design decisions, especially on users in vulnerable or marginalized communities. However, it is still not known how well designers' training prepares them to examine such far-reaching considerations and what gaps may exist in the ability of design pedagogy to help designers-in-training to consider the social consequences of their future designs.

While addressing these gaps requires multiple modes of inquiry, one starting point may be to reflect on current design education curricula and pedagogy. Self-reflections have been used and have been valuable in the past as illustrations of situational approaches to ethical issues in HCI work, e.g., in Munteanu et al. (2015). Additionally, inclusive design frameworks such as design justice also practice self-reflections for (e.g., Spitzberg et al., 2020), a study by members of the Design Justice Network Principles at Work Working Group).

To identify design pedagogical gaps that may result in far-reaching negative social consequences, we turned to the Digital Design Marginalization (DDM) framework (Sin et al., 2021). The DDM framework has been proposed to help expose the ways in which our designs can lead to users being pushed away and thus marginalized from both the actual design and from other aspects that may be connected to that design (e.g., services that have been transitioned from in-person to online). On the other hand, such designs are also the result of the foundational training that designers received. Many designers acquire this knowledge through university or college programs. In turn, our role as educators includes ensuring not only that our pedagogy is inclusive, but that the designers we train now will be equipped to conduct their future design practice in a manner inclusive to all users.

As such, in this paper we present the application of the DDM framework to help uncover pedagogical gaps and guide reflection of curricula in ways that better train future designers in considering broader societal and individual implications of the choices they will make in their future practice. We consider the DDM framework to be an additional tool to existing practices and approaches adopted around ethics and inclusivity (e.g., Microsoft's Inclusive Design Toolkit) by institutions when training designers. Through this paper, we aim to support, as examples, the increasing call for reflexivity in action research (Hayes, 2011) and the need to take care of risks exacerbating peoples' vulnerability, as supported by Sensitive HCI (Waycott et al., 2015). Our reflection is performed through our experience and expertise as educators and active researchers. Our academic background is grounded in (user experience) design education, as well as in the research and design of technology for populations that are often at risk of being marginalized, such as older adults, the homeless, indigenous people, disabled people, and people who are deaf or hard of hearing.

Through our reflections, which we present in this paper as case studies, we illustrate the types of gaps that can be identified by using the DDM as a reflection tool – namely, the shortcomings of our current curricula and pedagogical practices with respect to preparing designers to address long-term social consequences of their work. We further hope that readers of this paper can use our case study reflections as inspiration for similar introspection of their own curricula or consider further steps on how to practice pedagogy-oriented reflection through the DDM lens. Our work will also highlight the applicability of sociotechnical theories, such as digital marginalization and the DDM framework, in understanding the ways in which current design pedagogy can better train designers in avoiding practice that leads to the marginalization of certain user groups.

Designers-in-training will move on to create designs that can have great societal impact. In turn, as educators of design practice, we believe that analyzing our own pedagogical practices through the lens of DDM can help us better equip these designers to make more societally sound choices and adopt practices that minimize social harm to users. Through our case studies, we show that the DDM framework reveals gaps in what and how design methods are taught, how design courses are administered, and opportunities to enhance students' knowledge of DDM. Grounded in this introspection guided by the DDM framework, we then discuss in greater depth how the reflection of social consequences of design pedagogy can be operationalized within institutions, in order to reduce downstream design-mediated digital marginalization. Finally, we comment on avenues for further development of pedagogical reflection through DDM.

Background

Design education and inclusion

Inclusive design aims to design in a manner that accounts for the full range of human diversity through consideration of diversity and uniqueness, inclusive processes and tools, and awareness of the broader impact of design (Inclusive Design Research Centre, n.d.). Not much is known about how to best teach inclusive design to students (Oleson et al., 2018). However, evidence suggests that education within higher education institutions about the importance of inclusive design is valuable for motivating designers to use such techniques in their own practice (Zitkus et al., 2013; Lazem, 2021).

Furthermore, research into the pedagogy of inclusive design approaches such as GenderMag (Burnett et al., 2016a,b), a set of personas to evaluate a design's gender inclusiveness, suggests that strong knowledge of how to teach inclusive design (in addition to strong knowledge about the topic of inclusive design itself) is important to positive student learning outcomes on this topic (Oleson et al., 2018).

Inclusive design is an area of interest in the design education community (Hanson, 2007; Koepfler et al., 2014; St-Cyr et al., 2020; Gray et al., 2021; Pillai et al., 2021) and in higher education institutions (Grosz et al., 2019), such as through Harvard's Embedded EthiCS program (Grosz et al., 2019). Such interest and programs are created in part in reaction to students' interest in ethical issues yet lack the skill set (even upon graduation) to tackle these topics (Grosz et al., 2019). However, challenges remain in fully incorporating inclusive design into design education such as the need for strong administrative support and the lack of teaching resources (Putnam et al., 2019).

In all, inclusive design is a current and relevant topic to design and HCI education. Additionally, evidence suggests value in incorporating inclusive design in designers' training. Yet, challenges exist in fully incorporating inclusive design into design education. This provides an opportunity for the use of the Digital Design Marginalization framework to serve as an additional teaching resource and motivate administrative support.

Efforts to reflect on design pedagogy

Reflection is a tool often used to discuss and improve upon design and Human-Computer Interaction education. For example, reflections have been conducted to understand challenges and start dialogues with the HCI community on teaching HCI to computer science undergraduates (Larsen-Ledet et al., 2019). Furthermore, reflexive self-studies have been presented in papers before to discuss perspectives and experiences on successes, challenges, and obstacles in the remote teaching of inclusive design in HCI courses (Byers et al., 2021).

Reflection is also an important tool for evaluating existing design practice as well. An example exists with "empathy", which refers to the design practice and taught as an initial design phase of human-centered design processes to gain a better understanding of user needs and desires (Doorley et al., 2018). Empathy as a process is popular in design (Battarbee et al., 2015; Doorley et al., 2018), business (Deszca et al., 1999), and HCI (Mattelmäki, 2006; Wright and McCarthy, 2008; Dong et al., 2018). Empathy maps are taught in design education as a way for designers to synthesize and understand users' thoughts, feelings, and behaviors (Gray, 2018). However, empathy as a design technique has some shortcomings including potentially encouraging a "design savior" attitude (Irani and Silberman, 2016; Bennett and Rosner, 2019), promote feelings of fear, apprehension, or pity toward people with disabilities (Nario-Redmond et al., 2017), and fail to account for people's coping mechanism and capabilities (Nario-Redmond et al., 2017; Abreu, 2018) (Abreu, 2018; Bennett and Rosner, 2019). Concerns like these raise the need for designers to be reflective and critical about their design approaches and practices.

Overall, critical self-reflection is a valuable method for improvement of both design pedagogy and practices.

The digital design marginalization framework

The Digital Design Marginalization framework (Sin et al., 2021) proposes that digital marginalization is the "pushing away", whether intentional or not, of a defined group of users from a digital or online service or system, where the exclusion has additional, indirect, and long-lasting social consequences on that particular user group. For example, cashless retail stores that exclusively accept electronic/digital payments risk marginalizing socioeconomically disadvantaged users (Wick, 2019). Furthermore, online food ordering apps that are incompatible with screen readers not only excludes blind or low-vision users from using these online services, but also reinforces existing social inequalities (McKee, 2019). In each of these cases, digital online services lead to offline social consequences for users.

Designers can contribute, even unintentionally, to digital marginalization through their design practices and design choices they make (Sin et al., 2021). For instance, not establishing risk mitigation plans or inadequate consideration of all the social actors interacting with the primary user may result in the technology pushing others away from the primary user, thereby exacerbating social isolation and loneliness. Additionally, designs for older adults that over rely on external tech support can contribute to family tensions leading to social isolation and loneliness. Many activities across the spectrum of digital design research and practice have the potential to harm users. In turn, the DDM framework (Sin et al., 2021) helps one understand the ways in which digital interface design leads to the exclusion of potential users and contributes to digital marginalization. The DDM framework serves as an additional tool to existing practices and approaches adopted around ethics and inclusivity by institutions when training designers. The DDM framework, as well as this paper, aims to support, as examples, the increasing call for reflexivity in action research (Hayes, 2011) and the need to take care of risks exacerbating peoples' vulnerability, as supported by Sensitive HCI (Waycott et al., 2015).

In practice, the DDM framework has been shown to be promising in retrospective application for identifying design gaps leading to social consequences. Sin et al. (2021)

demonstrated the use of the DDM framework to identify gaps in a digital design of their own creation and evaluation (an application for older adults to socially connect with others), as well as one that was externally developed (accessibility features in mobile devices). This use of the DDM framework revealed gaps in existing designs and the design processes used to generate them. It is still not known how the DDM framework may be used to predict issues in designs that have yet to be put "in the wild". However, the retrospective use of the framework to reflect on design parallels our aims to reflect on our own design curricula and pedagogy after it has already been employed in the classroom.

The DDM framework holds promise for identifying, through self-reflection, existing designs that could lead to unintended social consequences. By examining one's design practices and projects through the lens of the DDM, one can better anticipate, articulate, and take action to prevent or mitigate, the harms of unintended social consequences.

Case studies

In order to identify the ways in which our design curricula may be contributing to downstream digital marginalization through design, we reflected upon our courses for which we are instructors through the lens of the Digital Design Marginalization (DDM) framework (Sin et al., 2021). In this section, we present our reflections in the form of case studies. For each case study, we provide the context of the course, the instructor's reflection of the course through the lens of the DDM, and a discussion of the final conclusions of the reflection and actions or intervention that would be taken for future iterations of the course resulting from the reflection.

Each case study is written by a separate author. The seven authors are from two different universities across four departments affiliated with diverse disciplines (computer science, information sciences, communication and media). In aggregate, the authors teach a variety of Human-Computer Interaction-related courses tailored to their disciplinary affiliation, across undergraduate, professional masters, and PhD levels. The individual teaching experiences cover a wide range, from 2 years to almost 25 years of teaching. In the following subsections, all use of the plural pronoun "we" or possessive adjective "our" refer to the co-author who contributed the respective case study (as opposed to all the authors of the paper).

Our goal with these case studies is to present an introspective reflection on how we were able to use the DDM framework, rather than to verify whether the DDM framework can be used as a tool for reflection or to validate the DDM's applicability. In other words, we aimed to show the types of gaps that can be identified by using the DDM as a reflection tool. The following case studies are meant to serve as examples of the use of the DDM framework for reflection on pedagogy. This paper is additionally an invitation to other educators to consider using the DDM in their self-reflections. This paper is a start of this process already, as only two of the authors on the paper are experts in the DDM framework, with the remaining authors (from different universities) invited to join with their reflections. Only one of the case studies is from an expert of the DDM framework.

Case study #1: Uncritically teaching potentially ableist usability testing methods

Context

The first case study we reflect on is drawn from the context of a third-year undergraduate introductory course in user experience design and human-computer interaction (HCI). While this particular course is delivered in a social science department, it is part of a program of study that aims to prepare students in both understanding the issues connecting technology with society and in designing (interactive) technologies that are better positioned to address such issues. The department itself is highly interdisciplinary and offers several programs of study at the intersection of technology studies, social sciences, and humanity-based media communication studies. The particular program of study where the introductory HCI course (that is subject of this case study) is offered bridges the gaps between computer sciences and social sciences. Students in this program take several foundational courses related to the general principles of design, media and interface design, video and graphic production, but also upper-year courses that introduce them to advanced topics in user experience design. The course we focus on here is a third-year course with an attendance of 80 students split in two sections. Students take this course after completing several more practical oriented courses in their second year (aimed at giving them the skills to handle design production and media creation). The course is the first to introduce students to the more rigorous study of HCI, and follows a curriculum common to such courses (Munteanu and St-Cyr, 2018). The curriculum covers topics such as understanding users (conducting user observations), developing user requirements grounded in observational studies, low fidelity and wireframe sketching, paper prototyping, early usability testing with paper prototypes, iterative prototype development and testing.

Reflections in pedagogy

We reflected on the core concepts behind the DDM framework, such as, among others, the notion of design approaches that are not obviously exclusionary but may lead to certain user groups being "pushed away" from the design that is created. We then inspected our own course materials and pedagogical artifacts that we employ in this course, and analyzed them from the perspective of the DDM framework. Among the several usability methods we teach in this course, one immediately stood out in this regard: the use of the think-aloud protocol for low-fidelity (paper prototype) usability testing, which is a key method we teach. We were somewhat familiar with prior concerns about think aloud potentially being an ableist usability method (Chandrashekar et al., 2006; Waugh, 2019). However, when we revisited, under the lens of DDM, how we teach this method, it became clear that the consequences of using such a method are not confined to inclusion/exclusion of students in the class, but to how students may use this method in their future design activities post-graduation, and the implications this has on those designs leading to marginalization.

When we teach the think aloud protocol, the limitations we convey to the students are about mechanical and procedural issues, such as users being too absorbed in the interaction to comprehensively verbalize their thoughts and actions. Thus, the limitations we discuss are intrinsic to the workings of this method. However, when we reflected on this through the DDM lens, it became clear that we never discuss the issues of think-aloud in relation to inclusivity. For example, we do not consider how users with visual or speech impairments may engage with this method (which were documented in literature such as Chandrashekar et al. (2006), Waugh (2019). Additionally, this has prompted us to consider other situation where the use of think aloud could be problematic–for example, older adults may face increased challenges with the think aloud protocol due to the cognitively taxing nature of the task (Neves et al., 2015). Our reflection with the DDM has helped us consider whether we are teaching students a design technique that may lead to (future) designers unwittingly ignoring specific groups of users and thus creating designs that may "push away" such users.

This reflection helped us realize that the uncritical use of methods such as think aloud goes against some of the other principles we teach in this class. For example, we teach students that, as a designer, "you are not the user" as a way to help them focus on users, instead of interpreting users' needs through the designer's own biases. However, for practical and pedagogical reasons, students often conduct usability testing in class, with their colleagues participating in usability testing sessions (we elaborate on this in the next subsection). Using DDM as a self-assessment or critique of our own teaching materials helped us realize that, in the end, these contribute to further entrenching exclusionary practices that students may later on apply to their post-graduation design professional practice. It has also helped us see that we may not fully subscribe to our own principle of "you are not the user". A similar reflection became apparent for using personas as a usability method–which is discussed in a further case study later in this paper.

Case study #2: Course-based community partner relationships

Context

This case study is about a first-year masters level design course of about 60 students studying user experience design in a professional program. In this course, students are asked to work in groups and partner with community organizations to redesign the organizations' websites. Students conduct multiple phases of user research (through e.g., requirements gathering, storyboard validation, card sorts, tree sorts), culminating in a mid- to high-fidelity prototype website designs that are graded primarily on their information architecture (the main topic of the course).

Reflections in pedagogy

Reflecting upon the course through the lens of the DDM revealed some examples where broader social consequences may come into play due to issues of access and power. These are demonstrated through the projects of two student groups within the course.

One group partnered with a community organization that worked to provide shelters for the homeless. The organization's website was aimed at multiple audiences, including potential volunteers, potential donors, current volunteers, and the homeless. Students needed to prepare a website design that was usable for and could serve the needs of all of these user groups. An effective design relied on students' success in identifying, interviewing, and engaging with members of the multiple stakeholder groups. However, access to any users apart from current volunteers proved to be, unsurprisingly, difficult. Firstly, a strong relationship with the organization needed to be in place for the staff to be willing to connect students with the homeless that use the website. This was challenging to do given the short timeframe (3 months) of the course. Secondly, those who worked at the organization themselves were not always there long-term, and thus often lacked the long-term, trusting relationships with the homeless people in question.

In lieu of not being able to access the stakeholder type in question, students were allowed to find a stand-in of someone to be similar. In the case of the volunteers, for instance, the students often simply found someone in their own social networks (often family or friends) to interview. This reinforces existing stereotypes or biases and often led to students designing for personas that spoke to generalizations or stereotypes. While tolerable in a classroom context, this practice can both perpetuate stereotypes and often miss the point of partnering with organizations serving vulnerable populations; that is, to provide a voice to those who don't have one (in the spirit of "don't write about us without us"). The fact that we take shortcuts in a time-bound college course context is unsurprising; however, one might imagine that it begins the creation of "bad habits" that would perpetuate as these students go on to work in the industry.

A second instance involved a group designing a website for an indigenous organization focused on creating a "historical record" of indigenous experiences in Canada. This organization was not well-funded, and completely volunteer run (while noting that these volunteers have day jobs elsewhere). In contrast, our educational institution is a historically "white" institution, and the students partnering with the organization formed a group of 5 to 6 people, of which was large but not unusual in a college context). Even at the time, it occurred to us that the organization may become uncomfortable engaging with and being interviewed by that many students at once. Dynamics could have been at play in terms of the numbers (lots-to-one) and power (historically powerful-to-historically powerless). The dynamics of the relationship risks social harm or perpetuating social inequalities if not handled carefully. Even when such dynamics were adequately considered and managed, there was also the issue of building enough trust to be able to effectively engage with the stakeholders themselves. Furthermore, due to student schedules, some of them might not have been able to attend the interviews themselves and had to rely on second-hand recounts or transcripts from their groupmates. This risked them not fully understanding the nuances required to be considerate designers for their project. Finally, it was important to recognize the issue of historical exploitation that is being perpetuated with this community project approach in this course. Namely, the students themselves are working with the community partners in order to receive a grade. This is, in many ways, an inappropriate pairing with this type of community partner–even if the students, deep down, wish to work with this partner for all of the right reasons. So, where does this leave community partners like this?

In short, "community partners" for this course is a great idea for the students. It means the students receive the chance to work with someone outside of their own immediate circle, learn some domain knowledge in a space outside of their norm, and work with "real" organizations. Yet, upon reflection through the lens of the DDM, it becomes clear that this community-partner approach primarily only works for "conventional, non-marginalized community partners." As we saw with the two examples, working with marginalized groups demands time to build trust, and a careful approach that is fundamentally non-exploitative.

While the students' intentions are well-intended, the structure of the course (i.e., 3 months) means that there is insufficient time to build rapport with some community partner organizations. In practice, this suggests that "conventional non-marginalized community partners" benefit the most from such partnerships–firstly because they are easier to access, and secondly because they are easier to work with within the constraints of a term of work. As a result, digital marginalization may be at play in the context of the course, and students may become accustomed to taking ethical shortcuts in future design practice. This reflection raises the need for increased guidance on the part of the instructor or equity experts to better equip future students with the skills to partner with community organizations serving vulnerable populations sensitively, effectively, and responsibly.

Case study #3: Civic engagement–personas and empathy

Context

This case study is grounded in a course that is part of a program focused on digital design for students majoring in management at a large Canadian university. This course is the first in a series and is offered at the second-year level. It focuses on teaching the fundamentals of user-centered design, including user research techniques such as interviewing and contextual inquiry, and the development of various design deliverables such as personas and paper prototypes. This is scaffolded by the production of a term project intended to help local citizens to become more engaged with their community and make informed choices in a meaningful part of their life.

Ongoing experience with term projects shows that students struggle to engage with specific audiences. An audit of the Fall 2019 projects showed that about two-thirds of the 25 projects aimed at a general public audience, with typical topics such as "climate change awareness" or "food waste". Of those who chose a narrower audience, typical topics included tips for young drivers, student loan advice, and volunteerism for high school students in need of mandatory hours. In another term, a persona for a website about menstrual products for low-income women (a strong topic choice) nonetheless included a 29-year-old teacher, who, as an "older user is not a heavy technology user." Taken as a whole, these demonstrate that there are standing issues with how we teach students to identify and empathize with a potential audience outside themselves (Bennett and Rosner, 2019).

Reflections in pedagogy

While user-centered design is intended to direct its practitioners toward an understanding of the humanity and fundamental needs of users, various critiques have also been made of the struggles with connecting to identified groups that are harder to work with such as children or older folks with dementia (Marti and Bannon, 2009). This struggle for practitioners is no doubt amplified for students without resources to connect with "actual users." However, the trend to not even engage with thinking about narrower audiences reveals something deeper in the training process.

Students are introduced to conducting background research on their potential audience to learn about them. Examples of data sources such as national census data and industry white papers are covered. However, in courses and particularly during the pandemic years, empirical research with users has been limited. This helps to further explain the trend in topics to very familiar ones and the empathy gap on display for those dissimilar to themselves.

Reflecting on these outcomes through the lens of the Digital Design Marginalization framework has helped to describe the potential outcome of this issue more concretely. Even within the chosen topics as described above, specific and more interesting audiences were overlooked. While many projects looked at the facts and figures around climate change, individuals who would be directly affected were not identified or considered. Whether these would be low-income individuals or climate refugees coming to the region, the resulting designs were generic and failed to consider actual needs. This failure to imagine actual social actors affected by the chosen topic pushes away from marginalized humans and precludes meaningful interventions.

Case study #4: Defining the user: The danger of generalizations in design

Context

This case study considers a design course taught at the undergraduate level in a large Canadian university with a focus on the use of open data to address a design challenge. In the course, students are introduced to data portals made available by different levels of government and provincial representatives are guests of the class, meeting with students to discuss government mandates regarding the collection and sharing of public data as well as tips on how to best navigate the provincial data catalog. Students are asked to submit a brief report on some of data sets, where they consider the meta data and potential uses of the data in a design artifact.

In groups, students are tasked with making use of open data to address a broad design question: "how could open data be used to improve citizen engagement?" A series of scaffolded assignments take students through various ideation exercises, including brainstorming, mind mapping, story boarding, user personas and eventually prototyping. Government representatives return to the classroom in order to discuss the student proposals; almost all of which are digital products (either mobile or browser-based applications). Students then develop wireframe prototypes to better communicate their concept and produce an academic poster as their final deliverable. This poster articulates the goals of the applications, which open data sets would be utilized, and the target audience.

Reflections in pedagogy

When considered through the lens of Digital Design Marginalization, several issues emerge. Perhaps most importantly is that the "user" is conceptualized in broad terms which serves to mask or hide potential marginalization and that there is a lack of awareness from the earliest stages that the needs of various users would not be addressed. In the early stages of design, where students engage in defining a potential user, they tend toward imprecise or "fuzzy" terms. For example, it is not uncommon for the user to be characterized as "a student", "between 18 and 29 years old", "someone who likes the outdoors" or "someone seeking mental health related advice." Such broad definitions serve to expand the potential of the design, which is not yet limited by specificity. However, the seeds of marginalization are present. Broad definitions, such as those listed above, carry assumptions regarding access to digital artifacts and the ability to interact with those artifacts.

In other words, a fictional user persona is a useful tool for articulating user motivations and behaviors, as well as serving as a communication conduit between members of the development team. Further, user personas serve to define a user outside of the development team. Unfortunately, a tool such as a user persona is too broad to capture the nuances at play in any design. A well-constructed user persona certainly appears "real", but because they must represent a large user group, they have difficulty capturing specificity of all group members. In particular, accessibility issues are not considered in user personas, even where the design artifact is intended to address specific issues. This problem appears to be baked into the design technique itself; a user persona is not an exhaustive list of issues and concerns, but rather stands as an aggregation. It may contain multitudes, but it can't articular them all. Viewed through the lens of DDM, this is problematic. Defining the potential users of our design is a critical first step. But when such design building blocks miss the nuances that characterize each of us, there is a risk that the resulting artifact will lead to marginalization. Addressing such issues in the late stages of design can be difficult.

Furthermore, for undergraduate students, many of whom are exposed for the first time to design techniques, the issue of design marginalization exists at the beginning of their design education. But what about senior undergraduate students? By the fourth year, students are close to graduation and hopefully ready to start careers in design. Are they aware of digital design marginalization in their work? A brief consideration of the HCI curricula suggests that the answer is no. Design techniques taught in such a class and used by industry practitioners, tend toward generalization. While understandable, it leaves little room for potential users who fall outside of broad characterizations.

It is not enough for instructors to explicitly discuss accessibility issues and respect for various interests. For a variety of reasons, the final deliverable leaves little room for a careful consideration of who might be excluded based on the design. This appears to be a result of both the design techniques used and perhaps a result of the speed with which a design course unfolds. Given the requirements of a course totaling 24 h (over

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12 weeks), the scaffolding process of design can leave inadequate room for reflection. This is an issue in the design profession and one that is mirrored in the course. Since students spend time exploring the data they must incorporate into their work, as well as time spent understanding the application of various design techniques, they may find themselves with inadequate time to fully consider the implications of their work. In a race to the finish line, concerns for the marginalized are jettisoned or likely not even considered. This is problematic as the course might represent the last opportunity to raise awareness of the implications of design work. Students will likely graduate with deficiencies and inadequate training necessary to consider the societal implications of their work.

Case study #5: Time is of the essence

Context

This case study is about a first-year master's level foundational Human-Computer Interaction (HCI) course. Upper-level undergraduate students have an option to enroll in this course as well. The class size for this course is typically between 25–30 students. The course aims to provide students with the skills to critically evaluate designs for accessibility and usability while understanding the typical underlying human processes related to memory and senses that explain why people have preferences for optimal system design. The students are taught key HCI concepts and assessed through a combination of individual and group assignments. User-centered design has a significant presence within the course, and the students learn to use various design, qualitative, and quantitative methodologies to elicit user requirements, distill them down into manageable information that can be shared with different stakeholders, and deliver low and high-fidelity prototype solutions.

Reflections in pedagogy

Although the course discusses the wider social consequences of poor design, it does not do so to the extent that would be acceptable through the lens of DDM. The course does emphasize the importance of accessibility and usability. In addition, we cover a discussion of guidelines, laws, and the consequences of poor design. However, there is a lack of discussion on the implications of exclusion beyond the argument that it is unfair not to be inclusive. DDM discusses a different perspective of "pushing away" instead of using the exclusion framing. The acknowledgment of "pushing away" would be an essential addition to reframing parts of the conversations with students on the course so that more nuance comes through concerning poor design outcomes.

Another aspect of the course that might be falling short is the completeness of stakeholder needs. We teach user profiles and personas, and the students should be identifying clear goals and motivations. Still, those are only as accurate as the data collected by the students in their ethnographic observations and contextual inquiry. Through the lens of DDM, it would be necessary to consider much more of the broader social consequences of design. There is an opportunity to encourage the students to include more user concerns related to the wider context of technology use. It is worth noting that the course does stress iteration within the design process, especially when evaluations highlight weak points that will need further refinement, but this does require time. The first case study described by Sin et al. (2021) observed that more time results in uncovering less obvious design issues. However, the luxury of time is challenging in an educational setting.

Design training happens best in practice—one can learn a lot through trial and error—and a possible limitation of the course (or any university course) is limited exposure to real users and time to engage with the process. In this class, we often emphasize to our students that the purpose of assignments in the course is to give them experience with each step of the design process, to understand what goes on from beginning to end. However, there is no expectation for the students to make ground-breaking discoveries. As welcome as this may be, it would be unfair to students if we were not considerate of the constraints they are working within, especially during COVID lockdown conditions. Students are often gaining experience on a small scale without many opportunities to follow up with their users. Under these conditions, the students will inevitably miss out on learning the limitations of their design work. Furthermore, there certainly is pressure falling on the person teaching the course to catch design issues contributing to potential digital marginalization. While anybody teaching a course will have experience and knowledge to share, the teacher will have their own biases and will not be an expert in all domains, limiting how many issues are caught when giving feedback.

Finally, even though this is a foundational course and there is an expectation the students will further refine their skills through more focused HCI courses in the degree program, there is undoubtedly a missed opportunity to start the conversation early about important issues raised by the DDM framework. A high percentage of our masters students are set on transitioning to an industry career after their degree, and we should be supporting them to become more socially conscious designers.

Case study #6: Sprint break: Finding space for speculative DDM evaluation in an intensive UXD fundamentals course

Context

In this case study, we consider an introductory first-year course in the user experience design stream for a two-year professional Masters program. The course is required for this stream, has an enrollment of about 150 students, and is the foundational introduction to design thinking for our students. It consists of an accelerated 4-week lecture portion followed by an 8-week design studio, in which groups of 4–6 students complete one cycle of research, ideation, prototyping, and evaluation of a digital product targeting students.

In order to seed student portfolios with a polished, presentable case study before they apply to internships, the course is intensely focused on industry design thinking methodologies and on the practicalities of getting the project completed: rigid templates, guided workshops, lean evaluation, and a short deliverables cycle ensure that students thoroughly practice the mechanics of the design thinking process. However, this intensive practical approach leaves almost no time for a holistic introduction to the design discipline and its role in shaping society. Important topics such as research ethics, accessibility, and evaluating marginalization are barely mentioned, and never practiced.

Project topics are constrained to the domain of improving university students' lives. This grants our students access to background research from our institution's student life organization, yields real, relatable problems to solve, and ensures a viable supply of research participants during the background research sprint. However, it also makes it easier for students to make assumptions about their target users by tacitly assuming them to be similar to themselves.

Reflections in pedagogy

Students typically identify important aspects of the student experience to improve, such as personal finance, health and fitness, social connectivity, and mental health. However, while they may be implicitly aware of marginalization and exclusions that already exist in these spaces, they are not guided to consider them in understanding their problem spaces.

Student projects are evaluated on their adherence to the process templates, producing legible deliverables, storytelling, and usability, but not on potential long-term impact, exclusion, or harm. Therefore, students are incentivized to present the successful, happy-path vision of their work, naturally gravitating toward safe, mainstream, undramatically helpful solutions: centralizing information on campus events, time management apps, mentorship matching services, etc. Because their target populations are not constrained and not examined for existing exclusions, their solutions are implicitly aimed at the median users our students imagine, while anyone else is invisibly excluded. Based on our grading schemes, students are trained to focus their self-evaluation on getting the templates right and convincing stakeholders of the benefits of their design. Upon successfully completing this project, students gain a sense of confidence and believe they understand how to perform the design process.

However, students have failed to grapple with three key issues. Firstly, they conclude that understanding a target population well enough to design for it only takes a week or so of lean research, whereas that is only the case because their problem space has been artificially constrained to be similar to their own experience. Secondly, having been taught design thinking as a series of replicable templates, they believe that following them will create a serviceable, usable product. When their process templates emphasize usability and appeal as the design's most important evaluation metrics, they tacitly omit considerations of access, equity, and marginalization. Finally, student projects often insert digital interfaces into previously non-digital, or less digital contexts, e.g., mentorship, networking, clubs and campus events, finding study space, using athletics facilities, etc., but they fail to consider the disparity in experiences for users that may be excluded from their new, digital solution.

In all, while students know in the abstract not to exclude, harm, or marginalize, the skills they are practicing do not challenge them to notice or counter these outcomes.

Case study #7: Pre-COVID hybrid design course with hearing and deaf or hard of hearing students

Context

This course was a graduate level user-centered design course, comprised mostly of Master of Science students, and some PhD students. It is an elective course in our program and provides more depth and context than the core course material that touches on similar topics (brainstorming, prototyping, etc.), typically taken in the second year of the Master's program. Approximately 26 students were enrolled in the course. In this pre-COVID hybrid in-person/online user-centered design course comprised of both hearing and deaf and hard of hearing students, students worked in groups on a semester-long design project, which culminated in a prototype and design specification. Project groups comprised of a mix of in-person and online and deaf or hard of hearing (DHH) and hearing students to increase engagement for online students and to encourage equitable communication practices, for example so that as much as possible all groups used Slack to communicate in the absence of interpreters. Through the course, students ideated, sketched, created paper prototypes, and finally user tested high-fidelity prototypes. They conducted a brief needs assessment interview and several feedback sessions, meeting with in-person users four times.

Reflections in pedagogy

Typically, such design courses introduce a design concept followed by a hands-on activity. All concepts and activities build on each other and culminate in a final prototype and specification. There is usually some effort to engage real-world users, either by requiring students to go out and find users, or by bringing users into the classroom.

Upon applying the DDM lens, we reflect on finding users for the "user-centered" portion of the design cycle: (1) if students are required to find users on their own, there may be issues as they are often likely to find friends, roommates, etc., people who are socially adjacent to them/their lives. This approach introduces the possibility of bias; students may never know how "strangers" might react to their designs. (2) If instructors connect students with users, again, bias can be introduced–as it may depend on user availability to meet with students (i.e., during class?), if compensation is involved, or if users are socially adjacent to the instructor (although the instructor could account for this a bit better than the students).

For the class we taught, there was bias toward finding users who were DHH (to counteract typical cases of not including DHH users at all)–however, in doing so we excluded the hearing user perspective (but, not the hearing designer perspective) as it relates to how behavior and interactions of hearing individuals influence technology use for DHH individuals. There is perhaps a missed opportunity to differentiate and better understand these roles. There is an opportunity to be intentional about who is included as users. Additionally, as a DDM reflection, our current focus of the course still only provides one view of disability and accessibility; specifically, we leave out other kinds of disabilities and so students may not realize how these perspectives can/should extend to accessibility and disability broadly. To address this, concerted effort should be made to contextualize accessibility as not just for a specific user group. If we teach this course again, we might be more intentional in discussing user bias, why it matters, and ways to mitigate it.

Case studies summary

This section presented reflections through the lens of the DDM on a variety of HCI courses. These courses differ on a number of dimensions, such as the education level of undergraduate (case studies 1, 3, and 4) and graduate levels (case studies 2, 5, 6, 7), whether the course is a core program requirement (case studies 1–6) or not (case study 7), and the expertise of the instructor with inclusive design in terms of expert (case studies 5 and 7), moderate (case studies 1, 3, and 4), and minimal expertise (case studies 2 and 6). The case studies also varied based on the core focus of the course such as introductory HCI (case studies 1 and 5), professional UX (case studies 2, 6, and 7), and civic engagement and open data (case studies 3 and 4). We aimed for this spread to illustrate the breadth of gaps that can be identified by applying the DDM framework in self-reflection, so as to demonstrate the relevance of this framework to not only instructors, but to program administrators and curricula coordinators as well. In the following section we provide an in-depth discussion of the pedagogical gaps identified by the DDM and the avenues through which DDM reflection can occur.

DDM in design pedagogy: A discussion

In the previous section, we presented seven case studies where we reflected on how our own design courses and curricula may be contributing to downstream—that is, once designers-in-training progress to industry practice–digital marginalization through design. These case studies demonstrate the application of the Digital Design Marginalization (DDM) framework to reflections on design pedagogy. Now, we build upon the case studies by discussing the types of design pedagogy gaps that can be revealed by the application of DDM to design pedagogy reflection. Then, we examine avenues for further operationalizing the reflection process through the DDM to benefit design pedagogy and the greater design community. Finally, we discuss future paths for continuing this work of reducing design-mediated social marginalization through design pedagogy through the DDM framework.

Design pedagogy gaps identified by the DDM framework

The examples presented in this paper cover a range of design courses from fundamentals to those more specifically emphasizing inclusive design practices. However, reflection through the DDM framework helped to uncover and articulate insights and possible interventions for the prevention of potential future design-mediated digital marginalization across all of the case studies. We present our case studies as examples that may start a longer-term discussion on how the DDM can be applied to reflect on and improve design education with downstream social consequences in mind. In aggregate, our reflections on our design courses demonstrate the suitability of the DDM framework in revealing at least three types of gaps in our pedagogy: how and what design methods and approaches are taught, how design courses are administered, and students' knowledge about design-implicated digital marginalization.

Gaps in how and what design methods and approaches are taught

Reflection through the DDM lens has demonstrated that the set of design techniques and approaches instructors add to students' "design toolkit" may themselves or in total encourage ableist methods of research and design, and lead to downstream social consequences. For instance, certain methods may not be wholly inclusive (e.g., the think-aloud protocol as illustrated in case study 1), or the ways in which the methods are applied in class may fall short of factoring in the social consequences of users of the design (e.g., shortcomings involving personas as raised in case studies 3, 4, and 5).

Gaps in how design courses are administered

The DDM framework has revealed potential flaws in instructors' administration of the course in terms of guidance in working with community partnerships and considering ethical issues in students' interactions with participants and users. Our reflection highlighted the impacts of the temporary nature of the course (e.g., as discussed in case study 2), limitations introduced by the duration of the course (e.g., as elucidated in several case studies including 2, 4, 5, and 6), and restricted access to target populations (e.g., as exemplified in several case studies including 2, 3, 5, and 6). Given these, students may require more support and guidance from the instructor to mindfully and adequately engage with community partners (e.g., as discussed in case study 2) and users (e.g., as discussed in case study 7), or critically evaluate their research and designs (e.g., as proposed in case studies 5 and 6).

Students' sensitivity and knowledge of design-implicated digital marginalization

Our reflections through the DDM framework highlighted that it is easy for students to graduate from their design programs without adequate tools, knowledge, or sensitivity to the implications of their work (e.g., as discussed in case studies 4 and 5). Moreover, in order to convey the weight of design choices, it may not be enough to only teach students about digital exclusion (as remarked upon in case study 5). The use of the DDM framework provided a language of marginalization that places names on the consequences of exclusion beyond only saying that users cannot use a design.

Avenues through which DDM reflection can occur

Digital Design Marginalization (DDM) captures the ways in which design choices and practices can result in digital marginalization, or in other words, social consequences for users. Sin et al. (2021) provided the theoretical framework of DDM and applied its lens to design. In turn, in this paper we demonstrate some benefits (as enumerated in the previous section) of applying the DDM lens to design pedagogy. Each case study is an illustration of a co-author's reflection through the DDM lens of their design course.

Although the main goal of this paper is not to provide the steps on how to practice reflection through the DDM lens, but rather to demonstrate the potential of the DDM to guide such reflection, these case studies demonstrate the suitability of the DDM lens as a discussion prompt for both solo reflection and group dialogue. This prompts the question of how might the process of reflecting on the social consequences of one's design pedagogy be operationalized? Grounded in the reflections and experiences described in this paper, we suggest three avenues for this: 1) through the educators themselves; 2) through program administrators or curricula coordinators across design courses; and 3) through institutional champions of equity and inclusion. We elaborate below on each of these avenues.

Reflection by instructors

On one hand, instructors (as we are ourselves) can use a tool such as the DDM framework to help guide reflection on the impact of their own design courses on downstream design-mediated digital marginalization. Many design course instructors pride themselves in applying on their own courses a practice that they teach within their own courses: iterative design. In other words, many design educators consciously and actively seek feedback from students and aim to improve the curriculum and delivery with each offering of the course. Reducing downstream digital marginalization through design is one additional dimension for which educators can consider when evaluating and adapting their courses.

Furthermore, for educators who are familiar with and teach concepts such as universal design, inclusive design, accessibility, and disability (e.g., the co-authors in charge of case studies 3, 5, and 7), the DDM framework can help articulate latent issues in curricula. The DDM framework can provide instructors with the language to articulate, for example in case 3, the consequences of generic designs that fail to consider actual needs. In turn, the DDM framework can help educators develop their soft skills in communicating with students about issues of inclusivity and marginalization and be more intentional about how users are included in class projects (e.g., as elaborated upon in case study 7). Lastly, the DDM framework can help educators reflect upon the existing HCI methods that they teach and reflect upon their potential problems of marginalization (such as in case study 1). This way, educators can question and re-evaluate how they teach and contextualize established HCI methods.

Reflection by program administrators and curricula coordinators

The DDM framework can be used as a tool by design program administrators and curricula coordinators (who often are also faculty members teaching the design courses, e.g., in case studies 1 and 3) to identify gaps in students' learning across the program with regards to design-mediated digital marginalization. These educators can use the DDM to consider, for example, whether or not students graduate the program with the training necessary to consider the societal implications of their work (e.g., as discussed in case studies 1 and 4), and to help address limitations posed by semester-long course structures to promoting and support student learning in these areas (e.g., as discussed in case studies 2 and 5). In our own reflections, we have found that students may not be graduating from their design programs with the tools, knowledge, or sensitivity necessary to understand and social implications of their work. In particular, course duration and the lack of time has been found in our reflections to be a key challenge. Although the lack of time should not be a limiting factor in trying to include inclusive design practices and pedagogy, our DDM reflections show that time constraints are systemic institutional issues that can lead to non-inclusive teaching. This can often be caused by program administrations' management of limited time resources.

Use by learning and academic support centers

Not only can the DDM framework be used by instructors and institutional divisions in charge of higher-level course structures, but it can be promoted as well by academic centers and services. Such divisions include but are not limited to institution-wide equity and accessibility offices, equity champions in teaching offices, and academic support centers. In such scenarios, members of these groups can provide instructors, program administrators, and curricula coordinators with materials to reflect on their educational materials through the DDM lens. Some of the case studies (1, 2, 3, and 6) also involved extended discussions over one to three 1-hour sessions between the lead author and the co-author in charge of the case study. The engagement and inspiration from such discussions may also transpire should the staff of these centers invite instructors and program instructors to meet with them.

Future considerations

Based on our experiences reflecting on our own course curricula and as educators in design ourselves, we suggest four paths to continue the work of reducing design-mediated social marginalization through design pedagogy: collecting case studies of design-based digital marginalization, creating guides to prompt educator reflections through the DDM of their courses, sharing these resources globally, and continuing the research started by this paper.

First, we suggest the creation of materials related to the topic of digital design-based marginalization from which educators may draw from for their course materials. Specifically, we suggest a public repository of case studies of digital marginalization through design and a collection of design evaluative questions informed by the DDM. Public common knowledge repositories could be organized to provide historic and recent examples of designs that have marginalized people, in similar style to the two case studies described by Sin et al. (2021). This could be helpful for facilitating discussion activities within a course where students are tasked with trying to identify problem scenarios with tech solutions. Evaluative questions could challenge students to try answer questions such as the following projects' designs [e.g., in the format of the Tarot Cards of Tech The Tarot Cards Of Tech, n.d.]. At the end of their project, we would ask students to reflect not only on the lessons they learned and the next potential steps in the project, but also on the limitations and exclusions of their work, and we would allocate grades to critical self-reflection.

These tools may serve as discussion activities within courses, where students could be tasked with identifying design-implicated social consequences within case studies and their own creations. Case studies can be discussed before group assignments to increase the likelihood that the students make more observant observation and ask deeper questions of their users to adhere to the DDM framework. Meanwhile, evaluative questions can prompt students to critically evaluate their designs and provide them with an additional criterion (i.e., the potential to marginalize users) by which to evaluate their projects.

Second, we recommend the creation of guides to facilitate educators' reflections and discussions of their courses through the lens of DDM. An example of a good starting point for this would be the Black Mirror Writers Room exercise (Klassen and Fiesler, 2022) which helps educators facilitate discussions on technology ethics. This can be adapted to DDM scenarios. These guides can sensitize design educators to the social implications of their pedagogy and encourage them to ask questions of themselves and each other about how they are teaching students design, as well as question how the educators themselves teach and contextualize established HCI methods. This process would empower educators to critically evaluate and improve their courses and pedagogical content in a socially conscious manner. Additionally, these guides can be used by champions of equity and inclusivity to promote design education for a more ethical and inclusive design future.

Third, we encourage the sharing of materials and resources created for the two recommendations above to be shared widely, through venues such as conferences, publications, and repositories of instructional materials (e.g., Call For Submissions | EngageCSEdu, n.d.). The global sharing of case studies and discussion points can not only promote more extensively the merits of reflecting on the social consequences of design pedagogy, but also invites global case studies of digital marginalization from which students may study design-implicated consequences.

Lastly, we suggest the continuation of the line of research exemplified in this paper. Specifically, this paper serves as a first step of seeing how instructors can reflect on their own teaching practice through the DDM framework. However, although educators can be reflective of the course and identify where it could be improved, students may have feedback given hands-on experience in the industry setting. Now that this paper has demonstrated how the DDM can help educators to expose gaps through self-reflection, we can follow up with a different study (involving a different methodological approach) to look at students who moved to industry. This future study can help round out the understanding of digital design marginalization in connection with design pedagogy.

Design choices and practices can contribute to digital exclusion, downgrading, and social consequences. Through frameworks like the DDM, one can identify places where design may be implicated in marginalizing people in society. These frameworks can also be applied to design pedagogy, and by purposefully critically evaluating the current ways in which design is taught to students, we are better equipped to intervene and contribute to a more equitable and inclusive design future.

Limitations

While the co-authors are based in different disciplines (computer science, information studies, communication and media) across different universities in two different countries, we still represent a western, North American perspective, and one that does not account for career colleges or other skills-oriented post-secondary schools outside of the university system. Finally, the insights presented in this paper are specific to curriculum introspection, and further methods (e.g., looking at on-the-job practices) will offer other insightful perspectives on how the DDM framework can be applied.

Conclusion

As it stands, it is easy for students to graduate from their design programs without the skills, knowledge, or sensitivity to address the social implications of their design practice. To minimize downstream social consequences of design practice, conscious attention must be paid on the implications of current design pedagogy. In this paper, we provided case studies of our reflections through the Digital Design Marginalization (DDM) framework on our own design courses. We present these reflections as case studies in order to discuss the types of shortcoming and opportunities that can be revealed through such self-reflection with respect to improvement in the training of design methods, the administration of design courses, and the course content related to issues of inclusivity. Based on our experiences with this reflection, we suggest incorporating the DDM as an additional reflection tool into the iterative improvements of design courses and into the agenda of existing champions of equity and inclusivity.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

Author contributions

JS contributed to the conception and design of the paper and wrote all of the sections except the individual case studies (Section Case study #1: Uncritically teaching potentially ableist usability testing methods onwards). CM, MN, VP, GT, KS, AT, and SS each contributed the text for one case study. All authors contributed to manuscript revision, read, and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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