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Navigating the Terrain:

Emerging Frontiers in Learning Spaces, Pedagogies, and Technologies

HCI Teaching and Learning Model Using Studio-Based Learning

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This research explores Studio-based Learning (SBL) within Human-Computer Interaction (HCI) subjects, focusing on the crucial elements required in the design of maker spaces to enhance user experience (UX) design education. As HCI becomes increasingly complex and interdisciplinary, traditional classroom settings often fail to provide the required experiential learning environment for certain subjects. Our study examines various subjects in the discipline, highlighting diverse interactivity requirements and the potential of Studio-based Learning to effectively address students' and staff's needs. We analyse the impact of studio settings on the learning outcomes and expectations of students, especially in fostering creativity, collaboration, and hands-on engagement. Our research findings indicate that studio-based classrooms significantly improve student learning experiences in interactive and practical subjects, although effective planning around space and time constraints can impede its full implementation.

Keywords: HCI Education, Studio-based Learning, Interactive Design, UX Design, Qualitative Research

Introduction

As the Human-Computer Interaction (HCI) field evolves to incorporate more complex, interdisciplinary approaches, the gap between theoretical knowledge and practical application widens. HCI education is increasingly challenged by the need for hands-on, interactive learning experiences that traditional classroom settings struggle to provide (Cennamo et al., 2011; Reimer & Douglas, 2003), underscoring the necessity for pedagogical innovation (Wilcox et al., 2019; Abdelnour-Nocera, 2012). The studio-based environments in the discipline are characterised as immersive spaces that foster creativity, practical application, and skill development through hands-on experiences, contrasting with the research-based approach that emphasizes evidence and theoretical study (Wilcox et al. 2019) while maker spaces provide the physical facilities and resources to enable and foster studio-based, hands-on learning through making, designing, and prototyping activities. These spaces are equipped with technologies like 3D printers, laser cutters, electronics workstations, and traditional tools for working with wood, metal, and textiles fostering a hands-on, experiential learning environment that complements traditional classroom instruction, allowing students to apply theoretical concepts through practical, studio-based learning activities (Barrett et al. 2015).

This study explores how studio-based learning and makers spaces can be effectively utilised in the HCI discipline, examining the varied interactivity requirements across different HCI subjects and how these needs can be met within the constraints of typical educational environments (Brocato, 2009; Ioannou et al., 2015). By focusing on the integration of studio-based learning, this research aims to bridge the gap between theory and practice in HCI education, ensuring that students acquire not only conceptual knowledge but also the practical and creative skills essential for success in this rapidly evolving field.

Experiential learning bridges theory and practice in Human-Computer Interaction (HCI) education. Hands-on activities foster creative problem-solving, continuous learning through trial-and-error, and ethical awareness aligning with Schön's model. Students apply concepts to real-world scenarios, reflecting on the implications for responsible design. This comprehensive approach prepares HCI professionals for innovative yet ethical practice (Oguamanam et al., 2020; Obrenović, 2012).

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In this research, we aimed to enhance the design of studio-based classrooms. We explored ways to better implement Studio-based Learning (SBL) in HCI subjects' classrooms. To find a solution, we examined the interactivity requirements across different HCI subjects concerning Studio-based Learning environments. Additionally, we investigated how students and staff engage with such classrooms and how maker spaces can facilitate the implementation of studio-based classrooms. Our investigation enabled us to develop a model of teaching and learning for HCI subjects using studio-based learning.

The remainder of the paper first discusses the related literature, including studies on maker spaces, and then elaborates on the research design and data analysis. It then describes the findings, discusses the model, and concludes with limitations and suggestions for future research.

Related Work

User Experience (UX) Design Using Studio-based Learning Environment

User experience (UX) designers focus on the overall experience of a user's interaction with a product. They consider more than just the ease of use of the user interface, but also the usability, efficiency, and emotional response of the user during product use. Key aspects of teaching UX design rely more on traditional teaching models or more independent, theoretical learning approaches (Kumaretal., 2021; Gallagher & Getto, 2023). UX design emphasises understanding user behaviour and psychology, which requires in-depth theoretical knowledge of human behaviour, psychology, and design principles (Gallagher & Getto, 2023; Vorvoreanuetal., 2017).

This knowledge can be gained through traditional theatre lectures, readings, and discussions without the need for an actual studio environment to do so (Da Silva et al., 2012; Kumaretal., 2021; Gallagher & Getto, 2023). In addition, UX designers are often required to design and perform research protocols such as user interviews, questionnaire design, fieldwork, etc. These core tasks are very often accomplished independently by individuals or small groups and do not necessarily need to rely on studio-style interactions. It is worth mentioning that contemporary User Experience (UX) design work involves various design and prototyping software such as Sketch, Adobe XD, and Figma, as well as the tasks of creating personas, user scenarios, etc (Yamazaki & Furuta, 2007; Gallagher & Getto, 2023). These tools can largely be learned through online tutorials, official documentation, and personal practice, without having to rely on a physical studio environment.

Interaction Design (ID) Using Studio-based Learning Environment

Interaction design focuses more on the direct interaction between the user and the product interface, including the layout of the buttons, interaction animations, feedback mechanisms, etc. Its primary goal is to guarantee that consumers can engage with the product straightforwardly and effectively (Cennamo et al., 2021; McCrickardetal., 2004).

On the design side, interaction design emphasises prototyping and iteration, a process that involves designing, testing, evaluating, and improving. A studio-style learning environment ideally supports this process, where students can adapt their designs as soon as they receive feedback, and this rapid iteration is essential to improving the quality of the design (Cennamo, et al., 2011; Reimer & Douglas, 2003; Wilcox et al., 2019). On the practical side, such classrooms provide an environment of close communication in which the instructor can provide immediate feedback on students' design work. In interaction design, immediate feedback from the instructor is crucial in guiding students to understand the relationship between user needs and technical implementation (Reimer & Douglas, 2003; Wilcox et al., 2019; Vorvoreanuetal., 2017). In addition, many design studios have collaborations with the real industry, which largely reinforces learning in the real world.

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Activities for Maker Spaces

Maker Spaces are versatile environments designed for hands-on activities, with tools and equipment that vary based on the space's focus. Whether specialising in electronics, woodworking, or digital fabrication, each Maker Space offers flexibility to meet diverse educational and creative needs. Dougherty's (2012) exploration of the maker movement in education emphasises the importance that maker spaces have for students. Human – Computer Interaction (HCI) education necessitates students' involvement in a diverse range of imaginative activities. Interactive prototyping is the process of designing and constructing interactive prototypes using a range of materials such as sensors, electronics, and 3D printers. These prototypes encompass wearable devices, smart home devices, or any other form of interactive technological product. During hardware programming, students must acquire the skills to program hardware devices to regulate certain interactive functions using microcontrollers and development boards like Arduino and Raspberry Pi.

By utilising the technological resources accessible in the Maker Space, students can develop virtual reality (VR) or augmented reality (AR) experiences that delve into the use of these immersive technologies in the field of HCI (Irwin, 2019). They are well-suited for producing enclosures, artwork, and real-world components. The assembly and refinement of electronic equipment will require essential soldering tools such as a soldering station, solder, and flux, as well as electronic work tools like screwdrivers, pliers, and wire strippers.

Table 1

Activities within the Maker Space

Type of Activity	Examples Tools required (Not an exhaustive list)	Significance in the instruction of HCI
Interactive Prototyping such as wearables and smart automotive devices, using a variety of materials	Sensors, electronic components	Through hands-on practice, students can explore the diversity of physical interfaces and user interactions (Cennamo, et al., 2011; Reimer & Douglas, 2003; Wilcox et al., 2019).
Hardware Programming	Controllers, development boards (e.g. Arduino, Raspberry Pi)	Students need to learn how to program hardware devices to control interactive functions (Chandramouli & Heffron, 2015).
Virtual Reality (VR) or Augmented Reality (AR) experience development	VR/AR Development Kit	Using VR or AR technology, students can create immersive experiences that help them understand the application and potential of these technologies in HCI (Boletsiset al., 2017).
Rapid prototyping, Precision cutting and engraving	3D printer, Laser cutter	With 3D printing, students can quickly produce and refine designs, which is particularly beneficial for producing personalised unit casings and components (Mueller, 2017).
Assembly of electronic equipment	Soldering station, flux, screwdriver, pliers, wire cutters	These tools are essential for assembling and fine-tuning electronic devices and help students develop a practical and deeper understanding of how electronic components work (Fernaueusetal., 2014).

Table 1 lists the tools required for different types of activities in HCI teaching. Interactive prototyping requires tools such as sensors, and 3D sketching (Cennamo, et al., 2011; Reimer & Douglas, 2003; Wilcox et al., 2019), while hardware prototyping requires students to work with microcontrollers and development boards, (Chandramouli & & Heffron, 2015). Virtual reality (VR) experience development needs VR/AR development kits and space for creating immersive experiences (Boletsis et al., 2017). Rapid cutting, precision cutting, and engraving can be achieved using 3D printers and laser cutters (Leichter, 1995) and, the assembly of electronic equipment requires tools such as screwdrivers, soldering stations, etc. (Fernaueusetal., 2014).

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Research Design

We conducted qualitative research employing interviews and observations as data collection strategies (Flick et al. 2004). The study participants included students and staff who designed and delivered undergraduate and postgraduate Human-Computer Interaction (HCI) subjects at a few Australian Universities. The ethics approval for this research is obtained from the university where the researchers work (ID: 208033).

Data Collection

We conducted eight face-to-face semi-structured interviews of 30-45 minutes each. We used observation as another investigation method in this project and gathered observations about the participants' behaviour while they attended lectures and workshops and made use of maker spaces. We intended to observe their level of engagement with the learning materials. Table 2 lists more details.

Table 2

Data Collection Method and Sample Size

Data Collection Method	Number of Participants/Activities
Semi-Structured Interviews	8
Observations (in HCI Subjects)	• Teaching and learning of lectures (1 lecture for 2 hrs) • Teaching and learning workshops (2 workshops for 2 hrs each) • Student activities in the university's Makers Space (4 visits of 1 hour each)
Questionnaires (Students)	40
Questionnaires (Teachers)	5

We created two versions of the online questionnaire for this study, one for the HCI teaching team and one for the students. The questions in the questionnaire centred around their teaching experiences, challenges, and needs in their current or previous HCI subjects. We used the questionnaires to help in data triangulation during the analysis.

Data Analysis

We started the data analysis from open codes, focused codes, and categories. Given the research direction and data type, semi-structured interviews were the most efficient way to understand participants' views on current HCI delivery (Adeoye-Olatunde & Olenik, 2021). We then identified themes from the categories. Table 3 provides an audit trail of how we interpreted the data during analysis as an example of categories related to HCI maker space training and classroom challenges that we formed from the data. The next section describes the themes which we have extracted from the data.

Table 3

Systematic Analysis Process

Quotes	Open Codes	Focused Codes	Category
(I start the class fully engaged, but my focus fades as the session goes on.)	Variability in student engagement	Students' Engagement	Classroom Challenges
(The theory taught in lectures is thorough but applying it during assignments feels disconnected.)	Disconnect between theoretical instruction and practical application	Subject Material	Subject Design
(I just needed to use the woodshop at maker space but had to undergo unnecessary training for other equipment.)	Student Training	Tools training and use	Maker Space Training
(Every time I need to do laser cutting, I require help, and sometimes there's no staff available.)	Insufficient staff support during practical	Tools training and use	Support in Maker Spaces

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Findings

Disparity in Teaching Resources and Practical Learning Opportunities

Several subjects incorporate hands-on exercises such as 3D printing and laser cutting. However, the execution of these activities is often hindered by limited equipment availability and constraints within instructional facilities. For instance, in interface prototyping subjects, hands-on training opportunities are severely restricted due to a lack of sufficient instructional equipment such as in Figure 1. Additionally, certain subjects mandate that students utilise specific hardware devices.



Figure 1. 3D printers, Sewing Machine and Workbench in the Maker Space

One of the student respondents pointed out, 'it takes time to go there (the maker space) and back to different classrooms and it's a bit of overwhelming when seeing all those unfamiliar equipment by myself there'. This lack of clarity confuses students during their semesters.

Pedagogical tools of the current HCI curriculum

The HCI discipline covers a wide range of subjects such as User Interface Design, Visual Design, User-Centred Research and Evaluation, Interaction Design, etc. These subjects have different learning tasks involved such as:

Prototyping. Students are usually given a theme to design a prototype which constitutes a key step in most HCI subjects. They are expected to understand the design process, from the client's needs, then create sketches, wireframes, and visual designs, and finally complete a high-fidelity prototype. Prototyping is characterised by rapid iteration and ease of editing with a high degree of flexibility. According to the questionnaire's feedback, 21 out of 40 students indicated that their subject required more than one design software for prototyping. From interviews we found that their assignments involve prototyping interactive devices which are difficult to design and develop.

Studio-based Activities. Based on the questionnaire, we found out that HCI students need to do a few studio-based activities to complete their assignments. 18 out of 40 participants indicated that they needed to use 3D printers and laser cutters or needed to do experiments in the university's Creator Space. These 18 students were taking interactive design subjects. One of the students responded, 'it would be great if we could have class in maker space (name removed) and use class time to complete some simple prototype and get more feedback of what we're making'.

Students in other subjects reported that their personal computers were fully adequate for classes and completing assignments.

HCI Pedagogical Approaches and Class Setting Environments

Theory-oriented approaches. By conducting interviews with staff from different teaching teams, we found that most of the current subjects in HCI are primarily based on theoretical knowledge. The students applied the

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knowledge they acquired during lectures in weekly tutorial sessions. The assignments incorporate subject content to assess student learning. Through our observations during lectures and tutorial sessions, we discovered that this teaching approach enables the delivery of course content to a large number of students within a limited timeframe. We also noted that students were highly attentive and actively engaged with tutors at the beginning of the session. However, their concentration and focus tended to diminish as the session progressed towards its latter stages.

Studio-based approaches. Through interviews with students, we explored the challenges associated with technology applications-based approaches in teaching Human-Computer Interaction (HCI) concerning software, hardware, and specific equipment requirements. Three out of the five student participants highlighted that accessing the necessary equipment for the subject was highly problematic. P1 stated, 'I just needed to gotoTCS to do some woodworking, but I was still forced to complete training for some other equipment, which I didn't think was necessary.'

Some participants stated that they still did not knowhow to use the equipment even after attending the relevant training sessions. P2 stated, 'Everytime I went for laser cutting, I needed to do it with the help of the staff and sometimes I couldn't find the staff.'

Our observations at the maker spaces revealed that students' abilities were a crucial factor contributing to the success of Studio-based learning (SBL). The staff highlighted that the subject's scale, the number of enrolled students, and the duration allocated for guiding students should be carefully considered when designing the subject and formulating learning outcomes.

One student's comment prompted us to explore alternative and innovative approaches to addressing the problem, 'It does not have to be the exact same machines in maker space, but maybe some virtual environment could help explain the process of tasks in maker space.' Although instructional videos and orientation training sessions are available to help students learn about the equipment in the maker space, these comments have led us to consider developing augmented and mixed-reality learning environments. Such immersive environments could potentially enable students to familiarise themselves with the equipment they need to use more effectively.

From the findings, we created an HCI Teaching and Learning Model which considers what is required to construct Studio-based Learning environments in universities.

HCI Teaching and Learning Model Using Studio-Based Learning

This paper identifies Studio-Based Learning (SBL) as an educational approach that emphasises hands-on, experiential, and collaborative learning. Figure 2 illustrates the several key factors which should be considered when implementing Studio-based Learning in the context of Human-Computer Interaction subjects.

Subjects

Implementing Studio-Based Learning (SBL) in classrooms requires customisation based on the subject. In Human-Computer Interaction (HCI), SBL can be tailored to fit the subject's nature and intended learning outcomes. Design-oriented HCI subjects, like Interaction Design and User Experience Design, thrive in studio settings where students engage in practical tasks like prototyping and user testing, benefiting from hands-on practice and feedback. Technology-oriented subjects, such as User Interface Programming and Hardware Prototyping, also benefit from studios, providing necessary tools for experimentation, examination, and innovation. In contrast, theory-oriented subjects, like HCI Theory and HCI Evaluation, may require less SBL focus, as they emphasise theoretical knowledge. While usability labs are used in evaluation subjects, they are typically engaged for only a few weeks. Finally, subjects that blend design, technology, and theory can utilise SBL to encourage multidisciplinary collaboration and integrated project work.

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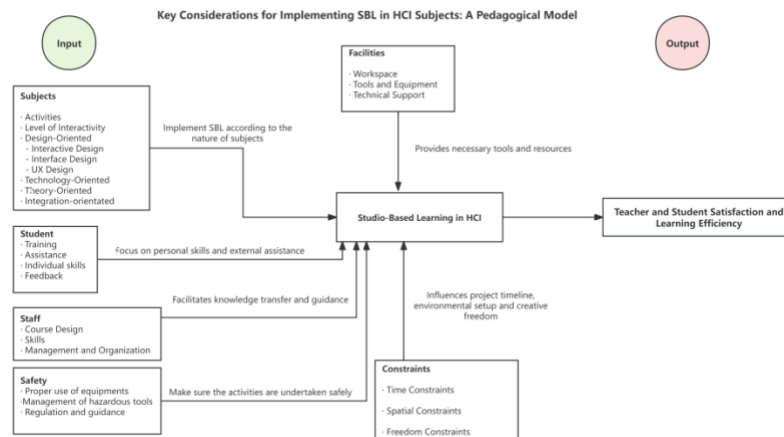


Figure 2. Key Considerations for Implementing Studio-based Learning in HCI Subjects: A Pedagogical Model

Students

Before joining the studio environment, students must get training in relevant skills and tools. This training usually involves instruction on proper tool usage, developing, and practicing design and production skills, collaborating as a team, and other associated abilities. Training is essential to ensure that students possess the necessary skills to engage in studio activities safely and effectively. Within a studio-based environment, students may need additional support to understand complex concepts or complete practical assignments. Educators and assistants can provide individualized guidance and assistance, especially when students face challenges. Moreover, a studio setting promotes collaboration among students and facilitates collaborative problem-solving through group work and peer mentoring.

Educators

Teachers need to come up with an SBL-friendly curriculum with clear learning goals, relevant material, and useful ways to teach. The curriculum design should incorporate hands-on activities, projects, and assignments to guarantee that students can effectively apply theoretical knowledge and cultivate abilities in the studio. Teachers' ought to vary the curriculum design according to the requirements and interests of their students in order to offer a flexible and individualised learning experience. Studio-based learning environments usually involve diverse activities and resources, and educators need to manage and organise these elements including scheduling activities, allocating resources, and monitoring progress.

Facilities

The workspace layout should be flexible to accommodate various activities and teaching needs, with major areas designed for large groups. Facilities should offer diverse, high-quality tools and equipment to support design, technology, and making. For portable workshops, educators can bring only the tools needed for current curriculum needs. Furthermore, reliable technical support, including equipment maintenance, guidance, and software training, is essential.

Safety

In a studio environment, students often need to use tools, equipment, and materials to conduct experiments, fabrications, and designs. Therefore, ensuring student safety while using these tools and equipment is a necessity. Studios should be equipped with the necessary safety equipment, such as safety glasses, gloves, and

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first aid kits. Faculties must provide safety training to students to ensure that they understand how to use tools and equipment safely.

Constraints

Typically, a semester in Australasia lasts 12 weeks. In such a short period, students need to complete all the tasks of the subject, including design, development, testing, and evaluation. Educators should be aware of the semester's time constraints and rationalise the subject content and project schedule according to the student's abilities and the complexity of the tasks.

Discussion

Literature studies and research findings widely agree that Studio-based Learning (SBL) is crucial for Human-Computer Interaction (HCI) education. The research findings indicate a strong need for studio-based learning among students enrolled in subjects involving interactive design (Reimer & Douglas 2003). These subjects involve practical tasks like 3D printing and laser cutting, which require hands-on experience (Cennamo et al., 2011).

Human-Computer Interaction (HCI) subjects encompass a broad spectrum of subjects, such as interface development, user experience research, and interaction design (Wilcox et al., 2019; Ioannou et al., 2015). They identify the deficiencies of typical classrooms in facilitating such HCI subjects. For example, Abdelnour-Nocera (2012) and Cennamo (2011) have identified shortcomings in conventional teaching and learning environments in the field of HCI. Our research has revealed that students in subjects that require designing interactive wearables and high-fidelity prototypes have faced comparable challenges. The absence of specialised equipment and adaptable layouts in these classrooms hinders the effectiveness of experiential learning. Ioannou et al. (2015), suggest that virtual technologies can enhance distance learning and promote collaboration. Our findings also indicate that in interactive design subjects, virtual tools offer students a diverse array of user interfaces and experiences that assist in the creation and assessment of interactive gadgets. Some universities have established dedicated VR classrooms to teach the relevant subjects.

Previous studies and our findings have drawn attention to the importance of maintaining a balance between theoretical knowledge and practical application in Human-Computer Interaction (HCI) education (Cennamo et al., 2011). Vorvoreanu et al. (2017) and Gallagher & Getto (2023) recognise that lectures and tutorials are effective methods of imparting theoretical knowledge and user experience (UX) assessment methodologies. However, studio-based environments facilitate design thinking and iterative optimisation processes. The study findings indicate that some subjects employ a pedagogical approach rooted in theory, whereas prototype designing adopts an SBL approach. The gap between theoretical concepts and practical application in certain subjects led students to face challenges during class.

Existing literature and our findings prove the significance of personalised training in the field of Human-Computer Interaction (HCI) education (Soloway et al., 1994; Oleson & Ko, 2020). Evidence indicates that students enrolled in subjects requiring hands-on activities benefit from customised feedback and instruction. Conversely, in larger theoretical subjects, it becomes challenging for the instructor to attend to every individual student, resulting in reduced tailored instruction, which can negatively impact learning outcomes.

The literature provided a general overview of the advantages of Studio-Based Learning (SBL) and environments, but it did not delve into the specific ways in which it can be tailored to suit the requirements of various subjects. The results of our research indicate that some Human-Computer Interaction (HCI) subjects, that need product design to be taught, necessitate immersive and SBL environments, while subjects that teach user evaluation or Front-End development tend to be more theoretical.

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Conclusion

The study of Studio-based Learning (SBL) in Human-Computer Interaction (HCI) courses has revealed a big gap between the current teaching methods and what students need to learn through experience. Our research has shown a strong need for environments that encourage creativity, teamwork, and hands-on activities – things that traditional classrooms often lack due to space and logistical limitations. Throughout this study, we looked at different aspects of HCI education, examining how SBL can improve the teaching of user experience design. This analysis provided important insights into how teaching strategies can be adapted and highlighted the significant potential of SBL to improve learning outcomes. However, it also uncovered several challenges, such as limited access to specialized equipment and inadequate learning spaces, which make it difficult to implement SBL effectively. By addressing these challenges, we can unlock the full potential of SBL, enabling students to develop practical skills, foster creativity, and gain a deep understanding of user-centred design principles. Moving forward, we will explore how to tailor studio-based learning environments and approaches to meet the unique needs of diverse subjects and classes, ensuring an engaging and effective learning experience for all students.

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