Design in the HCI Classroom: Setting a Research Agenda

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ABSTRACT

Interaction design is playing an increasingly prominent role in computing research, while professional user experience roles expand. These forces drive the demand for more design instruction in HCI classrooms. In this paper, we distill the popular approaches to teaching design to undergraduate and graduate students of HCI. Through a review of existing research on design pedagogy, an international survey of 61 HCI educators, and an analysis of popular textbooks, we explore the prominent disciplinary perspectives that shape design education in the HCI classroom. We draw on our analyses to discuss the differences we see in forms of design taught, approaches to adapting design instruction in computing-based courses, and the tensions faced by instructors of these classes. We conclude by arguing for the importance of pedagogical research on design instruction as a vital and foundational area of inquiry in Interaction Design and HCI.

Author Keywords

HCI Education; UX Education; Design Education; Pedagogy

CCS Concepts

•Human-centered computing → Empirical studies in interaction design; Empirical studies in HCI; •Social and professional topics → Computing education;

INTRODUCTION

Interaction design is considered to be a fundamental part of Human–Computer Interaction (HCI) education. However, as HCI has evolved over the decades, researchers have noted that the multidisciplinary nature of the field can cause fragmentation in approaches to design [12, 45]. We investigate what this means for design instruction: what types of design are being taught in the classroom and how are they taught given the disciplinary differences that shape HCI education?

Our scope includes HCI instructional programs in computer science departments, iSchools, and related areas that have historically been affiliated with the ACM. We recognize, however, that HCI is also taught in programs that have historically focused on creative practices, such as Parsons' Design and Technology program[1], New York University's Interactive Telecommunications Program [2] and others. Thus, while we are taking a broad approach to what is meant by "Design in HCI", we are concerned in this paper with how design is taught in programs that are more frequently affiliated with the ACM.

We undertook this research to explore the elements of effective design education practice and pedagogy in HCI. Recently, researchers and educators across the globe have been organizing efforts to cultivate an HCI education community of practice and to identify vital foundations of a unified HCI curriculum [1, 7, 9, 14, 25, 48, 50, 51]. Efforts to understand best practices for design education within HCI are in early stages [34, 54]. Three of the authors have collectively taught HCI for over 30 years and have experienced HCI courses[3] at seven institutions. Having each been trained in different fields, we observed that the approach each of us takes to design education varies, likely shaped by our disciplinary biases: the art studio, computer science lab, and industrial engineering classroom.

The work we present in this paper demonstrates a high degree of variability in education practice, with disciplinary influences shaping how design is taught. This is of concern, not because variability in teaching approaches is necessarily "bad", but because there can be a lack of acknowledgement in the HCI classroom of different approaches to teaching design, and how these approaches can support learning goals.

One particularly salient difference emerging from our analysis concerns an emphasis on *formal iterative design process*

DIS '19, June 23–28, 2019, San Diego, CA, USA

ISBN 978-1-4503-5850-7/19/06…$15.00

DOI: https://doi.org/10.1145/3322276.3322381

[1] http://www.newschool.edu/parsons/mfa-design-technology/

[2] https://tisch.nyu.edu/itp/admissions/itp-mps

[3] Uses and meanings of *course* and *class* can vary internationally. In this paper, we use the term *course* to mean a series of individual class sessions on a subject, usually taught over a quarter or semester of an academic year.

(e.g., human-centered design [27] or contextual design [32]) as opposed to a *creative design process* [57] that is typical of a studio-based approach to design. The former process is driven by research-based evidence; the latter is driven by ideation, designer expertise, and craft [38]. Each brings with it particular epistemic positions, values, and learning activities. Yet, we found no research literature on pedagogical methods for choosing among these different design processes in HCI courses. Moreover, we found no guidance on pedagogical methods to integrate design processes. This lack of guidance is problematic, because formal iterative approaches and creative approaches to design are not mutually exclusive. Just as divergent design thinking can play a role in an iterative design process, user research can have its place in studio-based instruction.

In this paper, we review the existing research on HCI education as a whole, and design education within HCI. We provide a review of popular textbooks used in HCI courses, along with findings from a survey of 61 HCI instructors, to characterize the distinctive design approaches commonly used in HCI education. Finally, we outline new directions for pedagogical research on design instruction as a vital and foundational area of inquiry in Interaction Design and HCI.

RELATED WORK

History of HCI Education

The 1992 report of the ACM Special Interest Group on Computer–Human Interaction (SIGCHI) Curriculum Development Group is perhaps the first major effort to understand and define HCI educational practices. The authors of the report outlined the objectives of HCI courses, highlighting an understanding of the complexities and diversity of socio-technical systems, the impact of the user interface, cost–benefit tradeoffs in HCI, and the necessity of interdisciplinary work. The report emphasizes a focus on:

> *"...design, implementation, and evaluation tools."* [31]

This description of HCI places *design* as the first of three primary concerns. Yet, despite the vital role design plays in HCI, few studies explore how its instruction is situated and developed as a disciplinary area in HCI education. The lack of studies could be due—in part—to the nature of HCI as an ever-evolving and multidisciplinary field. Indeed, pedagogical research on design in HCI must necessarily engage with the complex nature of the field more broadly.

The typical HCI class can suffer from fragmentation of topics—making it unclear what essentials should be taught [12, 45]. For example, Plimmer et al. pointed out that students must grasp knowledge from disciplines as varied as psychology, software engineering and design, which is hard to achieve in a single HCI class [42]. McCrickard made a novel point that HCI should be an *ordering* of various disciplines instead of a simple *combination* of all [40].

From 2011–2014, the ACM SIGCHI Executive Committee sponsored a project to investigate the present and future of HCI education, focused on what educators, practitioners, and students considered to be top priorities for the field [14]. St-Cyr et al. reported findings from this project, with survey responses and interviews suggesting a pressing need for HCI educators to develop a *community of practice*. In this, community, educators could exchange information and socialize it around their interest in HCI education [50].

They organized a workshop to address this need, synthesizing discussions about HCI education occurring over previous CHI conferences, and compiling educational resources to create a *living curriculum* that could address the multidisciplinary and inherently evolving nature of HCI as it responds to rapidly-changing technological trends, user types, and use contexts [28, 14].

Churchill et al. [14] noted that some of the principles and methods taught in HCI courses change as the current state of socio-technical systems changes—what they call a *progressional* approach to teaching HCI. This trend has also been identified by the design education field at large: the complexity of our world and the computing systems we create require us to change aspects of our design education over time.

HCI Education Research

Building off of the living HCI curriculum conference, researchers and educators held workshops to help build an HCI education community of practice and identify what should be included in (and excluded from) HCI curriculum [54, 14, 7, 56]. These efforts bring the field closer to a collected synthesis of knowledge, which could inform many dimensions of pedagogical research in HCI.

To date, however, educational research on design in HCI has focused on the use of specific techniques or methods such as sketching and storyboarding [13, 39, 52]. Others have developed technology, such as work by Aalst et al. [53] to develop and evaluate an interactive tutor with an emphasis on design space analysis methods to assist student learning.

Still others have focused on pedagogical methods in the HCI classroom, but are not necessarily concerned with design methods. For example, to support student collaboration in HCI group projects, Felker et al. [25] proposed integration of a scrum software development methodology with user experience development methods to keep teams motivated and to give clear structure to class projects. Plimmer et al. emphasized the use of peer learning in a multidisciplinary group in order to share existing knowledge and enable other team members to build upon it [42]. Others have advocated for the use of case studies in the classroom [46, 40].

Few research efforts have pursued an overview of HCI educational methods. Some exceptions include cultural and cross-cultural studies that investigate the methods, values, and ideas inherent in HCI education and their relevance and applicability to emerging local and global contexts [1, 9, 48, 51]. Even fewer studies address design education practices that fall under the larger HCI umbrella. In fact, as we detail below, there has been more research focused on defining design *practice* in HCI than on design *education*.

HCI Design Practices

In the 1st ACM conference on Designing Interactive Systems (DIS), Löwgren differentiated the use of the term "design" into two broad categories: *engineering design* and *creative design* [38]. Applying design methodology to software development, the authors note:

> *"Engineering design assumes that the 'problem' to be solved is comprehensively and precisely described, preferably in the form of a requirement specification. The mission of engineering design is to find a solution to the problem. ... Creative design work is seen as a tight interplay between problem setting and problem solving. In this interplay, the design space is explored through the creation of many parallel ideas and concepts. The given assumptions regarding the problem are questioned on all levels. Creative design work is inherently unpredictable. Hence, the designer plays a personal role in the process."* (p. 87)

In 2003 Fallman [23] built upon these distinctions and identified three different accounts of design:

- the process-oriented, conservative account focused on *"...solely scientific conduct, a fully transparent process."* (p. 231)
- the product-oriented romantic account *"...black-boxing design, where it becomes a curious art performed by some creative genius."* (p. 231)
- the down-to-earth, pragmatic account *"...concealing design as an unimportant practical bustle with reality..."* (p. 231)

He suggests that HCI design practices tend to fall into one of these accounts, whereas design should rather be defined by the pulling together of many accounts to make a whole:

> *"The role of design in HCI is thus to be found in the act of trying to unfold a coherent whole—a previously nonexistent artifact—from the various bits and pieces gathered in the process of research, but which simply put together do not by themselves form this whole. Fieldwork, theory, and evaluation data provide systematically acquired input to this process, but do not by themselves provide the necessary whole. For the latter, there is only design."*(p. 231)

Wolf et. al. [57] built upon Fallman's distinctions or accounts of design in the context of more current HCI practices (i.e., User Centered Design). They argue that design in the HCI context has suffered from a need to legitimize design choices through a formal iterative refinement process that is different from typical creative design practices that can be seen as "black art."

> *"The formality of this practice is not commonplace in creative design, but is an accommodation to the cultures of engineering and user-centered design. Formal iteration allows designers to prove or at least account for the evolution of their design in a manner acceptable to the CHI community. In this way designers reduce the need to justify design decisions, because they have empirical evidence that their decisions are 'correct.' In contrast, we describe the process of creative design and show how it has its own form of rigor, by which we mean not formalization, but 'rigor' as a repeatable process, of a consensual standard of quality, in use by a professional community of practice."* [57] (p.522)

This brief review of design approaches in HCI highlights a dichotomy that scholars have seen in the processes of both practitioners and researchers. The ongoing discourse surrounding the question, "what is **design** in HCI?" has a long, rich history. Instead, this paper asks a related question that is just as vital, "what is **design education** in HCI?"

Design in HCI Education

There is a robust body of literature addressing design education in creative settings, and how design courses have evolved to include interaction design [19, 55]. These sources provide us with insights into creative design teaching practices. A number of designers, educators and researchers have identified shifts in design education, moving from a focus on *artifacts* toward a focus on *interactions* that looks at the process involved in the design of complex socio-technical systems [19, 21, 41]. Research in the learning sciences has begun to address issues related to design and complex real world systems, building upon a long research history in Problem- and Project-based Learning [37, 11]. In HCI education it has also been noted that these complex systems, and the technology they involve, leave us training students for an ever-changing design landscape [36].

As Blevis et. al. [8] identify, there are significant issues in bringing design skills to HCI students, including issues with the constraints of physical classrooms, cultural differences, and incorporating project-based learning curricula across disciplinary fields. Faulkner et al. [24] point out that the lack of communication between more traditional computer science (CS) courses and HCI can make it harder for students to experience a real "design" environment, let alone one in which users' needs drive the design process.

These concerns have continued to pervade today's HCI classroom, motivating research efforts focused on addressing them, especially for those HCI courses situated in CS programs. Vorvoreanu et al. [54] and others [34, 44] presented a model for incorporating studio-based pedagogy into the HCI classroom. Vorvoreanu, argues for the benefits of the studio-based environment for CS students, noting the importance of project-based learning, creation of artifacts, class sessions lasting several hours each, collaboration between students and faculty, and critique sessions.

However, this studio pedagogical model also raises concerns about how to teach HCI with such an approach. For example, many HCI instructors seek to support students in making the transition smoothly from school to industry [54, 25, 24] and thus find it difficult to support creative practices with real-world, hands-on experience [46] while balancing individual cultivation of skills with collaboration in group projects [2]. Others have sought to find ways to address the physical challenges of studio-based design education in HCI courses where

classrooms are not equipped in the same way as studios [34, 16].

While these educational research efforts to understand and improve design pedagogy in HCI are useful, such efforts are few and far between. This situation is similar to other aspects of CS education [18]. Teaching design also poses unique challenges that cannot simply be addressed by applying one model of learning (e.g., studio-based learning) or one disciplinary approach without understanding the complexities of the discipline, the institutions in which it is taught, the backgrounds of students and faculty, and the influences of industry. Based on these insights, we argue for the need for concentrated research efforts that can inform and shape the HCI design education landscape as our field moves forward.

METHODS

To gain a better understanding of the range of practices and trends in design education in HCI, we conducted a review of popular instructional books used in HCI courses, and conducted an international survey of HCI instructors.

Design In HCI Instructional Books

To identify common approaches to design and design pedagogy taught in HCI instructional books, we reviewed a set of popular course texts. To determine popularity, three authors collectively consulted the Best Sellers list on Amazon.com.[4] The Best Sellers list organizes products (e.g., books) by topic and subtopic, rank-ordering products within each topic or subtopic by their sales. Beginning in Computers & Technology books, and further narrowing in on Graphics & Design we evaluated each subtopic, arriving at User Experience & Usability as the final, most relevant, subtopic in which texts are rank-ordered by sales.[5] The same three authors then collectively reviewed the top 50 books in the rank-ordered list, beginning with the most popular.

We excluded books that appeared multiple times on the list in different formats or editions, resulting in an initial list of 47 books. We then collectively reviewed and discussed each book to determine its suitability for use in an industry- or university-based (undergraduate or graduate) HCI design course. Thus, we included books that were geared toward training practitioners (e.g., [35, 17]) and university classroom instruction (e.g., [43, 49]) but excluded books that were narrowly and exclusively focused on more niche topics (e.g., service design, CSS).

This collective review further narrowed the list down to 14 books. With our final list (below), two authors independently analyzed the contents of each book to distill, in a thematic fashion, the general approaches to design inherent in each. The pair of authors subsequently reviewed each theme, followed by group meetings to resolve disagreements, revise the themes in a comparative fashion, and use them to finalize the pedagogical approaches embodied in the texts.

[4]Specific rankings on the Best Sellers list change frequently. We included 50 of the top-ranked texts in our initial review to help mitigate these fluctuations.

[5]https://goo.gl/aAy3KR

Instructional Books Reviewed

- *Don't Make Me Think revisited, 3rd ed.* [35]
- *Interaction Design: Beyond Human-Computer Interaction 4th ed.* [43]
- *Designing the User Interface: Strategies for Effective Human-Computer Interaction, 6th ed.* [49]
- *About Face: the Essentials of Interaction Design, 4th ed.* [17]
- *Handbook of Usability Testing: How to Plan, Design, and Conduct Effective Tests, 2nd ed.* [47]
- *Designing with the Mind in Mind: Simple Guide to Understanding User Interface Design, 2nd ed.* [33]
- *The UX Book: Process and Guidelines for Ensuring a Quality User Experience* [30]
- *Measuring the User Experience: Collecting, Analyzing, and Presenting Usability Metrics, 2nd ed.* [3]
- *Usability Testing Essentials: Ready, Set... Test!, 1st ed.* [5]
- *Sketching User Experiences: The Workbook, 1st ed.* [29]
- *Observing the User Experience: A Practitioner's Guide to User Research, 2nd ed.* [26]
- *Contextual Design: Design for Life, 2nd ed.* [32]
- *Sketching User Experiences: Getting the Design Right and the Right Design, 1st ed.* [10]
- *The Design of Everyday Things: Revised and Expanded Edition* [41]

HCI Education Survey

We conducted an IRB-approved, online survey of HCI instructors from 2016–2018. The survey was advertised on the SIGCHI and CHI Meta Facebook groups, as well as through snowball sampling with the authors' professional networks, ACM SIGCHI leadership, and respondents' suggestions. Paper postcards with both the URL and 2-D barcodes to access the survey were distributed at ACM CHI and ACM DIS conferences between 2016–2017.

Survey Design

We developed an online survey by referencing findings from Churchill, Preece, and Bowser's seminal multi-year study on HCI education [15] along with our own review of publicly-available HCI course syllabi.

In addition to the authors' own iterative testing of the survey, testers also included two faculty who teach at a top-ranked professional HCI program. All testers took the survey multiple times with different scenarios in mind in order to examine completeness of response sets. All testers commented on clarity of wording, layout, and order of questions, and perceived ability to answer the questions. We drew on findings from these tests to improve the survey design in an iterative fashion before deployment. The online survey was developed and deployed using Qualtrics.

The survey featured a total of 39 questions, including both closed- and open-ended questions. It focused on collecting baseline data about the administration of HCI classes, learning goals, current challenges faced by instructors of HCI classes, and more specifics about design components of such classes.[6]

Survey Participants

HCI instructors in our final set were affiliated with a wide range of institutions in the United States (n = 30), Latin America (n = 19), Europe (n = 11), and South Asia (n = 2). [7]

Respondents had varying experience teaching HCI, ranging from less than one year to over 20 years. Most respondents (n = 32) had five years of experience or under.

The majority of our participants' home departments were computer science (n = 26) and information science (n = 12) which includes information science, information systems and information technology. Other participants were part of departments such as design, communication, engineering, and human factors.

Survey Analysis

Beginning with an initial response set of 110, we reviewed each response to check for completeness and remove duplicates, resulting in 61 responses that met the completeness criteria.

We analyzed survey questions with single-selection and multiple-selection responses using descriptive statistics. We examined responses to open-format survey questions through inductive thematic analysis (by three authors, done collaboratively).

FINDINGS

Current Design Practices in HCI Instructional Books

Our qualitative analysis surfaced two fundamental approaches to the design process in the source texts, and seven specific instructional approaches to teaching them.

Distinct Approaches to Design Process

Formal Iterative Design (e.g., User Centered Design) is a sequenced ordering of methods that lead from determination of user, functional, and business requirements to the design, specification, and evaluation of an artifact. Underlying most HCI texts is an explicit or implicit assumption that they are following a UCD process, which produces evidence from user research that justifies design choices. For example, Schneiderman [49] (p. 105) and Preece [43] (p. 319) describe data-driven approaches to interaction design, e.g., user-centered design. Texts that focus on research methods (more below), e.g., [47], [3], [5], assume that these user-centered methods are part of a larger, research-driven design process.

Creative Design Process refers to a highly iterative exploration of many design concepts and solutions. Developed through the traditions of the design studio, a creative design process will proceed through steps including an exploration of related examples, experimentation with visual ideas and physical forms, parallel exploration of many design ideas, and formal and informal presentation of results with critique. Implicit to the creative design process is the idea that designers will be trained to make expert judgments to inform their design choices. Very few of the texts considered here touch on this process, and in most cases it is a superficial treatment, with the exception of the books on developing technical skill in executing visual design, such as sketching [29, 10].

Specific Pedagogical Approaches

Prescriptive texts described specific procedures for carrying out research and design work. For example, Greenberg, et al. [29] provide instructions on how to sketch a variety of HCI-relevant representations, from storyboards (p. 147) to state transition diagrams (p. 143). Holtzblatt and Beyer [32] specify how to facilitate a team visioning session (p. 280), create an affinity model (p. 127), sketch storyboards (p. 315) etc., while Krug [35] provides a step-by-step process to translate usability evaluation findings into UI design modifications (p. 137).

Descriptive texts characterize a topic, theory, or process. For example, Shneiderman, et al. [49] describe what Direct Manipulation is (p. 199), discuss its advantages and disadvantages (p. 204), and present several case studies to illustrate the concept. Preece, et al. [43] write about human cognition (p. 65), and provide a taxonomy of various types of interface (p. 159).

Theory-driven instruction and theoretical underpinnings for the information they provide were included in some texts. For example, Johnson [33] explains the implications of the Gestalt theory of perception for HCI design (p. 13), describes a model of human memory and its design implications (p. 87), and explores how the way people learn has implications for system design (p. 149). Norman's influential book, *The Design of Everyday Things* [41] derives its design guidance from a conceptual model of design — problems result when there is a mismatch between a user's conceptual model of a system, the way the system actually works, and the designer's understanding of both (p. 16).

Technology- and Applications-based approaches characterize the specific interaction considerations, challenges, and opportunities inherent in specific devices and media types. Shneiderman et al. [49] ground much of their text in the context of specific types of interactive media and specific interaction devices, e.g., video games (p. 208), data entry devices (p. 300), display formats (p. 328), and so on. Preece, et al. [43] also devote space to specific technologies, including virtual reality (p. 178), collaborative interfaces (p. 120), and robots and drones (p. 216). Cooper et al. [17] focuses heavily on user interaction with two-dimensional displays and controls, e.g., the mouse, dialog boxes, and toolbars.

Guidelines-based approaches describe design principles, rules or other guidelines for effective design based on theory, heuristics, or best practices. Many of the texts we reviewed provide

[6] The full survey instrument is included in Supplementary Materials.

[7] Several geographic areas (e.g., Africa and Australia) are not represented in the pool of survey respondents. This lack of representation likely reflects the makeup of ACM CHI and DIS conference attendees and the survey sample size. We recognize that the omitted regions may have other pedagogical approaches to HCI instruction that are not represented in these survey results. Such possible differences should be considered in future research.

specific guidance regarding design or process elements that will ensure effective and efficient human performance. The Cooper et al. [17] text, for example, contains a number of design principles, such as, "The selection state should be visually evident and unambiguous." (p. 396).

Krug [35] provides more specific guidance, e.g., "Your objective should always be to eliminate instructions entirely by making everything self-explanatory ..." (p. 51). Johnson [33] also provides a number of very specific design principles, such as "See and choose is easier than recall and type" (p. 125) and "Deactivate invalid commands" (p. 167). Norman [41] contains higher-level guidance, such as "Physical constraints are made more effective and useful if they are easy to see and interpret ..." (p. 84) and "A good conceptual model allows us to predict the effects of our actions."

Research Methods-based approaches focus on how to carry out investigative activities in formative, iterative, and evaluative phases of design, e.g., contextual inquiry, card sorting, usability testing. To varying degrees, almost all of the HCI books considered here provide instructions (sometimes step-by-step) to conduct HCI-related research activities. There are, however, notable exceptions that do not include such methods [33, 10, 41].

Patterns-based approaches include common ways to address specific user requirements and design concerns through specific UI design choices and element sets, e.g., tabs, scroll bars, or design templates. Some texts provide guidance about when and how these design patterns should be used. Cooper, et al. [18], provides the best example of a text that explains the use of interaction details, including controls, dialogs, menus, toolbars, and palettes. Krug [35] also provides design guidance for common patterns such as tabs, breadcrumbs, and page names.

User Community-focused instruction highlights different types of users (e.g., older users, children, users with varying hearing, vision, or cognitive abilities) and specific considerations and research engagement needs during the design process, to ensure the resulting product or system meets their needs. For example, Preece, et al. [43] (p. 483) outline the accessibility requirements of Section 508 of the US Rehabilitation Act. Krug [35] (p. 178) explores four things designers can do to improve the accessibility of their products.

Our qualitative analysis of popular HCI instructional books reveals large differences in approach, content, and style. To a large extent, this does not come as a surprise. Authors' backgrounds differ and books can be written to meet varying market needs. The prescriptive approach ("Do it this way") taken by a practitioner such as Krug [35], writing for other practitioners, is going to be very different from the descriptive approach taken by Preece, et al. [43] or Shneiderman, et al. [49], who are writing for an academic audience.

What is surprising, however, is the lack of emphasis on creative design processes in the typical HCI textbook. Some of the texts do touch on ideation-related instruction such as brainstorming or visioning as being a part of the process (e.g., [43], [49], [30]), with Holtzblatt and Beyer's book on contextual design explicitly identifying methods for going from data to design), but few explore methods that are common to a design studio approach. Buxton's and Greenberg et al.'s texts on sketching [29], [10] are notable exceptions.

HCI EDUCATION SURVEY

In addition to the review of texts, we conducted an online survey asking questions about HCI education, which focused on design instruction specifically for those who teach it. We asked respondents to keep a specific HCI course in mind when answering questions.

To define HCI in the survey, we stated:

> *"We note that ACM SIGCHI states that members of the SIGCHI community are involved in the 'design, implementation and use of interactive computer-based systems in the broadest sense.' If your classes train students at the college or graduate level in any of these aspects of interactive systems, your class counts."*

We found that 92% of our respondents reported that they teach design in their HCI classrooms. Below, we report on results pertaining to all survey respondents (i.e., general HCI instruction). We then dive into design-specific methods, goals, and challenges. Most questions in the survey included response sets that we provided with fill-in fields available to accommodate free-form responses, for each question.

We differentiate free-form answers (in quotes) from selections of given choices (in italics) when reporting results below.

We elaborate on our findings and discuss their implications for pedagogical research in the Discussion section.

Characteristics of HCI Courses

HCI courses span diverse disciplinary areas, topics and research methods. In the course descriptions given by participants, the word "design" was the most-frequently-used term in the course descriptions of our participants, followed by "interaction".

Topics taught in HCI courses

Instructors of HCI courses who responded to our survey taught a range of topics (see Figure 1).

The topics addressed most often included:

1. *Prototyping and software development* (92%)
2. *Design* (92%)
3. *User research; research and evaluation methods* (89%)

Research Methods Taught in HCI Courses

The most common research methods taught included *Interviews, Ethnographic Observation, Survey Design, Sketching, Personas and Scenarios*, and *Usability Studies* (see Figure 2).

Research and evaluation methods that were poorly represented included *Spoken language user interface techniques*, and both *Physiological* and *Psychometric data collection and analysis*.

Prototyping Methods in HCI Courses

To examine which prototyping methods are taught, we looked at the specific methods respondents identified (see Figure 3).

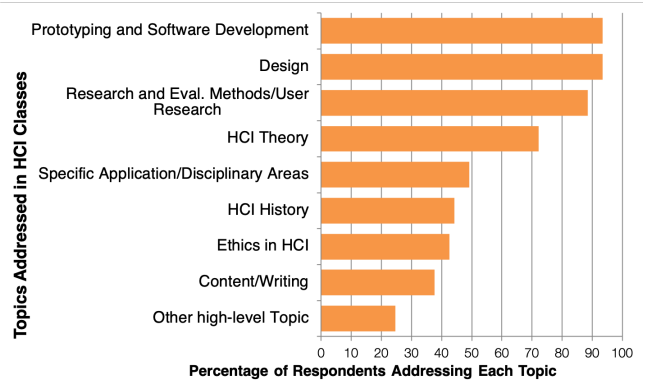

Figure 1. The topics addressed in the HCI classes taught by survey respondents (n = 61). Other high-level topics included "Sustainability, Responsible Design", "Advanced CSCW", and "UX".

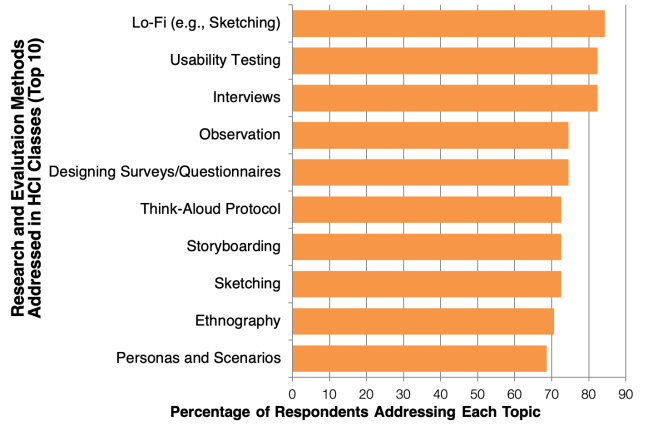

Figure 2. The top ten research and evaluation methods addressed in the HCI classes taught by survey respondents (n = 61).

The closest to uniformity we found was the use of *Low-fidelity (Lo-Fi) Prototyping* in class, which was taught by approximately 85% of the respondents.

The "middle ground" in prevalence included *Back-end software development*, *Graphical UI programming* and *Medium-fidelity prototyping* with *Specific software packages*.

These topics were spread according to the emphasis of the degree programs that respondents taught in, and the instructors' expertise.

There were low response rates for prototyping techniques that engaged with technologies popular in HCI research today, such as methods for design that incorporates or interacts with *Machine Learning*, *Microcontrollers/ Integrated circuits*, *Sensing applications*, *Natural Language Processing*, and *Fabrication*.

Evaluating Student Learning

Evaluation of student work often included a range of methods and most respondents selected several methods they use in their classroom (see Figure 4). In contrast, fewer evaluation methods reported focused on research efforts such as *Research deliverable(s)*, *Research reports*, *Literature Reviews*, *Reports on experiments/ Project work*, and *Requirement documentation*.

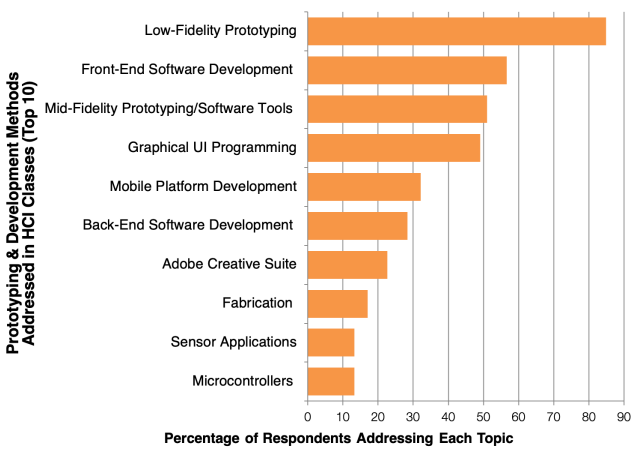

Figure 3. The top ten prototyping and development methods used in HCI courses taught by survey respondents (n = 61).

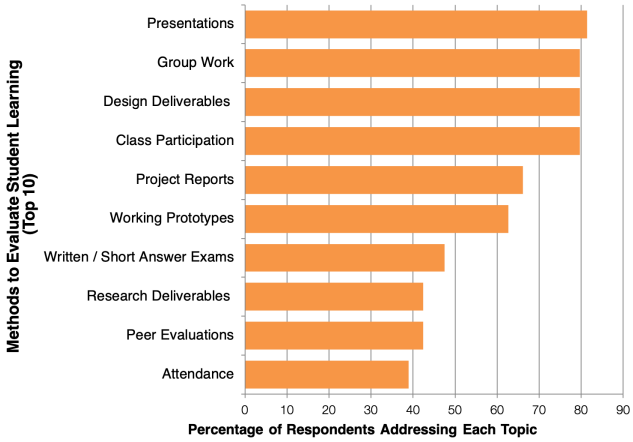

Figure 4. The top ten methods used to evaluate student learning in HCI courses taught by survey respondents (n = 61).

Similarly, evaluations of *Working software* and *Hardware applications* were less frequently used.

Design Instruction in HCI Courses

Design Topics Taught in HCI Courses

We found some concordance on the topics respondents taught in HCI courses, with *Interaction design* (93%), *Design techniques/practices* (84%), *User-centered and participatory design* (83%), *Visual design* (63%); *Accessibility and universal design* (57%) and *Design theory* (52%). All of these were selected by more than 50% of the respondents. In the mid range was *Information architecture* (40%).

Areas that had far less representation were *Critical design* (26%), *Privacy and usable security* (18%), *Speculative design* (13%), *Industrial design* (4%) and "Game design" (4%).

Learning Goals for Design in HCI Courses

There was less consistency in the learning goals that respondents set for their HCI courses (see Figure 5). The most frequently-specified goal included *research methods* at 75%; *research evaluation* at 64%, *empathy and understanding users* at 62%, *creativity* at 59%; and *visual communication* at 50%. No other goals were selected at more than 50% by participants.

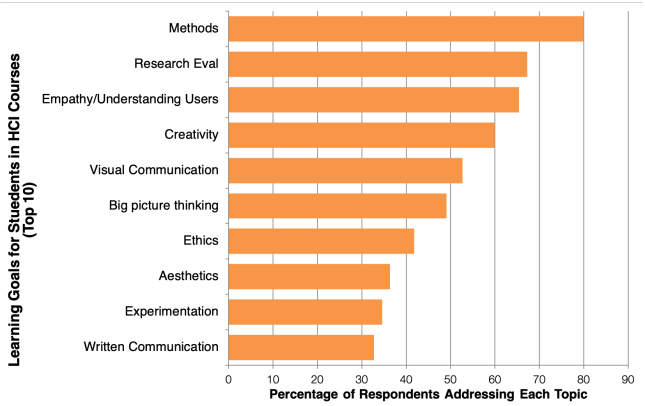

Figure 5. The top ten learning goals for students in HCI Courses taught by survey respondents (n = 61).

Despite the common goal among respondents to teach design methods, analysis of our results reveals that participants have widely-varying concepts of what makes design instruction, pedagogy, and evaluation of design products. The following section will explore this complexity, mapping it to discussions on the dichotomy of approaches to design instruction in HCI and the implications that follow.

DISCUSSION

We previously identified that while HCI design processes have been an ongoing area of interest, there has been a lack of research focused on design education in HCI. To address this, we sought to understand the approaches to teaching design in HCI courses at institutions of higher education, by looking at popular books used in HCI classes and by surveying HCI educators.

In this section, we explore how design education in HCI evinces the dichotomy that we see in the field as a whole. We then suggest approaches to design education research to address this dichotomy, and discuss how we might reconcile tensions between academic and industry influences on design instruction.

Distinctive Approaches to Design Education

Building upon the previous literature and the findings of our research, we identify two distinctive approaches to design in HCI education: *formal iterative design* and *creative design*.

Formal Iterative Design

What we identify as formal iterative design corresponds to Wolf's and Löwgren's "engineering design" [57, 38] or the "process-oriented conservative" account of Fallman [23]. We characterize this type of design as *formal iterative design*, rather than "engineering design", because the majority of literature on design education in engineering follows what has been summarized as, *"...an epistemological approach, systematic questioning, where known, proven principles are applied to analyze a problem to reach verifiable, 'truthful' answers or solutions"* [22].

This focus on teaching students to empirically test against "proven principles" suggests that proof takes the form of a priori assessments about what "good" heuristics or metrics are. These a priori principles, seen as objective, could be adopted without a critical analysis of their applicability to the particular design work.

We see this approach to testing against a priori principles—without critical analysis—as dissimilar to the instructional practices we discovered in HCI. There were few responses in our surveys, and in the methods sections in the textbooks we reviewed, that indicated that the iterative design process taught was based upon the engineering design approach. Instead we use the term "formal", because the design process taught is usually a set of explicit steps, which include both qualitative and quantitative notions of evidence that inform design choices, and progression toward meeting design goals.

We use the term "iterative" because the steps usually include identifying requirements, creating a design in response to those requirements, then testing that design, and then repeating the process, systematically iterating the design based upon feedback. This corresponds to many of the instructional approaches identified in our review of books, such as the *prescriptive* steps with specific procedures for designing, the specific evidence-based guidance in many *guideline-based* approaches and a heavy emphasis on *research methods* to gather requirements and to evaluate designs. In this way, formal iterative design is evidence-based, similar to engineering design, but also embraces qualitative methods and the explicit use of an iterative process.

Creative Design

Our use of the term "creative design" is similar to that of Wolf et al. [57], Löwgren [38] and what Fallman [23] calls the "product-oriented romantic account." The challenge inherent in the type of creative design they identified is that it is frequently "black boxed" or romanticized to be beyond methodology and instead based on innate talent.

Yet, the creative design process has a rich history of being taught in studio arts, industrial design, architecture, visual design courses and many more. The challenge that Wolf et al. highlighted is that the nature of the creative process is difficult to communicate and difficult to use as "evidence" for many audiences that HCI designers work for, such as software developers and more technical clients.

Creative design, as we use it here, is the process of pursuing many parallel design directions—through a variety of generative methods to explore envisioned solutions—to create a more divergent set of concepts [20]. In addition, the creative design process acknowledges the expertise of the designer, who must make judgments based upon experience and skill to identify what is "good design" or "poor design" and who is often not focused on evidence to justify design choices.

This experience is gained by designing, but is also gained through the process of analyzing and critiquing other designs [19]. Our review of instructional books suggest that some approaches identified, such as *theory-driven*, *pattern-driven* and higher level *guideline-based* instruction, leverage an approach that seeks to build students' capacity as experts, capable of making design choices based on the study of other designers and previous designs. At the same time, there are open

research questions relating to how to best cultivate creative design expertise in students who are new to this form of design.

Implications for Design Education Research

Industry recruiters report that they look to hire not only graduates trained in traditional user-centered design methods, but also those who are trained in the traditions of the design studio—traditions that are not reflected in the popular texts and HCI courses considered in this paper. An important research opportunity exists to explore more extensively how these creative processes can be integrated into traditional HCI education.

Although the field of HCI has recognized that there are distinctive design approaches used in industry and research settings, we found little evidence that these distinctions are recognized in the classroom. While some of the textbooks we reviewed touch on creative practices, such as brainstorming, creative sketching, storyboarding, speculative design, and cultural probes, most took an approach to design that is more aligned with formal iterative design. Some learning sciences research, which has tried to address design in non-creative classrooms, also focuses on a formal iterative approach to promoting student learning through linear iteration [37], and formalized rubrics for assessing student outcomes [11].

Indeed, design is central to how the HCI community defines itself. We found from the survey responses that design is among the most oft-used words in course names. However, key aspects of design, such as creativity and design theory, were not part of the curriculum for many respondents. Furthermore, few respondents offered consistency in their responses that indicated whether they aligned themselves with teaching formal iterative design or creative design. In other words, instructors seemed to waver between what they wanted to teach (i.e., both approaches to design) and what they did teach (i.e., generally formal iterative design).

This does not mean we need to privilege one type of design over another in the classroom. Rather, we see three main areas where this observation may provide direction for future work: 1) identifying distinctive design approaches and the value of each, 2) understanding effective approaches to teaching a formal iterative design process, and 3) addressing issues with teaching creative design in more traditional HCI programs. We consider each of these areas below.

Distinctive Design Approaches

Recognizing these two distinctive design approaches and communicating what we are teaching to our students could benefit both faculty and students. Many faculty members assume they are teaching creative practices – slightly more than 50 percent of our survey respondents listed creativity as a learning goal. We also identified that these distinctive approaches were apparent in the instructional books reviewed. But the techniques expressed in the survey and the instruction in the books reviewed do not match that goal. Instead we saw a greater emphasis on formal iterative design with many of the books outlining a step-by-step process to design and few books [41] providing examples and critique of design as one might find in a creative practice.

Evaluating curricula with an eye toward identifying what is formal iterative design and what is creative design is a first step toward focusing on design teaching. Once we identify what types of design are being taught, we can begin to balance our curriculum, focusing on different priorities for different classes and institutions. And then, we can teach students about the distinctive approaches to design, e.g., What type of design is being taught? Which approach is best for different design objectives? Which approach is used in different sub-fields of HCI?

To answer these questions, educational researchers should seek to conduct a review of syllabi, interviews, observations, and other techniques that would provide better insights beyond surveys and a review of books. It is not only important to identify what is taught and how it is taught but also to map the topics and pedagogy to learning goals and assessments. One could map formal iterative design learning goals, such as the use of evidence-based design choices, to the ways it is taught and study the effectiveness of different assessment techniques.

Similarly, one could map creative design goals, such as the ability to critique others' designs, to teaching practices and assessment techniques. This mapping would provide a set of approaches used by different instructors that could be evaluated for their effectiveness in the classroom and comparatively assess the learning outcomes. It would also help to identify the time devoted to each approach, assisting instructors balance between formal iterative and creative design learning goals, as is appropriate for their class.

Teaching Formal Iterative Design

We need to understand how to teach formal iterative design more effectively. While there is a long history of teaching creative design [19] and traditional engineering design [22], the formal iterative design process is rather different. The long list of textbooks and wide range of design and evaluation methods selected in our survey suggest that instructors teach myriad topics related to a formal iterative design process. But, to date, there is little research on how to teach these methods effectively.

Similar to research that has gone into identifying the factors that make a good "CS 1" course, we see a need to conduct research on teaching HCI more broadly, and the formal iterative design process particularly. We need to ask questions such as: What role does group work play in teaching design? How can one evaluate students learning design process versus design outcomes? How can we help students leverage their previous knowledge from more technical classes to HCI design?

Building upon learning sciences literature, we can identify best practices for the classroom in developing project-based work [6]. Research will also help us identify appropriate learning goals for a deep understanding of formal iterative design practices, develop scaffolds for learning these goals through instructor modeling and coaching, teaching embedded into the project work, and contrasting cases. Finally, research on how to conduct formative assessment of learning through the project, rather than relying on a summative assessment of the final presentations, will improve learning outcomes.

Teaching Creative Design

We need to leverage existing knowledge about teaching creative design and adapt that knowledge to the HCI classroom in technical programs of study. An obvious first step would be to hire faculty who have a background in design (as some programs have chosen to do). However, in most informatics, computing, and engineering departments that offer HCI courses, the bulk of the faculty have backgrounds in computing-related fields rather than creative fields.

Faculty hires are constrained by the tenure and promotion process, which, in computing departments, can heavily favor faculty with computing backgrounds who are more likely to have a Ph.D. To leverage existing knowledge in creative design, it is vital to conduct research that addresses how to integrate more creative-design-focused instruction and faculty partnerships into our computing and informatics-based programs. How can we best introduce pedagogical knowledge of creative design practices to faculty trained in engineering, psychology, computing, and informatics?

Students in computing programs (e.g, entering a CS masters program with an engineering background) may lack the knowledge of how to learn in a studio-based environment. The defensive climate of the CS classroom has trained CS students that open discussions are often something to either fear or use as an opportunity to demonstrate knowledge, rather than an opportunity to learn from each other [4]. Expectations in computing classes are also often centered on getting the correct answer, rather than developing an exploratory process that is part of a design studio pedagogy.

Other challenges in moving towards more creative design instruction are less about subject matter and more about infrastructure. One issue, for example, is class size. The HCI courses taught by survey respondents in technology-focused departments tended to include more than 25 students. Teaching a design studio course with a class of 25 is challenging, and it is impossible for a class of 40 without co-instruction.

Studio-based courses require extensive in-person time for faculty to help students work through design processes. The sheer size of a large class makes finding that time difficult. Time is often constrained by the length of the class period. CS courses generally include three hours per week of in-class instruction, compared to six or more hours per week for studio-based courses. With larger course enrollments and shorter class times, the traditional creative design pedagogy, which requires one-to-few interactions such as critiques, does not fit within the constraints of many HCI courses.

Another constraint involves the physical classroom configuration. In studio-based learning environments, for example, students work in classrooms that allow for creative activities. These classrooms may include mobile tables, pin-up boards, spaces to save work and various physical tools.

In technology-focused departments, on the other hand, it is likely that small desks, fixed tables, auditorium seating and other constraints interfere with a working environment that invites highly iterative, small group interaction. This lack of opportunity for just-in-time instruction means faculty are left evaluating the final products more than the design process itself, leaving them with few opportunities for formative assessment. This lack of early guidance, in turn, could lead to less effective teaching.

These constraints seem difficult to change in many institutions, but there are opportunities for education researchers to find approaches that allow for more creative design in HCI courses. Recently, Vorvoreanu et al. [54] identified many of these issues —along with others—when trying to integrate studio pedagogy into user experience classes. There are many opportunities for future research to expand upon novel methods for integrating creative practices in HCI courses.

We have yet to see design pedagogy research that focuses on adopting and integrating the two design approaches we identified in this paper, in technology-focused educational programs.

We propose not to neglect one approach to design education, but to embrace the differences, using educational research practices to identify methods to teach and to evaluate design learning under these unique circumstances.

CONCLUSION

While the field of HCI has grown and matured, there is a lack of research on design pedagogy in HCI. Research on education in HCI more broadly is also vital, to understanding how design instruction is situated.

In this paper, we review the existing research on HCI education as a whole, and design education within HCI. We provide a review of popular textbooks used in HCI courses, along with findings from a survey of 61 HCI instructors, to characterize the distinctive design approaches commonly used in HCI education.

We highlight a lack of awareness and integration of different approaches to design education in the typical HCI classroom. We see the need for research on HCI design education to: 1) help instructors identify the value and suitability of different design approaches, and how those approaches can best be used for different learning goals, 2) develop new pedagogical approaches to teaching formal iterative design that considers balancing creative effort along with evidence-based choices and the institutional constraints of many HCI programs, and 3) leverage previous research on studio-based pedagogy and integrate these approaches into HCI programs, creating an open discourse in classrooms that respects both evidence-based choices and design choices based upon expertise.

This paper provides a framing for design scholars to understand HCI design education better, along with evidence from teaching materials and HCI instructors about what the current design education practices are. We draw on these findings to identify an agenda for future research on design education as a foundational area of inquiry in Interaction Design and HCI.

ACKNOWLEDGMENTS

We thank our study participants and James McDowell, at Georgia Tech, for his help with the figures in this paper.

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