# Designing Voice Interfaces: Back to the (Curriculum) Basics

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## ABSTRACT
Voice user interfaces (VUIs) are rapidly increasing in popularity in the consumer space. This leads to a concurrent explosion of available applications for such devices, with many industries rushing to offer voice interactions for their products. This pressure is then transferred to interface designers; however, a large majority of designers have been only trained to handle the usability challenges specific to Graphical User Interfaces (GUIs). Since VUIs differ significantly in design and usability from GUIs, we investigate in this paper the extent to which current educational resources prepare designers to handle the specific challenges of VUI design. For this, we conducted a preliminary scoping scan and syllabi meta review of HCI curricula at more than twenty top international HCI departments, revealing that the current offering of VUI design training within HCI education is rather limited. Based on this, we advocate for the updating of HCI curricula to incorporate VUI design, and for the development of VUI-specific pedagogical artifacts to be included in new curricula.

### Author Keywords
Voice user interface; Conversational interface; Speech; VUI Design; HCI Education; HCI Curriculum

### CSS Concepts
• Human-centred computing → **Human computer interaction (HCI)**

## INTRODUCTION
Voice user interfaces (VUIs) such as those embodied by digital assistants (e.g. Amazon Alexa, Google Home, etc.) are rapidly increasing in popularity in the consumer space. This leads to a concurrent explosion of available applications for such devices, with many industries from tech companies, to financial service providers, to travel agencies, and even appliance manufacturers rushing to meet users' expectations of being able to interact with their product through voice. Until not long ago, developing VUIs was largely the purview of engineering. However, with advances in machine learning, speech processing, and natural language understanding, VUIs are now firmly established as mass-market consumer products, and are no longer just a niche product for techno-enthusiasts or for limited specialized domains. As such, the pressure to keep up with the commercial demand of designing voice interfaces and applications has been transferred to interface designers to handle.

However, a large majority of interface and user experience designers have been trained to mostly handle the usability challenges specific to Graphical User Interfaces (GUIs) [21]. This makes designing for VUIs difficult because, as previous research has shown, designing for voice interfaces is quite different than designing for graphical interfaces [30,43]. It has been shown that design principles and patterns that are currently applied to GUI interfaces can't be directly applied to VUIs. In particular, this may pose additional difficulties for designers currently trained in GUI design to transition to VUI. For example, a previous study showed that usability designers who are transitioning to designing for voice often found themselves lost when attempting to do so [42]. Due to the current popularity in the commercial market of conversational voice devices such as Amazon Alexa and Google Home, it is an immediate necessity to train both current and future designers in voice interaction design.

These issues call for an increase in HCI education development to help train designers to handle the new usability challenges that come with using voice as a primary mode of interaction. Our current HCI teaching methods are still geared towards traditional design principles and design/evaluation methods that were developed with GUIs in mind [21]. This makes it difficult for new designers to be properly trained in VUIs. Therefore, it is important for the HCI community to reflect the technical and research advances in such interaction techniques back into the foundations of our discipline (teaching/training being one such foundation). In fact, we are seeing an increase in research on updating HCI curricula for these newly emerging interaction techniques at CHI [5,14,17,27]. This



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captures the importance that the HCI community places on pedagogical research (including curriculum work). These advancements also call for an increase in pedagogical tools that can be used by educators to teach designers how to design for VUIs. Since VUIs differ significantly in their design and usability issues from GUIs, we investigate in this paper the extent to which current educational resources prepare designers to handle the specific challenges of VUI design.

For this, we conducted a preliminary scoping scan and syllabi meta review of HCI curricula at twenty-five top international HCI departments, revealing that the current offering of VUI design training within HCI education is rather limited. We first perform the preliminary scoping scan to explore HCI course offerings from a high-level perspective, in order to get a preliminary view on the courses offered in current HCI departments that potentially discuss VUI design. We then perform a detailed syllabi and course material meta-review on 10 of the courses identified in the scoping scan, where we more deeply explore the coverage on VUIs that exists in current HCI courses, and how these courses present VUIs - both as an interaction style and the practical design advice that is taught. We found that, as it stands, current HCI curricula has not been updated to take into account the new design problems that VUIs present, and design practices and principles for VUIs. Our analysis suggests that what is lacking in current VUI education within HCI are the *theoretical and practical considerations* of building VUIs, a focus on *voice-based* conversational UIs, and a focus on the *interaction design* of VUIs. Based on this, we advocate for the updating of HCI curricula to incorporate VUI design, and for the development of VUI-specific pedagogical artifacts to be included in new curricula.

## RELATED WORK

Here, we explore both the current state of VUI design and how it is conducted, along with how research on developing and improving design education has been conducted (both in the general HCI space and in particular areas).

### The State of VUI Design

Until recently, voice interfaces were mostly limited by engineering capabilities [11,23], resulting in voice being largely ignored as a modality by HCI research. New engineering advances in speech processing have reduced these limitations – as witnessed by the increased availability and affordability of voice-based devices such as smart speakers (Google Home, Amazon Echo, Apple Home Pod, etc.). However, interacting with these devices is still not seamless nor natural, with the experience being driven by interaction designs reminiscent of task-based dialogues [8]. Such design paradigms do not adequately support many emerging speech application areas (e.g. social companionship, fluid interactions with many embedded devices). Nor do they seem to avoid notorious usability issues, such as: interpreting non-speech conversational cues (e.g. pauses) [4], lack of awareness about what users can say [10], difficulty in retaining information presented through primarily audio [10], difficulty with navigating throughout the speech interface [4], etc. Digital assistants like Google Home and Amazon Echo currently employ command-based interaction, which does not match the conversational interaction that users often expect from these devices [1,16]. The cognitive effort requires to recall long lists of commands is another usability issue [9,11], along with difficulty recognizing and correction both user and speech recognition errors [10].

Given voice interfaces' current state of usability, improving the design of voice-based interactions must first involve improving the training that designers receive on VUI design, along with the pedagogical design tools that are provided to designers. One of these pedagogical tools may be better principles that guide us when designing such interactions. Such principles help to anchor the educational and training materials for a domain, as Norman's or Nielsen's heuristic principles have been for several decades in HCI teaching, which has been focused on GUIs [29]. The development of paradigm-specific heuristics has already been seen in other domains. For instance, Chung and colleagues [6] proposed new design principles (patterns) in order to support their newly-envisioned ubiquitous fluid interactions. Similarly, Ulmer and Ishii propose approaches for the design of tangible interfaces [37]. Very recent research has begun exploring the development of specific design heuristics, such as the work carried out by Suhm [35] and Wei and Landay [39]. Design heuristics and principles are one of the most foundational tools that designers have at their disposal, as evidenced by the inclusion of design heuristics such as Nielsen's or Schneiderman's [24,32] into virtually every university-level introductory HCI course. However, this is largely limited to the aforementioned heuristics, which are applicable to Graphical User Interfaces (GUIs). This prompts the question of whether the emerging VUI design heuristics (or for that matter, any other methods, tools, or theoretical paradigms for designing VUIs) have made their way into the everyday HCI teaching practice. We explore this question throughout this paper, and call upon designers and educator to consider how such tools can be made into fundamental pedagogical artefacts, in the same way that design tools such as the current GUI design heuristics are.

### Teaching Design: From GUI to VUI

Much effort has been dedicated to developing better methods for teaching Human-Computer Interaction in post-secondary education. The topic of HCI education and curriculum development has been long identified as an area that requires more focus and research, spawning the development of the SIGCHI Curriculum Development group [33]. At both CHI 2018 and CHI 2019, as well as at other HCI conferences (such as Graphics Interface in 2017 and 2018), workshops and symposiums have been held to bring HCI educators

together and to discuss the methods that others have been implementing to better teach HCI methods in their classrooms [44,45]. The topics of interest that are covered range from gaps in current HCI teaching [41] to teaching HCI to non-computing disciplines [19]. Several academic papers have also been published that discuss educators' practical efforts to develop a curriculum that can teach budding researchers and usability designers about proper HCI design methods. Some of these methods include design studio courses [15,28] and experiential learning [26].

However, among all these initiatives, there are no efforts that we are aware of that focus on developing and validating methods for teaching Voice User Interface design in HCI education. This means that new HCI experts leave these programs without the necessary knowledge to understand what the usability challenges are for VUIs, and how to design for them. We can see the result of this in present VUI designs, as several studies highlight a wide range of serious usability issues affecting current VUIs, as discussed earlier [9,10,22].

As shown in our previous research, the design methods and tools that are taught are usually grounded in Graphical User Interfaces (GUIs) [21]. However, as other previous research has shown, designing for VUIs is much different than designing for GUIs [43]. As the demand for VUI designers grows, it is increasingly important that VUI design is included in current HCI education - one example being in the form of teaching design principles for VUI design. Churchill [7] in fact advocates for the progression of education in design methods and principles in HCI, to accommodate for the changing state of technological systems over time.

### HCI Curriculum Research

Past research within the SIGCHI community has shown a great interest in developing general HCI curricula [13,18,34]. As mentioned in the 1992 SIGCHI Curricula for Human-Computer Interaction [13], the prompting of such curricula research in HCI arose from the rapid development of Computer Science, which led to new content being introduced in Computer Science, and new understanding of the nature of computers and information. HCI concepts were already slowly being incorporated into existing curricula. Yet there was a lack of proper educational materials for preparing courses in Human-Computer Interaction. As Hewett and colleagues argued as early as 1992, HCI was developed enough that it was appropriate to create proper general recommendations for HCI curricula [13].

Since then, many other new interaction paradigms have been emerging, bringing about new challenges in designing for them, such as Virtual and Augmented Reality, Ubiquitous Computing, Tangible Interaction, and the focus of this paper - VUI. Prompted by this, there has been an increased interest for HCI curriculum updates to account for these new interaction paradigms [2]. Churchill [7] explores the history of HCI education and how HCI education must continue growing and developing in the future in order to account for new technological needs. Works such as Wilcox [40,41] and Grandhi [12] review how HCI has currently been taught over the past few decades, with Wilcox [40,41] performing a review of HCI pedagogical materials such as textbooks, and conducting a survey with 61 HCI educators to identify the different approaches taken when teaching HCI. Further, Wilcox [40] particularly calls for the performing reviews and interviews with instructors in order to gain deeper insights on how HCI curricula needs to be updated.

As of yet, there is little research on updating curricula for VUI design in particular. Due to its recent popularity in the past few years, and to many commercial devices already existing for consumers, we argue that now is the time where immediate attention needs to be dedicated to properly developing a VUI design curricula within HCI. In this paper, we expand on our initial preliminary meta-review [21] to explore how VUI design is currently taught in HCI education.

## A BIRDS-EYE VIEW OF VUI DESIGN IN HCI CURRICULA

To explore the state of VUI design teaching in current HCI education, we first performed a preliminary scoping scan of HCI teaching at top HCI departments across the world. Expanding on our initial meta-review [21], we identify HCI course offerings in these departments that discuss VUIs and VUI Design, and explore their potential to incorporate VUI pedagogical artifacts, such as principles and design methods.

### Methods

We examined 25 universities with the top number of publications at the most recent CHIs (2018 and 2019) [46,47]. This number has been selected for practical reasons in order to make this problem tractable; these universities account for a total of 40% of the numbers of papers published at CHI. Our university selection is pragmatic, as a sample of those actively engaged and involved in HCI research. We used CHI as a proxy for a community standard of established HCI university departments, vs. a subjective assessment of what "established HCI" is. As illustrated by the proceedings of past "HCI Education" workshops held at conferences such as CHI or GI [33], there are significant commonalities between HCI curricula across the universities that are well represented at conferences like CHI. As such, through CHI's prominence and coverage, we can consider that our scan likely yielded representative examples of established HCI programs. Given that the universities we have captured in our scoping scan cover a large diversity in terms of locations, countries, public/private, and regulatory regimes (e.g. from government-regulated curricula to self-determined), we consider that our study provides insights that are of interest to a more general audience of HCI researchers and educators. It is important to note that our quantitative analysis is *within* the syllabi of such programs.

Expanding the scope may not have enriched the diversity of such syllabi, but would have potentially exposed the analysis to researchers' subjectivity in deciding inclusion criteria.

For each university, we examined all the courses offered in said university's HCI division/department (often encompassed by the university's Computer Science department or School of Information). Based on both the title and public description of the courses, we surveyed undergraduate, graduate, and cross-listed HCI courses offered by these universities, identifying which ones discussed VUIs or VUI design. We classified a course as one that discusses VUI design if either the course title or description contained any of the keywords identified in Table 1. These keywords have been previously employed by other researchers conducting meta-reviews related to conversational or voice user interfaces [8,22]. We excluded any courses whose primary focus was on the technical aspects of speech recognition, artificial intelligence, and natural language understanding/computation (such as "Introduction to Natural Language Computation"), as these courses do not focus on user interface interaction of VUIs, or on interaction design. We also excluded any courses that focused primarily on auditory perception without mentioning interaction design.

| VUI Course Keywords |
| --- |
| conversational interface; conversational agent; conversation; voice; voice agent; voice user interface; dialogue agent; audio; auditory; speech; speech interface; human-robot interaction; smart home; personal smart agent; personal smart assistant; interactive robot |

**Table 1: List of keywords used to identify VUI courses**

### Scoping Scan Findings

Each university that was surveyed had at least one general HCI design methods-oriented course. These are courses that teach traditional design and usability evaluation methods such as prototyping, usability studies, heuristic evaluations, design principles, etc. None of the methods-oriented courses explicitly mentioned VUI design methods or usability evaluations. On the other hand, at least 3 of the course descriptions made a point of explicitly stating that their focus was on design and evaluation methods for GUIs. Others that did not explicitly state so, mentioned designing and evaluating a mobile or web application, implying a focus on GUIs.

We also found through our review that other non-WIMP interaction techniques and technologies were covered in the courses observed – such as Ubiquitous Computing, Tangible Interfaces, Virtual and Augmented Reality, etc. While HCI education is still GUI-dominated, the presence of non-WIMP paradigms in our syllabi review suggests that there is a relatively strong interest in diversifying our HCI curriculum. However, VUIs and CUIs seem to receive disproportionately less attention, and appear as primary topics of HCI courses less frequently than other non-WIMP interactions.

While the methods courses do not explicitly mention VUI design, other HCI-related courses do mention VUIs or VUI design. These are captured in Table 2. Among the courses that mentioned VUIs in their title or description, most of them did not mention a particular focus on VUI *design*. Instead, most of these course descriptions listed VUIs as a general topic to be touched upon. Table 3 illustrates the main topics of the courses that mentioned VUIs or VUI design for each university from Table 2 that had at least one course identified as a VUI-related course. Out of the twelve universities that mentioned audio or speech as a form of interaction, the most common main course topics were "multi-modal interfaces", or "intelligent/smart agents", and therefore was not primarily focused on *designing* for voice or speech interaction. Three of the courses were also aimed towards "accessible interfaces" or "future/emergent interfaces". Carnegie Mellon University (CMU) was the one outlier among the universities we have included in this survey, offering several special topics courses that had VUI design as a topic of discussion. One of these courses primarily focus on "Ubiquitous Personal Smart Agents" (like Google Assistant and Siri). Only one of the courses surveyed, from Northwestern University, was primarily geared towards Conversational Interfaces. Even where courses discuss conversational interfaces, they often also encompass agents such as text chat bots. As evidenced by this survey, VUI design methods and principles are still not prominently present in current HCI education.

Some of the courses that we surveyed mentioned concepts or topics that were potentially related to voice or speech interfaces, but did not explicitly mention them as a key subject of discussion. Some were about the design of human-robot interaction; while these courses often mentioned topics like designing human-robot conversation, voice was often not explicitly stated as a topic of focus. An example of this is at Cornell University, where the course titled "Human Robot Interaction – Research and Design" describes examining "novel ways for robots to interact with people" without the mention of voice or speech explicitly. Others had more specific courses geared towards the design of ubiquitous interfaces or multi-modal interfaces; while these courses could encompass VUIs, it was not always clear from the course title or description if this was so. An example of this was a course offered at Carnegie Mellon named "Ubiquitous Computing", where, for example, one of the topics named in the description was "smart home, healthcare and assistive applications". While "smart homes" are often voice-assisted, and was a keyword we used in our search, there was not an explicit mention of voice or speech interaction. As can be seen, while universities are offering courses and training for other new interaction techniques

| Name of University | Rank (by # of pubs in CHI '18) | Rank (by # of pubs in CHI '19) | # of Courses discussing VUIs/ VUI design |
|---|---|---|---|
| Carnegie Mellon | 2 | 2 | 6 |
| University of Colorado Boulder | - | 19 | 2 |
| University of California, Berkeley | - | 17 | 2 |
| Northwestern University | 15 | 17 | 1 |
| University of Maryland | 16 | 12 | 1 |
| KAIST | 7 | 10 | 1 |
| University of Toronto | - | 8 | 1 |
| Georgia Tech | 5 | 6 | 1 |
| MIT | 8 | - | 1 |
| LMU Munich | 9 | - | 1 |
| Aurhus University | 18 | - | 1 |
| Aalto University | 19 | - | 1 |
| University of Stuttgart | 17 | 20 | 0 |
| Northumbria University | 10 | 18 | 0 |
| Monash University | - | 16 | 0 |
| Lancaster University | 14 | 15 | 0 |
| Eindhoven University of Technology | - | 14 | 0 |
| University of Waterloo | 12 | 13 | 0 |
| Newcastle University | 3 | 11 | 0 |
| Cornell University | 13 | 9 | 0 |
| Simon Fraser University | 11 | 7 | 0 |
| University College London | 20 | 5 | 0 |
| Stanford University | 6 | 4 | 0 |
| University of Michigan | 4 | 3 | 0 |
| University of Washington | 1 | 1 | 0 |
| **Total** | | | **20** |

**Table 2: Courses that Discuss VUI or VUI Design in Top HCI Universities**

outside of GUI interaction, this does not explicitly include VUIs in the overwhelming majority of cases. At best, there are only placeholders for possible VUI design teaching.

| Name of University | Main Course Topics |
|---|---|
| Carnegie Mellon | research methods; accessibility; artificial intelligence; future user interfaces; ubiquitous interfaces; personal smart agents |
| Georgia Tech | human-robot interaction |
| KAIST | human-computer interaction |
| MIT | intelligent interfaces; multi-modal interfaces |
| LMU Munich | intelligent interfaces; |
| Northwestern University | conversational interfaces |
| University of Maryland | practical hci skills |
| Aurhus University | multi-modal interaction |
| Aalto University | emergent user interfaces |
| University of Toronto | intelligent agents, speech-based interfaces; personal assistants |
| University of California, Berkeley | speech interfaces; audio |
| University of Colorado Boulder | human-robot interaction; voice input; speech recognition |

**Table 3: Main Course Topics in Courses that discuss VUI or VUI Design**

While courses such as these were not included in our counts in Table 2, as they do not explicitly mention discussing VUI design, it is worth noting the potential these courses have to incorporate VUI design teaching.

During our initial scan, we did find that many of these universities offered at least one course containing some of our keywords that was focused on speech recognition or natural language understanding/computation. We did not include these in our final count, as they do not focus on interaction design. However, the existence of these course offerings does show that much of the current focus on teaching about speech is on the engineering side of dialogue agents.

## DELVING DEEPER: A SYLLABI META-REVIEW

Our scoping scan described in the previous section revealed preliminary insights on how often VUI design may be discussed in HCI courses. In order to more deeply evaluate how VUI design is discussed and taught in HCI curricula, we next performed a syllabi and course material review. Similar analyses have been performed for the general HCI space [40, 41], and Wilcox [41] recommends the conducting of syllabi reviews in order to more deeply explore and improve interaction design education. This was carried out over the set of courses identified in our initial curricula scan that covers topics related to the design of speech or

conversational interfaces (as described in the previous section).

### Methods

We individually contacted 20 instructors (one for each of the courses we classified as potentially discussing VUIs in Table 2), inquiring whether their courses discussed VUI design, and requesting their syllabus or relevant course information materials - as such details were not always publicly available. We received 14 responses. Out of these 14 responses, 10 of the instructors provided us with either a copy of their syllabi/reading list, or a publicly available course website link where all their course materials were located. Out of the other 4 responses, one responded that they did not believe their course was relevant to our meta-review, another stated that their course was a project-based course and did not have a written syllabus, and in two cases, the course we inquired about was incorrectly listed (with the instructor not teaching topics related to VUI design). Table 4 shows the final 10 courses that we reviewed.

Through a critical analysis of the syllabi and course materials, we identified several themes in which we classify the coverage of speech and conversational UIs of these 10 courses. The analysis was conducted by the primary author, who is an experienced graduate researcher in HCI (with primary focus on VUI design), and who is actively involved in HCI education as a course assistant and teaching assistant for several years. The analysis was independently verified by a senior faculty member who has more than twenty years of experience as an educator and researcher in the field of voice interaction.

| Course Name | University Name |
|---|---|
| C1. Advanced User Interface Software | Carnegie Mellon |
| C2. Conversational Interfaces | Northwestern University |
| C3. Emergent User Interfaces | Aalto University |
| C4. Human-Computer Interaction | KAIST |
| C5. Human-Robot Interaction | Georgia Tech |
| C6. Intelligent Multi-Modal Interfaces | MIT |
| C7. Intelligent User Interfaces | LMU Munich |
| C8. Special Topics in HCI: Human AI Interaction | Carnegie Mellon |
| C9. Special Topics: Ubiquitous Personal Smart Agents | Carnegie Mellon |
| C10. The Interactive Society | University of Toronto |

**Table 4: Courses Surveyed, and the University where they are offered**

### Syllabi Meta-Review Findings

Below, we describe our findings from our meta-review of the syllabi and course materials of these 10 courses.

| Course Name | Homework/ Assignment | Lecture Material | Readings |
|---|---|---|---|
| C1. Advanced User Interface Software | | X | X |
| C2. Conversational Interfaces | | | |
| C3. Emergent User Interfaces | | X | |
| C4. Human-Computer Interaction | | | X |
| C5. Human-Robot Interaction | | | |
| C6. Intelligent Multi-Modal Interfaces | | | |
| C7. Intelligent User Interfaces | X | X | X |
| C8. Special Topics in HCI: Human AI Interaction | X | | X |
| C9. Special Topics: Ubiquitous Personal Smart Agents | | | X |
| C10. The Interactive Society | X | X | |

**Table 5: Course Materials Related to VUIs or CUIs**

We identified four overarching themes:

1. Course Materials Related to VUIs or CUIs
2. Breadth and Depth of VUI/CUI coverage
3. Framing of VUI/CUI Discussion
4. Extent of VUI or CUI Coverage Specific to Design

Below, we discuss each of these themes in more detail.

#### *Course Materials Related to VUIs or CUIs*

Table 5 illustrates the course materials (other than the syllabus itself) that discuss voice or conversational UIs in each of the courses. We found three key types of course materials that were relevant to VUIs or VUI design: a weekly homework exercise or larger assignment, lecture material (such as slide decks) that discusses speech or conversational UIs, or a set of readings related to VUIs. The course material that was the least available was a homework exercise or assignment – only three courses had them, and each of the three courses had only one assignment that was relevant to

| Course Name | Amount/Percentage of VUI Course Coverage |
|---|---|
| C1. Advanced User Interface Software | 0% prof-given Lectures; 33% student-given discussion lectures |
| C2. Conversational Interfaces | Not enough information |
| C3. Emergent User Interfaces | 17% lectures |
| C4. Human-Computer Interaction | 7% topics; 5% Lectures; Textbook readings |
| C5. Human-Robot Interaction | 15% lectures |
| C6. Intelligent Multi-Modal Interfaces | 20% Lectures; 12% classes (including studios) |
| C7. Intelligent User Interfaces | 35% Lectures; 25% Assignments |
| C8. Special Topics in HCI: Human AI Interaction | 7% Lectures; 1 Assignment (total unknown) |
| C9. Special Topics: Ubiquitous Personal Smart Agents | 19% lectures (reading/discussion based); Paper readings |
| C10: The Interactive Society | 2% lectures; 20% assignments |

**Table 6: Breadth and Depth of VUI/CUI Coverage**

| Course Name | Framing of VUI/CUIs |
|---|---|
| C1. Advanced User Interface Software | Toolkits for Development |
| C2. Conversational Interfaces | AI, Dialogue Systems; Principles/Practices for Conversational System |
| C3. Emergent User Interfaces | Sound Processing; |
| C4. Human-Computer Interaction | Voice Design |
| C5. Human-Robot Interaction | Understanding Communication Between Robots and Humans |
| C6. Intelligent Multi-Modal Interfaces | Speech Understanding; Multi-Modal Aspect of VUIs |
| C7. Intelligent User Interfaces | NLP; VUI Design; Health and Affective Computing |
| C8. Special Topics in HCI: Human AI Interaction | AI; Text Chatbots; Smart Conversational Agents |
| C9. Special Topics: Ubiquitous Personal Smart Agents | Natural Language Understanding; Embodied Conversational Agents |
| C10: The Interactive Society | Artificial Intelligence; Intelligent Agents; Speech; |

**Table 7: Framing of VUI/CUI Discussion**

speech or conversational UIs – suggesting a lack of practical application of VUIs or VUI design in current HCI courses. Relevant readings (e.g. recent papers from conferences such as CHI, or textbook readings) were the most common, with 6 of 10 courses (C1: Advanced User Interface Software, C4: Human-Computer Interaction, C7: Intelligent User Interfaces, C8: Special Topics in HCI: Human AI Interaction, C9: Special Topics: Ubiquitous Personal Smart Agents, C10: The Interactive Society,) containing a list of readings relevant to speech or conversational UIs.

*Breadth and Depth of VUI/CUI Coverage*

Table 6 illustrates the portion of each course that was dedicated to voice or conversational interfaces, and the level to which the course delved into these topics. 4 of 10 courses (C1, C3, C4, C8) only dedicated one lecture for these topics, one of the courses (C10) dedicated two lectures, and the remaining four (C5: Human-Robot Interaction, C6: Intelligent Multi-Modal Interfaces, C7: Intelligent User Interfaces, C9: Special Topics: Ubiquitous Personal Smart Agents) dedicated 3 to 5 lectures to these topics. One of the courses (C7: Intelligent User Interfaces) dedicated a quarter of their course to the design of VUIs (including a large assignment). While one of the courses is named "C2: Conversational Interfaces", which suggests that the entire course is dedicated to conversational interfaces, the online syllabus we were provided does not include a specific breakdown of what aspects of Conversational Interfaces were discussed in the course, or which of these were dedicated to voice interactions.

*Framing of VUI/CUI Discussion*

Table 7 illustrates the way that aspects from VUIs or CUIs were framed when discussed in the surveyed courses. 5 of 10 of the courses (C5: Human-Robot Interaction, C6: Intelligent Multi-Modal Interfaces, C7: Intelligent User Interfaces, C8: Special Topics in HCI: Human AI Interaction, C9: Special Topics: Ubiquitous Personal Smart Agents, C10: The Interactive Society) presented them in the context of "Smart" or "Intelligent" agents. Two of the courses (C8: Special Topics in HCI: Human AI Interaction, C9: Special Topics: Ubiquitous Personal Smart Agents) were special topics courses. While only one of the courses (C3: Emergent User Interfaces) particularly focused on voice/conversational interfaces as "new or emerging technology", there was a common theme among many of the courses that these interfaces were developing and still needed to be understood. 7 of 10 (all except C7: Intelligent User Interfaces and C10: The Interactive Society) of the courses did not make a particular distinction between text-based conversational interfaces and voice-based conversational interfaces, or spoke about both.

5 of 10 of the courses (C2: Conversational Interfaces, C6: Intelligent Multi-Modal Interfaces, C7: Intelligent User

| Course Name | Discussion about VUI or CUI Specific to Design |
|---|---|
| C1. Advanced User Interface Software | Some development (not really design), not clear if focusing on voice or text |
| C2. Conversational Interfaces | None |
| C3. Emergent User Interfaces | None |
| C4. Human-Computer Interaction | Practices and Principles of Voice UI Design (based on textbook readings) |
| C5. Human-Robot Interaction | None |
| C6. Intelligent Multi-Modal Interfaces | None |
| C7. Intelligent User Interfaces | Actual Conversational VUI Design/Interaction; Assignment (Can be theoretical or practical, very relevant to VUIs and Personal Smart Assistants like Alexa) |
| C8. Special Topics in HCI: Human AI Interaction | Chatbot Dialogue Design/Understanding; Twitter Text Chatbot Assignment (With User Testing and Iterating to fix Dialogue prompts) |
| C9. Special Topics: Ubiquitous Personal Smart Agents | None |
| C10: The Interactive Society | None |

**Table 8: Extent of VUI or CUI Coverage Specific to Design**

Interfaces, C8: Special Topics in HCI: Human AI Interaction, C9: Special Topics: Ubiquitous Personal Smart Agents) primarily discussed "Natural Language/Speech Understanding" or "Dialogue Design/Management" as a subtopic of conversational interfaces. One of the courses (C3: Emergent User Interfaces) primarily discussed audio and sound processing, which is not entirely relevant to our discussion of voice/conversational UIs. One of the courses (C6: Intelligent Multi-Modal Interfaces) discussed the use of voice in a multi-modal context. Only 2 out of 9 of the courses (C4: Human-Computer Interaction, C7: Intelligent User Interfaces) discussed the *design* of voice-based conversational UIs.

#### *Extent of VUI/CUI Coverage Specific to Design*

Table 8 illustrates the level and amount of coverage dedicated particularly to VUI or CUI *design* among the 10 courses. 5 of 10 courses do not discuss VUI design at all. 3 of 10 courses touched on voice-based conversational UI design – however only one of them provides an assignment where students can practically explore and apply their knowledge. One of the courses focused particularly on the design of text-based conversational interfaces.

### Discussion

Based on our meta-review, we can suggest that what is largely lacking from VUI education in HCI is the *theoretical and practical considerations* of building and designing speech and conversational UIs. Half of the courses we surveyed dedicate only one or two lectures to voice or conversational interfaces, and the focus is primarily on the existence of such interfaces, and the fact that they are new and developing. Over half of the courses that involve voice-based interfaces were special topics classes, where students read papers and discuss them. They did not provide guidance or advice on how to build or design for VUIs, as far as we could identify. This is also noticeable from the lack of homework exercises or assignments that focus on designing or developing voice-based interfaces – only two courses incorporate these, and one of them focuses on a text chatbot, not a voice-based UI. As such, our analysis suggests that budding HCI researchers and designers may not find educational resources at university level on how to design new VUIs.

When discussing conversational interfaces, there is little focus on *voice-based interfaces*. Most of the courses surveyed either do not distinguish between text or voice-based interfaces, or briefly discuss them both. They are often discussed in the larger category of "conversational interfaces". However, there are many differences between interacting with a graphical vs. a voice-based interface [30,43]. In particular, in a text-based interface, one can see a large amount of text at once (usually an entire response). For voice-based interfaces, the only output medium is audio, which is a slow medium of interaction, and requires users to exert more cognitive effort in order to recall what the VUI has said [31,43]. As well, voice-based interfaces do not have the convenience of text-based interfaces, where a user may type their entire response, view it, and correct any errors before responding. Interacting with a voice-based interface happens in real time, where users often have difficulty fixing things such as errors in speech recognition [10]. Users also must have the response thought out in their head before they speak to the device, which also takes much cognitive effort [10]. Such fundamental differences have prompted researchers to consider how designing VUIs is fundamentally different than GUI [22,35,39], including text-based chatbots. However, as illustrated by our meta-review, such differences are not yet visible in the HCI curricula, where GUI design continues to be disproportionately present.

There is also very little discussion on the *interaction design* aspects of conversational interfaces (both voice and text-based). Half of the courses we surveyed spoke about conversational interfaces in the context of "smart" or "intelligent" agents. This means there seems to be a larger focus on dialogue design, and how conversational interfaces interpret and understand different dialogue commands. While this is an important aspect of conversational interfaces which must be taken into account, there continues to be a lack of the other aspects of voice UI interaction that are important to take into account when designing VUIs – such as error recognition, remembering and recalling commands, etc. [10,22]. Wilcox [41] also makes note in her previous HCI education review of the change from a focus on *artifacts* to a focus on *interactions* in general HCI education. Based on our analysis, this is something that has yet to be achieved in the education of VUI design.

## TOWARDS A VUI CURRICULA

As we have discussed throughout this paper, it is becoming increasingly important to focus on updating HCI curricula to incorporate VUI design teaching. This becomes imperative as more designers are asked to incorporate voice into existing devices, or to design completely new devices with voice as a primary form of interaction. A syllabus meta-review is an important first step toward a comprehensive curriculum update [40]. In our review, we have highlighted the gaps that exist in current HCI curricula in terms of teaching the design of VUIs. This presents opportunities for additional pedagogical research tools to be developed and deployed, in order to expand the breadth and depth of such a curriculum update.

For example, interviews with HCI educators can highlight the personal perspectives of these educators in terms of barriers to and opportunities for teaching VUI design [41]. This could reveal what some of the possible teaching resources are that may help educators incorporate VUI and CUI design into their syllabus – examples of these being case studies of VUIs, usability walkthrough videos, lesson plans, etc. In our future work, we plan to expand our research to include such interviews. We also plan to expand our research by studying a larger number and variety of courses (such as non-academic courses offered at major SIGCHI conferences [20,38,48–50]).

A few of the courses that were surveyed classified VUIs as "emerging" interfaces, which signals the potential for these interfaces to become more prominent in the future. As research on proper design methods for VUIs develops, this knowledge must be passed on to new designers and usability experts. Current training offered in HCI curricula for speech and voice in particular is often focused on the technical engineering aspects, such as speech recognition, audio compression, or natural language understanding. It is important to provide equal course offerings and training for interface and interaction design for VUIs.

One conceptual framework that we suggest that the HCI community move away from is seeing VUIs as a "new" and "emerging" technology, and drawing on practical examples in already-conducted VUI-related courses at CHI and other SIGCHI conferences ([20,38,48–50]). Drawing from these practical examples of conducted courses may help instructors identify key topics to cover in a VUI curriculum.

Another key component of this proposed comprehensive curricula update is the development and teaching of pedagogical tools such as VUI design principles. One cannot imagine an HCI curriculum without the teaching of GUI heuristics, such as Nielsen's [24], Schneiderman's [32] or Norman's [25], as they are the center of established design and evaluation methods. In contrast, VUI heuristics are, at the present moment, in a preliminary state and not extensively validated [22,23,35,39]. Relatedly, we are seeing heuristics and design patterns in other non-WIMP technologies such as Ubiquitous Computing [6], Virtual Reality [36], and even Video Game design [3]. Therefore, VUI heuristics must first be developed and validated, then incorporated into curricula – as these would serve the same as valuable pedagogical artifacts like GUI heuristics. Any curriculum changes would need to account for the fact that existing VUI heuristics are not widely adopted. Thus, we invite HCI educators – many of them very familiar with GUI design principles and methods – to engage in the process of developing VUI heuristics that can then be incorporated into our pedagogy, and in re-imagining HCI curricula around such emerging interaction paradigms. The validation and incorporation of existing VUI heuristics and design patterns in literature (such as [35,39]) can also be a useful step towards developing a VUI curricula.

As HCI education has been centred around GUIs for a long time, it has benefited from the availability of many other pedagogical elements as well. For example, many introductory HCI courses across several universities would discuss similar examples of interface design (many grounded in Don Norman's "Design of Everyday Things" [25]). In contrast, the VUI design space does not yet benefit from an abundance of such pedagogical resources. This represents another opportunity for educators (but also researchers and practitioners more broadly) to share or to contribute to the development of collaborative repositories of such resources. Hands-on design practice (e.g. assignments using current interfaces such as Alexa and Google Home) are examples of pedagogical artifacts that can be incorporated into a VUI curricula, as has been similarly done in many GUI-focused courses in the past.

## LIMITATIONS

Developing a new curriculum is an administratively heavy process, often requiring external research and validation. As

such, we limit the scope of our contributions to highlighting the needs and gaps in current HCI curricula with respect to VUI design. We hope to start a discussion within the HCI community about how to begin developing a proper curriculum for teaching VUI design.

We aimed to avoid inserting our own subjectivity in deciding what institutions should be included in our search, to both generate a representative sample of universities, yet also to maintain feasibility of the review. We chose therefore to use ranking by number of publications published in both CHI 2018 and CHI 2019 [46,47] to select the top 25 academic institutions across both years. As such, we used CHI as a proxy for the community standard of HCI. This did yield universities that were diverse in both location and institution type, with established departments. However, this method does have the potential to exclude some institutions that may have established VUI courses or curricula.

## CONCLUSION AND FUTURE WORK

In this paper, we have presented a scoping scan of 25 top international HCI departments, and a deeper HCI syllabi meta-review of 10 courses in these departments, surveying how VUIs and VUI design is discussed in course offerings in current HCI curricula. Our meta-review suggests that there is a lack of *theoretical and practical considerations* in teaching of *voice-based* conversational interfaces, particularly in the *interaction design* of these interfaces. As commercial VUIs such as Amazon Alexa, Google Home, and Siri become more intelligent, more accessible, and increasingly ubiquitous, more HCI designers will need the appropriate knowledge to design for these emerging interfaces. HCI curricula needs to be adapted in order to account for voice as an emerging form of interaction, so that new HCI researchers and designers will acquire the proper background in their education in order to design usable conversational voice interfaces. In order to achieve this, we also call for the development of new pedagogical and educational tools which can assist in VUI design training in the HCI space.

The commercial popularity of Alexa and Google Home within the past few years urges immediate attention in training current and future designers, and solidifies our focus on updating HCI curricula to train properly for VUI design in this current paper. However, we also believe such curriculum and pedagogical reflections can and should be extended to other non-GUI interaction paradigms as well (such as VR, AR, Tangible, etc.).

We plan to expand this work with a longer-term qualitative study to explore the needs of current educators, and the barriers that may exist which prevent them from properly incorporating VUI design into their curricula. This will include studying non-academic courses (such as ones presented at major SIGCHI conferences). Future work will also include performing in-depth interviews with both academic faculty and practitioners, in order to discover the ways VUI design is being taught, and to identify the needs of educators in teaching VUI design (such as new pedagogical tools).


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