HCI Education in Brazil in the light of Curricula Guidelines

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Abstract—**Human-Computer Interaction (HCI) has been researched, practiced and taught around the world in diverse contexts. In this paper, we focus on Brazil and its particular context. We interviewed thirteen professors to investigate their approach in introductory HCI courses within computing undergraduate courses. This paper reports a portion of this analysis, focusing on the content being taught, and comparing it to national and international guidelines. Our results show that most professors use a project-centered approach in the course, balancing theory and practice. Semiotics and accessibility are strong influences in our context. No international guidelines mention any semiotic approach to HCI, although they are usually more detailed than national guidelines. International guidelines provide a list of topics together with a list of learning outcomes, while national guidelines are more focused on topics. We contribute to the HCI community by providing an analysis of the Brazilian context.**

Index Terms—**HCI Education, HCI in Brazil, HCI Curricula Guidelines, UDUM - Underlying Discourse Unveiling Method.**

I. Introduction

Human-Computer Interaction (HCI) Education has been discussed in various contexts. Some studies in this area are focused on describing challenges in different countries or regions, such as Asia-Pacific [1], Mexico [2], and Brazil [3], providing insights on particular takes on the topic. Others, such as [4] and [5], study HCI across different contexts showing similarities and differences around the world.

In Brazil, HCI research started in the late 1980's, and the first graduate courses on the field began in the early 1990's [3]. In the late 1990's, the Brazilian community started to become organized, and the national symposium (Brazilian Symposium on Human Factors in Computing Systems - IHC) was organized for the first time [3]. In 2000, BR-CHI - a national Local Chapter for ACM Special Interest Group on Computer–Human Interaction (SIGCHI) - was created, along with an HCI Interest Group (*Comissão Especial de Interação Humano-Computador - CEIHC*) within the Brazilian Computer Society (*Sociedade Brasileira de Computação - SBC*). Since then, the community has grown to be recognized nationally and internationally.

National and international curricula guidelines for HCI have been proposed since the 1990's. SIGCHI proposed a curricula for HCI in 1992 [6]. In Brazil, HCI was first incorporated to the national undergraduate curriculum in 1999 [7].

More recently, SIGCHI sponsored an Education Project, aiming to identify "HCI educators', practitioners', and students' perspectives on the current and future HCI landscape, asking them what they consider to be the top priorities for

HCI as a field" [8, p. 70]. A report [5] shows that different populations valued different topics, and one of the takeaways from the project is that "there is no one size fits all solution" [5, p.53] - regional and contextual differences should be taken into account on an HCI curriculum, offering more relevant content to the public it is aimed for.

We aim to understand in-depth how HCI specialists are approaching HCI teaching in Brazil. We interviewed thirteen active researchers of the Brazilian HCI community who also teach introductory HCI courses. The interview was not centered around topics and content covered in the course, but participants were asked about it. In this paper, we present a portion of our analysis, focused on the topics valued by these professors, and discuss them in the light of national and international curriculum guidelines. We do not aim to present an overview of what is being taught in the country as a whole, but rather provide an in-depth analysis of how these researchers approach HCI teaching.

Our results show that HCI is usually introduced with a focus on evaluation and design, mainly through course projects in which the students practice different methods. In addition, Semiotics and Accessibility are highly valued by professors, and the former is never mentioned in any international guideline. This indicates a different focus adopted by the Brazilian community in teaching HCI. Brazil has one of the most consolidated HCI communities within Latin America – with a national event that is completing 20 years since its first edition. In 2017 IHC offered 10 different tracks and had around 250 participants. Therefore, this paper can be especially relevant for researchers and professors from Latin America who can better understand how HCI is being taught in Brazil, and adapt the lessons learned to their own context.

This paper is organized as follows: first, we show relevant work on HCI Education in Brazil and Curriculum guidelines. Then, we present the methodology used in this work. Following, we present the results and discussion. Finally, we present our final considerations.

II. Related Work

In this section, we present related work on HCI Education in Brazil, which is our focus of investigation Then, we present national and international guidelines used in our analysis, including the context in which they were proposed, and how they are organized.

A. HCI Education in Brazil

The Brazilian HCI community understands the relevance that HCI Education has in shaping technology professionals. An evidence of this is that it promotes a national Workshop on HCI Education (WEIHC). Its first edition occurred in 2006, and it is now a permanent event within the main national symposium on HCI (IHC). WEIHC has become an important forum for the community to share experiences and collaborate in consolidating this discipline in computing courses [9].

Understanding HCI across Brazil has been a topic of investigation for researchers around the country. Three countrywide surveys have been conducted at different times. The first one was distributed in 2009, and gathered answers from 91 professors. They described 141 courses, 57% of which were considered introductory level [3]. In 2012, the survey conducted by the SIGCHI Education Project was translated to Portuguese and distributed in Brazilian discussion lists.

In 2013, another questionnaire was responded by 114 people (from which 75 were considered valid). Its analysis show that topics covered in HCI courses vary according to the majors they are in - Computer Science (CS), Information Systems (IS), and Computing Engineering (CE). Furthermore, there is little in common between topics covered in the courses and what Brazilian UX Professionals consider important [10]. In particular, Accessibility Tests are rarely performed by UX professionals, while it is a key concept to the HCI community. This shows HCI educators have an important role in shaping future HCI professionals to address such an important topic to the society as a whole. The results from the 2013 survey also informed a revised proposal of the HCI guidelines published by the HCI community in 2007 [11], in which some of the topics are detailed, and new ones are added [12].

In addition to research at national level, smaller contexts are also studied. For example, [13] reports an investigation of a Brazilian state in which most state universities do have introductory HCI courses, but do not offer graduate courses, resulting in little research on the field.

More recently, [14] show how HCI Research affects HCI Education in Brazil, based on two independent studies: a survey with educators, and an analysis of full papers published at IHC. It highlights two cases: Semiotic Engineering and Accessibility. Semiotic Engineering is an HCI Theory developed and widely disseminated in Brazil [15]. It is also an influence on books and teaching materials in Portuguese [14]. Accessibility is a topic of interest of both the Brazilian HCI community and the wider computing community [14].

As it is possible to see in the work presented in this section, previous researches on HCI are very focused on topics being covered by HCI courses. This includes a previous comparison between survey results and national and international guidelines [12]. However, none of them are in-depth analyses. Our research aims at filling this gap, showing how educators approach the topics, and which topics are valued by them, while contrasting it with curriculum guidelines. The guidelines used in this work are discussed in the next subsection.

B. Curriculum guidelines

There are several curriculum guidelines for undergraduate programs in computing. Internationally, a joint effort from the Association for Computing Machinery (ACM) and Institute of Electrical and Electronics Engineers (IEEE) Computer Society developed a Computing Curricula for Computer Science [16]. It was published in 2013 as a result of an effort that started in 2010. Despite being led by a steering committee, the effort involved the computer science community as a whole.

These guidelines structure the CS body of knowledge in 18 Knowledge Areas (KA). Each KA is subdivided in Knowledge Units (KU), that can be classified as either Core or Elective. Core is further divided in Tier-1 and Tier-2. According to [16], a curriculum in CS should include all topics in the Tier-1, at least 80% of topics in Tier-2, and a significant depth of elective topics. Neither KAs nor KUs are meant to be directly taken as courses within a CS major. Rather, it is expected that different institutions structure their curriculum reflecting local needs, "institution's mission, faculty strength, student needs, and employer demands" [16, p. 46].

HCI is considered as one of the KAs in [16], and is further divided into 10 KUs, namely: Foundations; Designing Interaction; Programming Interactive Systems; User-Centered Design and Testing; New Interactive Technologies; Collaboration and Communication; Statistical Methods for HCI; Human Factors and Security; Design-Oriented HCI; and Mixed, Augmented and Virtual Reality. The first two are classified as Core Tier-1 and Core Tier-2, and the others are considered Elective. Each KU has a motivation, set of topics and learning outcomes associated with it. They are not uniformly divided, nor do they have the same level of abstraction – meaning some are more general, and other more specific.

In 2010, ACM and the Association for Information Systems (AIS) published Curriculum Guidelines for Undergraduate Degree Programs in Information Systems [17]. They are based on knowledge and skills expected from IS graduates, which are grouped into three categories: IS specific knowledge and skills, foundational knowledge and skills, and domain fundamentals. HCI is explicitly mentioned in the first group, which includes "Improving various stakeholders' experience in interacting with the organization, including issues in human-computer interaction." [17, p. 19]. Curriculum topics are expected to be selected from the IS Body of Knowledge (BoK) taking competences into consideration, and delivered through courses.

The IS BoK "organizes the IS curriculum core content into four different Knowledge Area categories: 1) General Computing, 2) IS Specific, 3) Foundational, and 3) Domain-specific." [17, p. 25]. User Experience is a Knowledge Area (KA) listed within the second group (IS Specific).

The curriculum separates core from elective courses, in a way to address the concept of career tracks. This way, any IS major should cover the seven core IS courses, and the electives will have a distinct role depending on the intended career track. HCI is considered an elective course, and is not required for 12 out of the 17 suggested career tracks. From the

remaining five, HCI is expected to have significant coverage in the *Application Developer* and *User Interface Designer* tracks; and some coverage in the *e-Business Manager*, *ERP Specialist*, and *IT Consultant* tracks. It also provides sample elective courses, including *Introduction to Human-Computer Interaction*. The course has a catalog description and brief discussion, and lists topics and learning outcomes.

In Brazil, the latest national CS curriculum was published in 2005 by SBC, and includes recommendations for both CS and Computer Engineering (CE) majors. The curriculum is structured in six cores, which are grouped in computing (*Computing Foundations* and *Computing Technologies*) and other areas (*Mathematics*, *Basic Sciences*, *Electronics*, and *Social and Professional Context*). Each core has a set of subjects, and each subject has a list of topics. The subjects and topics can be used as basis for one or more courses, and topics within different subjects can also be grouped together in a single course. It is advised that the curriculum for a particular institution considers the intended major and specializations, institution vocation, the expected knowledge for alumni, and faculty strength [18]. There is no distinction between subjects offered in CS or CE. However, it is recommended that CS majors focus on *Computing Foundations Core*, and CE majors focus on *Computing Technologies Core*. HCI is considered one of the subjects within the *Computing Technologies Core*. The reference syllabus is divided in ten topics.

The latest IS curriculum published by SBC is from 2003 [19]. The curriculum is divided into five Knowledge Areas (*Áreas de Formação*), following the Curricula Guidelines (*Diretrizes Curriculares*) from the Brazilian Ministry of Education (*Ministério da Educação - MEC*): *Foundations in Computer Science, Mathematics, and Information Systems*; *Technological Foundation*; *Humanistic Foundation*; *Complementary*[1] *and Supplementary*[2] *Perspectives*. For each of these areas, there is a list of subjects. For each subject, there is an indication of whether it is supposed to be seen in depth or breadth. Each subject can be taught in one or more courses, or topics within a course. Human-Machine Interface is listed as a subject within *Technological Foundation* and a breadth approach is indicated. Furthermore, there is a reference syllabus with topics to be covered.

In 2017, SBC has published Guidelines for Computing Majors (*Referenciais de Formação para os Cursos de Graduação em Computação*) [20]. They are meant to be used as reference, together with other guidelines such as [18] and [16] when defining a particular curriculum. Rather than content-oriented, it is competence-oriented, expanding the curriculum to include abilities and attitudes students should acquire by the end of the course. It is expected that each institution defines their own strategy for tackling competences and contents for the majors they offer, taking their context into consideration. The document is divided into six chapters, one for each major: Computer Science (CS), Computer Engineering (CE), Soft-

ware Engineering (SE), Computing Licentiate (CL)[3], Information Systems (IS), and other Information Technology majors (IT). Each major has a general goal, which is subdivided into specific tracks. Each track is then divided into competences. For each competence, there is a set of subcompetences, which are related to one or more contents. HCI is a content linked with several competences for all the majors in the document.

In addition to the SBC curricula, the Brazilian HCI community has published their own guidelines for HCI courses in undergraduate and graduate levels. The first work group for discussing a proposal for HCI courses was organized in IHC 2006 [11]. The topics for undergraduate courses are grouped in *Introduction to HCI*, *Theoretical Frameworks*, *Evaluation*, *Interaction Design*, and *HCI Design Process*. Bibliography recommendations are also included in the proposal. A few years later, a revised proposal, informed by WEIHC discussions and a questionnaire answered by acting professors across the country is reported in [12]. Several topics were added to the previous groups, and a new group was proposed: *Domains/Platforms*. It also includes discussions about different topic emphases for different majors (CS, CE, and SE).

III. Methodology

As a way of exploring *how* HCI is being taught in computing undergraduate courses in Brazil, we decided to conduct semi-structured interviews with HCI professors using the Underlying Discourse Unveiling Method (UDUM) [21].

UDUM is a qualitative research method originated in clinical psychology [21] that has been successfully used in HCI. An important characteristic of UDUM is that it explicitly acknowledges that it deals with discursive material, and that the language helps shaping values, concepts, etc, that characterize a given social group. Therefore, the discourse can reveal inner characteristics of people in this group.

After choosing the focus of our investigation, we prepared the script for the data collection. The script consisted of open items grouped into blocks. Our script included the following blocks: Personal information, HCI courses in the institution, Content, Methodology, Classes, Being a professor, Students, and Extra (comments they wanted to add). Two pilot interviews were conducted before the actual interviews, there were minor adjustments to the script.

We aimed at recruiting participants who were active members of the Brazilian HCI community within SBC - which is mainly composed by people with a computing background - and participated in our national symposium (IHC) and/or WEIHC; who had had different trajectories (in regards to where and what they had previously studied); who worked at different institutions and were geographically distributed. We only selected participants who taught introductory HCI courses within computing majors, which were the focus of our investigation.

We invited researchers via e-mail, and thirteen were interviewed in total. We had participants from all five geographic

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[1] Knowledge from other fields, such as Management for IS.
[2] Internships and/or final year projects.

[3] We use the term Licentiate as in *permission to teach*. Licenciatura in Brazil, is a type of undergraduate degree that qualifies its holder to teach.

regions of Brazil. The interviews were conducted online, via audio, and were recorded. They were then transcribed and analyzed. The analysis was segmented and iterative [22], including coding and grouping categories that emerged from the discourse of all interviewees. We also looked for contradictions in each interview separately, as proposed in UDUM [21].

This paper reports a portion of this analysis, which contrasts the information gathered in the interviews regarding the content being taught with national and international curriculum guidelines. Since the majority of our interviewees taught in CS and IS majors, we chose to focus our analysis in CS [16], [18], [20] and IS [17], [19], [20] curricula guidelines. In addition, we included the HCI curriculum recommendation from the Brazilian HCI community, proposed in 2007 [11] and revised in 2014 [12]. It is important to note that, although the recommendations from [11], [12] were proposed by members of our HCI community, they are a result of discussions that happened within IHC (specifically within WEIHC), and represent the result of the work during a one-day workshop, while the other guidelines are a result of long work processes from organized committees, involving much more people and giving the opportunity of a broader participation for the members of the computing community.

For this analysis, we looked for explicit references about content in the interviews and contrasted them with the topics and competences listed in the guidelines above. From [16] we considered the topics and learning outcomes for each KU within the HCI KA. From [17], we considered the topics and learning outcomes in the sample HCI introductory course. From [18] and [19], we considered the topics in the proposed HCI syllabi. From [12], we considered the topics in the revised undergraduate course proposal. Neither [18] nor [19] or [12] mention competences. So, from [20], we considered the competences recommended for CS and IS majors. Although some guidelines include proficiency levels associated to the competences expected from the students, we did not address them in our analysis. As the interviews did not aim to investigate the content being taught, but rather the classroom dynamics and teaching methodology, we cannot claim this is a comprehensive analysis of the content being taught. However, we believe these results bring interesting and useful insights about our context.

Before we present our results in the next section, it is worth pointing out that a premise of the methodology chosen is that what is important to someone will show in their spontaneous discourse, therefore, the most important contents for each interviewee will emerge from their discourse. For each topic, we marked if there was an explicit mention either through classes, dynamics, activities or course projects. We also marked topics that were explicitly not covered - although there were only two occurrences of such comments (mentioned in the next section). For all the other topics, we cannot claim they were or were not covered, but rather that they were mentioned or not, which might be an indicative of their value to the interviewees, or be a result of different abstraction levels in the guidelines (eg. broader topics can be more easily mentioned than specific topics). For our analysis, we then took into account the number of interviewees who mentioned or not a topic as a way of understanding if that topic is highly or lowly valued among our interviewees. We do not present an analysis of relevant topics to them individually in this paper.

IV. RESULTS AND DISCUSSION

This section presents the results of our analysis. First, we present the profile of the respondents and their contexts. Then we show the results regarding each guideline separately.

A. Profile

We interviewed HCI researchers that taught undergraduate courses in computing across the country. All interviewees were at least 30 years old. Three were between 30 and 40 years old, seven between 40 and 50, and three older than 50. The great majority had their main background in computing courses. Only one of them had less than 10 years researching HCI, eight had between 10 and 20 years, and four had more than 20 years of experience. However, when it comes to their experience teaching the subject, four have been teaching for less than 10 years, five between 10 and 20 years, and four for more than 20 years.

B. Context

The courses taught by our participants were part of 28 computing undergraduate courses[4] across 14 universities[5]. By design, our research covered institutions with at least one introductory HCI course. However, we identified courses within the same institutions that did not have HCI as a part of the curriculum - eg. P05 currently teaches HCI for CS and SE majors, but the CE major in the same department does not cover HCI (all the courses within the major are mandatory, and HCI is not among them.). All the courses had the duration of one semester, but their lecture hours[6] varied from 30 to 72.

We found HCI courses in IS, CE, CS and SE majors. However, there is a difference on their distribution within these majors. All SE courses (2) have at least one required HCI course. Almost all IS courses (7/8) have at least one required course. CS has at least one required course more than half the time (7/11), so does CE (3/5). Overall, SI students are exposed to HCI sooner than in the other courses, that is, in the first half of their major (first two years out of four). Two of the universities only offer HCI courses as elective for all their majors. Additionally, as mentioned before, one university explicitly does not offer any HCI courses for their CE major.

In five universities, there is at least one course that is offered to both undergraduate and graduate students in the same class. In these cases, we found that: (1) the course was originally aimed at graduate students, but undergraduate students could enroll as an elective course; or (2) it was an introductory course offered together to both undergraduate and graduate students.

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[4]We only considered courses recognized by SBC. Other very specific courses, such as Bioinformatics were not considered.

[5]One of the interviewees (P03) taught at two universities.

[6]Lecture hours represent how many classroom contact hours professors have with their students during the course.

We asked the interviewees if there were other HCI professors in the institutions they worked on. Most of the answers included "we have other X professors who are *qualified* to teach HCI". Their discourse revealed they differentiated (1) colleagues that had their main focus on HCI, and were specialized in the subject, from (2) colleagues that specialized on other subjects, but were somewhat interested in HCI and could teach, ocasionally teach, or have taught an introductory course. This means that although in theory most universities have more than one qualified HCI professor (10/14), in practice some universities only have one who has HCI as his/her main field, and others who could teach the class if needed. P06 says there is another HCI researcher in the same department. However, this researcher does not teach undergraduate courses, only graduate ones. The undergraduate course is an elective course in the major offered in the university, so the students can only enroll when the interviewee is able to offer the class. They[7] say they make an effort to offer it at least once a year, but this usually depends on their availability, since the university requires professors to offer other mandatory courses. So, usually when they offer the HCI course, it is as an 'extra load of work'. On the other hand, we found two universities in which there are five qualified HCI professors. In one of them, one of the majors offers an emphasis on HCI with seven HCI courses, which are distributed among the professors. Half the universities (7/14) have three professors qualified to teach HCI. One other has two. In four others, the interviewees are the only faculty member qualified to teach the subject.

C. Guidelines

This subsection focuses on the topics taught in the introductory HCI courses investigated in the interviews. For the analysis, we identified parts of the discourse related to course content, and contrasted them with national and international guidelines for HCI, which are discussed below.

1) International CS guideline: The **Foundations** KU is considered Core Tier-1 in [16]. Its topics cover basic knowledge in HCI, such as key concepts, understanding context, different measures for evaluation, among others. Topics from this KU with fewer mentions on the interviews are related to ergonomics and cognitive models. The least mentioned topic is *Interfaces for differently-aged population groups (e.g., children, 80+)*. P05 and P06 mentioned having course projects involving children in past semesters. However, this is not the case for every semester. It does not mean that these population groups are not addressed in the courses, however they are not necessarily emphasized by the professors and are very specific to mention.

The curricula associates five Learning Outcomes (LOs) with this KU [16, p. 90]: (1) *Discuss why human-centered software development is important*; (2) *Summarize the basic precepts of psychological and social interaction*; (3) *Develop and use a conceptual vocabulary for analyzing human interaction with software: affordance, conceptual model, feedback, and so forth*; (4) *Define a user-centered design process that explicitly takes into account the fact that the user is not like the developer or their acquaintances*; and (5) *Create and conduct a simple usability test for an existing software application*. All interviewees mentioned 4 out of the 5 LOs in their courses. The only LO not mentioned by all professors is (2).

Interviewees who mention teaching psychological aspects usually also talk about theoretical frameworks such as Cognitive Engineering and Semiotic Engineering. So, although the interviewees do talk about basic concepts and foundation topics, their approach is a little different from what it is considered foundational by the guideline. This is evidence of the influence different HCI theories and foundations may have in the curricula. Internationally, HCI is greatly influenced by cognitive and ergonomic engineering, and user-centered design process. In Brazil, teaching is greatly influenced by semiotic approaches to HCI [14], which are not listed in the guideline.

Designing Interaction KU is considered Core Tier-2 in [16]. Its most mentioned topics are *Task analysis, including qualitative aspects of generating task analytic models*; and *Low-fidelity (paper) prototyping*. The most mentioned LO is *For an identified user group, undertake and document an analysis of their needs*. All interviewees except P11 mention techniques for gathering user needs. P13 is the only interviewee who explicitly requires programming in their course project, so that the students have a finished (simple) product by the end of the semester. Therefore, P13 is the only professor who covers the *Create a simple application, together with help and documentation, that supports a graphical user interface* LO, although others do require functional prototypes with GUIs, and documentation. Three interviewees mentioned talking about interface standards and guidelines, such as accessibility recommendations from the World Wide Web Consortium (W3C), covering both the *User interface standards* topic and the *Discuss at least one national or international user interface design standard* LO. P10 is the only interviewee who mentions talking about *Elements of visual design (layout, color, fonts, labeling)*. Most of the evaluation methods mentioned in the interviews have a qualitative nature. P08 is the only one who mentioned using log analysis, which we considered as covering the *Quantitative evaluation techniques, e.g., keystroke-level evaluation* topic and *Conduct a quantitative evaluation and discuss/report the results* LO. There were no mentions of *Handling human/system failure*.

Topics from the **User-Centered Design and Testing** KU cover approaches to the design process, and parts of design cycles such as requirements gathering, prototyping, and testing. The great majority of the interviewees (10/13) reports following a design process within the course, covering aspects of project design and testing[8]. Additionally, they choose to do so through a course project, in which the students experience a whole design cycle. P13 reports the idea is that they go through all the design phases, and have a finished product at the end of the course. In most cases, the final product

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[7]We refer to all participants as *they*, to avoid their identification.

[8]The other three focus on testing, as detailed below.

developed by the students is a functional prototype, rather than a fully working application. Students also deliver a report explaining the decisions, the process, and results of each phase.

Some interviewees prefer starting the cycle through evaluation of similar interfaces, followed by a design or redesign phase. P10, for example, prefers starting by presenting evaluation because they think it is more practical, and therefore the students become more engaged in the course. P09 also starts with evaluation, but they say they like to include a second round of evaluation at the end of the project, so that the students understand the difference between what they expected from the design and what actually happened.

Others start the project from requirements gathering, designing and then evaluating the design. P12, in particular, follows the design cycle *twice* within the same course: first the students work on a small project to better understand the design process; then they work on a bigger project, in which they are more independent.

Some of the interviewees do not cover the whole design cycle (3/13). In those cases, the course is focused on evaluation, with little to no project design. P05, for example, reports not covering design topics because the students have a following course on HCI design, and thus the introductory course is focused on evaluation. However, other two interviewees focus on evaluation even though the program of the major in their institution includes only one introductory HCI course. This shows how evaluation is highly valued by some interviewees. P09, who covers both evaluation and design, can give an insight about why that might be the case: "I *strongly* prioritize evaluation, right, because I think that, you know, for introductory disciplines, the *most important* thing is that they [the students] develop a sense of quality [towards software]".

Regarding the LOs, all interviewees mentioned multiple evaluation methods, and being able to compare them, covering the *Use a variety of techniques to evaluate a given UI* and *Compare the constraints and benefits of different evaluative methods* LOs. P11 was the only interviewee who did not mention low-fidelity prototyping. Among the others, it was widely used as an intermediate state for the final prototypes, used for design evaluation. Thus, we can say *Use lo-fi (low fidelity) prototyping techniques to gather, and report, user responses* is well covered. Almost half of interviewees (6 out of 13) explicitly mentioned connecting design cycles with Software Engineering processes, covering the *Explain how user-centered design complements other software process models* LO. Five professors mentioned they let the students choose (at least some of) the methods they will use in the projects, covering the remaining LO: *Choose appropriate methods to support the development of a specific UI*.

An interesting topic mentioned by some is *Critically Reflective HCI* within **Design-Oriented HCI** KU. Some interviewees commented on the importance of developing critical thinking and a sense of responsibility and ethics within the introductory courses. This emerges in two different ways. First, as trying to develop critical thinking regarding design and techniques choices within a project, in which students are required to justify their choices throughout their course project. Second, as trying to develop a sense of responsibility towards the solutions they propose. For example, interviewees report teaching a Socially Aware approach to design, considering social and cultural aspects in the design process. A challenge mentioned by P09 is that sometimes the students are not mature enough to discuss some of these ethical issues involved in HCI.

Regarding its LOs, the *Explain what is meant by "HCI is a design-oriented discipline"* LO is covered by the ten interviewees who require course projects. This is because in the project, the students must follow a design cycle and come up with a design of their own for the problem they are working on. Most of the time, the cycle or design approach is established by the professor, which means the students achieve the *Detail the processes of design appropriate to specific design orientations* LO. In those cases, however, students do not use different approaches, as stated in the *Apply a variety of design methods to a given problem* LO. Both P06 and P12 mention they do talk about different design approaches in the course, but choose one for the course project. P12, in particular, mentions asking students to build different prototypes, so they can explore different solutions for the problem.

Most of the topics in **Programming Interactive Systems** and **New Interactive Technologies** KUs were not explicitly mentioned, but some are covered by the course projects. Some interviewees mentioned discussing *Interaction Design Patterns: visual hierarchy, navigational distance*; *Choosing interaction styles and interaction techniques*; *Cross-platform design*; and *Design for resource-constrained devices (e.g. small, mobile devices)*. In many cases, students are free to choose the platform (or platforms) they will develop for in the course project. In other cases, the professors define the platform for that specific course - for example, P03 mentions a semester in which the students had to design a wearable device. However, most of the professors who decide the theme for the course project usually change it every semester. This means in a particular semester students can study HCI concepts and processes applied to wearable devices, while in another it will be mobile applications, and so on. Also, in some cases professors will vary whether they specify the project theme or not from one semester to another. *Choosing interaction styles and interaction techniques* and *Representing information to users* were not explicitly mentioned, but are clearly a part of the decisions taken by the students in the course projects. Other topics in are very technology-specific, such as *Modern GUI libraries* and *Approaches to design, implementation and evaluation of non-mouse interaction*. These were not explicitly mentioned. However, most of the time the students are required to deliver functional prototypes in the course projects. This indicates that the courses focus on the actual design rather than implementation - which is likely covered in other courses within the curriculum. Several interviewees mentioned the rapidly evolving technologies and the new opportunities they bring as a challenge in HCI Education, since they have to keep the courses up-to-date to motivate the students and convey

relevant content.

In the same way the topics from the *New Interactive Technologies* KU are covered through the course project, so are its corresponding LOs, which are concerned with describing and understanding advantages (and disadvantages) of non-mouse interfaces. As mentioned before, several interviewees mentioned using mobile devices in the classroom and/or in the course project; and P03 has used wearable devices as the theme of the course project. Furthermore, some professors do talk specifically about alternative interfaces, such as: P13 who always gives a lecture on mobile interfaces; P08 who teaches about voice, gesture, and multi-touch interactions; and P12 who sometimes includes Internet of Things in their course.

Most of the LOs from *Programming Interactive Systems* KU are not mentioned by the interviewees. Like some of the topics, the LOs are very focused on programming aspects such as particular architectures and paradigms - which are definitely not the focus of the courses in our investigation. It is difficult to say if the *Create an application with a modern graphical user interface* is covered in the courses we investigated. It is fair to assume that *create* intended to include programming a product in this context (based on the KU motivation: "To take a user-experience-centered view of software development and then cover approaches and technologies to make that happen." [16, p. 91]). In this case, P13 covers this LO, since they ask for a product in their course. In the cases where the students deliver functional prototypes, they usually can choose the delivery format. This means some can and will program it, while others may use prototyping tools that do not require any programming at all. In either case, as mentioned before, programming is not the interviewees main concern, but rather the application design and rationale behind it. In part, this is why in most cases the students are free to choose how they will prototype their design. Whether the student projects are *modern* or not is easier to say, since the interviewees mention different modern platforms such as web, mobile and wearable devices. Some also mention the course project can be cross-platform (eg. work on desktop and mobile devices). P08, in particular, mentions they teach about voice, gesture, and multi-touch interactions. Therefore, we can conclude that a few interviewees do cover the *Identify commonalities and differences in UIs across different platforms* LO.

Finally, KUs with least topic mentions in the interviews were: **Collaboration and Communication**; **Statistical Methods for HCI**; **Human Factors and Security**; and **Mixed, Augmented and Virtual Reality**. These can be considered more specific or advanced topics, which seem not to be as important to be conveyed in introductory courses - which was the focus of our research. However, some universities offer more than one HCI course. For instance, one of the interviewees mentioned the existence of Computer-Supported Cooperative Work course, which likely covers topics mentioned in the *Collaboration and Communication* KU.

Strictly speaking, there were no mentions of the LOs associated to the *Collaboration and Communication* KU. The KU motivation is "Computer interfaces not only support users in achieving their individual goals but also in their interaction with others, whether that is task-focused (work or gaming) or task-unfocused (social networking)." [16, p. 93]. As it can be seen through the motivation, and the topics associated with it, this KU is completely focused on the communication between *users* in the system. However, looking at the LOs from a Semiotic Engineering perspective, it is possible to say that some courses cover the *Discuss the HCI issues in software that embodies human intention* LO. This is because Semiotic Engineering sees HCI as a communication between system *designers and users*. Therefore, the designers convey their intention through to the users through the interface. In addition, it would also cover the *Describe the difference between synchronous and asynchronous communication*, since the communication between designers and users is asynchronous and happens at interaction time.

No LOs from *Statistical Methods for HCI*; *Human Factors and Security*; and *Mixed, Augmented and Virtual Reality* were mentioned.

Fig. 1 shows the KUs arranged by Topics and LOs coverage. The KUs on the left are ordered from higher (top) to lower (bottom) topic coverage - i.e. the first has more topics mentioned than the second, and so on. Similarly, on the right they are ordered by LOs coverage. The KUs are grouped by high, medium and low coverage. The gray background represents the medium coverage group. Above it, we can see the high coverage group, and below it, the low coverage one. KUs closer to the top have topics and LOs mentioned more often in the interviews, while the ones on the bottom have little or no mentions.
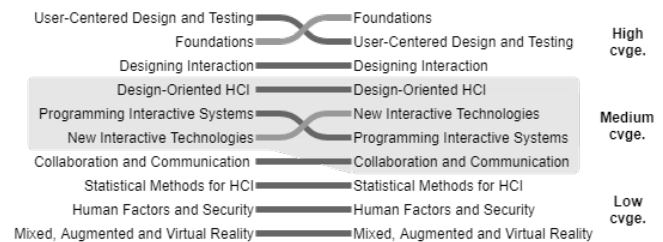

Fig. 1. KUs Coverage of Topics (left) vs Learning Outcomes (right).

When comparing the KU coverage regarding Topics and LOs groups, we can see they are almost identical. However, *Collaboration and Communication* KU is in the low coverage group when we evaluate topics, and in the medium coverage group when we look at LOs. This is because even though the interviewees do not cover its topics as proposed in the guideline, Semiotic Engineering allowed some of them to achieve the LO *Discuss the HCI issues in software that embodies human intention*, as discussed above. This shows that although topics and LOs are associated with each other in the curriculum, some LOs can be achieved through topics they are not explicitly associated with, or not in the guideline at all.

This is also the case when looking at the *Designing Interaction* KU, which is also in the high coverage group in both rankings. Its most frequently mentioned topics are cited by approximately half the interviewees (while the first two KUs have topics covered by all interviewees). However, its LO concerned with user needs analysis is covered by 12 of the 13 interviewees. This shows that while specific topics such as task analysis were not widely mentioned, professors reported covering that LO through other techniques, such as surveys and interviews.

When comparing both rankings, we can note two position inversions. One inversion occurs with the first two KUs. Both are highly covered in topics and LOs. Some topics from the *Foundations* KU are specifically related to psychological and visual aspects of HCI (and are less covered than topics from *User-Centered Design and Testing* KU). On the other hand, the LOs associated to Foundation are more abstract and can be achieved through the topics and practices used by the interviewees, and thus, is higher up in the LOs ranking on the right.

The other inversion occurs with *Programming Interactive Systems* and *New Interactive Technologies* KUs. The former includes topics concerned with design (cross-platform, resource-constrained devices), but its LOs are more related to development and technological aspects. Therefore, it is lower in the LOs ranking than the latter, which has both topics and LOs mainly covered by the course projects.

Based on our analysis, we can say that (1) LOs can be achieved through topics that are not explicitly associated with them, or even listed in the curriculum; and (2) a topic can be taught with different outcomes in mind. (1) is evidenced in the change in the medium coverage group discussed above, related to the *Collaboration and Communication* KU, along with the inversion between *Foundations* and *User-Centered Design and Testing* KUs. The inversion between *Programming Interactive Systems* and *New Interactive Technologies* KUs evidences (2), because while some topics from *Programming Interactive Systems* are addressed in the courses, the interviewees goals for teaching them are different than what is described in its LOs - eg. they are more concerned with the design than technology or development.

2) International IS guideline: The most mentioned topics from [17] were *Relevance of HCI*; *Development (Introduction to projects, Prototyping, Contextual inquiry, Usability engineering)*; and *Evaluation Methods (Heuristics, Cognitive evaluation, Usability testing, Questionnaires, Research design)*. Similarly to what we discussed above, these topics are usually approached in practical projects, where the students can experience and conduct evaluations and design techniques. Several methods mentioned by the interviewees are not listed in the curriculum, such as methods from Semiotic Engineering.

The topic on *Devices (PCs, Industrial devices, Consumer devices, Mobile devices)* was mostly considered in the course projects. In some cases, the projects were focused on a specific platform (wearable devices, mobile devices, etc); in others the students were required to consider cross-platform design; and

in others the students were allowed to choose the appropriate platform for the problem they were working on. A few participants mentioned having classes on Internet of Things - not necessarily as a regular topic, but rather motivated by students' requests. P13 mentioned they always give a lecture on mobile devices in the course, but says it is difficult to find good references for this topic in particular.

Special HCI Issues Related to Users (Children, Elderly, Accessibility, Gender); *Organizations*; *Society*; and *Task Analysis* topics were somewhat mentioned, with accessibility being the most mentioned. In fact, accessibility was mentioned in several ways by different people. Some mentioned it as a property linked to software quality, along with usability, and communicability. Some mentioned accessibility testing, W3C guidelines, requiring it on the course project, designing for inclusion, using it to engage students, among others. Additionally, P11 mentions that accessibility is not the students' focus, but it is where their heart is.

The less covered topics were *Principles in HCI design (Ergonomic, Cognitive, and Affective engineering)*, with Cognitive Engineering being the most mentioned; and *User-Centered Design (Users Capabilities, Conceptual models, Metaphors, Mental models)*, explicitly mentioned by only one interviewee. Similarly to [16], we can see that this curriculum does not account for Semiotic Engineering in *Principles of HCI design*, which is something mentioned by several interviewees.

The guideline has eight LOs [17, p. 62]: (1) *Design, implement and evaluate effective computer interfaces*; (2) *Understand the concepts of user differences, user experience and collaboration as well as how to design contextually*; (3) *Understand the basic cognitive psychology issues involved in HCI*; (4) *Understand the different devices used for input and output and the issues / opportunities associated with these devices*; (5) *Interact with the software design process in order to create computer interfaces*; (6) *Understand the role of theory and frameworks in HCI*; (7) *Apply a number of design techniques*; and (8) *Apply contemporary techniques to evaluate computer interfaces*. All interviewees explicitly mentioned (8) and (4). Regarding (1), all participants mention evaluation, but the implementation and design are not necessarily covered in the three without a course project. Eight interviewees mention (3) and (5), and five cover (6). They do so when discussing different theories and approaches to HCI, such as Cognitive and Semiotic Engineering, and when they connect HCI to other disciplines such as Software Engineering. Finally, (4) is sometimes discussed when the course project involves cross-platform design, mobile or wearable devices. P12 discusses different design approaches in the course, covering (7), although they focus on one. In the cases where students are free to choose methods in the project, it is also discussed (they make and justify their design decisions).

3) National CS guideline: The most covered topics from [18] are *Usability: Definition and Evaluation Methods*; and *Human Factors in Interactive Software: Theory, Principles and Basic Rules*. Both are fairly broad topics, so different interviewees might have different approaches to them. *Interface*

Standards; *Interactive Styles* and *Devices* were mentioned by a few interviewees, and mostly covered by the course projects, in which students should make decisions about these aspects in order to solve the problem they are working on. *Command Languages*; *Direct Manipulation*; *Virtual Reality: Nature and Benefits*; *Components: Graphics and Sounds*; and *The Nature of User Interacion in Virtual Environemtns* were not explicitly mentioned by the interviewees, but have a very specific scope.

The CS chapter from [20] associates three competences with HCI. *Apply HCI principles to evaluate and build a variety of products with user interfaces, web pages, multimidia and mobile systems*: Although not all interviewees cover all these platforms, since platforms are usually less important in the courses we investigated, all convey HCI principles to their students. As mentioned before, all cover evaluation, and most cover design. Therefore, we can say that the HCI courses contribute towards the development of this competence.

Conceive computational solutions from decisions that balance all factors involved: This is certainly covered by HCI courses, since the students are required to reflect on the choices they make as software developers, and how they affect users - either by evaluating and/or designing solutions. In particular, P06 mentions how students are required to report identifying and dealing with the demands of different stakeholders within the course project.

Solve problems using programming environments: Since most of the interviewees do not demand programming from their students, HCI courses are contributing less towards this competence than other more technology-focused courses.

4) National IS guideline: Regarding the IS curriculum [19], most of the interviewees covered the topics indicated since they are broader. *HCI Concepts*; *HCI Foundations*; and *Methodologies, Techniques and Tools for Systems Design and Evaluation* were all mentioned by all interviewees, with the exception of three who did not cover Systems Design, as mentioned before. *Software Ergonomics*; *Software Architectures and Interface Standards*; and *I/O Devices* were the least mentioned topics.[9]

The IS chapter from [20], there are five competences associated with HCI, concerned with (1) evaluating, (2) elaborating, (3) designing, (4) building and (5) introducing effective and efficient information systems, considering technological, economic, social, and environmental aspects. HCI courses are contributing a lot for the first three, especially since they provide not only theoretical but also practical knowledge to the students, through lectures, ativities and projects. The fourth, as mentioned before, is only addressed by some of the interviewees. The courses, however, do not provide any practical experience about introducing the systems in a real setting, but it is possible to argue that evaluation methods contribute to insights about the possible successes and failures of the developed solutions within different contexts.

5) National HCI guideline: All the topics in [12] were mentioned by at least one interviewee, with the exception of *Online Help Systems*. Topics within *Introduction to HCI*; *Evaluation*; and *HCI Design Process* group were covered by the great majority of the interviewees.

Within *Introduction to HCI*, the least mentioned topics were *HCI History/Evolution* and *Related Fields*. All the other topics, which are related to basic concepts, were mentioned by all interviewees.

Within *Evaluation*, the only topic that was not mentioned by all interviewees was *Predictive Evaluation*[10]. This shows that this type of evaluation is less valued by them, when compared to others. No specific comment was made towards the conscious choice of not covering these methods, however the limited course time and students struggle to understand abstract concepts such as theoretical methods and models might be some of the reasons why they choose not to emphasize these methods.

Within *HCI Design Process*, *Storyboarding* and *Prototyping* were mentioned by almost all interviewees. About half the interviewees mentioned (1) *User-Centered Design, Usability Engineering, Participatory Design, Ethnographic Methods, Universal Design/Usability, Redesign*; (2) *HCI and Software Engineering*; and (3) *Task Modeling*. The latter (3) was explicitly not covered by P01, who stated that the syllabus was too long for the actual time they had in the course, so they decided to take this item off on the last semesters.

Interaction Design was somewhat covered. Approximately one third of the interviewees mentioned *Interaction Standards and Guidelines*. The *Interaction Styles* topic within this group and the *Domains/Platforms* group can be considered covered in the course projects, in which students had to make decisions about them, but not necessarily explicitly addressed by the interviewees in the courses.

Theoretical Frameworks was the less covered topic group. The great majority of the interviewees mentioned students actually struggle with theoretic or abstract contents, as a whole. Several of them mentioned the students struggle linking practical observations and results with the theories and concepts studied, struggle when asked to do analysis and critical thinking about their own decisions throughout the course project, for example. Some of the possible reasons spontaneously raised by interviewees were that: in their opinion, the students are not as dedicated as they should be (for example, they do not read enough, do not pay as much attention to the class as they should); their own classes, explanations, and examples are not good enough and do not convey theoretic content as easily or as well as technical content; the students are not mature enough to take the course.

Among the interviewees who do mention discussing *Theoretical Frameworks*, there are mentions of Cognitive and Semiotic Engineering, Ergonomics, Organizational Semiotics, and Human Factors.

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[9]The curriculum does not describe any of the topics, so we considered *Human-Machine Dialogue Techniques* as equivalent to *Interactive Styles* in this analysis.

[10]Predictive Evaluation refers to methods where specialists try to predict the use of a software using previous knowledge about its use, users, tasks, etc. The guideline details it as *Theoretical models, GOMS*.

V. FINAL CONSIDERATIONS

This paper presented an in-depth analysis of topics and competences being addressed by HCI researchers who teach introductory HCI courses, in the light of national and international curriculum guidelines. For each guideline, we show how they address (or not) the expected topics and competences.

The most detailed guideline is [16], providing ten Knowledge Units regarding HCI, each with corresponding motivation, topics, and learning outcomes. Within the national guidelines, the ones from the Brazilian HCI community ([12]) are more detailed than those from the broader Brazilian Computer Society ([18], [19]). Nevertheless, none of the three address competences expected from students. The competences provided in [20] are very broad and not aimed exclusively at HCI, but rather at computing undergraduate courses as a whole. So, although HCI certainly contributes towards developing these competences, other contents and courses also contribute towards their development.

We interviewed representative members of the HCI community, including people with different backgrounds and geographically distributed in the country. It is known that most of the members of this particular community come from computing, and members of other communities[11] would certainly have brought other topics, pedagogical strategies, and overall approach to HCI. That is because this paper is part of a larger project investigating how HCI introductory courses are being taught in computing majors. Furthermore, since the interviews had a broader scope, interviewees were more prone to talk about the course content in a broader way than if the interview was aimed at investigating course content only. Additionally, the abstraction/granularity levels of topics and competences within the analyzed guidelines varied, so the more specific it was on the guideline, the less probable it was mentioned in the interviews.

Our analysis provides insights on HCI Education in Brazil, in the light of the guidelines. In particular, we show how most courses are project-centered, enabling students to acquire both theoretical and practical HCI knowledge. This approach allows tackling HCI evaluation and design, while discussing HCI foundations related to them. Furthermore, the projects allow for exploration of critical thinking about different solutions, technologies and themes. It is clear, however, that the focus is on the design aspect rather than programming, even when programming is required in the course.

Our analysis also show differences on approaches to HCI in practice versus in the guidelines. The influence of Semiotics is very clear within the Brazilian context. Even among professors who do not dive into discussing different theoretic foundations we see Semiotic Engineering evaluation methods being mentioned, and Organizational Semiotics. In addition, accessibility is another strong influence, being mentioned by several people, and a requirement of the course project of one

interviewee. It is also used to engage students in the course, and broaden students perspective on how different users might interact differently with the same software and devices.

Our research also contributes to HCI by identifying and presenting different national [18]–[20] and international [16], [17] curricula guidelines, making it easier to see the different perspectives and recommendations for HCI courses within computing majors. It can also help professors and researchers from other countries to understand how HCI is being taught in Brazil, which can help in identifying characteristics of their own contexts. In addition, some of the practices, topics, and pedagogical approaches reported here can be used as inspiration for improving courses in Brazil and other countries.

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[11]There are other HCI communities in Brazil, with events that attract participants from other areas such as Design, Arts, Communication and Information Science.