"Core" Components in HCI Syllabi: Based on the Practice of CS and LIS Schools in North America

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Abstract. The "core" of HCI education remains debatable because of its multidiscipline nature. This paper developed an integrated HCI classification schema of teaching topics. A content analysis with 104 HCI syllabi from 28 computer science and 23 library and information science programs in North America revealed no significant differences between two programs. The social network analysis of co-occurrence 2280 teaching topics in courses identified 9 HCI core course components and 4 topic clusters. Three teaching styles emerged in social network analysis of university co-occurrence network. In conclusion, it is suggested that HCI educators should design syllabi or curricula according to their own contexts.

Keywords: HCI education · Syllabi map · Content analysis · Social network analysis

1 Introduction

Human Computer Interaction (HCI) has ever been defined as sub-discipline, multi-disciplinary or interdisciplinary field since late 1960s (Gasen 1996). When computer human interface design (CHI) was first introduced into higher education system, it was a sub-discipline of computer graphics, studying mainly on CAD/CAM, ergonomics and some separated disciplines. But in late 1970s, scholars recognized the multidiscipline nature of HCI, and tried to combine independent areas to create a new discipline. Based on previous research (Denning et al. 1988), HCI has already evolved into one of the nine core areas of Computer Science in 1980s. When an authoritative report ("Lime Green Report") was issued by ACM SIGCHI in 1992, HCI was clearly defined as: "*a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them*."(Hewett et al. 1992), which manifested the coming of HCI multi-discipline paradigm. Currently, HCI is also viewed as one of the eleven elective courses in IS field (Topi et al. 2010).

Although HCI education has been greatly developed, the knowledge structure of this "emerging" discipline remains unclear. The first survey of HCI education

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(Mantel and Smelcer 1984) confirmed the emergence of systematical HCI education by scholars in computer graphics, human factor, and industrial psychology, but had no report on the knowledge structure of HCI courses.

To identify the core of HCI education, Gary Perlman and Jean Gasen have been conducting a systematic survey on HCI education since fall 1992 following ACM SIGCHI's curricular program (Gasen 1994a, b, 1994c, 1995a, b 1996, 1997). According to Gasen's report (Gasen 1994a), there were already 67 programs, 160 faculty and 137 courses included in 1993, but they found "HCl Education still on the fringes", lacking "awareness, support and demand", need more supports in further development.

During 2000–2005, there were nearly half of published HCI education papers proposed recognition or further integration (Edwards 2006). Educators worried about the failure of HCI education, argued "the characteristics of a living HCI curriculum" (Lazar et al. 2002). Some researchers complained that educators had little understanding of HCI's multidisciplinary context (Carroll 2003), for lacking of updated data and tools for unstructured data analysis in HCI.

Current researches noticed the diffusion of global consensus as well as localized application in HCI education (Churchill et al. 2013; Boscarioli et al. 2013; Oestreicher 2013), but educators still questioned the core and methodologies in HCI education in terms of multidisciplinary rigor, pedagogical transitions, and new paradigms (Grandhi 2015). A 2011–2014 SIGCHI Project on HCI Education highlighted that the shared understanding of the HCI curriculum is challenged by the competing tensions of standardized vs. flexible curricula, breadth vs. depth of interdisciplinary theories and methods covered, need for technical vs. nontechnical skills, and other conflicts (Churchill 2014).

How can educators adapt to HCI evolvements? In this paper, a content analysis of HCI syllabi is to reveal the most frequent topics, and a social network analysis of teaching topics is to excavate the relationships of topics and the knowledge structure of HCI courses.

2 Related Work

In order to develop a coding schema for HCI syllabi topics, related HCI classification systems, HCI curriculum and research frameworks are reviewed in the following.

2.1 Classification Systems in HCI

Classification systems are not only covering all the terms occurred in this area, but also well-organized by hierarchy or ontology. ACM issued many hierarchy classification systems to organize and control published papers in computer science since 1964, and the latest edition is released in 2012. In 1982, "Computer Graphics", "Computer-communication networks", "Human factors" were first introduced in the system. In 1998, "H.5 INFORMATION INTERFACES AND PRESENTATION (e.g., HCI)" was created as an independent category with 5 sub-categories and 41 items (Coulter et al. 1998). In 2012, the category occurred as first level (Human-centered computing) and broadened to 6 sub-categories and 112 items (CCS2012). But the granularity of this classification is challenged with rapid growing HCI publications.

2.2 Curriculum and Research Frameworks in HCI

Curriculum framework, covering the main topics and major themes occurred in teaching, is quite suitable for syllabi tagging as organization tools. There are two important HCI curriculum frameworks.

The first one was proposed by ACM SIGCHI Curriculum Development Group. The first edition was released in 1984, merely focused on the curriculum structure and tried to select the major themes to "inventory the current state of results in the field of human-computer interaction". In 1992, Hewett etc. issued a framework (NUHCD-P) with 5 aspects content structure of 16 groups, covering almost all the topics that were known and worth teaching (Hewett et al. 1992). This is the most cited framework in HCI education structure research, although 20 years passed.

The second one was proposed by the Joint Task Force on Computing Curricula ACM. They issued curriculum guidelines every five or ten years since 1968. The latest curricular volumes was released in 2013 (CS2013) (Sahami et al. 2013). In Sahami's report, HCI was listed as one core "knowledge body" and covered 10 domains and 86 items.

In addition, (Zhang and Galletta 2006) proposed a HCI research framework covering major HCI research issues.

3 Method

3.1 HCI Syllabi Collection in North America

While most HCI programs reside in CS (computer science) departments (64 %) (Gasen 1994a), many LIS (library and information science) schools also host HCI courses/programs. Thus HCI syllabi were collected from both CS and LIS programs for this study. The weekly topics and course schedule were extracted from HCI syllabi for the analysis of knowledge structure of HCI education.

Collecting Syllabi Data in CS. A random sampling of 28 CS programs was chosen from hundreds of computer science programs all around North America (see Table 1). Then 35 syllabi of HCI and related courses were collected from above program websites. Finally HCI topics (682 records and 917 items) are extracted from syllabi.

Collecting Syllabi Data in LIS. According to LIS courses database (Self-built, updated in September 2015, and tagged by ALISE Classification Schema, data collected from the curriculum of LIS school), there are more than 150 courses classified into HCI, and 118 of them located in North American, affiliating to 43 LIS programs (73 % of all LIS schools). Among 43 organizations and 118 courses, 69 syllabi of 23 LIS program (see Table 1) are publically available. For HCI topics, 970 records and 1400 items are extracted.

Table 1. List of CS and LIS programs for HCI syllabi of this study

CS programs	LIS programs
1. Worcester Polytechnic Institute	1. Wayne State University
2. Vanderbilt University	2. University of Pittsburgh
3. University of Wisconsin–Madison	3. University of Western Ontario
4. University of Stanford	4. University of Washington
5. University of Maryland, Baltimore County	5. University of Texas at Austin
6. University of Manitoba	6. University of Tennessee
7. University of Maine	7. University of Syracus
8. University of Iowa	8. University of Pittsburgh
9. University of Hawaii	9. University of North Texas
10. University of Florida	10. University of North Carolina, Chapel Hill
11. University of Cornell	11. University of Michigan
12. University of California, San Diego	12. University of Maryland
13. Tufts University	13. University of Illinois
14. The University of the West Indies	14. University of Hawaii
15. The University of Texas at El Paso	15. University of Alberta
16. The Pennsylvania State University	16. University of California at Berkeley
17. SUNY Buffalo	17. Rutgers, The State University of New Jersey
18. Nova Southeastern University	18. Queens College/CUNY
19. Northeastern University	19. Pratt Institute
20. North Carolina State University	20. North Carolina Central University
21. Mississippi State University	21. Long Island University
22. Loyola University	22. Indiana University
23. Georgia Institute of Technology	23. Drexel University
24. Dalhousie University	
25. Carnegie Mellon University	
26. Carleton University	
27. Arizona State University	
28. Stevens Institute of Technology	

3.2 Procedure

Step 1: *Topic extraction*. Focused on pure theories and terms mentioned in course schedule, coders extracted terms from the description of "course chapter" or "week chapter" in raw data separately, an initial consistency between two coders reached 82.5 %, 1927 terms in common among a total 2336 terms. After group discussion, 56 terms were deleted, remaining 2280 terms.

Step 2: *Development of an integrated HCI classification schema*. A classification schema was initially developed based on previous related work reviewed in Sect. 2 of this paper. Then all 2280 terms from Step 1 were coded by two coders. In order to keep our classification schema being exhaustive and inclusive for the sampled syllabi, domain (level 1) and category (level 2) codes were revised, merged, reorganized through iterative discussions and coding comparisons.

Table 2 showed our integrated HCI classification schema as a result of this iterative process. Inter-coder reliability as measured by Cohen Kappa was 0.96 for the domain coding, and 0.77 for the category coding.

Table 2. An integrated HCI classification schema

Domain	Category
Foundations/nature of HCI	General introduction
	Theoretic foundations/models
	Research methods/topics
Human aspects of HCI	Human characteristics
	User experience and behavior
	Group & communities
Computing aspects of HCI	Computer
	Web technology
	Ubiquitous and mobile computing
	Systems and application
	System & engineering skills & tools
Interaction of HCI	Interaction devices/technology
	Information interaction
	Designing interaction/interface
	Interactive behavior
Development process	Design process\approaches and methods
	System analysis & requirements
	Conception design
	Prototyping
	Programming and implementation
	Tutorial, demo & running
	Testing & evaluation
	Example systems and case studies
Application & context	Context analysis
	Collaborative & social computing
	Mixed, augmented and virtual reality
	Copyright and security
	Other application
Teaching issues	Lecture
	Capstone/project
	Team work
	Guest lecture
	Report
	Review
	Exam
	Presentation

4 Data Analyses

4.1 Descriptive Analysis of Teaching Topics Distribution

Level 1 - Domain Distribution in CS and LIS Schools. Choosing domain as topic descriptor, there is no difference between CS and LIS schools. The similarity is as big as 99.5 %, which is calculated by correlations of domain counts' distribution, and 98.5 % of domain frequency distribution. There is only a little difference in the domain of "Computing Factors of HCI", with the total frequency of 8 % in CS versus 4.6 % in LIS (See Fig. 1).

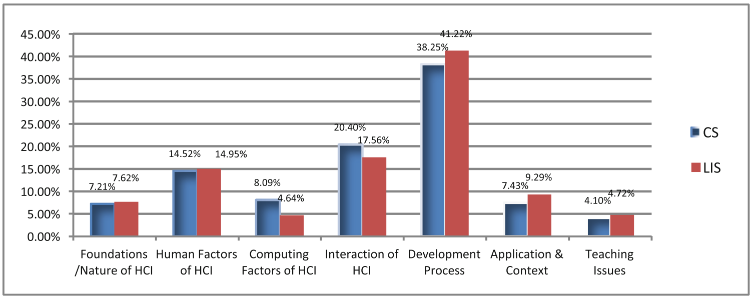

Fig. 1. Domain distribution in CS and LIS (Color figure online)

According to domain counts, the "core" of HCI teaching measured by the top 3 highest frequent domains are: "Development Process", "Interaction of HCI" and "Human Aspects of HCI".

Level 2 - Category Distribution in CS and LIS Schools. Choosing category as topic descriptor, there is still no significant difference between CS and LIS schools, concerning the similarity of 85.3 % calculated by the correlations of counts distribution (See Fig. 2).

Taking a TFIDF-like method, which created a characteristic index (CI) calculated by the count frequency in LIS group dividing the count frequency in CS group, we can find some particular topics in each group (CI > 2). In CS schools, their characteristic categories are: "Copyright and Security", "Example Systems and Case Studies", "Tutorial, Demo & Running", "Interaction Devices/Technology", "System & Engineering Skills & Tools" and "Computer". In LIS schools, characteristic categories are: "Information Interaction", "Context" and "User Experience and Behavior".

4.2 Social Networks Analysis of Course Co-occurrence Network

4.2.1 Construction of Co-occurrence Network

Teaching category co-occurrence relationship is defined as two categories which occurring in the same course. When constructing category co-occurrence relationship

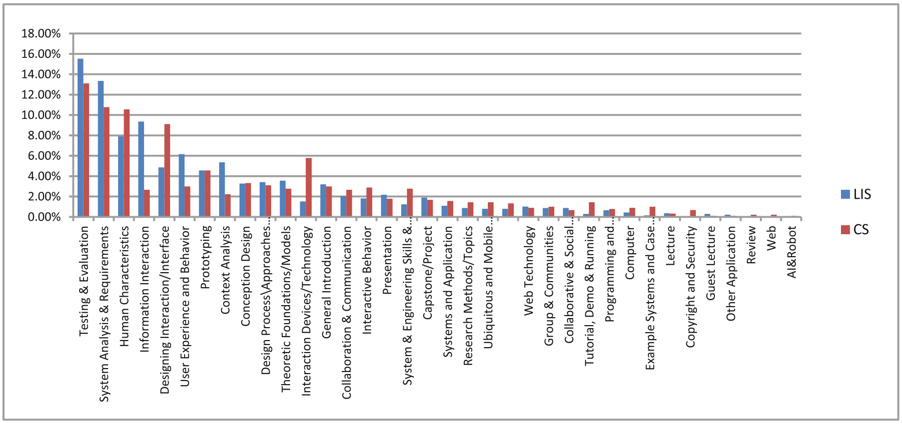

Fig. 2. Category distribution in CS and LIS (Color figure online)

in courses, 104 courses were listed with 2280 category items, and a 104 × 35 matrix was created (called 2-Mode network later), then transformed the matrix to a 35 × 35 category co-occurrence matrix (see Table 3).

Table 3. Category co-occurrence matrix in course chapter (partial)

	Capstone/project	Collaboration & communication	Collaborative & social computing	Computer	Conception design	Context	Copyright and security
Capstone/project	41	9	4	5	19	16	1
Collaboration & communication	9	53	11	7	9	18	3
Collaborative & social computing	4	11	18	1	4	9	1
Computer	5	7	1	14	7	6	1
Conception design	19	9	4	7	75	16	2
Context	16	18	9	6	16	94	4
Copyright and security	1	3	1	1	2	4	7

Centrality Analysis

The centrality of network indicates the “necessary” or popular topics in course design according to existing practices. Figure 3 shows the collapse of “core” in co-occurrence network: when frequency of co-occurrence increased from 20 to 40, the core clusters’ size decreased from 17 to 9 (when choose 50 as parameter, the number of points comes down to 3), thus these 9 points could be named as the “necessary” or basic teaching sets, which are: General Introduction, Human Characteristics, Design Process\Methods \Approaches, System Analysis & Requirements, Conception Design, Prototyping, Design Interaction\Interface, Testing & Evaluation, User Experience and Behavior.

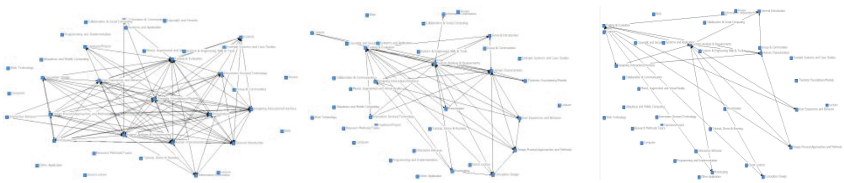

Fig. 3. Collapse of "core" in category co-occurrence network

4.2.2 Cluster Analysis

Transform the 2-Mode network into category-category relationship network, and using two-dimensional MDS analysis by dissimilarity. Figure 4 shows the categories' clusters map, categories co-occurred frequently would be placed near each other in the map. The clusters of teaching topics show that categories can be classified into four distinct fields: Information Aspects, Technical Aspects, Behavioral Aspects and System Design.

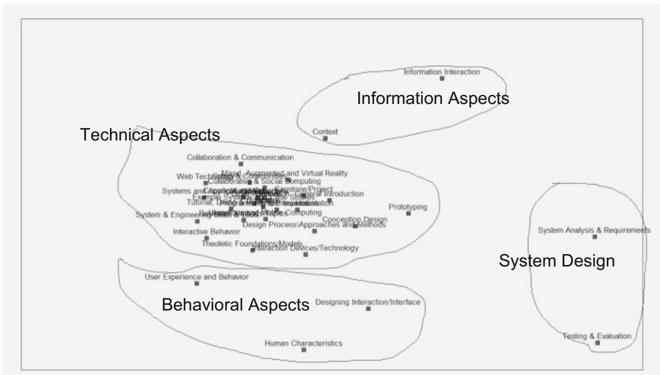

Fig. 4. Multidimensional scaling analysis of HCI categories by course title

4.2.3 Similarity Analysis

Besides that, these categories have weak relationship evaluated by the similarity of distribution among courses, and this relationship may indicate the style of teaching. Figure 5 shows the relationship of categories (similarity > 0.2), and 3 points formed the core "components", which are "Interaction Devices/Technology", "Designing Interaction/Interface" and "System Analysis & Requirements"(See Fig. 5). When choosing closeness as centrality judgment, "Interaction Devices/Technology", "System & Engineering Skills & Tools" and "Designing Interaction/Interface" are in the center.

The experimental result demonstrates that system design and technical analysis is the consensus of foundation in HCI teaching.

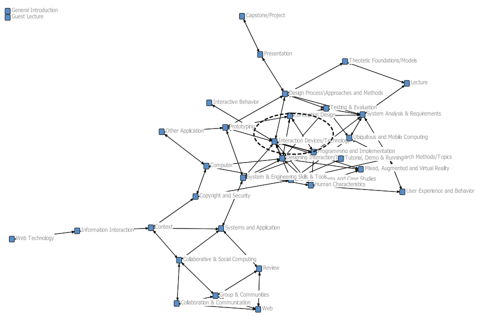

Fig. 5. Categories centrality in category co-occurrence network

4.3 Social Networks Analysis of University Co-occurrence Network

According to heterogeneous distribution of HCI courses in different institutes, we take university as container in the co-occurrence network construction. In this case, there would be less difference between the solo HCI course in a university and that one of a set of HCI courses. Taking similar method, a 51 × 35 2-Mode Network and topic cluster map (35 × 35) can be drawn through the data.

Centrality and Cluster Analysis
Taking the 2-Mode network as analysis object, 3 topics can be found in the center, which are "Testing & Evaluation", "Design Process" and "Human Characteristics" (See Fig. 6), being quite consistent with the conclusion from frequency statistics.

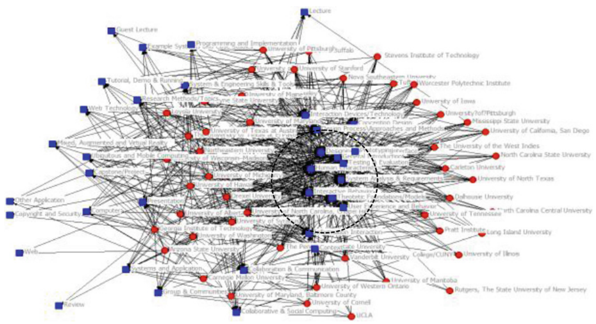

Fig. 6. Centered categories in university_Topic 2-mode network

Compared with Fig. 4, only 3 classes were extracted in the cluster map (See Fig. 7), which means information issues in HCI and behavioral aspects can be merged in university-category co-occurrence scale.

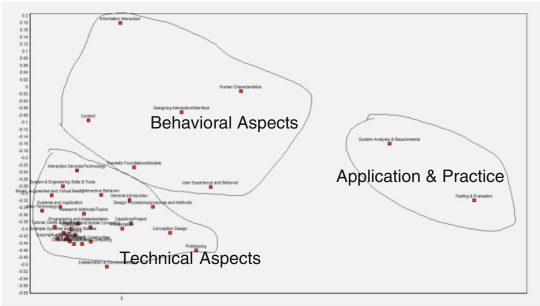

Fig. 7. Multidimensional scaling analysis of HCI categories by university

4.4 Teaching Styles in Category-University Network

Besides that, a university similarity matrix can also be deducted from the co-occurrence matrix. According to Fig. 8, universities can be divided into 3 groups: iSchools, Multidisciplinary Schools and Traditional CS/LIS Schools. Teaching topics in iSchools are quite dissimilar with others (The data of University of Washington is not complete, thus it located in Multidisciplinary Schools), covering behavioral, technical and information aspects of HCI topics. The multidisciplinary schools seem to cover two aspects in behavioral and technical area, and traditional LIS schools and CS schools may only emphasize one aspect. Surprisingly, the course structure between traditional LIS schools and CS schools reached a high consistency.

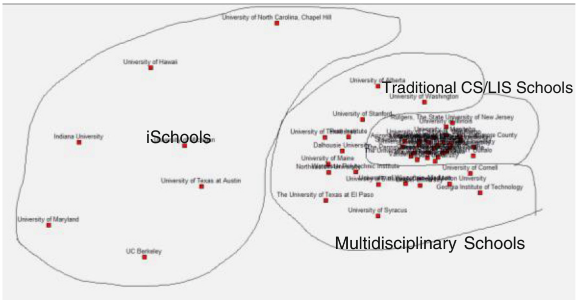

Fig. 8. Multidimensional scaling analysis of university similarity

5 Discussion and Conclusion

What is the core of HCI teaching? As mentioned above, the discussion of "core" in HCI education is argued for years (Gasen et al. 1994b, 1996b; Sears et al. 1997; Churchill et al. 2014), former researchers may "feel" or be aware of the "core" of HCI education, and create some framework or core components lists, while this study calculated and identified the "core" of HCI education in practice.

5.1 Knowledge Architecture in HCI

According to former researches, the landscape of HCI kept on changing and the curriculum of HCI and related courses had to be renewed every 5 or 10 years, but the architecture of this course remained stable.

In our research, no matter in CS schools or LIS schools, the whole construct of HCI contains three basic aspects: human and behavioral aspects, technical aspects, practice and design. First, behavioral or psychological research always put in the front of the syllabi to be the theoretic basis of the whole course. Second, "development process" or HCI thinking in system design is viewed as the most important contribution of this course, nearly 40 % concepts or teaching time are spent on this field. Third, HCI courses tend to be practice oriented, thus presentation and practice play an important role in the course teaching. Fourth, although computing and relative basic techniques tend to be important in semantic structure of HCI, these techniques are always pre-taught or occurred in other courses.

5.2 Core Components in HCI

In our study, the HCI courses do have a boundary-clear core. There seems to be some difference between CS and LIS schools, more behavioral contents ("Information Interaction" and "User Experience and Behavior") in LIS and more programming practice in CS, but data in Figs. 1 and 2 clearly indicate that design and "development process" of interactive system is the most popular topic in HCI teaching, especially user requirements analysis, prototype design and usability test. In Fig. 3, a structural core set of HCI education with 9-components is extracted, excluding "Information Interaction" which has high frequency in calculates. Despite "General Introduction" as teaching issues, the last 8 components represent the necessary or basic content in HCI teaching.

5.3 Differentiated Teaching in HCI

Although they get consensus on knowledge structure of HCI, the educators emphasize different areas according to their own disciplines. When calculating the similarity of topics distribution among universities, three clusters are extracted in Fig. 8, and named "iSchools", "Multidisciplinary Schools" and "Traditional CS/LIS Schools" approximately. The research demonstrates a serious phenomenon ignored before, that the coursed in traditional LIS schools have quite similar structure and contents with those in CS schools, which means the HCI education in traditional LIS schools did not adapt to its own context successfully. On contrary, iSchools tend to be quite dissimilar with others, carrying out differentiated teaching in HCI.

In summary, HCI educators in North America may get consensus on a 9-components core in HCI teaching, but different institutes do have differentiated teaching styles. The HCI educators should design syllabi or curricula according to own contexts, instead of "copy" or strictly based on one authoritative agenda.

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