

# Human-Computer Interaction (HCI)

## Preamble

Computational systems not only enable users to solve problems, but also foster social connectedness and support a broad variety of human endeavors. Thus, these systems should interact with their users and solve problems in ways that respect individual dignity, social justice, and human values and creativity. Human-computer interaction (HCI) addresses those issues from an interdisciplinary perspective that includes psychology, business strategy, and design principles.

Each user is different and, from the perspective of HCI, the design of every system that interacts with people should anticipate and respect that diversity. This includes not only accessibility, but also cultural and societal norms, neural diversity, modality, and the responses the system elicits in its users. An effective computational system should evoke trust while it treats its users fairly, respects their privacy, provides security, and abides by ethical principles.

These goals require design-centric engineering that begins with intention and with the understanding that design is an iterative process, one that requires repeated evaluation of its usability and its impact on its users. Moreover, technology evokes user responses, not only by its output, but also by the modalities with which it senses and communicates. This knowledge area heightens the awareness of these issues and should influence every computer scientist.

**Changes since CS 2013:** Driven by this broadened perspective, the HCI knowledge area has revised the CS 2013 document in several ways:

- Knowledge units have been renamed and reformulated to reflect current practice and to anticipate future technological development.
- There is increased emphasis on the nature of diversity and the centrality of design focused on the user.
- Modality (e.g., text, speech) is still emphasized given its key role throughout HCI, but with a reduced emphasis on particular modalities in favor of a more timely and empathetic approach.
- The curriculum reflects the importance of understanding and evaluating the impacts and implications of a computational system on its users, including issues in ethics, fairness, trust, and explainability.
- Given its extensive interconnections with other knowledge areas, we believe HCI is itself a cross-cutting knowledge area with connections to Artificial Intelligence; Society, Ethics and Professionalism, Software Development Fundamentals, Software Engineering.

## Core Hours

Knowledge Unit	CS Core	KA Core
Understanding the User	2	5
Accountability and Responsibility in Design	2	2
Accessibility and Inclusive Design	2	2
Evaluating the Design	1	2
System Design	1	5
<b>Total Hours</b>	<b>8</b>	<b>16</b>

## Knowledge Units

### Knowledge Unit 1: Understanding the User: Individual goals and interactions with others

- CS Core Topics
  - **User-centered design and evaluation methods:** “you are not the users”, user needs-finding, formative studies, interviews, surveys, usability tests
- KA Core Topics
  - **User-centered design methodology:** personas/persona spectrum; user stories/storytelling and techniques for gathering stories; empathy maps; needs assessment (techniques for uncovering needs and gathering requirements - e.g., interviews, surveys, ethnographic and contextual enquiry); journey maps. See also: Knowledge Unit on Evaluating the Design.
  - **Physical & cognitive characteristics of the user:** physical capabilities that inform interaction design (e.g., color perception, ergonomics); cognitive models that inform interaction design (e.g., attention, perception and recognition, movement, memory); topics in social/behavioral psychology (e.g., cognitive biases, change blindness).
  - **Designing for diverse user populations:** how differences (e.g., in race, ability, age, gender, culture, experience, and education) impact user experiences and needs; internationalization, designing for users from other cultures, and cross-cultural design; challenges to effective design evaluation (e.g., sampling, generalization; disability and disabled experiences); universal design. See also: Knowledge Unit on Accessibility and Inclusive Design.
  - **Collaboration and communication:** understanding the user in a multi-user context; synchronous group communication (e.g., chat rooms, conferencing,

online games); asynchronous group communication (e.g., email, forums, social networks); social media, social computing, and social network analysis; online collaboration, social coordination, and online communities; avatars, characters, and virtual worlds.

- Non-core Topics (including Emerging topics)

Illustrative Learning Outcomes

- CS Core
  - Conduct a user-centered design process that is integrated into a project.
- KA Core
  - Compare and contrast the needs of users with those of designers.
  - Identify the representative users of a design and discuss who else could be impacted by it.
  - Describe empathy and evaluation as elements of the design process.
  - Carry out and document an analysis of users and their needs.
  - Construct a user story from a needs assessment.
  - Redesign an existing solution to a population whose needs differ from those of the initial target population.
  - Contrast the different needs-finding methods for a given design problem.
  - Reflect on whether your design would benefit from low-tech or no-tech components.
- Non-core
  - Recognize the implications of designing for a multi-user system/context.

## **Knowledge Unit 2: Accountability and Responsibility in Design: Sustainability, security, privacy, trust, and ethics**

- CS Core Topics
  - **Design impact:** sustainability, inclusivity, safety, security, privacy, harm, and disparate impact.
  - **Ethics:** in design methods and solutions; the role of artificial intelligence; responsibilities for considering stakeholder impact and human factors, role of design to meet user needs.
  - **Requirements in design:** ownership responsibility, legal frameworks, compliance requirements, consideration beyond immediate user needs, including via iterative reconstruction of problem analysis..
- KA Core Topics
  - **Value-sensitive design:** identify direct and indirect stakeholders, determine and include diverse stakeholder values and value systems.
  - **Persuasion through design:** assessing the persuasive content of a design, persuasion as a design goal.
- Non-core Topics (including Emerging topics)

Illustrative Learning Outcomes

- CS Core

- Identify and critique the potential impacts of a design on society and relevant communities to address such concerns as sustainability, inclusivity, safety, security, privacy, harm, and disparate impact
- KA Core
  - Identify the potential human factor elements in a design.
  - Identify and understand direct and indirect stakeholders.
  - Develop scenarios that consider the entire lifespan of a design, beyond the immediately planned uses that anticipate direct and indirect stakeholders.
  - Identify and critique the potential factors in a design that impact direct and indirect stakeholders and broader society (e.g., transparency, sustainability of the system, trust, artificial intelligence).
  - Assess the persuasive content of a design and its intent relative to user interests.
  - Critique the outcomes of a design given its intent.
  - Understand the impact of design decisions
- Non-core

### Knowledge Unit 3: Accessibility and Inclusive Design

- CS Core Topics
  - **Background:** societal and legal support for and obligations to people with disabilities; accessible design benefits everyone.
  - **Techniques:** accessibility standards such as Web Content Accessibility Guidelines.
  - **Technologies:** features and products that enable accessibility and support inclusive development by designers and engineers
  - **Inclusive Design Frameworks:** recognizing differences; universal design
- KA Core Topics
  - **Background:** demographics and populations (permanent, temporary and situational disability); international perspectives on disability; attitudes towards people with disabilities
  - **Techniques:** UX (user experience) design and research; software engineering practices that enable inclusion and accessibility.
  - **Technologies:** examples of accessibility-enabling features, such as conformance to screen readers
  - **Inclusive Design Frameworks:** creating inclusive processes such as participatory design; designing for larger impact.
- Non-core Topics (including Emerging topics)
  - **Background:** unlearning and questioning; disability studies
  - **Technologies:** the Return on Investment of inclusion
  - **Inclusive Design Frameworks:** user-sensitive inclusive design
  - **Critical approaches to HCI:** critical race theory in HCI, feminist HCI, critical disability theory.

### Illustrative Learning Outcomes

- CS Core

- Identify accessibility challenges faced by people with different disabilities, and specify the associated accessible and assistive technologies that address them.
- Identify appropriate inclusive design approaches, such as universal design and ability-based design.
- Identify and demonstrate understanding of software accessibility guidelines.
- Demonstrate recognition of laws and regulations applicable to accessible design.
- KA Core
  - Apply inclusive frameworks to design, such as universal design and usability and ability-based design, and demonstrate accessible design of visual, voice-based, and touch-based UIs.
  - Demonstrate understanding of laws and regulations applicable to accessible design.
  - Demonstrate understanding of what is appropriate and inappropriate high level of skill during interaction with individuals from diverse populations.
  - Analyze web pages and mobile apps for current standards of accessibility.
- Non-core
  - Find examples of how biases towards disability, race, and gender have historically, either intentionally or unintentionally, informed technology design and consider how those experiences (learnings?) might inform design.
  - Conceptualize user experience research to identify user needs and generate design insights.

#### Knowledge Unit 4: Evaluating the Design

- CS Core Topics
  - **Methods for evaluation with users:** formative (e.g. needs-finding and exploratory analysis) and summative assessment (e.g. functionality and usability testing); elements to evaluate (e.g., utility, efficiency, learnability, user satisfaction); understanding ethical approval requirements before engaging in user research.
- KA Core Topics
  - **Methods for evaluation with users:** qualitative (qualitative coding and thematic analysis), quantitative (statistical tests), and mixed methods (e.g., observation, think-aloud, interview, survey, experiment); presentation requirements (e.g., reports, personas); user-centered testing; heuristic evaluation; challenges and shortcomings to effective evaluation (e.g., sampling, generalization).
  - **Study planning:** how to set study goals, hypothesis design; approvals from Institutional Research Boards and ethics committees; how to pre-register a study; within-subjects vs. between-subjects design.
  - **Implications and impacts of design:** with respect to the environment, material, society, security, privacy, ethics, and broader impacts.
- Non-core Topics (including Emerging topics)
  - **Techniques and tools for quantitative analysis:** statistical packages; visualization tools; statistical tests (e.g., ANOVA, t-tests, post-hoc analysis,

parametric vs non-parametric tests); data exploration and visual analytics; how to calculate effect size.

- **Data management:** Data storage and data sharing (open science); sensitivity and identifiability.

#### Illustrative Learning Outcomes

- CS Core
  - Discuss the differences between formative and summative assessment and their role in evaluating design.
- KA Core
  - Select appropriate formative or summative evaluation methods at different points throughout the development of a design.
  - Discuss the benefits of using both qualitative and quantitative methods for evaluation.
  - Evaluate the implications and broader impacts of a given design.
  - Plan a usability evaluation for a given user interface, and justify its study goals, hypothesis design, and study design.
  - Conduct a usability evaluation of a given user interface and draw defensible conclusions given the study design.
- Non-core
  - Select and run appropriate statistical tests on provided study data to test for significance in the results.
  - Pre-register a study design, with planned statistical tests.

### Knowledge Unit 5: System Design

- CS Core Topics
  - **Prototyping techniques and tools:** e.g., low-fidelity prototyping, rapid prototyping, throw-away prototyping, granularity of prototyping
  - **Design patterns:** iterative design, universal design, interaction design (e.g., data-driven design, event-driven design)
  - **Design constraints:** platforms, devices, resources
- KA Core Topics
  - **Design patterns and guidelines:** software architecture patterns, cross-platform design, synchronization considerations
  - **Design processes:** participatory design, co-design, double-diamond, convergence and divergence
  - **Interaction techniques:** input and output vectors (e.g., gesture, pose, touch, voice, force), graphical user interfaces, controllers, haptics, hardware design, error handling
  - **Visual UI design:** color, layout, Gestalt principles
- Non-core Topics (including Emerging topics)
  - **Immersive environments:** virtual reality, augmented reality, mixed reality, XR (which encompasses them), spatial audio.
  - **3D printing and fabrication**

- **Asynchronous interaction models**
- **Creativity support tools**
- **Voice UI designs**

#### Illustrative Learning Outcomes

- **CS Core**
  - Propose system designs tailored to a specified appropriate mode of interaction.
  - Follow an iterative design and development process that incorporates understanding the user, developing an increment, evaluating the increment, and feeding those results into a subsequent iteration.
  - Explain the impact of changing constraints and design trade offs (e.g., hardware, user, security, etc.) on system design
- **KA Core**
  - Evaluate architectural design approaches in the context of project goals.
  - Identify synchronization challenges as part of the user experience in distributed environments.
  - Evaluate and compare the privacy implications behind different input techniques for a given scenario
  - Explain the rationale behind a UI design based on visual design principles
- **Non-core**
  - Evaluate the privacy implications within a VR/AR/MR scenario

#### **Knowledge Unit 6: HCI and SEP**

- **CS Core Topics**
  - Universal & User-Centered Design
- **KA Core Topics**
  - Participatory & Inclusive Design Processes
  - Evaluating the Design: Implications and impacts of design: with respect to the environment, material, society, security, privacy, ethics, and broader impacts

#### Illustrative Learning Outcomes

- **CS Core**
  - Learning Outcome 1
  - Learning Outcome 2
- **KA Core**
  - Critique a recent example of a non-inclusive design choice, its societal implications, and propose potential design improvements
  - Evaluating the Design: Identify the implications and broader impacts of a given design.
- **Non-core**
  - Evaluate the privacy implications within a VR/AR/MR scenario

#### **Professional Dispositions**

- Adaptable
- Meticulous
- Empathetic:
- Team-oriented The successful HCI practitioner should focus on the success of the team.
- Creative: An HCI practitioner should design solutions that are informed by past practice, the needs of the audience, and HCI fundamentals. Creativity is required to blend these into something that solves the problem appropriately and elegantly.

## Math Requirements

### Required:

- Basic statistics to support the evaluation and interpretation of results, including central tendency, variability, frequency distribution

## Shared Concepts and Crosscutting Themes

### Shared Concepts:

- Personal assistants (AI)
- Robotics (AI)
- Augmented intelligence (AI)
- Override in autonomous systems (AI)
- Data privacy (SEP)
- Inclusivity (SEP)
- Product Requirements (SE)
- Software Verification and Validation (SE)
- Interfacing with stakeholders (SE)
- Testing, design and communication tools (SE)

## Competency Specifications

- **Task 1:** Compare and contrast different user-interface frameworks
- **Competency Statement:** Describe the strengths and weaknesses of particular frameworks for particular software design and development problems. This should demonstrate knowledge that design is goal-directed and involves tradeoffs in addition to knowledge of particular frameworks.
- **Competency area** Software
- **Competency unit** Requirements, Design, Documentation, Evaluation, Management
- **Required knowledge areas and knowledge units:** HCI / KU 1,4,5
  - HCI / KU 1,4,5
- **Required skill level:** Evaluate
- **Core level:**



- **Task 2:** Plan, document, and execute a usability study
- **Competency Statement:** Demonstrates knowledge of how feedback loops are used in a holistic design process and the ability to design a study that is appropriate to the system being studied, phase of the development process, and particular stakeholders under consideration.
- **Competency area** Application
- **Competency unit** Design, Documentation, Evaluation, Management, Consumer Acceptance, Adaptation to social issues, Improvement
- **Required knowledge areas and knowledge units:**
  - HCI / KU1,4
- **Required skill level:** Apply, Evaluate
- **Core level:**

- **Task 3:** Evaluate and provide recommendations to improve a user-facing system's usability, accessibility, and inclusivity
- **Competency Statement:** Demonstrate knowledge of various lenses for evaluating user-facing systems.
- **Competency area** Application
- **Competency unit** Evaluation, Documentation, Adaptation to social issues, Improvement
- **Required knowledge areas and knowledge units:**
  - HCI / KU1,3,4,5,6
- **Required skill level:** Evaluate
- **Core level:**

- **Task 4:** Collaborate on a cross-disciplinary team to support the design, evaluation and iteration of a user-facing system
- **Competency Statement:** Integrates the HCI knowledge units toward the goal of using software to solve real-world problems
- **Competency area** Software, Application
- **Competency unit** Requirements, Design, Development, Documentation, Evaluation, Management, Consumer Acceptance, Improvement
- **Required knowledge areas and knowledge units:**
  - HCI / KU1-6
- **Required skill level:** Develop
- **Core level:**

- **Task 5:** Given design requirements, prepare engineering specifications for a user interface

- **Competency Statement:** Develops software requirements specifications for user-facing interfaces in keeping with standards for usability, user needs, and user experience in accordance with a provided design.
- **Competency area:** Software, Application
- **Competency unit:** Requirements, Documentation
- **Required knowledge areas and knowledge units:**
  - HCI / K1,2,3
- **Required skill level:** Develop
- **Core level:**

- **Task 6:** Determine what aspects of an implementation require revision to support internationalization
- **Competency Statement:** Evaluates a system to identify culturally-relevant or language-relevant text, symbols, and patterns that may vary by locale.
- **Competency area:** Software / Systems / Application
- **Competency unit:** Design, Evaluation, Adaptation to social issues, Improvement
- **Required knowledge areas and knowledge units:**
  - HCI / K1,2,3,4
- **Required skill level:** Evaluate
- **Core level:**

- **Task 7:** Conduct a formative study to offer design strategy recommendations for a user-facing system
- **Competency Statement:** Designs, develops, and implements usability and user experience testing sessions to identify strengths, weaknesses, and opportunities for improvement within a user-facing system.
- **Competency area:** Application, Theory
- **Competency unit:** Design, Testing, Consumer Acceptance, Improvement
- **Required knowledge areas and knowledge units:**
  - HCI / K1,3,4
- **Required skill level:** Evaluate
- **Core level:**

- **Task 8:** Interpret and communicate feedback to support the iteration of a user-facing system under development
- **Competency Statement:** Demonstrate the ability to plan for collecting feedback, interpreting the feedback through an understanding of the language and priorities of the evaluator, and provide appropriate summaries and proposals for iterative development.
- **Competency area:** Software

- **Competency unit:** Requirements/Testing/Documentation/ Customer Acceptance/Adaptation to Social Issues/Improvement
- **Required knowledge areas and knowledge units:**
  - HCI /KU1-4
- **Required skill level:** Evaluate
- **Core level:**

- **Task 9:** Assess the ethical implications of deploying a user-facing system in a particular population
- **Competency Statement:** Demonstrate the ability to research a population and consider a proposed system's impact along multiple dimensions.
- **Competency area:** Application?
- **Competency unit** Requirements/Evaluation/Consumer Acceptance/Adaptation to social issues/Improvement
- **Required knowledge areas and knowledge units:**
  - HCI / KU1-4
- **Required skill level:** Evaluate
- **Core level:**

- **Task 10:** Prototype a user-interface based on a design specification and industry-standard guidelines
- **Competency Statement:** Develops a prototype for a user-facing interface of a software system according to a provided software design specification and in line with professional standards and expectations.
- **Competency area:** Software, Application, Theory?
- **Competency unit:** Requirements, / Design, Development
- **Required knowledge areas and knowledge units:**
  - HCI / K1,2,5
- **Required skill level:** Develop
- **Core level:**

## Course Packaging Suggestions

**Introduction to HCI** for CS majors and minors, to include the following:

- HCI KU Understanding the User: 7 hours
- HCI KU Accountability and Responsibility in Design: 2 hours
- HCI KU Accessibility and Inclusive Design: 4 hours
- HCI KU Evaluating the Design: 3 hours
- HCI KU System Design: 10 hours
- HCI KU HCI and SEP: 2 hours

Pre-requisites:

- Agile software development

Skill statement: A student who completes this course should be able to describe user-centered design principles and apply them in the context of a small project.

Description: This sample course takes an integrative, project-oriented approach. The students learn HCI principles and apply them in a short, instructor-provided project in weeks 5-6. This motivates students to continue learning new concepts before embarking on a community-engaged final project in which they have to do the requirements analysis, design, implementation, and evaluation using rapid, iterative prototyping.

Weekly Topics:

1. Introduction to design (KU1,5)
2. Thinking, Acting, and Evaluating (KU1,4,5)
3. Memory and Mistakes (KU1,3,4)
4. Principles and Processes (KU5)
- 5-6. Integrating Design Processes and Software Development (KU5)
7. Design Thinking and Heuristic Evaluation (KU1,4)
8. Accessibility (KU2,3,6)9. Visual Design and Personas (KU1,3,4,5)
10. Final Project: Empathy and Identification (KU1-6)
11. Final Project: Ideation and Low-Fidelity Prototyping (KU1,4,5)
- 12-13: Final Project Implementation (KU5)
- 14: Final Project: Testing (KU4)
- 15: Final Project: Reporting (KU1-6)

**Introduction to Data Visualization** to include the following:

- GIT KU Visualization: 30 hours
- GIT KU Basic Rendering: 10 hours
- HCI, KU Understanding the User: 3 hours
- KUs DEI, Privacy, Ethics from SEP Knowledge Area: 4 hours

Pre-requisites:

- CS2
- Linear Algebra

Skill statement: A student who completes this course should understand how to select a dataset; ensure the data are accurate and appropriate; design, develop and test a visualization program that depicts the data and is usable.

### **Advanced Course: Usability Testing**

- HCI KU 1 Understanding the User - hours
- HCI KU 2 Accountability and Responsibility in Design - hours
- HCI KU 3 Accessibility and Inclusive Design - hours
- HCI KU 4 Evaluating the Design - hours
- HCI KU 5 System Design - hours
- HCI KU 6 HCI and SEP – hours

#### **Pre-requisites:**

- Introductory/Foundation courses in HCI
- Research methods, statistics

Description: This project-based course focuses on the formal evaluation of products. Topics include: usability test goal setting, recruitment of appropriate users, design of test tasks, design of the test environment, test plan development and implementation, analysis and interpretation of the results, and documentation and presentation of results and recommendations. Students will understand the techniques, procedures and protocols to apply in various situations for usability testing with users. Students will be able to design an appropriate evaluation plan, effectively conduct the usability test, collect data, and analyze results so that they can suggest improvements.

#### **Suggested topics:**

1. Planning the usability study
  2. Defining goals
  3. Study participants
  4. Selecting tasks and creating scenarios
  5. Deciding how to measure usability
  6. Preparing test materials
  7. Preparing the test environment
  8. Conducting the pilot test
  9. Conducting the test
10. Tabulating and analyzing data
11. Recommending changes
12. Communicating the results
13. Preparing the highlight tape
14. Changing the product and the process

#### **Learning outcomes:**

- Design an appropriate test plan
- Recruit appropriate participants
- Conduct a usability test
- Analyze results and recommend changes
- Present results
- Write a report documenting the recommended improvements

## Committee

**Chair:** Susan L. Epstein, Hunter College and The Graduate Center of The City University of New York, USA

### Members:

- Sherif Aly, The American University of Cairo, Egypt
- Jeremiah Blanchard, University of Florida, USA
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- Ajit Narayanan, Google, USA
- Nathalie Riche, Microsoft, USA
- Kristen Shinohara, Rochester Institute of Technology, USA
- Olivier St-Cyr, University of Toronto, Canada

## Appendix: Core Topics and Skill Levels

