Human Computer Interaction (HCI)

**Preamble**
Computational systems are intended to solve problems with and for their human users but, to be effective, the people who build them must make certain that these systems solve the right problem in the right way. 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.

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 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.

### Allocation of Core Hours

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**Description of Knowledge Units**

Understanding the User: Individual goals and interactions with others

- **Topics**
  - **User-centered design and evaluation:** personas/persona spectrum; user stories/storytelling and techniques for gathering stories; empathy maps; needs-finding/NEEDS assessment (techniques for uncovering needs and gathering requirements e.g., interviews, surveys, ethnographic and contextual enquiry); journey maps; evaluation methods (e.g., observation, think-aloud, interviews, surveys, usability tests). 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.
  - **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.

- **Illustrative Learning Outcomes**
  - Compare and contrast the needs of users with those of designers.
  - Identify the representative users of a design and discuss who else could benefit from it.
  - Describe empathy and evaluation as essential parts of design.
  - Carry out and document an analysis of users and their needs.
  - Construct a user story from a NEEDS assessment.
  - Adapt an existing design to a population whose needs differ from those of the initial target population.
  - Contrast the different needs-finding methods for a given design problem.
  - Conduct a user-centered design process that is integrated into a project.
  - Recognize the implications of designing for a multi-user system/context.

Accountability and Responsibility in Design: Sustainability, security, privacy, trust, and ethics

- **Topics**
  - **Value sensitive design:** identify direct and indirect stakeholders, determine stakeholder values and value systems.
  - **Design impact:** sustainability, inclusivity, safety, security, privacy, harm, and disparate impact.
  - **Persuasion through design:** assessing the persuasive content of a design, persuasion as a design goal.
  - **Ethics:** in design methods and solutions; the role of artificial intelligence; responsibilities for considering stakeholder impact and human factors.
  - **Requirements in design:** ownership responsibility, legal frameworks, compliance requirements.
Illustrative Learning Outcomes

- Identify and understand direct and indirect stakeholders.
- Identify the potential human factor elements in a design.
- 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 impacts of a design on society and relevant communities to address such concerns as sustainability, inclusivity, safety, security, privacy, harm, and disparate impact.
- 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.

Recommended reference: Understanding the impact of design decisions (SLO) - connects to intention behind design

Accessibility and Inclusive Design

- **Topics**
  - **Background**: unlearning and questioning; disability studies; demographics and populations (permanent, temporary and situational disability); international perspectives on disability; attitudes towards people with disabilities; societal and legal supports for and obligations to people with disabilities.
  - **Techniques**: UX (user experience) design and research; software engineering practices that enable inclusion and accessibility. See also Web Content Accessibility Guidelines.
  - **Technologies**: features and products that enable accessibility and support development by designers and engineers (e.g., conformance to screen readers), the Return on Investment of inclusion
  - **Inclusive Design Frameworks**: recognizing differences; creating inclusive processes; designing for larger impact; universal design; user-sensitive inclusive design.
  - **Critical approaches to HCI**: critical race theory in HCI, feminist HCI, critical disability theory.

Illustrative Learning Outcomes

- 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 understanding of laws and regulations applicable to accessible design.
- Demonstrate a high level of skill during interaction with individuals from diverse populations.
- Apply inclusive frameworks to design, such as universal design and usability and ability-based design.
- Conceptualize user experience research to identify user needs and generate design insights.
- Analyze web pages and mobile apps for current standards of accessibility.
Evaluating the Design

- **Topics**

  **Methods for evaluation with users**: qualitative, quantitative, and mixed methods (e.g., observation, think-aloud, interview, survey, experiment); elements to evaluate (e.g., utility, efficiency, learnability, user satisfaction); presentation requirements (e.g., reports, personas); user-centered testing; functionality and usability testing; needs-finding and exploratory analysis.

  **Study planning**: how to set study goals, hypothesis design; approvals from Institutional Research Boards and ethics committees; how to pre-register a study; how to calculate effect size; within-subjects vs. between-subjects design.

  **Implications and impacts of design**: with respect to the environment, material, society, security, privacy, ethics, and broader impacts.

  **Techniques and tools for analysis**: statistical packages; visualization tools; statistical tests (e.g., ANOVA, t-tests, post-hoc analysis, parametric vs non-parametric tests); qualitative evaluation (e.g., qualitative coding, inter-rater reliability, thematic analysis); data exploration and visual analytics; challenges to effective evaluation (e.g., sampling, generalization); data management and handling, including storage, data sharing (open science); sensitivity and identifiability.

- **Learning Outcomes**

  Compare the constraints and benefits of different evaluative methods.

  Discuss the benefits of using both qualitative and quantitative methods for evaluation.

  Identify 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.

  Use a variety of techniques to evaluate a given user interface.

  Pre-register a study design, with effect size calculations and planned statistical tests.

  Select and run appropriate statistical tests on provided study data to test for significance in the results.

System Design

- **Topics**

  **Design patterns and guidelines**: universal designs, designs under constraints (e.g., platforms, devices, resources), software architecture patterns, cross-platform design, synchronization considerations.

  **Design processes**: prototyping techniques (e.g., low-fidelity prototyping, rapid prototyping, throw-away prototyping), prototyping tools, iterative design, participatory design, co-design, double-diamond, interaction design (e.g., data-driven design, event-driven design), 3D printing and fabrication.

  **Interaction techniques**: input and output vectors (e.g., gesture, pose, touch, voice, force), graphical user interfaces, controllers, haptics, hardware design, error handling

  **Immersive environments**: virtual reality, augmented reality, mixed reality, XR (which encompasses them), spatial audio.

- **Illustrative Learning Outcomes**

  Propose system designs tailored to a specified appropriate mode of interaction.

  Evaluate architectural design approaches in the context of project goals.

  Identify synchronization challenges as part of the user experience in distributed environments.
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.

**List of Professional Dispositions Appropriate for this KA**
- Adaptability
- Meticulousness
- Empathy

**Math needed and wanted**
- Basic statistics to support the evaluation and interpretation of results

**Crosscutting and Overlapping topics**
- Artificial Intelligence: personal assistants, robotics, augmented intelligence, override in autonomous systems
- Society, Ethics and Professionalism: data privacy, inclusivity
- Software Engineering: Product Requirements (all areas); Software Verification and Validation; Interfacing with stakeholders; Testing, design and communication tools

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