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# Paradigms of Interaction

### Interaction Paradigms

Successful approaches to interactive systems that have helped make it easier to use technology.

### Batch Session

Individual programmers submitted jobs on punched cards or paper tape to an operator who then ran the individual jobs on a computer.

### Time sharing

single computer could support multiple users at once and programming became an interactive activity. Time sharing shifted programming as a preplanned set of instructions for a computer to an exchange between programmer and computer.

## page24image46676864Video display units (1950s)

### Sketchpad

allowed data to be represented visually, abstracted, manipulated and changed. It adapted the computer to the human’s way of thinking.

### Bootstrapping

Small programming components can be combined to create larger ones.

## Personal Computing (1970s-1980s)

### LOGO

programming language for children which demonstrated that powerful tools for hackers could be used by novices. It made use of a graphical “turtle” that could be commanded to draw shapes through simple English-based phrases (e.g. “turn left”).

### Smalltalk

simple, but powerful, visually based programming environment especially for personal computing.

### Windows and WIMP

Previous interfaces were command-line based. There was increased support for engaging in multiple tasks at once, with humans in control. Supporting multiple threads of interaction in conventional command line interfaces became complicated and difficult to manage. **Window-based** systems supported physical and logical separations of tasks.

### Xerox Star

introduced the first commercial WIMP interface.

### WIMP

Interface based on Windows, Icons, Menus and Pointers.

### page12image34073648Direct manipulation

creates the illusion of operating directly on data and objects, rather than giving commands to a computer. The first commercial success of a direct manipulation interface was the Apple Macintosh computer (1984).

## Hypertext (1940s-1960s)

Vannevar Bush proposed a “memex” apparatus, a desk with the ability to produce and store massive amounts of photographic copies of documents.

## World Wide Web (1990s)

The **WWW** was a revolutionary paradigm which lowered the barrier for access to the internet, lowered the barriers to creating and publishing information and increased the purchases of computers and their use. It led to the rapid growth and increased value of internet content including leisure and commerce.

The beginning of computer networks can be traced back to the 1960s where computers started to communicate with each other. This enabled **CSCW** (Computer-Supported Cooperative Work).

### Agend based interfaces

Agent-Based Interfaces started a departure from direct manipulation. It created the illusion of someone working on your behalf to perform the tasks.

### Multi-Modality

Multimodality allows people to engage in multiple tasks at once and to give input in different ways.

### Ubiquitous Computing

Researchers at Xerox PARC (1980s) attempted to move computing “off the desktop” and into everyday life, making computing seamless with everyday activities. Ubiquitous Computing also refers to a shift in computer to human ratios.

### Sensor-based and Context-aware Interaction

Context-aware computing extends the notion of ubiquitous computing. More invisibility and seamlessness of computing with everyday life.

### Augmented Reality

Combines physical world and digital content, Requires knowledge of environment. QR codes, IR sensors

### Virtual Reality

Replaces physical world with digital world, Gesture recognition, eye gaze, full body sensing

# Humans and interactive Systems

## Interactive system

The purpose of an interactive system is traditionally to aid a user in accomplishing a goal within an application domain.

### Domain

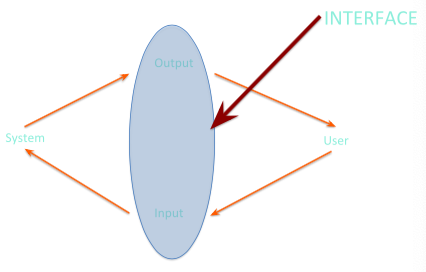
area of expertise and knowledge in a real world activity, consists of concepts

## Interaction Framework

An interaction Framework has four major components:

* The systems
* The user
* The input
* The output

One of the main issues in the interaction framework is that the system and the user have different languages.



### Interface

An interface has the following requirements:

* The user needs to be able to articulate their goals and tasks in the input language specified by the interface
* The input needs to be translated into stimuli for the systems upon which the system can perform
* The new state of the system must be presented as output as specified by the interface
* The output must be observed and interpreted by the user

## Input-Output-channels

### Human Memory Information types

Factual, procedural & experiential knowledge

### Human Memory types of memory

Sensory, short-term/working & long-term memory

### Sensory Memory

Serves as buffer for incoming sensory input

* Iconic memory – for visual stimuli
* Echoic memory – for aural stimuli
* Haptic memory – for touch stimuli

Most information is filtered out and lost. Rest gets transferred to short-term memory

### Short-term memory

Working memory is a temporary storage for information that is currently being used. Can be accessed rapidly but also decays rapidly. Has limited capacity (7 ± 2 units).

Information can be “chunked” – combined into larger units, thus increasing short-term memory capacity. Is subject to recency effects, may have different channels for different types of information.

Information is transferred to long-term memory through repetition or rehearsal.

### Long-term memory

Main repository for memory; stores factual, experiential, and procedural knowledge; has potentially unlimited capacity, but slow access time. Meaningful information can be learned more easily

Two types of long-term memory:

* Episodic – memory of events and experiences in a serial form
* Semantic – structured record of facts, concepts, and skills, structured as a network

#### Total time hypothesis

the more time spent learning, the more will be learned. Distribution of practice effect – learning is more effective if it is distributed over time

# Information Visualization Basics

## How much Information?

40 zettabytes=10^21 bytes

### Information Visualization

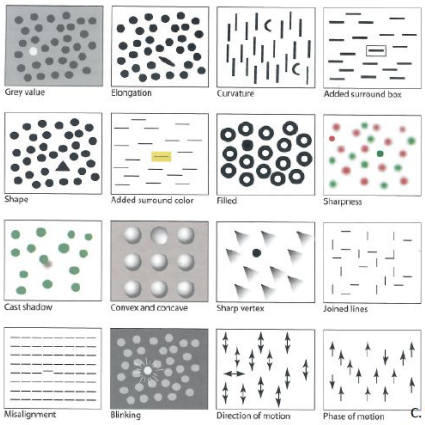
The use of computer-supported, interactive visual representations of abstract data to amplify cognition

Abstract data with no physical correspondence, Free mapping of data to 2D or 3D space

### Scientific Visualization

Scientific data corresponding to physical phenomena, Fixed positions in space for visualizations

## Visual thinking and Perception



### Gestalt Laws

* Proximity (distance)
* Similarity
* Connectedness
* Continuity
* Symmetry
* Closure

### Elementary Graphical Perception

* Density
* Area
* Length

## Guidelines for Visualization

### Tufte’s Principles of Graphical Excellence

* The well-designed presentation of interesting data – a matter of substance, statistics, and design
* Consists of complex ideas communicated with clarity, precision, and efficiency
* Gives the viewer the greatest number of ideas in the shortest time with the least ink in the smallest space
* Tells the truth about the data

### Tufte’s Principles of Graphical Integrity

* The representation of numbers, as physically measured on the surface of the graphic itself, should be directly proportional to the numerical quantities represented
* Clear, detailed, and thorough labeling should be used to prevent distortion and ambiguity
* Show data variation, not design variation
* Graphics should not quote data out of context

### Tufte’s Principles of Data Graphics

* Above all else show the data
* Maximize the data-ink ratio
* Erase redundant data-ink
* Revise and edit

# Principles for design

## Design in Interaction

### Usability versus usefulness

* **Usability** – Is a system or object easy to use
* **Usefulness** – Does a system or object serve a function that is valuable to me?

### Three Fields of Design

* **Industrial design**: Focuses on function and appearance of products and systems, often physical
* **Interaction design**: Focuses on how people interact with technology, in particularly understanding how to use it
* **Experience design**: Focuses on quality and enjoyment of experience, particularly of services, environments, and events

### Human-centered design

Makes human capabilities and behavior central, and designs to accommodate. Focuses on communication between the person and the system.

## Design principles and concepts

### Conceptual Model

usually simplified explanation of how something works. It’s not necessarily an accurate reflection of the actual workings of the system. It’s not necessarily complete and varies from person to person.

### Mental Model

Conceptual models are the conceptual models of a system that people have in their minds. Mental models are often developed from experience.

### User’s Conceptual Model

varies from person to person and in completeness and correctness. It’s based on experience and influenced by system image.

### System Image

The total information that is available to the user. This involves Appearance of the system, instructions, articles about products, … The system image can be incomplete or contradictory.

Good design facilitates communication of the designer’s conceptual model via the system image to the user and enables user to develop a good conceptual model.

### Fundamental Design principles

#### Affordances

The relationship between an object and a person (or other entity). It determines how the object could possibly be used and depends on both the properties of the object and the capabilities of the person. Affordances need to be perceivable to be effective

#### Signifiers

any perceivable indicator that communicates an appropriate behavior to a person. They don’t communicate everything that can be done, only what should be done. They’re important in design for fostering discoverability, but can be misleading, poor, or superfluous. Perceived affordances often serve as signifiers. Simple objects or systems should be self-explanatory.

#### Constraints

Clues that help you discover what to do by putting limits on the set of possible actions. Constraints especially useful for helping people determine proper course of action in new situations.

Constraints can be physical, cultural, semantic and/or logical.

##### Interlock

forces actions to take place in a particular sequence

##### Lock-ins

keep an operation active preventing it from being ended prematurely

##### Lock-out

prevents an unwanted event from occurring, or prevents someone from entering a space or state that is dangerous

##### Cultural constraints

* Cultures have embedded guidelines and cues for acceptable behavior
* Cultural constraints in design prevent incorrect action by relying on culturally understood cues and expectations
* Cultural constraints are not universally interpretable

##### Semantic constraints

Semantic constraints prevent incorrect actions by relying on the meaning of the situation (“Common sense” actions)

#### Mapping

Refers to the relationship between two sets of elements, frequently devices and their controls. Mappings that take advantage of spatial relationships are called “natural mappings”. Natural mappings are especially valuable for fostering discoverability and good conceptual models.

#### Feedback

The communication of the outcome of an action. Humans have numerous mechanisms for perceiving and receiving feedback, e.g. visual, auditory, and touch sensors

Must be immediate – long delays are disconcerting and may cause users to abandon system

# Modeling Interaction and Cognition

## Interaction Models

### Model Definition

A constructed representation intended to help understand and reason about the world, or some phenomenon in the world.

### Interaction Models

Tools for modeling and thinking about how humans interact with objects or systems. Different models enable different types of thought, tasks, explanations

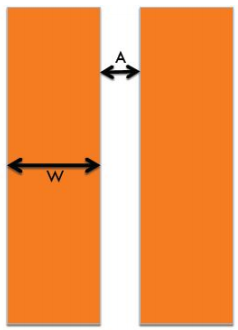
### Purpose of Interaction Models

* Predict human performance
* Understand the interactions and interaction cycles
* Explain physical and cognitive processes
* Examine individual parts of the interaction

## Fitts’s Law

Essentially a formulation of the idea that movement time is proportional to distance and target size

### Movement time

Movement Time (MT) is proportional to the Index of Difficulty (ID) of a selection task. Increases as the distance A to the target increases; and decreases as the size of the target W increases. Movement time is

Empirical measurement establishes constants *a* and *b*. *a* and *b* are different for different devices and different ways a device is used.

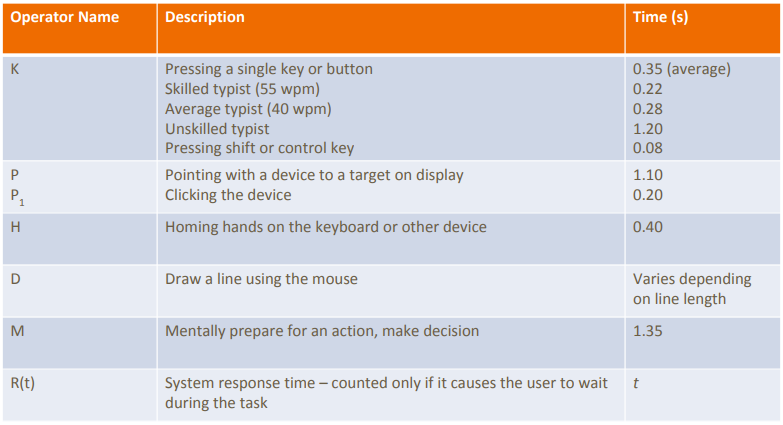
When 2-dimensional W is distance from target edge to centroid

### Index of Difficulty



## Keyboard-Level Model (KLM)

KLM adds cognition into models. Decomposes tasks into low-level elements with time values.



Can be used for comparing alternate ways of executing a task. Does not take time for cognition into account.

## GOMS Model

Stands for Goals, Operators, Methods, and Selection rules. Attempts to model the knowledge and cognitive processes involved when users interact with system\*

### Goal

a particular state the user wants to achieve

### Operators

the cognitive processes and physical actions that need to be performed in order to attain goals

### Methods

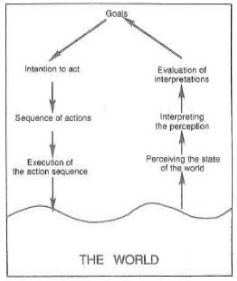
learned procedures for accomplishing goals. Consist of the exact sequence of steps required

### Selection rules

determine which method to select when there is more than one available for a given stage of a task.

## Seven-Stage Model of interaction

### 7 stages

1. **Forming the goal**: What does the person want to change
2. **Forming the Intention**: What does the person want to do in this step?
3. **Specifying an Action**: What are the exact steps the person decides to take to address the intention?
4. **Executing the Action**: Actually doing the steps that have been chosen, thus acting upon the world
5. **Perceiving the state of the world**: The person must physically perceive the current state of the world, whether changed or unchanged (i.e., see, hear, feel, etc.)
6. **Interpreting the state of the world**: The person must figure out what the perceived changes mean, i.e., what just happened?
7. **Evaluating the outcome**: The person must conclude about whether the original goal has been addressed

### Breakdowns

1. Breakdown in forming the intention
2. Breakdown in specifying the action
3. Breakdown in executing the action
4. Possible breakdown in the interpreting the perception
5. Breakdown in perceiving the state of the world

## Model Human Processor

Three systems: perceptual, cognitive, and motor. Each system has processor and memory. Each system has principles of operation.



### Perceptual system

Create internal representation of physical sensations. Stores temporary information buffers. Transfers information in buffers into working memory.

### Perceptual Processor

#### Cycle time

time between when stimulus is presented and when it is available in buffers. Multiple similar stimuli can combine during one cycle

### Cognitive System

Connects inputs from Perceptual System to outputs of Motor System. Handles learning, remembering, and problem solving. Includes working memory (WM) and long term memory (LTM)

### Cognitive Processor

Recognize-act cycle: contents of WM trigger actions in LTM which modify WM. Principle: CP cycle time is shorter when greater effort is induced by task or information. Cycle time diminishes with practice

### Motor system

Thought is translated into physical (muscular) actions. Motor system corrections require cycles of perceptual and cognitive systems.

# Computer-Supported Cooperative Work

## CSCW background and history

### Definition

A field of research concerned with understanding social interaction and technologies supporting social interaction in groups, organizations, and communities. CSCW examines the possibilities and effects of technological support for humans involved in collaborative group communication and work processes.

### Focus of CSCW

1. technology in software and hardware
2. group work and social phenomena

### Boundaries of Traditional CSCW

* <1k people
* Small groups/ organisations
* Work, Hobby
* <years

### Social Computing

* >10
* All sizes of groups
* Purpose: Hobby, Family, Entertainment
* Open-ended time-limit

### Groupware

Computer-based systems that support groups of people engaged in a common task (or goal) and that provide an interface to a shared environment.

## CSCW Technologies

### Classes of CSCW technologies

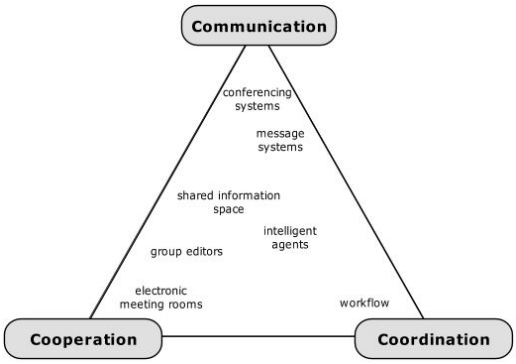
* **Computer-mediated communication** – systems that support the direct communication between participants (Skype, phone, instant messaging, …) Can be synchronous or asynchronous
* **Meeting and decision support systems** – systems that capture common understanding (Comments on documents, …)
* **Shared applications and artifacts** – systems that support participant interaction with shared work objects – the artifacts of work (shared documents, …)
* **Awareness applications** – systems that promote awareness of individual and group status (video walls, …)

## CSCW Frameworks and Conceptualizations

### CSCW Time/Space Matrix

|  |  |  |
| --- | --- | --- |
|  | Same Time (synchronous) | Different time (asynchronouse) |
| Same place (co-located) | Face-to-face interactions | Continuous task |
| Different place (remote) | Remote interactions | Communication + coordination |

### Groupware 3C Model

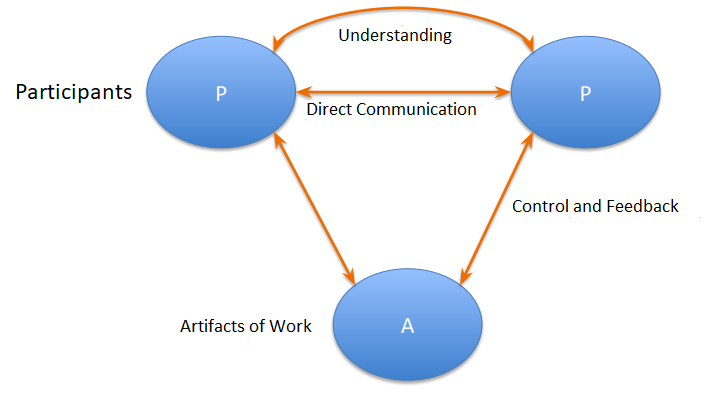


Considers three dimensions of support:

1. **Communication**: is the tool’s primary purpose to provide channels of communication among group members? (Skype)
2. **Cooperation**: is the tool’s primary purpose to support collaborative activities? (Google Docs)
3. **Coordination**: is the tool’s primary purpose to facilitate the organization of joint work activities? (Shared calendars)

### Cooperative Work Framework

Also known as “People-Artifact Framework”.



## Barriers to CSCW success

* Despite the ubiquity of CSCW tools in the workplace, many challenges still exist and a lot of potential is not yet fulfilled
* Groups and organizations are complex and dynamic
* When CSCW systems are introduced into an organization without a full understanding of how all people will be affected, problems can arise
* Groupware can lead to activity that violates social taboos, threatens existing political structures, or otherwise demotivates users crucial to its success

### Stakeholders

1. **Primary stakeholders**: end users of the system
2. **Secondary stakeholders**: people who do not directly use the system, but receive output from it or provide input to it
3. **Tertiary stakeholders**: not in the first two categories, but directly affected by success or failure, e.g., someone whose profits increase or decrease as a result of the system’s success
4. **Facilitating stakeholders**: people involved with the design, development, or maintenance of the system

# Ubiquitous Computing

## Methods for informing CSCW technologies

Despite the ubiquity of CSCW tools in the workplace, many challenges still exist and a lot of potential is not yet fulfilled

### Challenges for CSCW

* Difficult to model and analyze groups
* Difficult to predict effects on all parties
* Many groups of stakeholders affected
* Disparity between work and benefit
* Difficult to attain critical mass
* Effects on social processes and norms

### Contextual inquiry

Develops models to represent knowledge about the work environment

* **Task models**: specify required steps for work tasks
* **Physical model**: represents physical work environment and its impact on practice
* **Flow model**: shows lines of coordination and communication between people
* **Cultural model**: reflects influences of work culture and policy including official and unofficial codes of behavior and expectations
* **Artifact model**: describes structure and use of artifacts within work processes

## Ubiquitous Computing

“The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.”

### Off-the-desktop

a move away from interaction with a single workstation

## Directions for ubiquitous computing

### Defining the appropriate physical interaction experience

New approaches to input and output. Input technologies are becoming increasingly diverse, and along with it increasingly implicit

#### Multi-scale and Distributed Output

Ubiquitous computing requires novel output technologies and techniques. Output technology design needs to move beyond visual displays and consider form and aesthetic appeal

### Discovering general application features

How should the technology work? How does it function and what does it support?

#### Context-aware Computing

Using implicitly sensed context from physical and electronic environment to determine the correct behavior of a service. Intended to make interactions with services more seamless and less distracting from everyday activities

#### Automated Capture and Access

Focuses on preservation and recording of live experiences for review or access by user in the future as well as access interfaces

#### Continuous Interaction

Providing continuous interaction moves computing from localized tools to constant, ubiquitous presence

### Theories for designing and evaluating the human experience

As with CSCW, understanding ubicomp interaction is more complicated than understanding interactions between a single user and a single machine

#### Activity Theory

A descriptive theory that recognizes traditional concepts such as goals, actions, and operations. Treats goals and actions as fluid based on the changing state of the world rather than a priori plans

#### Situated Action

Theory that rejects the notion of pre-planned goals as the motivation for action. Emphasizes the improvisational nature of human behavior based on the changing world

#### Distributed Cognition

Another theory that de-emphasizes internal human cognition. Objects themselves act as triggers for action and reflect the state of the system.

#### Ethnography

Descriptive approach based in anthropology that focuses on observation of everyday practices. Recognizes that people’s conscious conceptions of what they do are incomplete and inaccurate.

# Ubiquitous Computing and Domestic Technologies

## Technologies and the Home

### Domestic Technologies

Originally conceived of as the application of technologies in the home (e.g., appliances or home automation) often with the intention to increase efficiency or reduce work.

In actuality the reduction of work is questionable because access to technologies has also changed expectations

Questions go beyond technology to sociology, culture, politics, and psychology

### The “Smart” Home

A term frequently used to refer to homes augmented with technology or a home of the future. Today’s modern homes are already filled with “smart” technologies

**Definition**: Domestic environments in which we are surrounded by interconnected technologies that are, more or less, responsive to our presence and actions.

## Early forays into smart home research

### Living Laboratories

Early smart homes were research laboratories designed in the form of living spaces. Infrastructure for smart homes was expensive and difficult to deploy in real homes; test systems instead built in laboratories.

## Challenges for the design of smart home technologies

### The “Accidentally” Smart Home

* Pervasive infrastructure for ubiquitous computing does not exist in most homes
* Houses require specific outfitting for ubicomp technologies
* Homes that are not intentionally built as smart homes must be upgraded to support new technologies creating problems of interoperability between systems

### Impromptu Interoperability

* The ability to interconnect between systems and devices with little or no advance planning will often be desirable
* It is not easy to predict what future services or devices will need to connect with each other
* If people cannot predict or know which services can interconnect, it will lead to frustration and poor interaction with the home

### No Systems Administrator

* Increasing complexity of computing technology in the home leads to need for increasing knowledge to administer and maintain
* Cannot expect that all homes will have a systems administration expert (just as homes usually do not have an electrical or plumbing expert)

### Designing for Domestic Use

* There is a lack of understanding of domestic environments to inform the design of smart home technology
* Real technology use can differ greatly from its intended use

### Social Implications of Aware Home Technologies

* Privacy is a key concern because many systems rely on collection of data and context
* Machines for automating work may change expectations and shift the burden of work without reducing work

### Reliability

* Reliability becomes increasingly challenging when systems are embedded in the home environment
* If systems are interconnected, designers also need to take care that a failure in one component does not bring down the rest of the systems

### Interference in the Presence of Ambiguity

* Systems that attempt to understand what the inhabitants are doing have long been a goal but have met with mixed success in reality
* How smart should a home be? How much inference is required for a smart home to be successful? How to fix incorrect interpretations?

## Addressing barriers to smart home success

Found that most technologies pertained to lighting, security, media, or environment. Systems offered peace of mind and some conveniences.

### Barriers

* High cost of ownership in terms of time and money and little desire for additional functions
* Lack of flexibility because of poor interoperability between systems and limitations in configurability
* Poor manageability because of unreliable behavior, slow response time, complex user interface and need to hire professionals
* participants were less interested in the direct benefits of the technologies, was not regarded as a “game changer”

### PervasiveCrystal

Keeps track of recent events in smart homes

Presents list of available “why” or “why not” questions depending on recent events. Automatically generates responses by linking smart home events to triggers

### Jigsaw Puzzle Interface

Interface for end-user programming

Provided a simple interface for specifying the behaviors of technologies in the home, i.e., programming with little programming knowledge

Three transformers: Physical to digital, digital to physical & within digital

Provided simple graphical editor for composing “programs” for smart home behaviors

### CAMP Interface

Offered a simple interface for end-user programming of smart home technologies, specifically for capture and access purposes

# Gender and Computing

## Universal Design

### Definition

Designing with the goal of making things as widely useful and usable as possible

### Gender differences in computing

Many known differences have been studied and found:

* Perceptual differences
* Attitude differences
* Behavioral differences
* Performance differences

#### Perceptual Differences

differences are greater when navigating virtual environments; Females build less accurate conceptual models of the space

#### Attitude Difference: Self-Efficacy

Much research has shown that women (computer science students and end users) have lower self-efficacy than men regarding computer-related abilities. Females also exhibit higher risk aversion when interacting with computers

#### Behavior Difference: Tinkering

Educational research indicates that tinkering is a strategy more commonly adopted by males

## Addressing gender inclusiveness issues

### GenderMag

Considers five known facets of gender differences:

#### Differences

* Motivation
* Information processing style
* Computer self-efficacy
* Risk aversion
* Tinkering

# Computing for health and wellness: Pervasive Healthcare

## Computing for health and wellness

### Pervasive healthcare

Pervasive healthcare refers to the set of technologies designed to seamlessly integrate health education, interventions, and monitoring technology into our everyday lives, regardless of space and time.

### Human-centered Model of Healthcare

#### Preventative Care

Targets behavior and lifestyle choices (e.g., smoking, diet, inactivity) to prevent disease or injury, rather than treating or curing them

#### Hospital Care

Technology for managing and sharing health information and supporting decision-making

#### Chronic Care

Considers impairments or deviations from the norm that last three or more months

## Personal informatics and wellness management for preventative care

* Automated and selected capture and access
* Persuasive and self-monitoring technologies
* Social support for health

## Pervasive computing for hospital care

* Hospital work conditions are substantially different from typical office conditions
* Primary goal is to make information available and allow people to access relevant information when and where they need it

## Chronic care Management technologies

* Focuses on health conditions or diseases with long-term effects
* Often require a variety of pharmaceutical and behavioral interventions to monitor and maintain patient health over time
* Remote patient monitoring often more desirable than hospital care

# Technology and sustainability

## Sustainability

### Environmental Sustainability

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs

### Jevons Paradox

Technological improvements increase the efficiency with which a resource is used; total consumption of that resource may increase rather than decrease.

### E-Waste

trash produced by the disposal of electronic devies

### Sustainable Design

1. **Sustainability in design**: Asks how technologies can be designed so that their use is sustainable
2. **Sustainability through design**: Asks how technology can support sustainable behaviors or lifestyles

## Sustainability in design

### Blevis’s Rubric

Rubric for understanding and assessing the sustainability of particular instances of design in terms of use, reuse, and disposal. Approximately ordered from greatest to least negative impact:

1. Disposal
2. Salvage
3. Recycling
4. Remanufacturing for reuse
5. Reuse as is
6. Achieving longevity of use
7. Sharing for maximal use
8. Achieving heirloom status
9. Finding wholesome alternatives to use
10. Active repair of misuse

## Sustainability through design

### Sustainable HCI Technology Genres

* Ambient awareness
* Persuasive technology
* Pervasive and participatory sensing

# Ethics and Computing

## History and challenges

### 1940-1950s

Several insights about the potential ethical impact of information systems. Identified key ethical questions for computing and predicted a second industrial revolution

### 1960s

Donn Parker (SRI) began to study unethical and criminal use of computers by computer professionals

### 1970s

Joseph Weizenbaum created ELIZA (1960s), a program that could imitate a psychotherapist to interact with a patient.

### 1980s

Social and ethical impacts of computing become public issues. Disasters caused by computer failures, Invasions of privacy via databases, Major lawsuits over software ownership.

First international conference on computer ethics takes place