Child-Computer Interaction

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Photo by Cade Martin, Dawn Arlotta, USCDCP

Personal introductions

- Name
- Affiliation
- What are your interests in child-computer interaction?
- What would you like to get out of this course?

A brief history of CCI

Photo by Adrian Pingstone - https://en.wikipedia.org/wiki/Home_computer#/media/File:Cpc464.computer.750pix.jpg

Definition

- Child-computer interaction concerns the study of the design, evaluation, and implementation of interactive computer systems for children, and the wider impact of technology on children and society

The early years

- Late 1960s
- Graphical user interfaces are in the very early stages
- No home/personal computers
- Internet starting out as ARPANET
- AI is about 10 years old
- First ideas on CCI from researchers at MIT

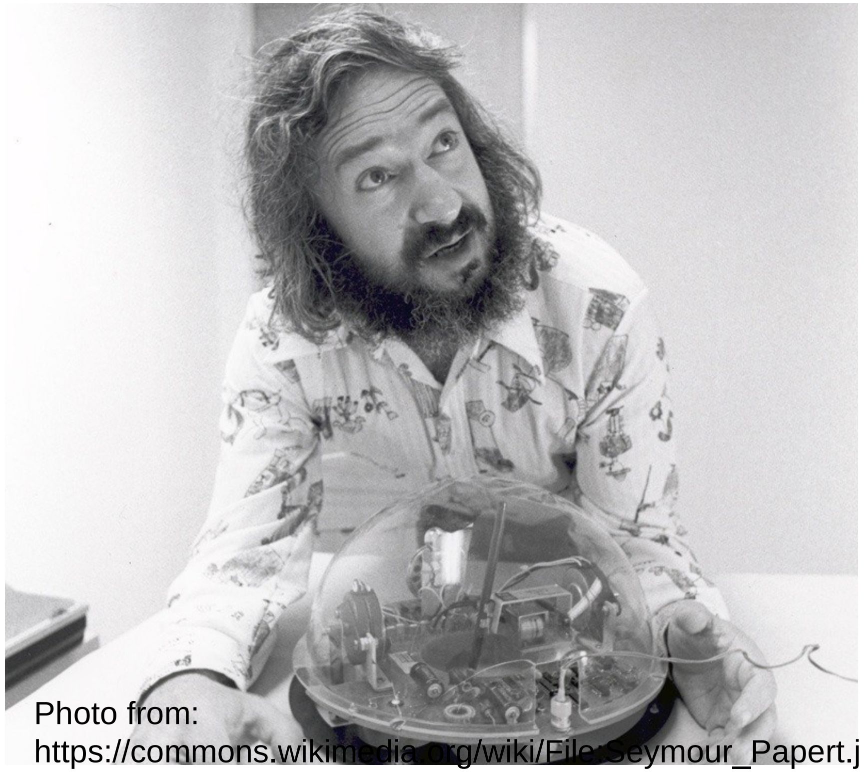


Photo from: https://commons.wikimedia.org/wiki/File:Seymour_Papert.jpg

Early focus on programming

- Logo programming language
- Initially intended for children to program robots
- Seen as potentially revolutionizing education
- Deployed worldwide in 1980s through personal computers
  - Typically keyboard-only interactions
  - Focus on schools
  - Shared computers

HCI and CCI

- Human-computer interaction arises in early 80s
  - computer scientists, engineers
  - psychologists
- Exploration of more appropriate user interfaces for children
- Growing influence of developmental psychology, design, learning sciences

Photo from https://hcipioneers.wordpress.com/portfolio/druin-allison/

A subfield of HCI is born

- Growing research in CCI in late 90s
- Technology design processes appropriate for children developed by Rogers, Druin
- IDC workshop in 2002
- IDC conference starts in 2003
- Specialized conference for HCI research on children's technologies

CCI today

- Diverse field
  - Computing
  - Design
  - Child development
  - Children’s media
  - Learning sciences
- Different research foci based on geography
  - Due to funding priorities

Activity

- How/where do you fit into CCI?
- What parts of CCI do you identify with?

Ten Pillars of CCI

Source: Province of British Columbia

Work in interdisciplinary teams

- varied expertise
- design and evaluation method experts
- technology builders (computer scientists, engineers)
- designers (graphic, industrial)
- experts in child population (children, teachers, psychologists)
- domain experts (education, media)

Deeply engage with stakeholders

- Throughout design process
  - start before deciding whether to build something
- Engage with stakeholders to understand
  - needs
  - abilities
  - preferences
  - daily realities
  - contexts of use
- The less familiar design team is with stakeholders the greater the need for engagement

Evaluate impact over time

- Due to emergence
- Need to see how technology affects children over time
- Challenging due to logistics and costs associated with long-term evaluations

Design the ecology, not just the technology

- Take into account broader context of use
- Design for physical space
- Design for social context

Make it practical for children’s reality

- Must work in children’s real contexts
- Tech that may ever work only in a lab will have limited impact
- Relevance to children’s lives, needs, and interests

Personalize

- Children come with a wide range of experiences, neural structures, bodies, contexts of use
- Personalize to optimize benefits
- Do not let personalization get in the way of social use

Be mindful of skill hierarchies

- Many domains require mastery of basic skills before adding complex skills
  - music, math
- Know which skills build on each other when designing technology
- Consider behaviorist approaches for acquiring basic skills

Support creativity

- Constructionist approach
- Learning through building and self-expression
  - not just programming or physical building
  - also storytelling, music, textiles, and so forth

Augment human connections

- Do not let tech get in the way of human connections
- Use technology to enhance self-expression and provide more options for connecting with others
  - both face-to-face and remotely

Enable open-ended, physical play

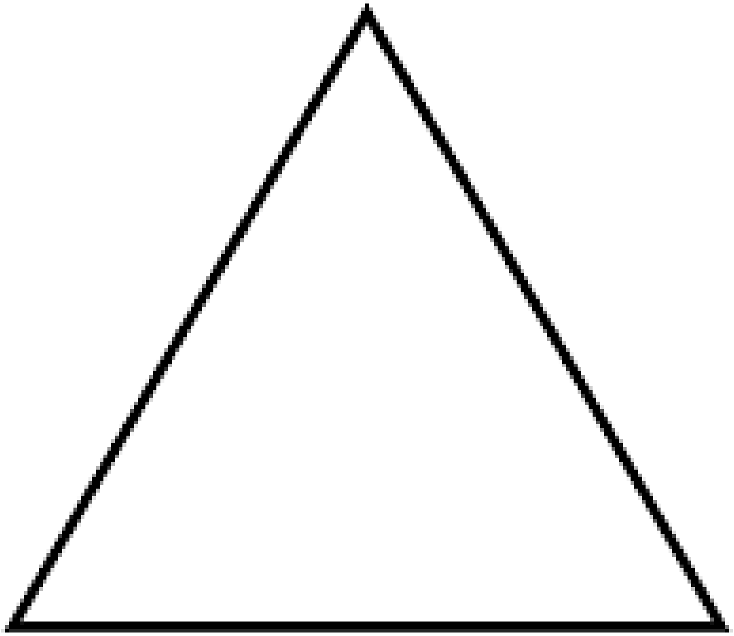
- Social
- Creative
- Physical
  - including with physical toys or props
- Including planning

What is child development?

Photo by Donnie Brzuska, US Coast Guard

Study of child development

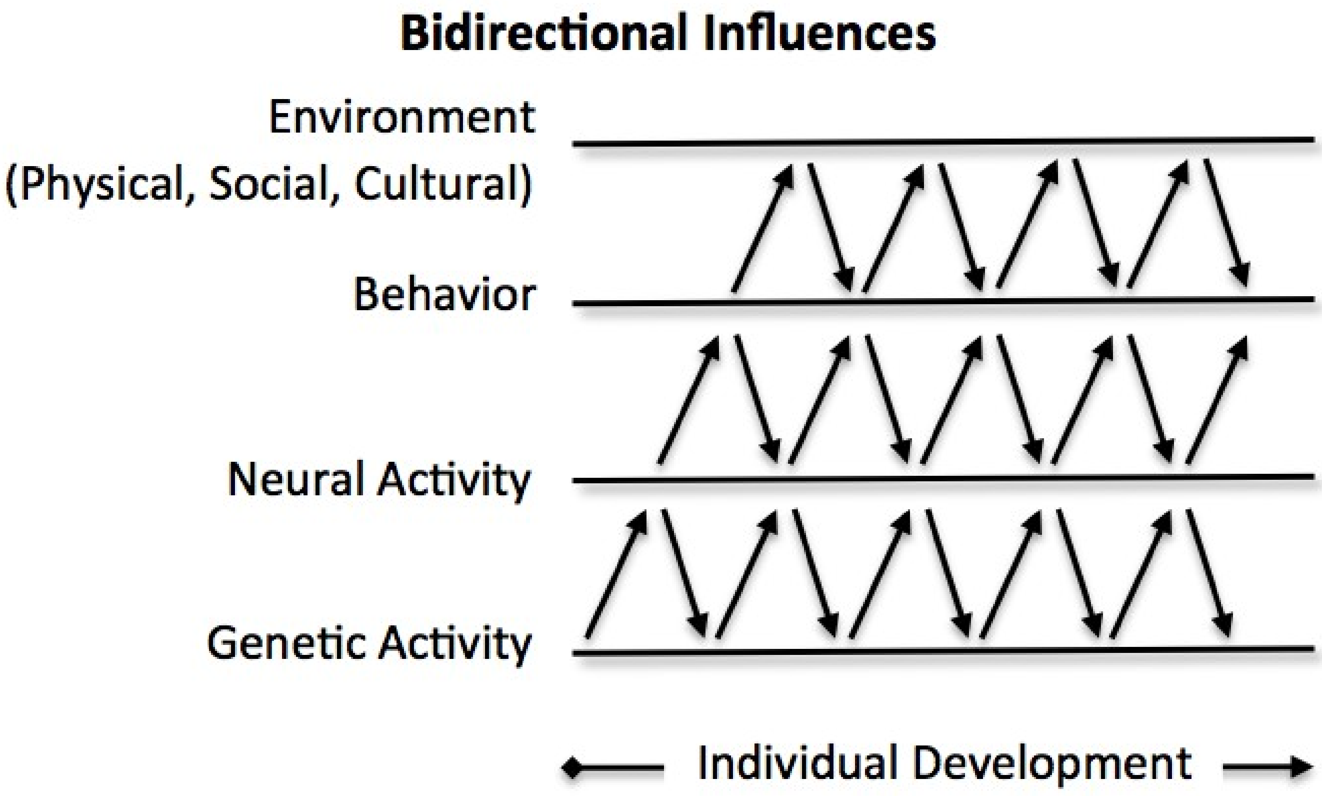
- Early focus was on what happens when
  - In what order do skills develop?
  - What can children typically do at specific ages?
  - Developmental milestones
- Modern focus is on change
  - What are the mechanisms of development?
  - How do humans change throughout their lives?



Change is dramatic

- Children typically learn 60 thousand words in their first 18 years of life
- Rapid improvements in
  - motor abilities
    - handwriting, musical instruments
  - cognitive abilities
    - reading, writing, math
- High variability
  - within children
  - between children

Gottlieb’s bidirectional influences



Activity

- How is ubiquitous technology changing child development?
- Write 4-5 ideas, one per sticky note

Piaget & Papert

Photo by Fotocollectie Anefo

Source: Wikimeida, Shen-montpellier

Jean Piaget

- Arguably the most influential developmental psychologist of the 20th century
- Constructivism
- Factors affecting development
- Developmental stages

Constructivism

- Adaptation
  - Development occurs through adaptation to the environment
- Construction of knowledge structures
  - Children experience the world
  - If experience fits knowledge structures these are validated
  - If not, knowledge structures are modified

Constructivism

- Name for this approach to child development
- Refers to construction of knowledge structures
- Key implication
  - Every child arrives at an experience with a different set of knowledge structures
  - Diversity in effects of the same experience on different children

Papert and constructionism

- Papert worked with Piaget in the late 1950s and early 1960s
- Piaget’s ideas influenced Papert’s views on computers
- Papert’s constructionism builds on Piaget’s constructivism

Constructionism

- Learning works best when children are consciously engaged in building a public entity
- Making something of interest to share with others helps children construct knowledge
- Constructionism emphasizes
  - social aspects
  - motivation
  - modifying environment instead of experiencing it

Activity

- What are the implications of constructivism and constructionism to CCI and your own work?

Factors affecting development

- Piaget identified four factors in one of his last major works
- Maturation
  - physical maturation increases potential for learning
  - maturation is also affected by environmental factors
- Experience
  - goes back to constructivism
  - richness of experiences affects development

Factors affecting development

- Social interaction
  - acknowledgement of sociocultural factors in development
  - role of adults and more knowledgeable and experienced people
- Motivation and emotions
  - relevance
  - interest and passion
  - will vary significantly between children

Activity

- What are the implications of these factors affecting development on the design of tech for children?

Developmental stages

- Piaget’s earliest work and what he’s most known for
- He went beyond these concepts later in his career
- Concept of developmental stages
  - all children go through a series of developmental stages in the same order
  - at each stage children present typical behaviors and abilities
  - each stage increases logical-mathematical ability

Developmental stages

- Sensory-motor (age 0-2)
  - dramatic speed of development
  - language, cognitive, and motor development affect possible tech use
- Preoperational (age 2-7)
  - egocentric view of world
  - tend to focus on one characteristic of an object at a time
  - greater difficulty understanding hierarchies

Developmental stages

- Concrete operations (age 7-11)
  - understand hierarchies
  - remember steps taken
- Formal operations (age 11-16)
  - deductive reasoning
  - logical analysis of options
  - better understanding of abstract concepts (e.g., algebra)

Activity

- How do we apply knowledge from developmental stages?

Sociocultural approaches

Source: Joint Base San Antonio

Lev Vygotsky

- Developmental psychologist during early years of Soviet Union
- Died in 1934 at age 37
- His work faced government opposition in Soviet Union after his death
- Not well-known in West in part due to ties to communism
- Rediscovered in the United States in 1970s

Vygotsky's views on development

- Language, tools, and symbols play a crucial role in cognitive processes
  - Planning first happens through speech, later inner speech of adults
- Writing and external tools augment human cognition
- Learning mostly social in nature
  - children can do something with someone else's support before doing it on their own

Concepts arising from Vygotsky

- Scaffolding
  - Help children require to complete a task before they can complete it on their own
  - Necessary until children internalize processes
- Zone of Proximal Development (ZPD)
  - Children are in ZPD when they can complete a task with scaffolding, but not on their own

Activity

- How can we apply Vygotsky’s ideas to children’s technologies?

Sociocultural context

- Instead of studying learning in isolation study learning in a given sociocultural context
- Can be studied at societal level
  - What knowledge and skills are valued?
- Can be studied in the immediate vicinity of the child
  - family, school, neighborhood environment
- Knowledge distributed among individuals, tools, artifacts

Attachment

- Child psychiatry literature places a strong emphasis on attachment to primary caregivers
- Secure attachment makes children feel secure, helps with self-regulation, social skills, and confidence
- Lack of secure attachment leads to hostility, poor social skills, low self-confidence, poor academic performance

Literacy environment

- Higher language and cognitive skills for children in rich literacy environments
  - literacy activities (e.g., shared book reading)
  - quality of participation of primary caregivers (e.g., quantity and quality of speech)
  - access to appropriate learning materials

Play

- Increasingly considered to play a crucial role in development
- Make-believe play can promote self-regulation
- Abstract thinking through use of generic props in play
- Social and self-advocacy skills
- Planning
- Physical activity
- Creativity

Activity

- What are the implications of these concepts on how we should envision the role of technologies in children’s lives?

Computationally and Biologically-inspired theories

Source: ZEISS Microscopy, Germany

A bridge

- Piagetian and sociocultural approaches consider development at a very high level
- Can we bridge these approaches with what we know about the biology of the brain?
- Can this bridge be in the form of computational models that predict how learning will occur over time?
- Neuroconstructivism, dynamic state theories, connectionism

Embodiment or situatedness

- Development occurs through bidirectional interactions between the brain, the body, and the environment (including other people)
- Knowledge structures are not independent of the body or environment
  - Only sufficient in a given context
- Development arises from challenges or changes in the body and environment, which are used to solve them
- As change occurs, the brain, the body, and the environment change together

Emergence

- Dynamic nature of environment means that knowledge structures, representations, and behaviors are constantly emerging
- What are the optimal environments for desired development to emerge?
- Emergence of skills and behaviors is complex and unfolds over time

Plasticity

- Ability of nervous systems to dynamically change in reaction to experiences and the environment
- Some changes are more likely to occur during childhood and adolescence
- Plasticity remains at work throughout human life

Variability

- Computational models used in these theories are stochastic
  - outcomes of a particular combination of brain, body, and environment are probabilistic, not deterministic
- Given the same conditions, the same child may behave differently
- Variability decreases with more experience in given contexts as knowledge structures and neural pathways become strengthened
  - as neural pathways strengthen, plasticity decreases

Activity

- What are the implications of biologically and computationally inspired approaches on how we design and evaluate children's technologies?

Other approaches to development

U.S. Navy photo by Mass Communication Specialist 2nd Class Shannon Renfroe

Behaviorism

- Studies learning from the perspective of observing and measuring behaviors as a response to stimuli
- Studies interactions between learner and environment
- Feedback to aid in learning
  - To reinforce “good” behavior
    - positive reinforcement (you get something you want)
    - negative reinforcement (you avoid something you don’t want)
  - To discourage behaviors
    - punishment (take away something wanted, or give something unwanted)

Behaviorism

- Shaping
  - Breaking down a complex behavior into smaller segments
  - Use behaviorist approaches to teach each segment
- Widely used in animal training
- Approach behind drill and practice learning
- Useful in situations where automatic responses are useful
  - typing, music, basic arithmetic
- Used with children with atypical development
  - Example: Applied Behavioral Analysis

Theories of intelligence

- Psychometric theories attempt to measure intelligence
  - Predict a generic intelligence factor g
- IQ testing, standardized tests
- Problems
  - don't predict "success" in life
  - someone scoring in the 90th percentile in 1892 would score in 5th percentile in 1992
  - don't prescribe how to better educate children

Theories of intelligence

- Multiple intelligences
  - Multiple interacting intelligences
  - linguistic, logical-mathematical, musical, spatial, bodily kinesthetic, naturalistic, interpersonal, intrapersonal
  - different combinations of strength a better match for different professions
- Successful intelligence
  - Someone’s ability to succeed in life given their goals within a sociocultural context
  - Three types of abilities: analytical, creative, practical

Activity

- What role can behaviorism and theories of intelligence play in children's technologies?

Executive function

- Cognitive processes necessary for goal-oriented behavior
- Can be improved independent of general intelligence
- Key predictor for school success together with numeracy and literacy

Executive function

- Inhibit and monitor
  - Resist impulses, stop inappropriate behavior, understand personal impact on others and their goals
- Emotion regulation
  - Switch attention appropriately
  - Regulate emotional responses to challenging situations
- Cognitive regulation
  - Initiating action, holding and processing relevant information, generating plans, checking on progress, being organized

Activity

- How can we apply ideas from executive function to children's technologies?

Safety considerations

Physical considerations

- Common-sense recommendations to avoid
  - Sharp edges
  - Toxic materials
  - Chocking, squeezing, strangulation hazards
- Obesity
  - Is it advertising or a sedentary lifestyle?

Intellectual considerations

- Complex set of factors affects whether media has a positive or negative influence on children
- Challenges with media with
  - Poor (or no) use of vocabulary
  - No communication directed at children
  - Lack of interaction requested from the child
  - No parental involvement
  - Lack of strong storylines

Social, emotional, and moral considerations

- Social isolation
- Fear, depression, nightmares, sleep problems
- Violent content
- Negative stereotypes
- Cyberbullying
- Privacy & surveillance

Usability and children

Optimal experience

- Concept from Csikszentmihalyi
- Challenging activity that requires skill
  - Too much challenge can lead to anxiety
  - Not enough challenge can result in boredom
- Consider adjusting challenge based on performance
- Consider role of novelty
- Enable children to become more skilled over time

Optimal experience

- Sense of control
  - Related to avoiding anxiety
  - Should feel in control when in difficult situations
- Merging of action and awareness
  - All attention is focused on the activity
  - Loss of self-awareness
  - Feeling of being one with the activity

Optimal experience

- Clear goals and feedback
  - Is progress being made?
  - Feedback is important
- Transformation of time
  - Time appears to go faster
  - Could be useful to assess user experience with teenagers
- Emotional interest
  - How children feel about participating
- Personal significance
  - How important is the experience

Other kinds of user experience

- Enjoyable
- Fun
- Entertaining
- Helpful
- Motivating
- Rewarding

Usability goals

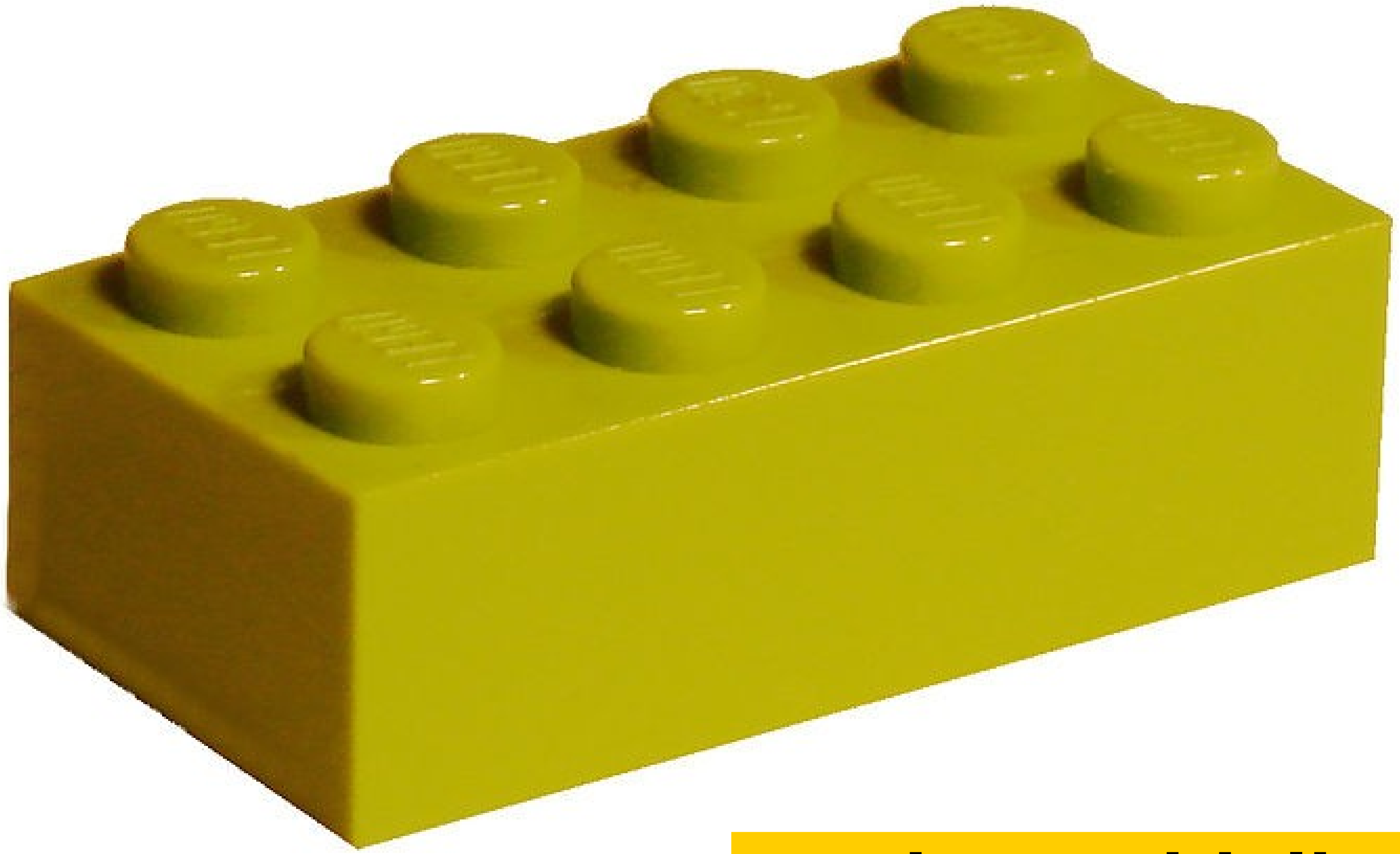
- Challenges for children have to be in the right places
  - If using a programming environment, challenge should be in designing algorithms, not manipulating the program
- Usability goals established for adults work well for low-level interactions in children's software

Usability goals

- Efficiency
  - Time
    - Could be a challenging metric for young children
  - Number of steps
    - Appropriate across all age groups
- Effectiveness
  - How accurately and completely users can complete tasks
  - Important for children
  - Ensure, for example, that icons are large enough for young children
  - Provide guidance to complete tasks

Usability goals

- Learnability
  - Very important for children
- Memorability
  - Important for repeated, infrequent tasks
  - Less likely to apply to children
- Utility
  - For children, sometimes less features may be more appropriate



Design guidelines

Image by Stilfehler

Revisiting guidelines for adults

- Help achieve usability goals
- Don Norman, Jakob Nielsen, Ben Shneiderman
- Generic; may not always apply

Perceivability

- What can I do with the technology?
- What is the technology currently doing?
- Concepts that can help
  - Simplicity
  - Communicate in age and culturally appropriate manner
  - Mappings
    - Match between child goals and options
    - Match between selected options and perceived outcomes
    - Match between perceived and actual outcomes
    - Match between possible outcomes and child goals
  - Recognition over recall

Operability

- Can children operate a technology?
- Physical reach, strength, size of items
  - Needs will vary by age
- Affordances
  - Perceived or actual properties of an object given child's abilities & goals
- Constraints
  - Ensure only reasonable outcomes

Developmental fit

- Children's ability to understand how to use a technology in a positive, constructive way
  - Depends on child experience, cognitive abilities, context of use
- Break up complex tasks into simpler ones
  - Rapid, reversible, incremental actions
- Provide appropriate amount of feedback
- Consistency
- Error-free technologies
- Personalization
- Social use
- Ecology of use

Design and evaluation methods

Selecting methods (and activities)

- Available resources
- Child characteristics
- Type of technology
- Team experience
- Time constraints

Lifecycle models

- Phases and strategies involved in designing, developing, and evaluating technologies
  - Identifying needs and establishing requirements
  - Design
  - Implementation
  - Evaluation
- Early models were linear
- Modern models emphasize iteration
  - Changes are expected to occur
  - Example: agile software development

HCI's contribution

- Greater emphasis on role of the user
- Involve users and stakeholders from the very beginning of projects
- Participatory and co-design approaches involve stakeholders in design decisions
- Pay more attention to physical and social context of use

Children's roles

- Ethical concerns
  - Informed participation (and consent) by children
  - Activities should provide intrinsic benefits
  - Consider evaluating benefits of child participation

Children’s roles

- User
  - Evaluation with and without technology use
  - No impact on technology
- Tester
  - Most common role
  - Little impact on design since participation comes late in the process
- Informant
  - Share ideas and opinions with design team at critical junctures
- Partner
  - Equal partners throughout design process
- Protagonists?
  - Emphasize children’s personal growth and the role of technology in their lives

Identifying needs and establish requirements

- Who are the users and stakeholders?
- Contexts of use
- What needs should technology address?
- Do not confuse requirements with specifications!

The University of Iowa

Identifying needs and establish requirements

- Technology immersion
  - To introduce children to technology
  - Or to acquaint adults with how children use technology
- Competitive assessment
  - Contextual inquiry
- Interviews
  - Could be conducted by children
  - Communicate with a proxy (a fake Martian, or a voice agent)

Developing design ideas

- Low-fidelity prototyping
  - Art supplies
  - Sketching
    - Layered elaboration
  - Storyboarding
- High-fidelity prototypes can be used to obtain feedback
- Brainstorming
- Use design patterns
- Scripting
  - For voice interactions
- Role play

Evaluation

- Informal evaluations with children
- Expert reviews by adults
- Usability testing
  - Works better with pairs of friends (so they talk more)
  - Researchers can also ask questions
  - Peer tutoring
  - Physiological data
  - Eye-tracking
- Questionnaires
- Interviews
- Field studies


Source: Journalist Seaman Ryan Clemen, US Navy

Thank you!

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