Human-Computer Interaction

Accessibility, Assistive Technologies, & Universal Design

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Today's Agenda

» Topic: *Accessibility*

» Topic: *Accessible Design*

» Topic: *Assistive Technology*

» Discussion

What is accessibility?

Definition of Usability: The effectiveness, efficiency, and satisfaction with which a specified set of users can achieve a specified set of tasks in a particular environment. — ISO 9241-11

Definition of Accessibility: The usability of a product, service, environment, or facility by people with the widest range of capabilities. — ISO 9241-20

What are key challenges regarding accessibility?[1]

Risks	**Description**
Inaccessible devices/services	Devices or services that cannot be used by people with special needs, even if they have adequately adapted equipment
Loss or privacy	When personal information stored and/ore transmitted without the authorization of the user
Loss of autonomy	When decisions about the user are taken by others rather than the user or the person(s) authorized by the user
Economic factors	Devices and services out of the financial capability of the users because excessive technology is used
Invasive and/or socially unacceptable location systems	Systems for personal location that invade personal freedom and/or devices for location that are socially unacceptable

[1] Abascal & Nicolle, 2005, Moving towards inclusive design guidelines

How is accessibility related to disability?

Accessibility is the extent to which an interactive product is accessible by as many people as possible.

The primary focus of accessible design is making systems accessible to individuals with *disabilities*.

What is disability?[2]

Definition: A *disability* is any condition of the body or mind (impairment) that makes it more difficult for the person with the condition to do certain activities (activity limitation) and interact with the world around them (participation restrictions).

Disability can change over time with age or recovery, and the severity of the impact of disability can change over time. Fewer than 20% are born with a disability, although 80% of people will have a disability once they reach 85.

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[2] Source: CDC

Three Dimensions of Disability[3]

1. **Impairment** in a person's body structure or function, or mental functioning (e.g., loss of a limb, loss of vision, or memory loss)
2. **Limitation in activities** (e.g., difficulty seeing, hearing, walking, or problem solving)
3. **Restrictions in participation** in activities of daily living (e.g., working, engaging in social and recreational activities, and obtaining health care)

Impairment → Limitation in activities → Restrictions in participation

[3] Source: World Health Organization

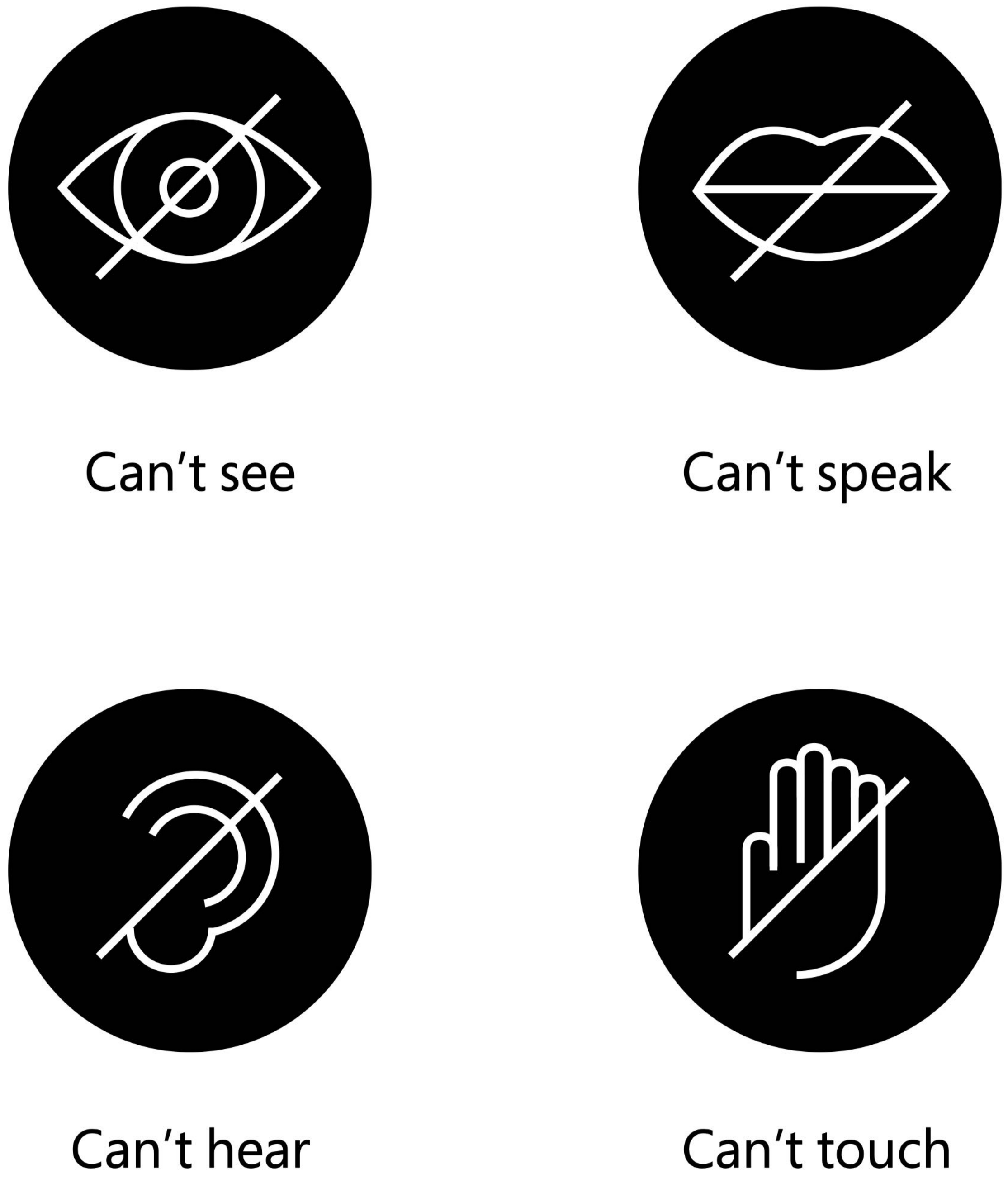
Types of Impairments[4]

Accessibility research and design focus on supporting people with diverse functional abilities.

Common categories:

1. **Sensory impairments** — affecting perception (e.g., vision, hearing)
2. **Physical or motor impairments** — affecting movement or control
3. **Cognitive impairments** — affecting memory, learning, or information processing

We'll look at each in turn.



[4] Image source: Microsoft Inclusive Design Toolkit

Types of Impairments: ***Sensory***

Definition: Impairment in one or more senses, such as loss of vision or hearing.

Examples

» **Visual:** Long-sightedness, blindness, low vision, color blindness

» **Auditory:** Hearing deficits differing in severity, e.g., deafness

Design Implications

» Provide multiple modalities (visual + auditory + haptic)

» Include text alternatives (captions, screen-reader support)

» Avoid relying solely on color or sound cues

Types of Impairments: ***Physical (Motor/Mobility)***

Definition: Loss of function in one or more parts of the body, e.g., congenitally or after stroke or spinal-cord injury.

Examples

» **Motor/Mobility:** Muscular or skeletal impairments in hands, arms, or body that affect interaction or mobility (e.g., wheelchair users)

» **Speech:** Difficulty or inability to speak due to neurological or physical causes

Design Implications

» Support alternative input (voice, switch, eye tracking)

» Avoid small touch targets or time-sensitive controls

» Design for flexibility in reach, movement, and posture

Types of Impairments: **Cognitive**

Definition: Cognitive deficits such as learning impairment or loss of memory/cognitive function due to aging or conditions like Alzheimer's disease.

Examples

- **Cognitive/Learning:** Developmental, congenital, or traumatic (e.g., TBI)
- **Memory:** Age-related decline or neurodegenerative conditions
- **Seizure-related:** Photosensitive epilepsy triggered by light, motion, or flicker

Design Implications

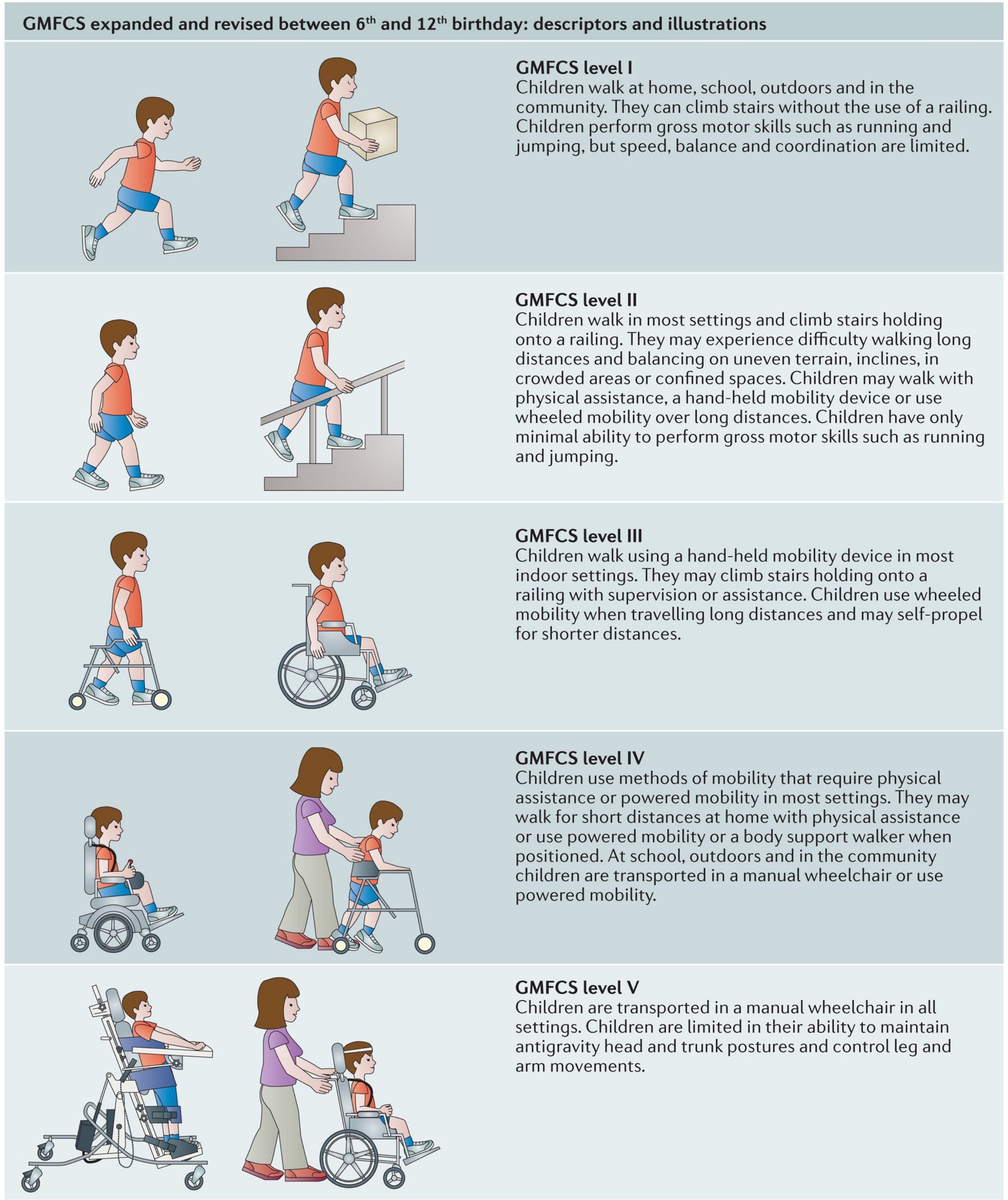
- Use consistent layouts and clear information hierarchy
- Provide reminders, progress indicators, and error recovery
- Avoid flashing or flickering visuals

How do impairments vary?[5]

Impairments can vary in severity or structure depending on the source and nature of the impairment.

Severity: Children with cerebral palsy can have basic mobility or completely depend on a caretaker.

Structure: Vision impairments can include color blindness, peripheral-only vision, no light perception.



Nature Reviews | Disease Primers

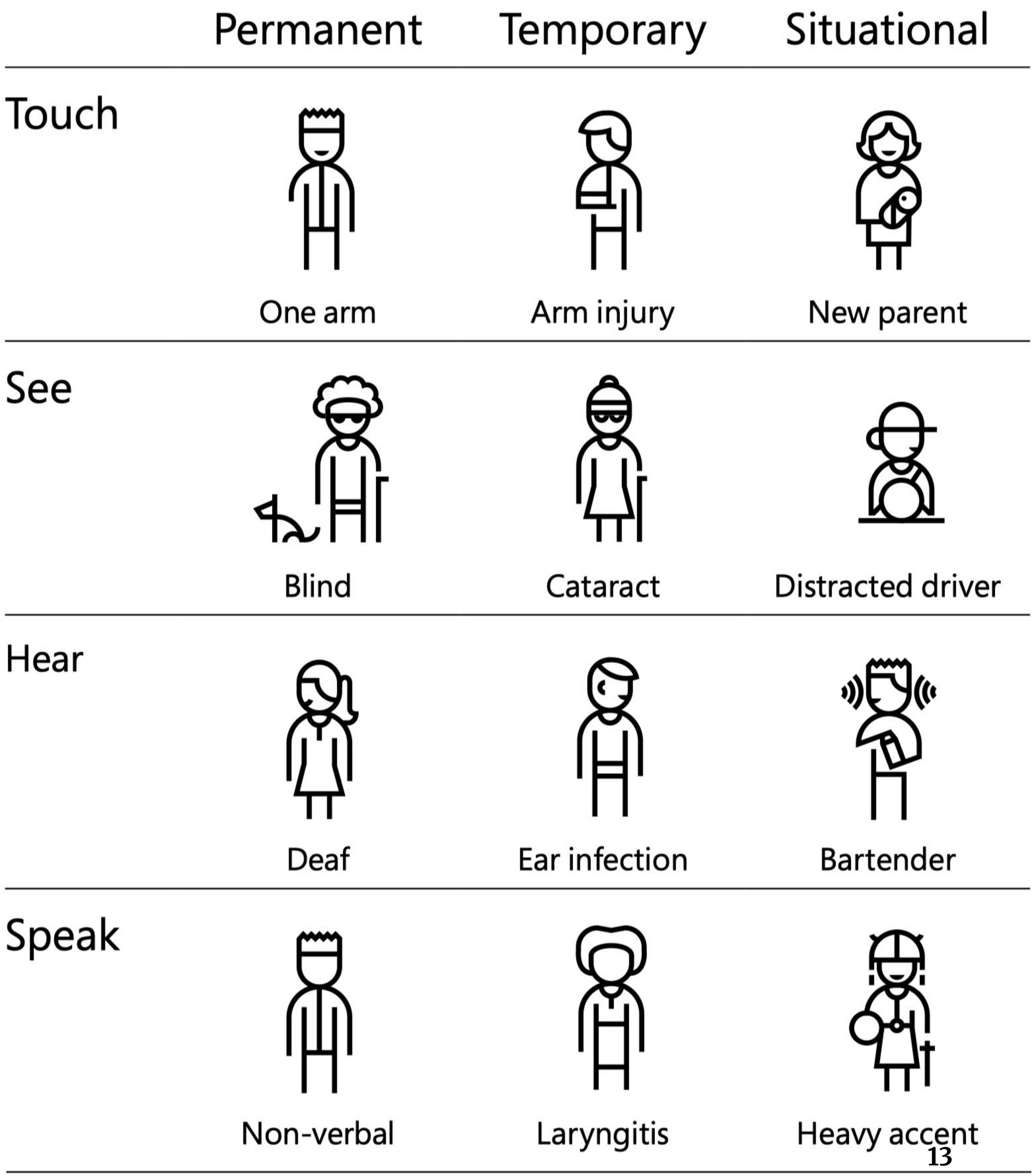
[5] Image source; Gross Motor Function Classification System (GMFCS)

Are impairments permanent?[6]

Permanent Impairment: Congenital or long-term conditions, such as color blindness, missing body parts, etc.

Temporary Impairment: Impairments that improve over time, such as recovery after illness or accidents, e.g., a broken arm.

Situational Impairment: Impairments introduced by context, such as environments with low light or noise.



[6] Image source: Microsoft Inclusive Design Toolkit

How do we improve accessibility?

Two ways to address accessibility problems:

1. Accessible design
2. Assistive technologies

How can we do accessible design?[7]

Context dependence: Disability is not just a health problem. It is a complex phenomenon, reflecting the interaction between features of a person's body and features of the society in the person lives.

Context-dependent disability results from a mismatch between abilities and the environment:

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Ability + Context = Disability
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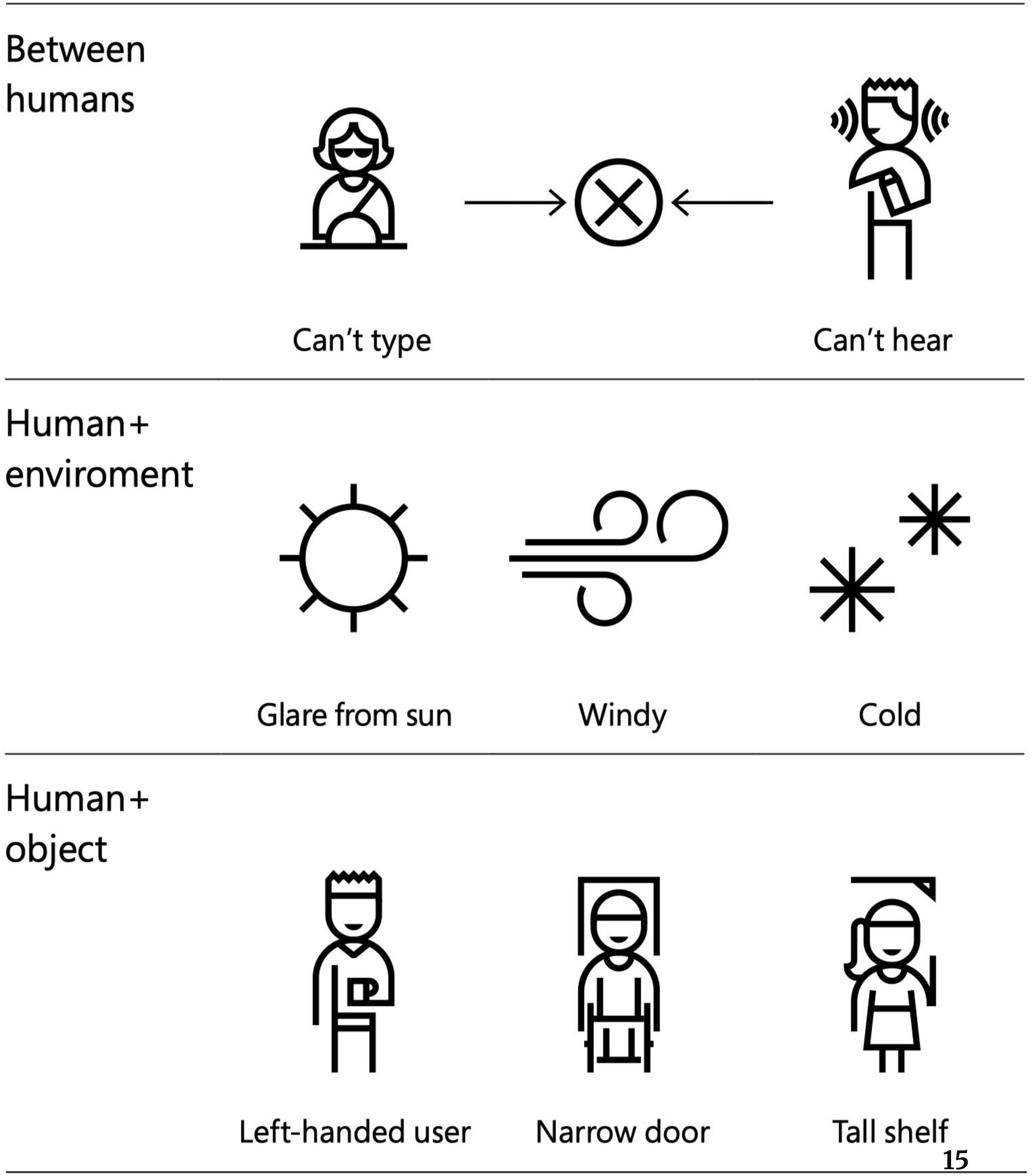

[7] Image source: Microsoft Inclusive Design Toolkit

What is universal (or inclusive) design?[8 9]

Definition: The design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design.

The main premise: Design solutions that benefit some individuals may benefit the whole society. E.g., in the US, only 26K people suffer loss of upper extremities. Designs that would benefit these 26K would also benefit another 21M people with temporary or situational disabilities.

Also called the *curb-cut effect.*[10]

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[8] Ron Mace, 1996, The Principles of Universal Design

[9] Image source: Microsoft Inclusive Design Toolkit

[10] Petrick, 2019, Curb Cuts and Computers

What's an example?[11]

Closed Captioning: Although closed captioning was originally developed for individuals with hearing impairments, they now also benefit reading in noisy environments and learning to read.

[11] Image source: Microsoft Inclusive Design Toolkit

Origins of universal design

The concept of *Universal Design* emerged from a broader movement toward ethical and inclusive design in the late 20th century.

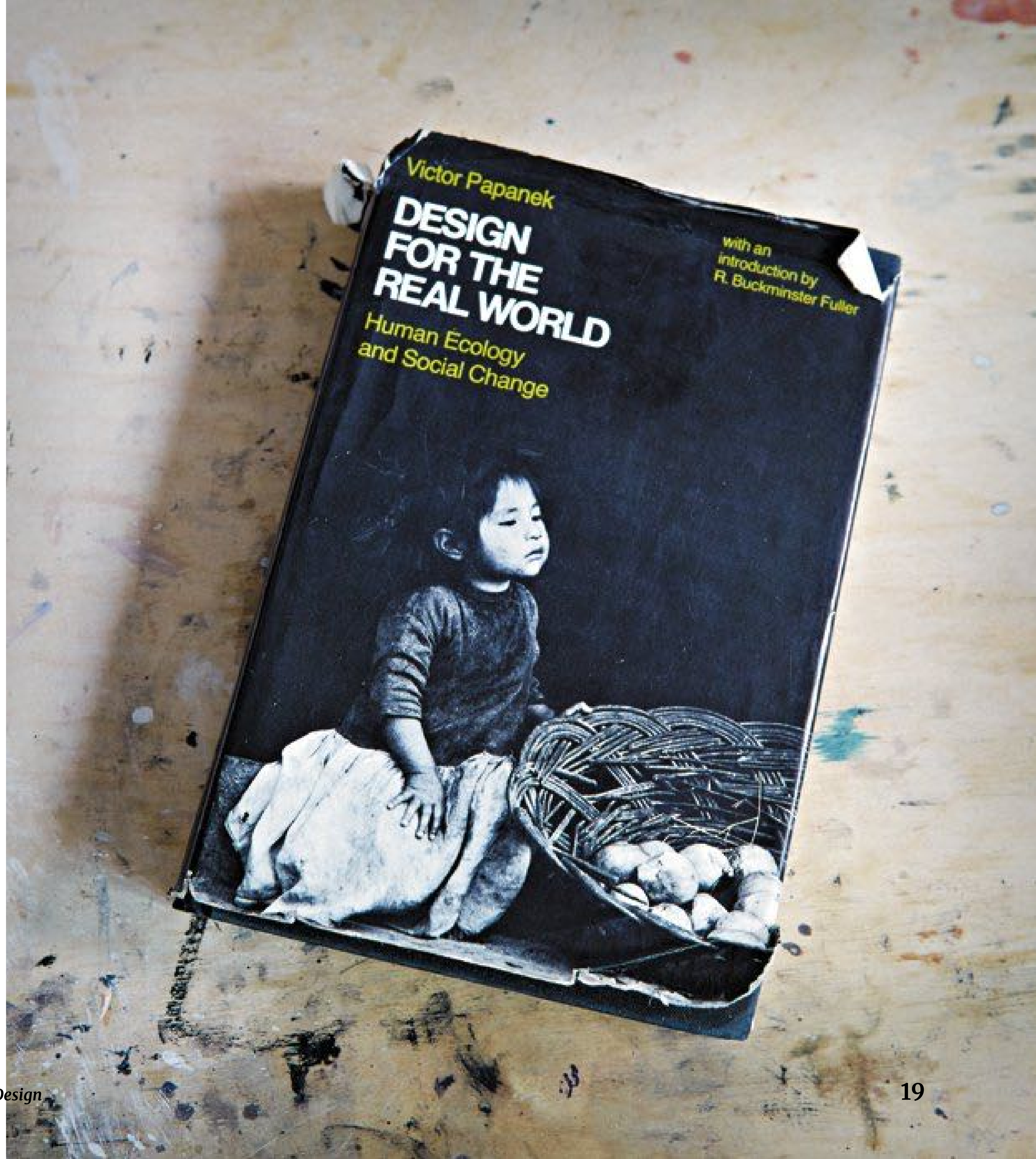
"There are professions more harmful than industrial design, but only a very few of them." — Design for the Real World, ***Viktor Papanek (1971)***[17]

[17] Papanek, V. (1971). *Design for the real world: Human ecology and social change.* Pantheon Books.

Papanek argued that:

- Design must serve human needs, not consumer trends.
- Designers have a social and moral responsibility to consider *everyone*, including people with disabilities, older adults, and marginalized groups.
- Accessibility is not a constraint—it is a measure of good design.

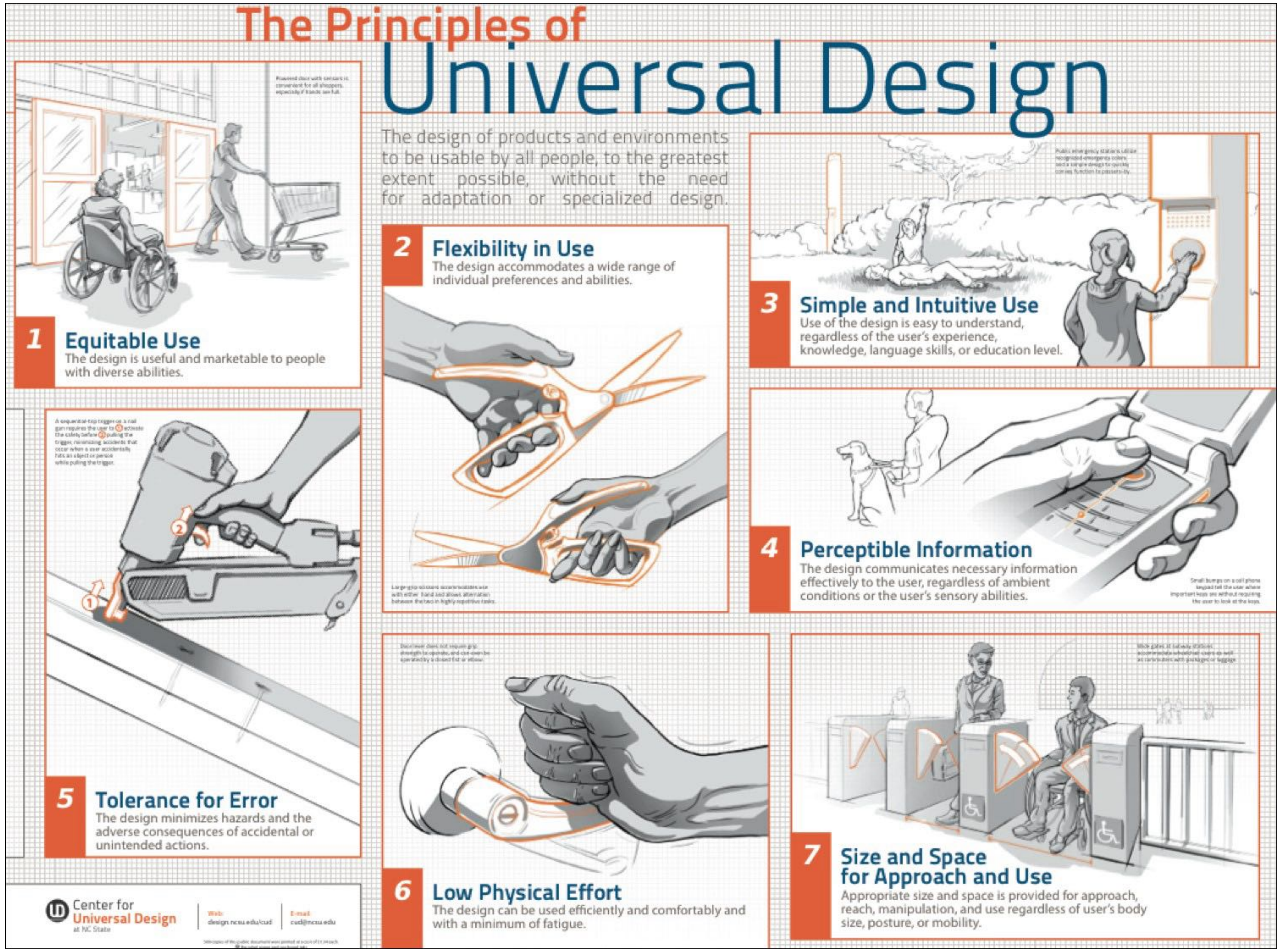
These ideas inspired the work of *Ron Mace* and the Center for Universal Design at NC State, which formalized the *Seven Principles of Universal Design*[8] in the 1990s.



[8] Ron Mace, 1996, The Principles of Universal Design

How do you do universal design?[12]

1. Equitable use
2. Flexibility in use
3. Simple and intuitive use
4. Perceptible information
5. Tolerance for error
6. Low physical effort
7. Size and space for approach and use



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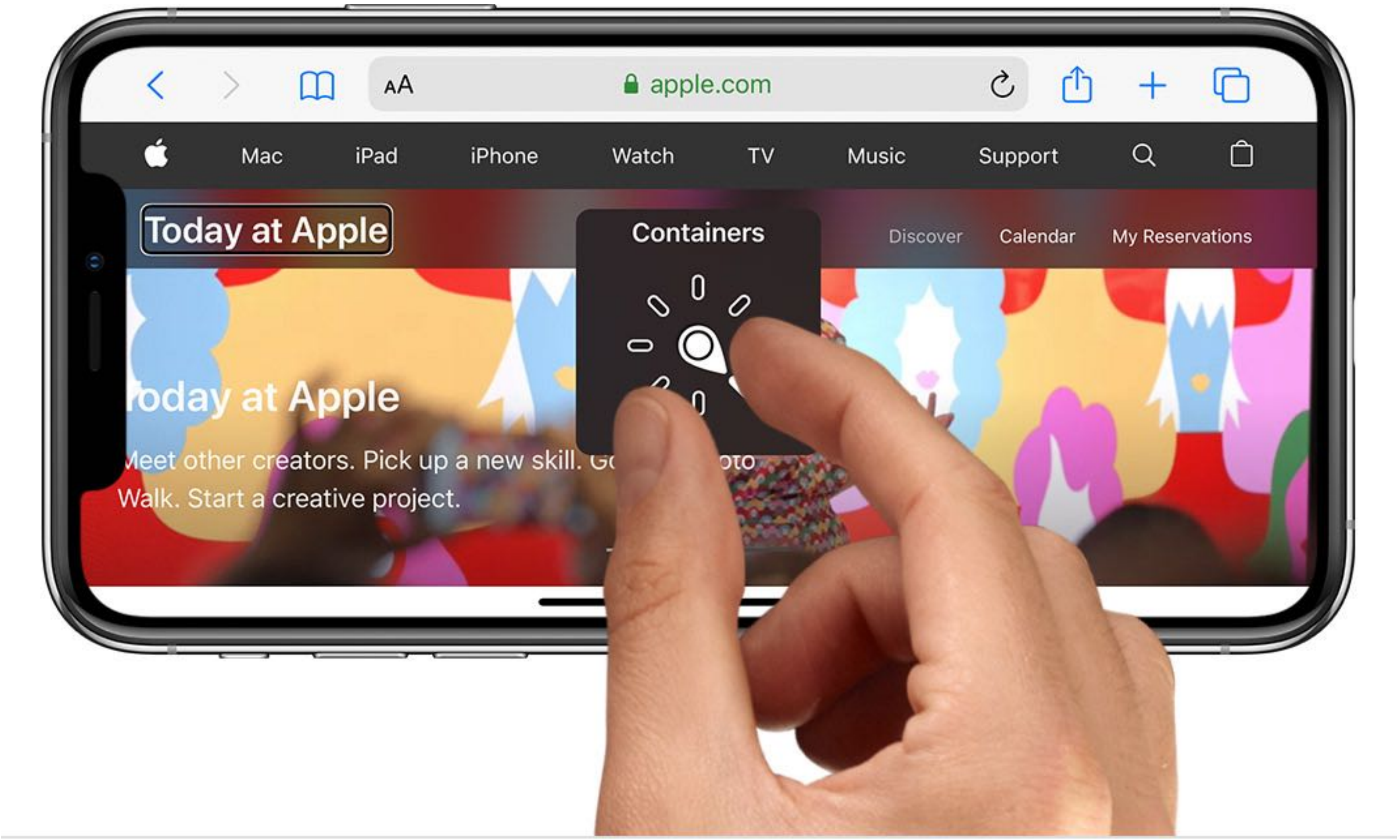
[12] Image source: Interaction Design Foundation

What are assistive technologies?

Definition: Specialized tools that close accessibility gaps.

Screen Readers: Software used by individuals with vision impairments to read screen content. E.g., VoiceOver in iOS.[13]



Screen Magnification: Enlarges text or graphics on screens to improve visibility of content for individuals with limited vision.

[13] Images: Left, Right

Text Readers: Tools that read out loud text on screens to support vision and learning disabilities.[14]

Braille for the Web: A mechanical device that translates textual content on the screen into Braille.

[14] Images: Left, Right

Alternative Input Devices: Tools that help users with motor impairments who cannot use a mouse or keyboard with pointing. E.g., motion/eye tracking.[15]

Alternative & Augmentative Communication: Tools that help individuals who are unable to use verbal speech to communicate.

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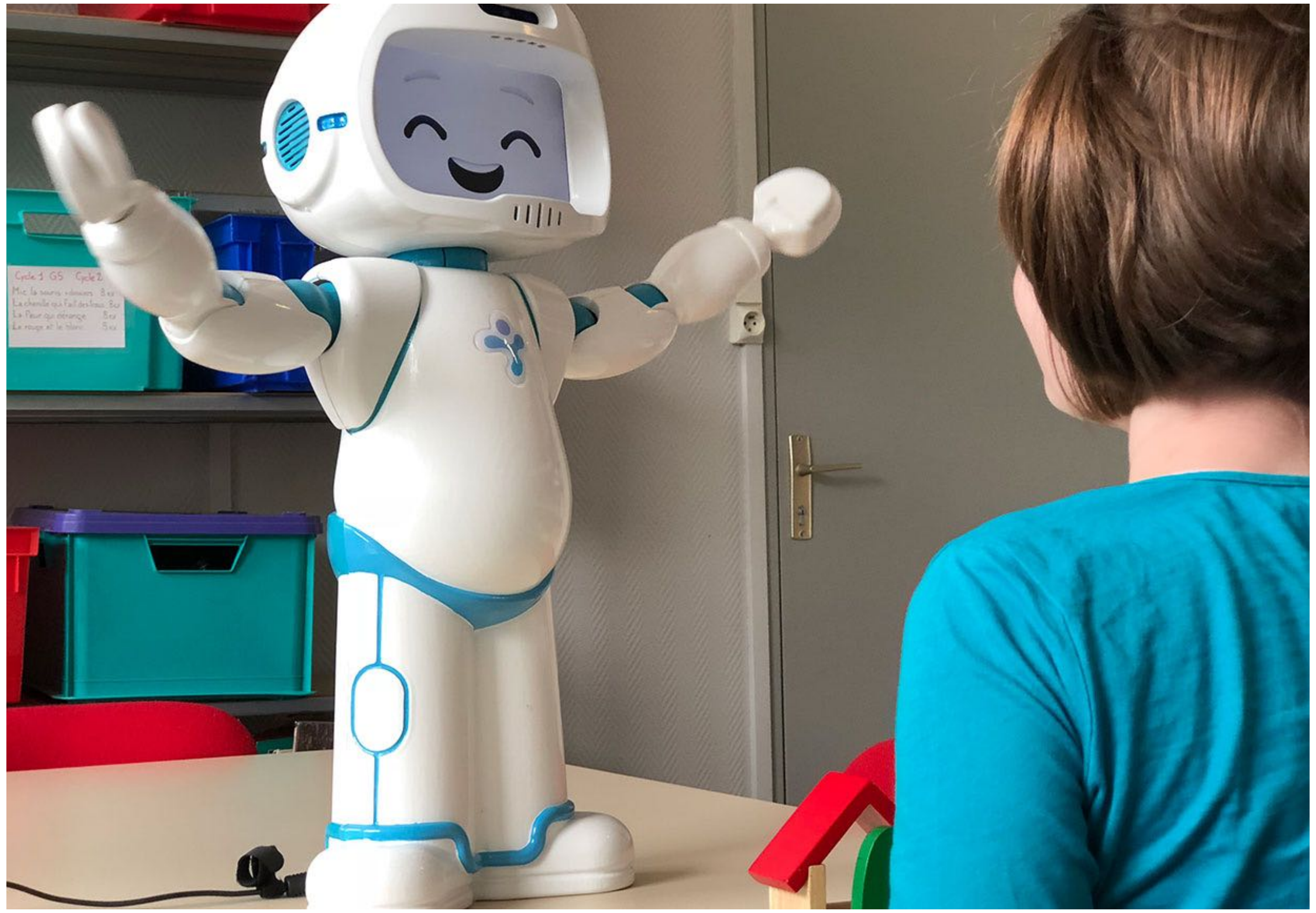
[15] Images: Left, Right

Physically assistive robots: Machines that offer physical assistance and/or reclaiming of autonomy in physical tasks.[18]

Socially assistive robots: Robotic assistants that support social and cognitive skill development.



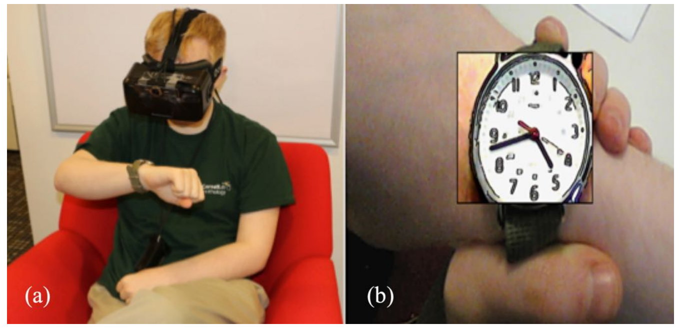
[18] Images: Left, Right

What is the research space like?

Research on accessibility in HCI primarily involves design-based research on assistive technologies.

VizWiz (Bigham et al., 2010)

ForeSee (Zhao et al., 2015)



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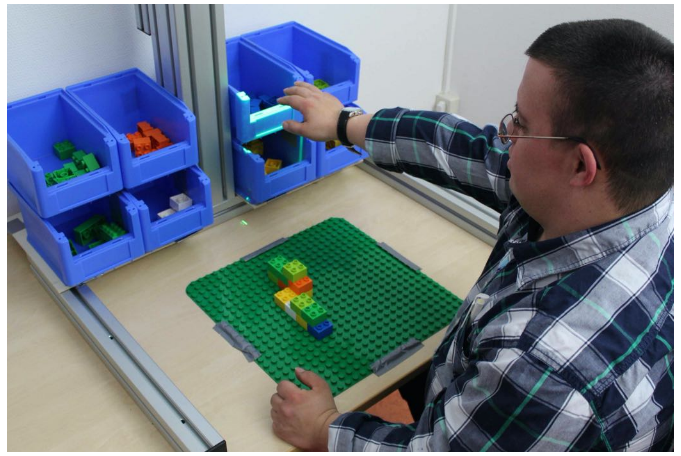
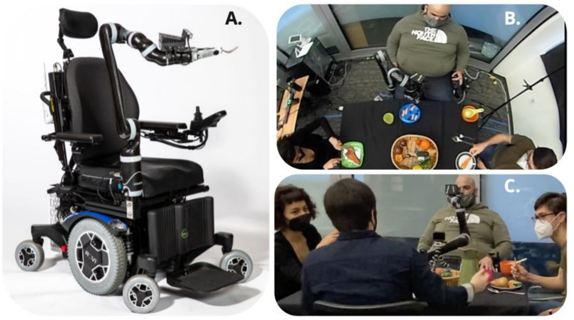
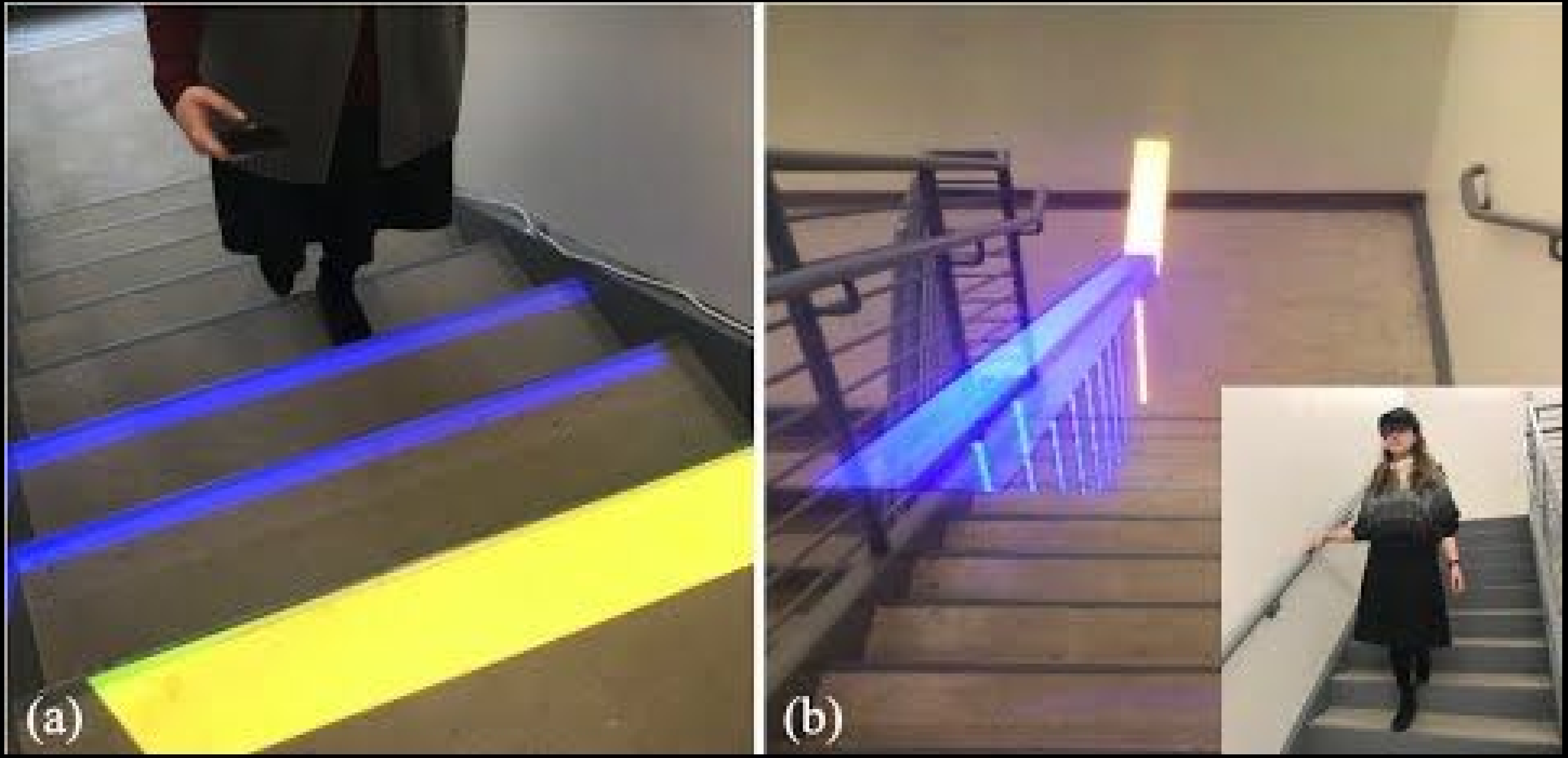


N/A (Nanavati et al., 2023)




(a)
(b)

Discussion Format

- » We'll let AI randomly pick 3-5 names
- » In the selected order, students:
  - » Present their provocation/critical artifact/policy or design recommendation (30 secs)
  - » Lead class discussion (5-8 min)