Al-Mustaqbal University

Biomedical Engineering Department

Class: 3rd

Subject: Rehabilitation Science

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2nd term – Lect. 2: Assistive Technology: Theoretical Models, Frameworks, and Human Factors.

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Defining Assistive Technology (AT)

- AT is broadly defined as "devices, services, strategies, and practices that are conceived and applied to ameliorate the problems faced by individuals who have disabilities".
- Key Concept – Beyond the Device:
  - Rehabilitation engineers must think of AT as extending beyond just a physical device.
  - It includes the service delivery, the training strategies, and the practices that make the device usable.
- Scope of Study:
  - We will explore the complex relationship between the Human, the Activity, the AT, and the Environment.
  - We will cover functional areas including Mobility, Manipulation, Communication, and Cognition

Why Do We Need Theoretical Models?

- Establishing Common Ground: Models allow professionals (engineers, clinicians, researchers) to establish a "common ground" for inquiry, practice, and reflection.
- Simplification of Complexity:
  - AT exists at the intersection of engineering, health sciences, and humanities.
  - The interaction between a human, their activity, the environment, and technology is highly complex.
  - Models help by "abstracting and approximating" the most relevant properties to guide the design process.
- The Goal of AT Models: To reduce the disabling influence that environments can have on an individual.

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The Three Roles of Models in AT

1. Informing Research & Development:

- Models help characterize the system: Who is the user? What is the context? What are the device characteristics?
- They help interpret raw data (e.g., from focus groups) into meaningful design specifications.
- They provide a framework for evaluating prototypes and comparing competing technologies.

2. Informing Practice (Evidence-Based Practice - EBP):

- EBP: The conscious, explicit use of current best evidence to guide decision-making.
- Client-Centeredness: Models ensure the client is an active partner, not just a recipient of tech. This ensures the solution is sustainable.

3. Informing Education:

- Teaches "professional reasoning" rather than just knowledge of hardware.
- Helps students understand why a technology might fail if the context or user needs aren't met.

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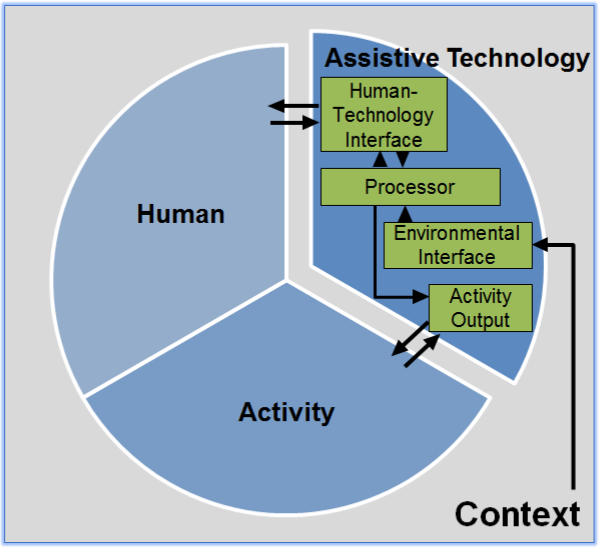
The HAAT Model (Core Framework)

- HAAT Definition: A model describing a **H**uman doing an **A**ctivity in a **C**ontext with the use of **A**ssistive **T**echnology.
- System Nature: These four elements form a "transactional system, " meaning they all influence each other constantly to enable participation.
- Visual Representation:
  - The Human, Activity, and AT are interconnected.
  - All three exist within the Context.



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HAAT Component 1: The Human

- The User's Role: Understanding the human clarifies what the client can do versus what the technology must do.
- Key Abilities to Assess:
  - Physical & Sensory: Motor control, range of motion, strength, vision, and hearing.
  - Cognitive: Processing speed, memory, and learning ability.
- Emotional Component:
  - Does the user want to do this alone or with help?
  - What is the personal "meaning" of the activity?

The HAAT Component 2: The Activity.

- **Definition**: Also called "occupation," this covers self-care, productivity (work/school), and leisure.
- **Fundamental Actions**: The activity is supported by functional actions like mobility, manipulation, communication, and cognition.
- **Detailed Analysis Required:**
  - **Timing**: How often and for how long is the activity performed?.
  - **Location**: Where does it happen?.
  - **Social Nature**: Is it solitary or done with others?.
  - **Why it matters**: Understanding these factors determines what the technology needs to do to support the user.

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HAAT Component 3: The Context: The context determines if a device succeeds or fails. It has four parts:

Physical Context:

- Built/natural environments.
- Environmental Factors: Heat, light, and sound (e.g., glare on LED screens makes them hard to see in high light).

Social Context:

- The presence of others and their willingness to support the tech.

Cultural Context:

- Values regarding independence and inclusion of people with disabilities.
- Example: Does the culture view using a device as "giving up" or "being independent"?

Institutional Context:

- Legislation, regulations, and funding (who pays for it?).

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HAAT Component 4: Assistive Technology

- **The Continuum:** AT ranges from Low Tech (simple, easy to get, e.g., mouth stick) to High Tech (complex, hard to get, e.g., AAC devices).
- **Hard vs. Soft Technologies:**
  - Hard Tech: The physical device itself.
  - Soft Tech: The decision-making, training, strategies, and manuals required to make the hard tech work.
- **Human/Technology Interface (HTI):**
  - The boundary where the user interacts with the device (e.g., a joystick, a keyboard, a screen).
  - This must match the user's sensory and motor abilities to allow for input and the reception of information.

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The SETT Framework (For Education)

Purpose: Designed specifically for school settings to create student-centered systems.

The Acronym:

- **S - Student**: What does the student need to do? What are their special needs and current abilities?.
- **E - Environment**: What materials/devices are available in the classroom? What is the physical arrangement?.
- **T - Tasks**: What specific learning tasks are required? How can they be modified?.
- **T - Tools**: What no-tech, low-tech, or high-tech strategies will increase performance?

The CAT and MPT Models

CAT Model (Comprehensive Assistive Technology):

- Goal: To identify barriers, analyze systems, design new AT, and evaluate outcomes.
- Hierarchy: Organized into Attributes (Person, Context, Activity, AT) -> Components -> Factors.
- Activity Types: Distinguishes between Fundamental Activities (walking, talking) and Contextual Activities (employment, leisure).

MPT Model (Matching Person and Technology):

- Goal: To prevent technology abandonment by ensuring a good "match".
- Three Elements:

1. Milieu: The environment/context (social, cultural, physical).
2. Person: Personality, temperament, and preferences.
3. Technology: Cost, aesthetics, and performance.

- Process: A user-driven process balancing client needs with constraints to ensure the device is actually used.

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The HETI Model (Detailed Breakdown)

Definition: The Human Environment/Technology Interface (HETI) model, developed by Smith (1991), focuses specifically on the interaction between the human and the technology.

- Engineering Perspective: It uses a control-system framework involving Input, Processing, and Output.

Applications:

- Used to assess computer access (Hoppestad 2004).
- Used to assess powered mobility (Field 1999).

Value: It provides engineers with tools to design the specific "micro-interactions" needed for successful device control.

The HETI Model (Detailed Breakdown)

The Detailed Logic Loop:

1. Environmental Input: The user receives a cue from the environment (e.g., "I see a door I need to open").
2. Human Processing: The user processes this information and decides on an action.
3. Motor Output: The user performs a motor action (e.g., moving a hand to push a joystick).
4. Device Input: The user's motor output serves as the AT device's input.
5. Device Processing: The AT device processes this signal (e.g., joystick coordinates translated to motor voltage).
6. Device Output: The device performs the action (e.g., the wheelchair moves forward), which provides new feedback to the user.

Theoretical Career Path

- **Concept:** Developed by Gitlin (1998), this views the AT user as having a "career" in AT use.
- **Stages of Expertise:**

1. Novice: (e.g., hospitalized, new need) Requires instruction and environmental fit.
2. Early User: Developing skills.
3. Experienced User: Competent in use.
4. Expert User: (e.g., using device for years) Has mastered the device and uses it at home.

- **Implication:** An engineer must realize that a Novice needs different support (instruction) than an Expert (who needs efficiency and refinement).

Human Factors – Needs and Wants

- **Central Principle:** The user's needs are the center of the process.
- **Defining "Meaning":**
  - An activity is "meaningful" based on past experience, sense of competence, and emotional engagement.
  - Example: A user may need a computer for work (high productivity demand) OR to talk to family (high social demand). The AT solution for these two goals might differ significantly.
- **Fluidity:** Meaning changes over time; what is important today may not be important next year.

Human Factors – Body Functions (ICF)

- The ICF: The International Classification of Functioning, Disability and Health provides the standard definitions.
- **Specific Functions to Evaluate:**
  - Mental: Alertness, attention, memory, emotion.
  - Sensory: Seeing, hearing, tasting, pain.
  - Voice/Speech: Ability to produce sound.
  - Neuromusculoskeletal: Joint mobility and stability.
- **Design Implication:**
  - If a user has reliable head movement but poor hand control, the engineering solution must utilize the head for input.
  - If voice function is degrading, voice-activated tech may not be viable.

Human Factors – Habits and Roles

Habits:

- Behaviors done without conscious thought (e.g., reading the paper with coffee vs. checking news online).
- Challenge: AT often requires changing habits (e.g., an older adult must switch from visual reading to auditory news), which can be difficult.

Roles:

- Social identities like "parent," "employee," or "student".
- Contextual Need: A user may need a formal, fast voice output for their role as an "employee" (reading technical docs), but a softer, more emotive voice for their role as a "parent" reading a bedtime story.

Technology Acceptance & Abandonment

The Problem: High rates of AT abandonment.

- Phillips & Zhao (1993): 29.3% abandonment rate.
- Cruz et al. (2016): 37% abandonment rate.

Why do users abandon tech?

- Top reason**:** They "did not like it".
- Other barriers: Doesn't fit habits/routines, mismatch with age/gender, or negative attitudes from family/friends.

Engineering Solution: Involve the user early and use assessments (like MPT) to maximize "Technology Acceptance".

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Activity Area 1 – Mobility

Definition: Moving from place to place, including localized movement (sit-to-stand) and community distance.

AT Solutions:

- Simple: Canes, walkers, grab bars.
- Complex: Manual and Powered Wheelchairs.

Wheelchair Engineering:

- Seating: Critical for tissue integrity (preventing sores), postural support, and comfort.
- Controllers: Joystick vs. pneumatic switches (sip-and-puff) vs. proximity switches.
- Smart Wheelchairs: Emerging tech with collision avoidance and autonomous navigation.

Activity Area 2 – Manipulation

Definition: Activities normally done with hands/fingers.

- Gross Motor: Reaching, lifting, pushing.
- Fine Motor: Pinching, pointing, typing.

Types of Aids:

- **General Purpose:** Robotic arm, mouth stick, hand splint (can be used for eating, writing, typing).
- **Specific Purpose:** Electronic page-turner (does only one task).

EADLs: Electronic Aids to Daily Living allow control of lights, doors, and appliances.

- Constraint: These are high-cost and rarely funded by the government.

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Activity Area 3 – Communication (AAC)

AAC (Augmentative and Alternative Communication):

- Strategies for people with Complex Communication Needs (CCN).
- Population: ~2 million people in the USA; 0.3–1.0% of school-aged children worldwide.

Categories:

- Unaided: Body-based (gestures, sign language, eye-gaze).
- Aided (Low Tech): Picture boards, pen and paper.
- Aided (High Tech): Speech-Generating Devices (SGDs) that use synthesized speech.

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Activity Area 4 – Cognition

- **Cognitive Functions:** Orientation (time/place), Memory, Attention, and Executive Function (planning).
- **Causes of Impairment:** Congenital (Down syndrome) or Acquired (Traumatic Brain Injury, Dementia).
- **AT Solutions:**
  - Customizability is key: Smart technology can be programmed to be very simple (picture sequences for tasks) or complex (GPS navigation).
  - Range: From paper day-planners to smartphones and prompting systems.

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Ethical Tensions – Autonomy & Fidelity

- **Autonomy:**
- The right to self-determination and freedom from unnecessary constraints.
- Conflict: Monitoring systems for dementia patients ensure safety but violate privacy/autonomy. Who decides?.
- **Fidelity:**
- Being faithful, loyal, and trustworthy.
- Conflict: Engineers often face a "Conflict of Interest" between what the user needs and what the funding agency/manufacturer wants to provide.

Ethical Tensions – Beneficence & Justice

Beneficence (Do Good) & Non-maleficence (Do No Harm):

- Engineers must strive for the good of the user.
- Robotics Dilemma: A driverless wheelchair or companion robot cannot "reason" morally. The engineer is responsible for programming safety protocols.

Justice:

- Fairness in distribution and access.
- Challenge: How do we balance high-cost innovation with the need for affordable access for marginalized populations?.

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Stigma & Future Vision

Stigma:

- AT can mark a user as "less able" or "weak".
- Engineering Goal: Design aesthetically pleasing devices to reduce social stigma.

Future Vision:

- Rapid advancement in robotics and AI.
- The Ultimate Goal: The future of AT should not just be about cooler tech, but about increased autonomy, self-determination, and equity.

Thank You
For Your Attention