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Assistive Technologies

Principles and Practice

Jan Miller Polgar | Pedro Encarnação
Emma M. Smith | Albert M. Cook

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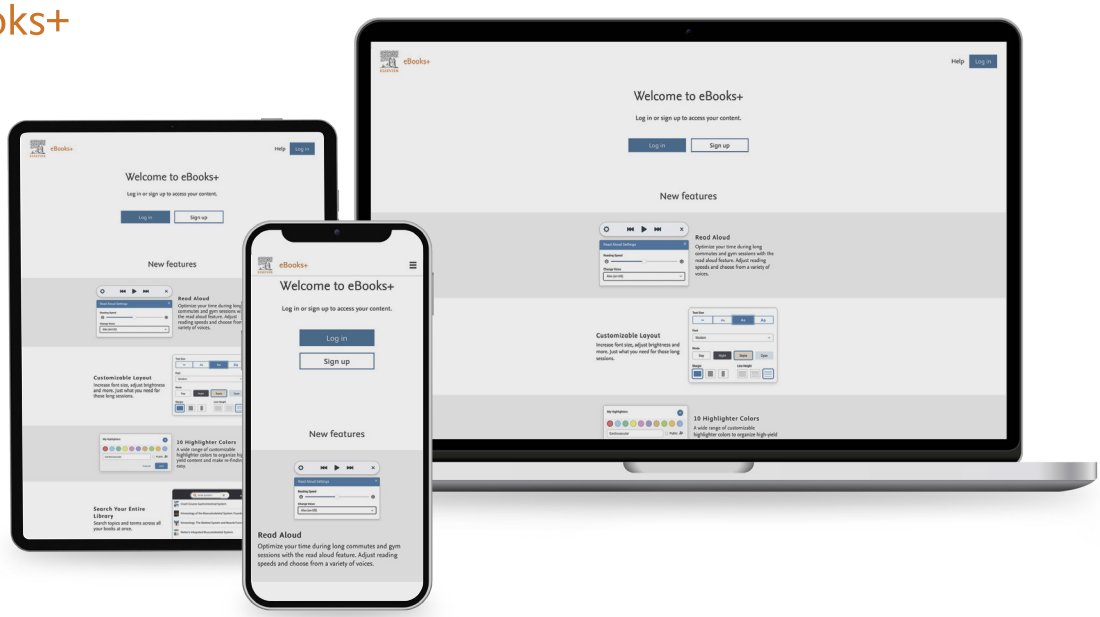

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COVER PHOTO: Child at the Centro de Reabilitação de Paralisia Cerebral Calouste Gulbenkian, Lisbon, Portugal, using the INMAC (Independent Mobility for All Children) vehicle developed by Anditec (www.anditec.pt). Courtesy © P. Encarnação.

This book is dedicated to Dr. Albert (Al) Cook. Al's contribution to the world of assistive technology is unparalleled. There is no measure to describe how much he has given to our field. Without Al, there would be no Human Activity Assistive Technology model. Thirty years ago, he conceptualized the Human Activity Assistive Technology model and reminded practitioners in the field that what mattered was the person doing something they valued, with assistive technology as an aid. We recognize Al's continued contributions to the field through this dedication.

PREFACE

Technology is nothing. What's important is that you have faith in people, that they're basically good and smart, and if you give them tools, they'll do wonderful things with them.

—Steve Jobs

Assistive technology (AT) is commonly considered to be technology to enable persons with disabilities. However, the rapidly expanding products that are available now meet the needs of a wide range of individuals including those with disabilities, but also those who may have functional limitations not associated with disabilities, including those associated with aging. "Mainstream" products that enable people with disabilities are included in this book. We use the current World Health Organization (WHO) definition of AT, which includes services, knowledge, skills, and systems that support acquisition and use of assistive products. Therefore, in this book, the term *assistive product* designates a device or app to maintain or improve an individual's functioning and independence, and *assistive technology* is an umbrella term for assistive products and related systems and services.

Throughout the book, we use a rights-affirming language, congruent with a social model of disability. We have opted for the "person-first" language, emphasizing the person and not the disability, which is more common in North America. Nevertheless, we acknowledge that "identity-first" language recognizes that disability is part of a person's identity and that it may be preferred by others. We use gender-neutral language throughout.

The book is written to support students in rehabilitation, engineering, and other relevant academic programs and service providers in the acquisition and application of knowledge that supports the provision of AT. It is not meant to be a catalog of assistive products. Rather, the goal is to describe the principles that should guide AT service delivery.

With this edition, Dr. Albert (Al) Cook becomes author emeritus. Thirty years ago, Al and his first coauthor, Dr. Susan Hussey, published the first edition of *Assistive Technology: Principles and Practice* and introduced the Human Activity Assistive Technology (HAAT) model to the field of AT. HAAT puts the person doing activities within a context at the center, with AT in a supporting role, a concept that may be difficult to embrace when technology can be so exciting. Al continues to say that the HAAT model is a living idea, something that should change along with changes in our understanding of how people do activities with the support of technology. We recognize Al's contributions to previous editions and trust that we have moved his ideas forward with this edition.

The sixth edition welcomes a new author, Dr. Emma Smith, originally from Canada and now living in Ireland. Her background in AT is broad, with expertise in many areas including wheeled mobility and seating, communication, robotics, cognition, and aids to daily living. Emma is very involved with the WHO's and other international organizations' initiatives on AT, with a particular interest in the policies and systems that guide how AT is delivered. Together with Dr. Encarnação, Emma's contribution advances the international perspective of AT.

One of the first steps in the revision of this book was for the authors to get together to discuss major changes and influences in the field since the publication of the previous edition. In addition, we discussed ways that the book could be made more useful to readers. To this end, we streamlined the chapters that focus on specific areas of technology to make the application of the HAAT model more explicit. We further considered who the readers of this book are in order to identify content that was not relevant. Following this discussion, the decision was made to remove the chapter on AT for vision impairment and include the relevant information in other chapters. While these areas are very important, we felt they were better served by specialist training and resources dedicated to the area of low vision.

An exciting development in our field is the rapid expansion of research. We recognized that we could not summarize or do justice to the research that is now available. Moreover, we acknowledged that today people have wide access to the latest research through different means beyond a traditional textbook. Consequently, we removed sections that reviewed literature, condemned to be incomplete once the book was published, keeping only the discussion of research necessary to illustrate content, and pointed the reader to other sources when possible.

One of the exciting changes in this book is that it is produced in color. We took this opportunity to update the figures throughout.

Feedback we received on previous editions of the book included the lack of answers to the questions that are at the end of each chapter. While we still leave it to the reader to compose their own answers to these questions, we have indicated where, in each chapter, the information needed to respond is located.

Chapter 1 presents foundational ideas for the subsequent chapters in this edition and begins by providing key information about disability that guides our understanding of users of AT. In addition to the principles and the HAAT model, definitions of AT, complementary models of health and functioning, legislative aspects, and a summary of key applications of the HAAT model are covered in this introductory chapter.

The HAAT model guides assessment and evaluation of AT use by individuals. It provides a framework for assessing the usability of technology and guides product research and development. The basic structure of the HAAT model remains unchanged from earlier editions. However, readers will note that the description of different components of the model is updated to include newer understanding of AT/products and concepts related to the person, activity, and context.

Chapter 2 combines the ideas included in Chapters 2 and 3 of the fifth edition to present a more integrated discussion of the HAAT model. The HAAT components of activity, human, context, and AT are discussed individually. The model is then reconstructed to demonstrate how the individual components influence and interact with each other. Here we apply ideas of

social justice to the access to and use of AT, understanding the ability to access affordable, appropriate AT to be a right for all individuals for whom the technology will support engagement in daily activities and participation in their communities. We streamlined the discussion of legislation in the institutional section of the context. We still provide description of relevant legislation in the United States, recognizing that many readers live in that country. For all other countries, we provide a list of questions that readers should ask about legislation to maximize their understanding and application of it.

Several recent global initiatives have been impacting the understanding of disability and the world of AT. The United Nations Convention on the Rights of Persons With Disabilities has been ratified by 186 of the 197 independent states of the world. In 2015, the United Nations General Assembly adopted the 2030 Agenda for Sustainable Development with 17 Sustainable Development Goals, disability being included as a crosscutting issue. The WHO-United Nations Children's Fund's Global Report on Assistive Technology, published in 2022, provided the first global overview of the need, access to, and preparedness of countries to support AT. The WHO has a specific program on AT, the Global Cooperation on Assistive Technology. These and other global initiatives are covered in Chapter 3. With this chapter, we aim to provide a more encompassing perspective of the AT field, looking at how different contexts affect disability, AT needs, and provision and how the international organizations are addressing these global issues.

As technologies become more and more pervasive and consequently have a greater and greater impact on the ways people with disabilities live and interact with the world around them, ethical considerations become important. Some of these are the direct result of the application of AT in particular ways, for example monitoring or tracking of individuals with dementia. Other ethical concerns are related to secondary effects of AT application such as the dependence on technology for storage and retrieval of private information. Still other ethical issues arise as a result of particular disabilities such as cognitive limitations. Chapter 4 explores these ethical issues in some depth.

AT service delivery is discussed in Chapter 5. General principles are presented and the whole process of AT service delivery is outlined, having in mind the new challenges brought by the availability of new mainstream technologies that persons with disabilities may acquire on their own, without any specialized referral, but that may then need to be adjusted to meet the particular needs of the person. The discussion is framed within the four-step process (select, fit, train, follow up) outlined by the WHO for wheelchair services, which is broadly applicable to other forms of AT.

As much as possible, we maintained the format we adopted in previous editions in the chapters discussing different types of AT. Each of these chapters will (1) discuss the activities supported by the technology that is the chapter focus; (2) describe the individuals who benefit from use of the technology, as well as impairments that affect the ability to engage in the activity supported by the technology; (3) discuss contextual factors that influence use and service provision; (4) discuss specific technologies; (5) discuss assessment to identify the need for and most appropriate AT; and finally, (6) describe outcome evaluation. In some chapters, the format is followed in the order in which it was just stated; in others, the order of these within chapter topics varies to fit the specific topic area. When relevant, sections on fitting and training are also included.

Interaction between a person and an assistive product is through the human–technology interface. In Chapter 6, we discuss the various ways in which individuals can access AT, including the major approaches to the design of control interfaces that are used with ATs for computer access, power mobility, environmental control, and communication.

In Chapter 7, we focus on the general principles underlying the utilization of mainstream technologies as ATs, as well as computer access for individuals with disabilities.

Chapter 8 discusses seating and positioning technology. We describe different indicators of use or need for seating and positioning technology. The chapter includes assessment and application of AT for this area. Specific to assistive products, we include the different types of seating and positioning systems and hardware, the features of materials, and construction techniques.

Chapter 9 describes personal mobility AT, with the focus on manual and powered wheelchairs. Recent developments of power-assisted products and smart wheelchairs are described. Because seating and mobility products are usually integrated, references are made to indicators and assessment that are presented in Chapter 8. Specific assessment for wheelchair fit and operation is included. We describe the structure of and means to control manual and powered wheelchairs, including specialized bases.

Chapter 10 has two main components: (1) technology for safe transportation when traveling in a vehicle, either while seated in the vehicle seat or in a wheelchair; and (2) technology for driving. Each area is governed by legislation specific to a particular jurisdiction. Because legislation differs across jurisdictions, we describe some of the common rules related to occupant safety products and recommend that the reader becomes familiar with relevant legislation in their jurisdiction. Technical standards have been updated along with autonomous vehicle technology.

ATs to replace or augment manipulative ability are discussed in two chapters. Chapter 11 discusses manipulation aids to daily living, including both low-tech devices, like reachers, utensils, and aids to dressing, and electronic aids to daily living and smart home concepts that can replace or augment manipulative ability. Because low-tech devices are so readily available online and in retail shops, this chapter provides some details on a process for selecting these devices without the input of a health care professional and a discussion on acquisition of these devices in different areas of the world. The presentation on electronic aids to daily living emphasizes mainstream smart technology, prevalent in many homes today, that can seemingly be used to control the environment.

Chapter 12 addresses robotic assistive technologies that aid manipulation. Although there are still only a few of these technologies widely available, considerable research and development effort is underway to fulfill the expectations placed on assistive robots. In this chapter, we provide an overview of the

different types of assistive robots and discuss robotic assistive technologies that aid manipulation currently available.

Chapter 13 addresses the area of AT applications for individuals who have cognitive limitations, including both developmental and acquired conditions, as well as mental health conditions where cognition may be impaired. Again, the use of mainstream technologies with appropriate apps has dramatically expanded the options in this area. The use of monitoring technologies for individuals with dementia has also grown.

Augmentative and alternative communication is discussed in Chapter 14. This field has expanded considerably in recent years, and Chapter 14 only scratches the surface of this vast topic. Nevertheless, the basic principles are introduced, and the reader is referred to other sources of information when relevant. Along with other areas of AT, augmentative and alternative communication has a great impact of mainstream technologies, with many new communication applications appearing almost daily. The changing technology landscape has influenced both the practice of assessment and the implementation of communication alternatives for those with speech and language difficulties. This topic is also analyzed in Chapter 14.

Throughout the book, we provided information and links to further resources that provide more depth to some of the topics we present here. We encourage use of these resources, with which we are familiar, to enhance knowledge acquisition and dissemination in this ever-changing area.

It is our hope that individuals familiar with AT will find something new in this text and that readers who are new to this subject will develop familiarity with AT and appreciate their potential.

ACKNOWLEDGMENTS

Dr. Liliana Alvarez was extremely helpful in providing background research for a number of chapters in the fourth edition. The results of her work are evident in this edition as well. Dr. Laura Titus and Dr. Linda Norton provided invaluable support in the fourth edition in the areas of seating and mobility and wound prevention technologies. Their knowledge and experience continue to be reflected in this edition. The relevant sections of this book are stronger for their ongoing willingness to provide input and insight to this content. We thank Lauren Willis, Laura Klein, Shweta Patel, and Sneha Kashyap from Elsevier for their assistance with this project.

Janice M. Polgar
Pedro Encarnação
Emma M. Smith
Albert M. Cook

Al Cook becomes author emeritus with this edition of *Assistive Technologies: Principles and Practice*. His commitment to users of assistive technology (AT) and his passion for the area have influenced readers of this book for more than three decades. Al and I have worked together on these books for almost 20 years. It is hard to sum up all that working with Al has meant to me. Most importantly, Al and his wife Nancy have become cherished friends. Over the years, we've discovered that we have many interests in common and enjoy trips to pursue these interests.

Al asked me if changes had been made to the Human Activity Assistive Technology (HAAT) model during one of our Zoom meetings. I replied that we'd only made minimal changes, thinking that he didn't want us to change it. His response was interesting and reflects his personality. He reminded me that the model should not be stagnant, that current issues and challenges, both in and out of the field of AT, should be reflected in its basic concepts. While some ideas have been updated, the essential statement of the HAAT model remains: the technology is not the focus—rather, it supports a person doing, within their environment. Al remains what he has always been to me, someone who both guides and challenges my thinking and always the best of friends.

It continues to be a great pleasure to work with Pedro Encarnação on this current edition. Pedro, you were a steadfast support for me during the writing of this edition. You were the organizer who kept us focused on the task, which was very difficult during our sometimes chaotic Zoom meetings. Your clear and thoughtful feedback on my chapters resulted in significant improvement. I needed to reflect on your feedback for some chapters, but when I eventually figured out your intent, I realized that your suggestions greatly enhanced the message I was trying to convey. I'm lucky to have you now as a friend and trust that we will find ways to collaborate in the future.

This edition is my last as an active author. When I thought about who would make an excellent addition as a coauthor with Pedro, the first person who came to mind was Emma Smith. Fortunately, Emma said yes when I asked her if she was interested in being part of this work. I've known Emma for many years; we first met through a mutual friend at an International Seating Symposium. I immediately recognized someone who is intelligent, energetic, and motivated, who would make substantial contributions to the field. And she has! We became friends almost immediately, and that friendship grew over the past several years. Emma, I enjoy our talks and adventures, even when they include a cow that somehow escaped her enclosure!

I retired from academia after the publication of the fifth edition and engaged in other occupations. Pedro and Emma renewed my excitement for AT, particularly the rights-based ideas of access to and use of AT. I love hearing about the international work in which you are involved and lead. I know that the next editions of this book are going to be interesting, filled with new ideas. I look forward to reading them.

My ideas about disability, AT, and inclusivity were strongly influenced by my child Dre Polgar and Camille Bérubé. We have stimulating conversations that frequently result in me reflecting on my opinions and beliefs. Conversations with my son, Dr. Alex Polgar, and his wife, Dr. Cheyenne Christopherson, both research chemists, bring new ideas of science and incorporating research into practice. I cherish the time that we have together and the joy that we share. Last, but certainly not least, I thank my husband, Roger, for his continued love and support. I couldn't be without you.

Janice M. Polgar

My involvement with this book began over 15 years ago when I started reading the third edition to deepen my knowledge of assistive technology. Shortly thereafter, I was very fortunate to work with Al Cook on several research and editorial projects, and this collaboration extended to the preparation of the fifth edition.

This sixth edition of the assistive technology "cookbook" is the first in which Al was not actively involved as an author. His absence constituted, for me, a weighted responsibility in adapting and preserving the book as a timeless reference. However, Al's expertise and visionary contributions to the field made the job easier. The HAAT model, conceived three decades ago, remains a steadfast framework. The language used in the field has evolved, new assistive technologies have been developed, but the foundational principles laid down in the first edition endure.

It was a continued privilege to work with Jan on this new edition. Her deep knowledge of the field and thoughtful comments have been invaluable to me, not only providing a wealth of insights but also shaping my own understanding of the AT field. It was the last edition in which Jan participated as an active author. I will miss her contributions to the book and also her kindness, positive attitude, and sense of humor that made our meetings always joyful events.

I did not know Emma in person before starting to work on this new edition. Emma Smith was a name that kept popping

up on different occasions given the huge amount of AT-related projects Emma has been involved in. Working with Emma was a pleasure, and her reputation for knowledge, thoughtfulness, and resourcefulness proved well deserved. Her contributions enriched the collaborative process and elevated the quality of the work.

The journey of this edition brought forth new challenges, demanding a delicate balance with my other professional commitments. My deepest gratitude goes to my wife, Raquel, and my daughter, Joana, for understanding that they were not losing me to work but enabling me to be who I am.

Pedro Encarnação

I was first introduced to this book while working as an occupational therapist and preparing for my Assistive Technology Professional examination in 2012. I was also considering pursuing a PhD, and a mentor invited me to the International Seating Symposium in Nashville, Tennessee, so I could explore my options. That conference was fateful, as it was where I had the opportunity to meet Jan. I was starstruck. I had just spent months preparing for the ATP by reading her book, and I suddenly found myself discussing the potential of doing a PhD at Western University, where Jan was a professor. While I ultimately did not end up at Western, it was the start of a wonderful friendship and collegial relationship, for which I am immensely grateful.

When Jan began contemplating her own retirement from authorship of the book, she humbled me by asking if I would consider joining her, Pedro, and Al for the sixth edition. I, perhaps naively, said yes immediately, upon which Jan encouraged me to think about it a bit more. She knew the amount of work that had to go into it—I gratefully did not! I have been so honored to have had the chance to work with and learn from Jan over the years. It has also been an absolute delight to know the person behind the name on the cover, from our shared love of animals to her dry sense of humor. Jan, I am humbled by your trust in me to carry on your legacy.

Pedro and I met more recently, but our paths have crossed multiple times. I am continuously impressed by Pedro's ability to see the bigger picture and how multiple parts fit together in a larger whole. I have also appreciated Pedro's gentleness in his edits and suggestions. Pedro, thank you for trusting Jan in bringing me into the authorship team for this edition. I am looking forward to many years of work together.

While I had not met Al prior to writing the book, I certainly knew his name. Al, while we did not have the chance to spend a lot of time together on this edition, I have benefited from your immense contributions to this book, and the field of assistive technology more broadly. It will always be an honor to have had our names grace this cover together.

It is difficult to complete a project like this without a supportive family around you. My parents have been a constant source of love and support. I particularly need to thank my husband, Dave, for his contributions while I was writing. Oftentimes his contributions were motivation (and reminding me of my deadlines), and on more than one occasion he contributed his technical expertise to ensure my understanding of some of the more complex technical content was up to date.

I would be remiss if I did not express my immense gratitude to the clients, colleagues, and mentors who have taught me so much over the years. Working with clients has been a great joy in my life, and I have learned something from every single one of them. From watching a client with visual impairment excel at indoor powered wheelchair navigation to having wonderful conversations with clients using communication devices, each person I have worked with has had an impact on my love for the field and my commitment to improve access to assistive technology as a right.

Emma M. Smith

CONTENTS

1

Principles of Assistive Technology

LEARNING OBJECTIVES

On completing this chapter, you will be able to do the following:

1. Define assistive technology (AT) and assistive products.
2. Describe key principles of AT service delivery.
3. Describe contributions of existing ecological models of health to the conceptualization of the Human Activity Assistive Technology (HAAT) model.
4. Describe the purpose of the HAAT model.
5. Describe the activity, human, context, and AT components of the HAAT model.
6. Describe four applications of the HAAT model for AT clinical applications and AT research.

CHAPTER OUTLINE

KEY TERMS

Activity
Activity Output
Assessment
Assistive Technology
Assistive Product
Assistive Technology Services
Autonomy
Beneficence
Context
Cultural Context
Disability
Ecological Models
Enabler
Environmental Sensor
Ethics
Evidence-Informed
Human
Human/Technology Interface
Institutional Context
Justice
Mainstream Technology
Nonmaleficence
Outcome Evaluation
Person Centered
Physical Context
Processor
Rights
Rights-Based Model of Disability
Social Context
Social Model of Disability
Social Justice
Sustainability
Usability

CONTEXTUAL BACKGROUND OF THE BOOK

In this book, **disability** is viewed as a socially constructed phenomenon that results from barriers that are present in the environment. This view of disability locates it within the environment rather than within the person. The World Health Organization's (WHO) International Classification of Functioning, Disability and Impairment (ICF) views disability as the result of an interaction between the person and their environment. Viewed this way, disability is possible in everyone's experience (Bickenbach et al., 1999).

The worldwide prevalence of disability is difficult to estimate because of challenges of agreement on consistent definitions of disability and technical aspects of data collection. However, the WHO estimates that approximately 1.3 billion people worldwide experience some form of disability (WHO, 2023). The World Report on Disability (WHO & World Bank, 2011) suggests that approximately 3.8% of the world's population experiences "severe disability" that affects their ability to participate in daily activities.

The presence of a disability has a differential effect on the individual's life depending on circumstances including where they live, age, gender identity, and income. Estimates suggest that 89% of people with vision impairment, 76% with hearing impairment, and 92% of those with a disability resulting from an intentional or unintentional injury live in a low- or middle-income country (Samant et al., 2013). Similarly, women, older adults, and people living in poverty have a greater prevalence of disability (WHO, 2023).

Disability has significant consequences on an individual's life. Persons with a disability have a greater likelihood of being under- or unemployed; they and their families are more likely to have a lower socioeconomic status; they experience poorer health; they are less likely to receive an education; and they experience more social isolation, less community participation, and less safety and security (they are more likely to experience physical, mental, or financial abuse) (WHO & World Bank, 2011).

Assistive technology (AT) is one of many strategies that are necessary to reduce the disabling influence of many environments. Throughout this book, we follow the current definitions of AT and assistive products from the WHO (2016). These formal definitions are articulated below, but briefly, AT encompasses all products, systems, and services that enable and empower people with disabilities, while **assistive products** refer to the actual device, whether that be tangible, like an augmentative or alternative communication device or a wheelchair, or less tangible, like an app. In subsequent chapters where we focus on specific AT applications, we are inclusive of both the products and the services, as both are necessary for successful use of technology to support engagement in desired activities.

This book focuses on different aspects of using technology to meet the needs of individuals with a variety of disabilities. We present a model, the Human Activity Assistive Technology (HAAT) model, developed to guide service delivery, **outcome evaluation**, and research and development of AT. *The HAAT model describes a person doing an activity in certain contexts using AT.* We articulate the model in this way for a very particular reason: the focus of AT service delivery, outcome evaluation, and research and development must be on the person engaged in activities that they need, want, or are expected to do, not on assistive products alone. The principles of service delivery and the structure of each chapter that discusses specific AT reflect this viewpoint.

Our goal is to help the reader apply a person-centered process for both service delivery and research and development. To this end, we structured the book into two main parts. Chapters 1 to 5 provide general information, applicable to all of the categories of AT that are further developed in the latter part of the book. Chapters 6 to 14 discuss specific applications of AT that are consistent with the outputs identified in the HAAT model (mobility, manipulation, cognition, and communication).

CONSTRUCTS OF DISABILITY

The United Nations (UN) Convention on the Rights of Persons with Disabilities (CRPD) opens with a statement that recognizes the "inherent dignity and worth and the equal and inalienable **rights** of all members of the human family as the foundation of freedom, justice, and peace in the world" (UN, 2007, p. 1). It recognizes that disability occurs at the intersection of the person and the **context** in which they live and, consequently, two people with similar personal circumstances may experience disability differently in different contexts. This document describes the rights of persons with disabilities, with the explicit expectation that member states who are signatories to the document will enact legislation, regulations, and other measures to realize these rights for their citizens.

The CRPD enshrines the rights of persons with disabilities to be treated as equals before the law and to be "entitled without any discrimination to the equal protection and equal benefit of the law." Persons with disabilities have the right to be recognized as "persons before the law" (UN, 2007, p. 8). In other words, the presence of a disability does not nullify the state's recognition that the individual is entitled to the full benefits and responsibilities of citizenship. This convention prevents a member state from declaring a person with a disability to be a nonperson, which means that person is not entitled to vote, own property, participate in civic governance, or enter into a legal contract. You will better understand the intent of this particular article of the CRPD if you recall the limitations on the rights of women before the suffragette movements of the early 1900s. Women and children with disabilities are given particular attention in the CRPD, recognizing their vulnerability to discrimination and abuse because of gender and/or age.

Beyond rights and protections afforded to all global citizens, the CRPD identifies several rights that are specific to persons with disabilities. While AT plays a role in realizing all of the rights described in the CRPD (Smith et al., 2022), Table 1.1 identifies some of the key articles that are relevant to AT use, service delivery, and research and development and articulates their relevance to assistive products and services.

AT is mentioned specifically in many of the sections of this convention, calling for research and development of all types of AT, requiring many other forms of technology (information and communication technology in particular) to be accessible

TABLE 1.1 Articles of the United Nations Convention on the Rights of Persons With Disabilities Relevant to Assistive Technology

Article Number	Article Title	Relevance to Assistive Technology
4	General obligations	Articulates agreement to undertake research and development of assistive technologies, with emphasis on affordable devices. Agreement to provide information about AT and related services and supports in an accessible format.
9	Accessibility	In support of full participation by all, member countries agree to provide equitable access to transportation, information (and information communication technology), public buildings, and services.
19	Living independently and being included in the community	Persons with disabilities have the right to choose where they live in the community and to participate fully in necessary and chosen life activities.
20	Personal mobility	Requires provision of personal mobility choices, including mode of mobility and time, with an affordable cost. Quality mobility aids should be accessible and affordable. Persons with disabilities should receive training in the use of mobility aids. Requires production of mobility aids to consider the full range of mobility requirements of persons with disabilities.
21	Freedom of expression and opinion and access to information	Persons with disabilities have the same rights to express their ideas and opinions as others, in a manner of their choice. Information should be provided in accessible formats. Use of alternate forms of communication (e.g., Braille, sign language, alternative and augmentative communication) is required for all official interactions. Private enterprises are encouraged to similarly use these alternate forms of communication; mass media, including the Internet, and are encouraged to use and accept alternate access and forms of communication. Sign language is used and promoted.
24	Education	Persons with disabilities have equal access to an education. Reasonable accommodation to educational needs of persons with disabilities is made, including individualized programs as required.
25	Health	Persons with disabilities have the right to the "highest attainable standard of health" (p. 14).
26	Habilitation and rehabilitation	Member states should support habilitation and rehabilitation with the desired outcome of achievement and maintenance of maximal functional independence. Availability, knowledge, and use of AT should be supported.
27	Work and employment	Persons with disabilities have the right to equal access to gainful employment of their own choice. Reasonable accommodation of needs of the person with disability is required in the workplace.
29	Participation in political and public life	Ensures accessibility of location and means to enable persons with disabilities to exercise their right to participate in political activities, including their right to vote. Active promotion of an environment that enables full participation in community activities of choice.
30	Participation in cultural life, recreation, leisure, and sports	Accessible formats, materials, and environments are required to support the participation of persons with disabilities in all aspects of cultural life, recreation, leisure, and sports.

AT, Assistive technology.

From United Nations. (2007). Convention on the rights of persons with disabilities (CRPD), resolution 61/106. https://www.un.org/development/desa/disabilities/convention-on-the-rights-of-persons-with-disabilities/convention-on-the-rights-of-persons-with-disabilities-2.html.

in terms of use, availability, and information; promotion of AT accessibility; and provision of information about AT in accessible formats. It further calls for education of professionals to support all aspects of AT service delivery (UN, 2007)

A **rights-based model of disability** is inherent in the CRPD; the language of the document is explicit regarding the focus on the rights of persons with disabilities. Complementary to a **social model of disability** that identifies social contexts as creating disability, the rights-based model essentially recognizes "the inherent dignity of the human being and subsequently, but only if necessary, [focuses on] the person's medical characteristics" (Lawson & Beckett, 2021, p. 150). A rights-based model codifies the CRPD (Degener, 2016; Lawson & Beckett, 2021).

Lawson and Beckett (2021) identify four implications of a rights-based model of disability to the CRPD. It specifies that disability strategies must be included in legislation, regulations, policies, and so on, at all levels of government and institutions. Further, involvement of persons with disabilities in the creation

and monitoring of these system documents is imperative. The model can be used to identify situations in which there is infringement on the rights and freedoms of persons with disabilities. The model is also used to raise awareness of these situations that restrict the freedom of persons with disabilities.

The social model of disability is a paradigm shift in the understanding of disability, reflecting a movement away from the medical model. The medical model locates the "problem" in the individual, as some impairment that needs to be fixed. Intervention that focuses solely on making changes to the individual follows a medical model. Although these interventions are certainly useful and often necessary, use of the medical model exclusively limits recognition of other causes of disability that lie outside of the individual's body structures and function (McColl & Jongbloed, 2006; Whalley Hammel, 2006).

The social model of disability moves the location of the disability out of the person and into social structures (Oliver, 2013). It recognizes that social perceptions, attitudes, institutions, and policies all contribute to the creation of disability. Furthermore, disability creation results from a dynamic combination of personal characteristics, physical settings, and cultural norms that is "situational and interactive" (Fougeyrollas & Gray, 1998). These situations lead to exclusionary practices that limit the activity and community participation of individuals on the basis of their impairments.

The social and rights-based models of disability complement each other, with the first identifying and describing the influence of context (physical, social, cultural, and institutional) on the creation of disability, while the latter prescribes how political and institutional structures are developed and monitored to be inclusive of the rights of persons with disabilities. In practice, the enactment of a rights-based model is dependent on the descriptive and conceptual aspects of a social model.

DEFINITIONS OF ASSISTIVE TECHNOLOGY

Formal Definitions

Definitions allow us to frame the construct of interest and convey to others what we include and exclude in the use of a term. In a legislative or policy context, definitions delimit the scope of the law or policy, influencing how each is interpreted and applied. For example, in jurisdictions where AT funding is supported through the government, a definition is used to determine what constitutes an assistive product that is eligible for funding versus one that is not.

The WHO defines AT as "the application of organized knowledge and skills related to assistive products, including systems and services. Assistive technology is a subset of health technology" (WHO, 2016, p. 1). Assistive products are "any external product (including devices, equipment, instruments or software), especially produced or generally available, the primary purpose of which is to maintain or improve an individual's functioning and independence, and thereby promote their well-being. Assistive products are also used to prevent impairments and secondary health conditions" (WHO, 2016, p. 1).

We consider both the assistive products and the services that support their selection, acquisition, and use in this book. Our understanding of assistive products is inclusive of mainstream technologies and those developed specifically for persons with some form of impairment (see Chapter 2). The importance of services, policies, and infrastructure is highlighted in this book; service delivery and product support are not simply the provision of a product. Rather, the opportunity to use a device for desired occupations, across multiple environments and without prejudice, is critical. Throughout this book, we focus on activities broadly categorized as communication, cognition, mobility, and manipulation and the technologies that enable them. However, we do so by incorporating mainstream and specialized technologies; discussing services and policies that support their development, acquisition, and use. Research into different aspects of AT is expanding rapidly. We focus on the principles and practice of AT service delivery, outcome evaluation, and research and development and direct the readers' attention to useful sources where relevant. We do not attempt to present all the evidence that supports AT effectiveness in enabling users to engage in the personal, political, social, and economic occupations of their communities, as this task is not possible within the confines of this book.

Differentiating Assistive Technology From Other Technologies

Discussions and writings about participation and function of individuals with disabilities include a vast array of terms that include constructs of technology. Some of these include rehabilitation technologies and educational technologies.

We understand rehabilitation technologies to be devices that have a primary use in a clinical setting, such as parallel bars, overhead slings, and tilt tables, and that are primarily used for habilitation or rehabilitation purposes. Educational technologies are those that make educational materials more accessible, such as apps that provide educational curricula in some alternative, accessible format.

We do not include rehabilitation or educational technologies in this book, although some of the products that we discuss do have application in a rehabilitation or educational setting. Many of the products that promote communication, positioning, computer access, or support cognitive activities also assist the learner in engaging with educational technologies, with the difference being the emphasis on enabling participation versus achieving specific educational goals.

Additionally, our focus is on AT for personal use, technology that is "individualized and usually follows the person" (Sanford, 2012), in contrast to designs that make environments more accessible to individuals with a variety of abilities, such as automatic door openers and ramps that stay fixed in a location and are used by many who come to that particular location (Sanford, 2012). We include these environmental modifications in the context component of the HAAT model.

PRINCIPLES OF ASSISTIVE TECHNOLOGY SERVICE DELIVERY

AT is presented in this book primarily from the perspective of the application of a clinical process to identify the need for AT,

determine the most appropriate product(s), obtain the product, and then provide follow-up and outcome evaluation to ensure the user is able to use the product.

We propose several principles that foreground **AT service delivery**: (1) the process is **person centered**, (2) the outcome is enablement of participation in desired activities, (3) an **evidence-informed** process is used for service delivery, (4) AT service delivery is provided in an ethical manner, and (5) AT services are provided in a sustainable manner. These principles are introduced here, explored in greater detail in Chapters 3 through 5, and applied in subsequent chapters that discuss specific categories of AT. They should be interpreted from the context within which AT services are provided.

Person Centered

The provision and development of AT are not about fitting the person to the technology. Rather, they are about using a process with the outcome of meeting the needs of the user when engaging in relevant activities across necessary contexts. Central to this principle is the recognition that the user of the technology is in control of their own life.

On the product development side, technology that is developed without adequate input from end users throughout the design process or adequate knowledge of how the technology will be used is less likely to be adopted for its intended purpose. The resulting technology may be designed to meet a need that does not exist for the intended user.

On the service delivery side, AT that is recommended or prescribed without input from the user and relevant others ends up abandoned or not used to its full potential. One participant in a project that collected stories of individuals with spinal cord injuries and their use of AT illustrated this point well. He described his abandonment of complex technology that did not provide him with any perceived advantage over simpler devices. Furthermore, the necessary products were recommended before returning to live at home. Some products were not needed, and others that would have been useful had not been acquired (SCIPILOT, n.d.). There are many reasons for product abandonment; a large proportion of it is the result of a process that does not adequately involve users of AT. More will be discussed about product discontinuance/abandonment in Chapter 5.

Focus on Functional Outcome and Participation

Similar to the ideas expressed in the first principle, this second principle indicates that what a person does with a product is important, not simply that they are provided with a device. In other words, a product that is provided without proper training, fitting, or follow-up can result in suboptimal use that may limit the user's ability to engage in activities. Our conceptualization of AT includes the activities in which the user engages. It is important to understand what a person wants, needs, and is expected to do, throughout the AT service delivery process. More important, though, is the recognition that simply noting that a person can operate a product is insufficient in predicting whether they will use it in their daily life.

It is critical to understand how people are using their products and whether they are used in a manner of their choosing. For example, an individual may be able to control a power wheelchair (i.e., use a joystick to regulate speed and direction). However, if the wheelchair cannot be used in desired environments—perhaps it is too large to maneuver in a user's home—then the user will be unable to use it to support activities in these locations. Similarly, if the use of a power wheelchair holds the stigma of disability for the user, then it is likely to be underused. The idea here is that the device becomes an extension of the person for many users (i.e., it conveys part of their image). When its use contributes to an undesired self-image, it is not used to the full advantage. It is not sufficient for the device to enable function; it must do so in a manner that supports how the user wants to engage in that function. This concept is discussed in more detail in Chapter 2.

Evidence-Informed Process

Use of an evidence-informed process benefits the user of AT by ensuring that elements of AT service comprehensively include steps to identify technology that is most appropriate for the user; to provide necessary training and support for initial and ongoing use of the technology; and to evaluate adequately the outcome of the technology, not only for the individual user but for aggregate groups as well. Evidence may come from data collected systematically through the service delivery process and through research studies investigating a wide range of questions surrounding AT. The different types of evidence and research that support AT are discussed in Chapter 5.

Amassing aggregate data concerning different aspects of the AT service delivery process is key to building the evidence base. Throughout the years, a corpus of evidence has been built to support the AT assessment and recommendation processes, training, ongoing evaluation, and functional outcomes. However, as professionals experienced in AT are aware, more research is necessary to support this area. Moreover, funders of AT frequently require evidence that supports specific outcomes of AT use before they will support the purchase of products.

Ethical Process

An ethical process includes multiple perspectives: professional or clinical code of **ethics** along with embodying constructs of **autonomy**, **justice**, **beneficence**, and **nonmaleficence**, as well as broader philosophical and ethical worldviews that speak to means of creating an inclusive society that enables meaningful engagement in community participation for all. Key ideas that form the background for ethical AT service delivery are introduced briefly here. We expand on these ideas in Chapter 4.

Professional and Clinical Codes of Ethics

Many reading this book are engineering or health care professionals or students whose practice is guided by a formal code of ethics. A review of several different codes of ethics (e.g., from the Rehabilitation Engineering and Assistive Technology Society of North America, the Institute of Electrical and Electronics Engineers, the Canadian Association of Occupational Therapists, the Swedish Association of Occupational Therapists, the American Physical Therapy Association, the World Confederation of Physical Therapy, and the American Speech-Language-Hearing

BOX 1.1 RESN Code of Ethics

RESNA is an interdisciplinary professional association dedicated to promoting the health and well-being of people with disabilities through increasing access to technology solutions. It is committed to the high standards of practice and ethics in the AT field. Its members:

- Hold paramount the welfare of persons served professionally.
- Practice only in their area(s) of competence.
- Maintain the confidentiality of privileged or confidential information.
- Disclose all conflicts of interest.
- Know and comply with the laws, regulations, and policies that guide professional practice.
- Act in a manner that positively reflects upon the AT profession.

RESNA, Rehabilitation Engineering and Assistive Technology Society of North America.
Modified from Summary of RESNA Code of Ethics. https://www.resna.org/Certification/Ethics-and-Standards-of-Practice/Code-of-Ethics.

Association) uncovered many commonalities. Box 1.1 shows the Rehabilitation Engineering and Assistive Technology Society of North America Code of Ethics.

The principles of beneficence (do only good), nonmaleficence (do no harm), and fidelity are prominent in these professional codes. These principles are translated into practice through actions that embody professional integrity, accountability, and maintenance of continuing competence and professional standards.

Ethical codes explicitly describe the client/patient-clinician/provider relationship. Simply stated, this relationship is guided by respect for the welfare, rights, and self-determination of the client. In practice, the clinician recognizes the client's autonomy and right to be fully engaged in the clinical or service delivery process. The clinician or service provider acts in a trustworthy and truthful manner, maintaining client confidentiality. These codes assert the balance between client–service provider roles while concurrently declaring the responsibilities for providing competent, honest, and respectful service.

Some codes *suggest* that practice be based on principles of **social justice**, which is described in more detail in the following sections. Social justice in this context refers to accessibility of AT services for all who require it.

Social Justice

John Rawls expressed foundational principles of social justice that inform our discussion. Social justice concepts were initially framed from an economic perspective, referring to equitable access to rights and resources (e.g., income and material goods) within society (Rawls, 1999). Capability theory advances Rawls' ideas to further suggest that all individuals have equal access to basic rights and freedom of choice (Nussbaum, 2011; Sen, 2009).

Application of these ideas to persons who use AT in their daily lives recognizes the economic disadvantage they experience through fewer opportunities to participate in income-generating activities and the concomitant reductions in their incomes because of the greater expenses incurred because of the disability.

Specifically, the lack of availability of or access to AT limits the ability of a person with a disability to engage in community occupations; in particular, it limits the person's ability to participate in economic activities that, in turn, afford sufficient resources to support themselves or their families (Samant et al., 2013; WHO & World Bank, 2011). For example, a person who has difficulty communicating with unfamiliar others, but who could do so with the use of an augmentative and alternative communication (AAC) device, is barred from employment and other civic activities (among other things) when access to such AT is not available. In this situation, societal elements are the limiting factor, restricting the individual's full participation in the community and beyond.

A second source of inequity is seen in a situation in which two people with the same level of income, one with a disability (or who supports a family member with a disability) and one without, will have very different incomes when the costs associated with the disability are considered (Samant et al., 2013; WHO & World Bank, 2011). Persons with disabilities have many expenses that those without disabilities do not encounter, such as personal assistant costs, higher transportation costs, home modification costs, and, of course, the cost of AT, which is often significant. Globally, the purchase of these devices is inconsistently supported, with the result that a person or family who must obtain AT will have to pay them out of their pocket.

A formal approach to social justice is seen in legislation such as the Americans With Disabilities Act of 1990 that attempts to legislate formal mechanisms to remove barriers to full participation in society for individuals with disabilities (Danermark & Gellerstedt, 2004). Similarly, the United Nations Convention on the Rights of Persons with Disabilities (UNCRPD) identifies basic rights that all member states must support for their citizens and explicitly states that AT must be accessible regardless of gender, age, or impairment. Throughout this book, we identify and apply formal social justice mechanisms as they relate to AT service delivery.

In Chapter 2, we identify key questions to be asked of relevant legislation in the reader's own jurisdiction in order that they gain knowledge about how these formal structures affect accessibility and acquisition of AT. When relevant, we discuss these issues as they relate to individual categories of AT. Chapter 4 discusses ethical principles, including principles of justice in more detail.

Assistive Technology Services Are Provided in a Sustainable Manner

In the context of AT service delivery, **sustainability** means providing AT in a manner that ensures that people who need it have access in a timely and continuing manner. This basic idea is enacted somewhat differently in well-resourced and under-resourced economies.

Many well-resourced countries face a population shift that is well known; their populations are aging, with the largest proportional increase seen in the "old-old" (i.e., persons older than 75 years). These individuals experience a greater incidence of disability, including multiple impairments, and account for the largest proportion of health care spending. The cost of health

care is significant in developing countries to the point that current systems are not sustainable.

Some of the health care funds in these countries are used to support the cost of selected AT, including products and services associated with **assessment** of and training in the use of assistive products. Clinicians contribute to sustainability by balancing the rights and needs of clients with the reality of limited health care funds. This statement does not mean that health care and other professionals do not advocate for the needs of clients; rather, it means use of an evidence-informed process to identify AT that will meet the client's needs, including the client in this process, to ensure that devices obtained are used (i.e., do not end up in a closet, drawer, or the garage) and are used to their maximal potential.

In underresourced economies, sustainability often means development and establishment of AT services. Products and services that are readily available in developed countries may not be present in these emerging economies, generally because of cost, legislation, lack of infrastructure, and other resource limitations (Samant et al., 2013). Establishment of AT services and an AT industry means working with local manufacturers, using local materials, and designing products that are functional in the local context (Borg et al., 2011; Owen & Simonds, 2010; Samant et al., 2013). It also means providing technology that can be maintained and repaired using local knowledge, technology, and materials (Owen & Simonds, 2010). Furthermore, it means provision of products and services that are affordable by persons with disabilities (WHO & World Bank, 2011).

THE HUMAN ACTIVITY ASSISTIVE TECHNOLOGY MODEL

Cook and Hussey (1995) introduced the HAAT model in the first edition of *Assistive Technology: Principles and Practice* (1995). The model describes someone (**human**) doing something (**activity**) in a context using AT. As previously stated, this basic explanation is deliberately worded to demonstrate where AT fits in the model. The emphasis is on the person engaged in an activity within chosen environments. Consequently, any application of the model starts with someone doing something in context and then introduces the AT. This order reminds users that AT is intended to meet the needs of the person, rather than requiring the person to adapt to the AT. Fig. 1.1 illustrates the HAAT model.

The HAAT model is introduced briefly in this chapter. We provide a detailed discussion of each element in Chapter 2, while the model is applied to specific categories of AT in the second part of the book.

Foundational Concepts

The HAAT model shares many features of other models that integrate activity (occupation), the person, and the environment. It has evolved in parallel with influential models such as the WHO's ICF (WHO, 2001), the Canadian Model of Occupational Performance and Enablement (CMOP-E) (Townsend & Polatajko, 2002, 2013), and the Person-Environment-Occupational-Performance (PEOP) model (Baum & Christiansen, 2005).

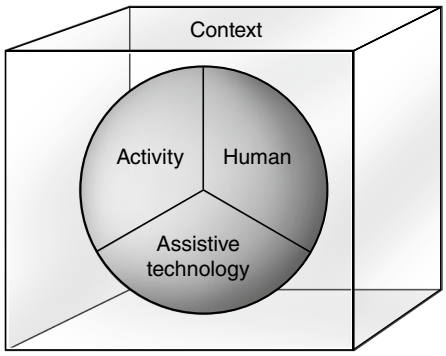

Fig. 1.1 The Human Activity Assistive Technology model.

These related models inform the different elements that comprise the HAAT model, which differs from these other models through its explicit consideration of AT.

International Classification of Functioning, Disability, and Health

The WHO's ICF (WHO, 2001) is a well-recognized and frequently applied model that classifies components of body structures and functions, activities and participation, and the environment in terms of their influence on health. Four aims are stated for the ICF, two of which have relevance to our discussion: (1) to provide a basis for research on health and its determinants and (2) to establish a common language that will foster effective communication across different users (WHO, 2001). Relevant components of the ICF are described in greater detail when discussing the components of the HAAT model (see Chapter 2).

AT is primarily located in Chapter 1 of the ICF, "Products and Technology of the Environmental Factor." AT for certain participation contexts, such as education, is also identified. The ICF describes environmental factors as external to the person. The challenging aspect of this concept when considering AT is that although AT is certainly external to the user, it is much more personal than other elements of the environment, such as an elevator that is adapted to meet the needs of individuals with mobility or vision impairments. As we discussed earlier, AT often becomes part of the individual's self-image—essentially an extension of themselves. AT is commonly recommended for a specific person who brings the technology along to different situations. Similar to other environmental elements, AT is designed and modified to suit the needs of the person. However, the personal nature of most devices requires the consideration of the person using a certain device when thinking about activities and participation within and across environments.

Ecological Models in Occupational Therapy

Models that describe the relationships among the person, the environment, and occupation inform the practice of occupational therapy. Two particularly influential models are the CMOP-E (Townsend & Polatajko, 2002, 2013) and the PEOP model (Baum & Christiansen, 2005). Fig. 1.2 demonstrates a comparison of the main components and subcomponents of each of these models and the HAAT model.

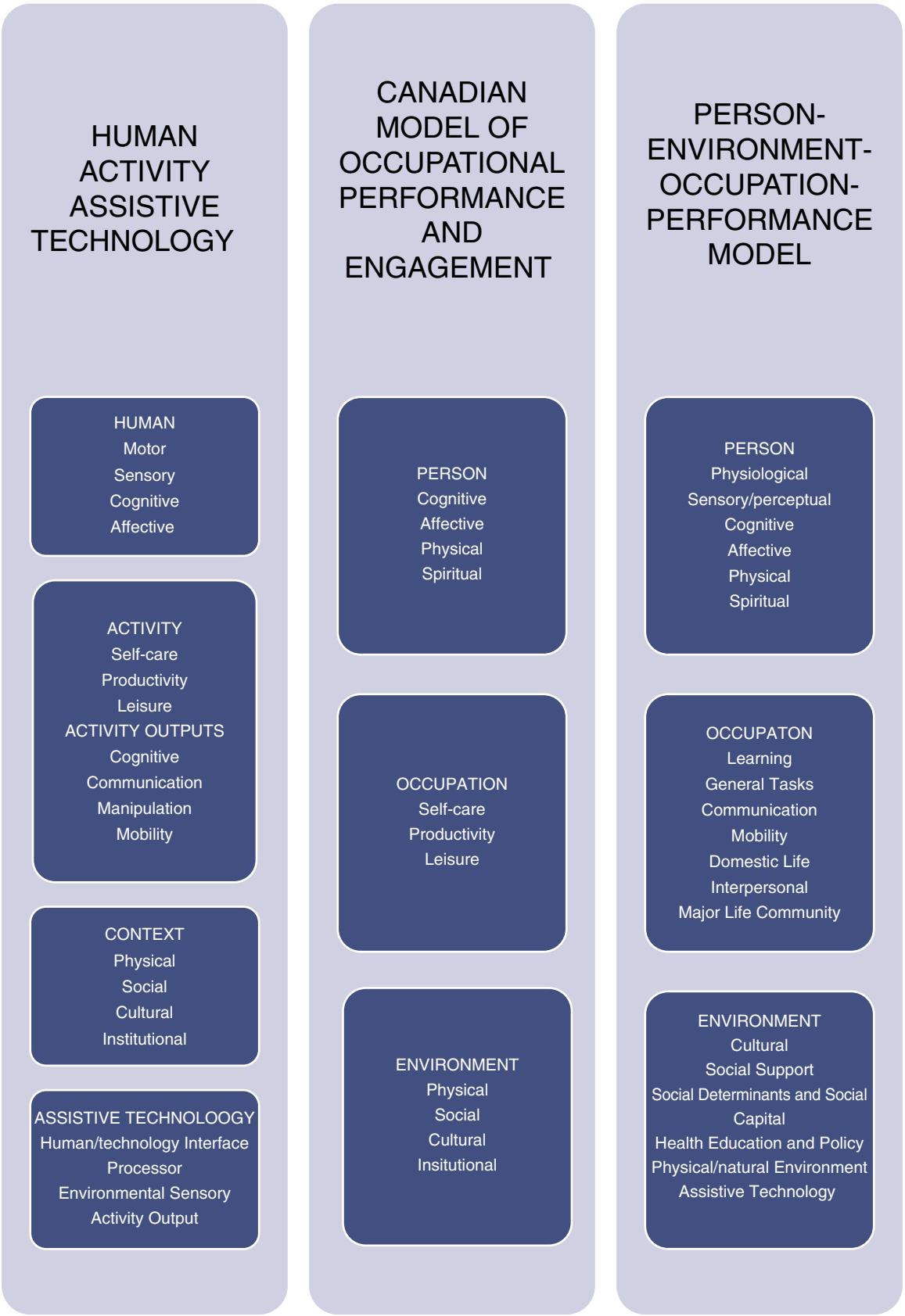

Fig. 1.2 Comparison of the Human Activity Assistive Technology, Canadian Model of Occupational Performance and Enablement, and Person-Environment-Occupational-Performance models.

The CMOP-E and PEOP are **ecological models**; specifically, they consider the influence of the interaction of a number of elements on occupational performance, participation, health, quality of life, and well-being. It is the transactional nature of the person, environment, and occupation that results in the occupational performance outcome.

In addition to the central constructs of person, environment, and occupation, these models share other ideas. Both articulate notions of environmental enablers and barriers, which are features of the environment that facilitate occupation or limit it. Occupation, or activity, is seen as the interface between the person and environment, the means by which the person is part of the world. They help guide clinical practice by articulating a practice process. The CMOP-E does not explicitly identify AT; however, the PEOP, which is based on the ICF, locates AT within the environmental component.

Models such as the PEOP and the CMOP-E influence our recent articulations of the HAAT model by informing the notion of activity to move beyond a mere classification of what the person is doing and incorporate the complexity of the phenomenon of occupation, which helps us understand the place of AT in the performance of occupation and the enablement of participation. It is not only about how the AT supplements the performance of an activity (e.g., how a calendar application can supplement memory by reminding the user of upcoming events) but also about how the user views the occupation and the influence of the different aspects of the environment (or context using HAAT terminology). Similar to the ICF, the CMOP-E and PEOP models move the emphasis away from the technology and back to the person doing something in a context, which is the essence of the HAAT model.

The HAAT model is built on four components: the activity, the human, the AT, and the context. The model is conceptualized as transactional in nature to capture the experience of individuals as they engage in activities. This transactional nature broadens our understanding of a person's participation as enabled by AT through the recognition of the dynamic nature of the person's experience in a situation as they interact with other people and the nonhuman aspects of the context.

Activity

Activities are described in the ICF as the execution of tasks; participation is defined as the involvement in a life situation (WHO, 2001). Activities and participation go hand in hand in the ICF, congruent with the construct of occupation in occupational therapy models. In the HAAT model, the activity element encompasses what the person is doing, why, how, where, temporal aspects, and other activities it may support. Following the ICF and the CMOP-E and PEOP models, activities of daily living can be classified into self-care, productivity (work, volunteer activities, or education), and leisure. However, this categorization scheme has been challenged as being too limiting (Jonsson, 2008). The reason for performing a given task may change its classification (one can ride a bicycle to commute between home and work or to enjoy leisurely rides for fun during weekends). Many of us experience the need to perform multiple tasks concurrently, suggesting that this notion of categories of activity is artificial, something that allows us to discuss activity conveniently. Although we will discuss different categories of activities to aid understanding of the concepts and the application to AT, it is understood that the person may engage in multiple activities concurrently and that engagement in activity is dynamic, with participation flowing among different activities.

It is important to understand if the activity should be performed independently or if assistance from others or technology can be considered. Does it involve other persons, perhaps in a collaborative way, or will it be performed alone? Knowledge of where the activity occurs is necessary to determine the contextual influences on activity performance and the effect on the use of AT across these contexts, as well as issues affecting transportation of the device as required. Temporal aspects of length and frequency of participation in activity (e.g., multiple times a day, weekly, monthly, seasonally) need to be taken into account.

The activity component of the HAAT model assists the understanding of the tasks in which the user of AT participates. It guides product research and development, selection of AT, identification of functional outcomes to evaluate AT use, and definition of the research question. It helps us think about what the user does with the AT, bearing in mind that sometimes the doing is not observable.

Human

The human component of the HAAT model includes the user's abilities in motor, somatosensory, cognitive, and affective areas. Understanding of the human's function in these foundational areas is necessary to guide the recommendation of effective AT and to develop training programs. Therefore, the user's abilities should be covered in initial and ongoing assessments and outcome evaluations. Assessment here also includes acknowledgment of whether a change in ability is expected to occur (i.e., improvement through developmental changes or recovery or decline through age-related changes or due to the nature of a progressive condition). Function of these basic elements is interpreted in terms of their ability to support performance of desired and necessary occupations, enabled through the use of AT.

Beyond knowledge of body function, an understanding of the person's roles in life and experiences with technology and motivation, and use of a lifespan perspective are important aspects of the human component of the HAAT model. Roles involve the combination of many activities across different contexts and contribute to a person's identity. Common roles include parent, worker, student, and consumer. Motivation is an important aspect of the human and is understood from two perspectives, motivation to return to performance of specific activities and motivation to use AT.

A lifespan perspective directs the clinician to consider the developmental aspects of the human. A young child's skills and abilities are developing, necessitating reliance on their parents to support activity performance and AT use. An older adult with age-related functional losses will have different needs for AT design and support. In addition, the use of AT may be perceived as a visible sign of loss, often related to aging.

The concepts of novice and expert technology user influence the balance between clinician and user input into the assessment and training processes. A novice user, lacking knowledge and experience, relies more on the clinician for information. In contrast, experienced users know what they want the technology to do and are more active in driving the AT acquisition process.

Context

The HAAT model uses the term *context* in contrast to many other models that use the term *environment*. The original HAAT model was based on a human factors understanding of the human-system interaction (Bailey, 1996). The notion of context, as used by Bailey, described human factors in the use of systems and was more inclusive than the term *environment*.

The HAAT model reflects the social model of disability by making the contextual aspects of AT design, service delivery, and use explicit and prominent. Four contextual components are included: (1) physical context, including natural and built surroundings and physical parameters; (2) social context (e.g., with peers, with strangers); (3) cultural context; and (4) the institutional context, including formal legal, legislative acts, and regulations; policies, practice, and procedures at other institutional levels, such as educational, work, organizational, and community settings; and sociocultural institutions, such as religious institutions.

The **physical context** includes elements of the natural and built environments that support or hinder participation. Different natural terrains (e.g., snow, ice, sand) are examples of aspects to consider in the physical context as they affect mobility. The built environment may include features such as Braille signage or ramped building entrances that support participation. Physical parameters of noise, light, and temperature also are part of the physical context.

The **social context** includes individuals in the environment who affect activity participation and AT use. Direct and indirect interactions are distinguished here, with recognition that interaction with others face-to-face, remotely, or indirectly all have an influence. Individuals who exert an influence indirectly are those responsible for the development and enactment of policies and procedures that affect the participation of persons with disabilities. The social context also includes consideration of the society in which individuals live and the social values, norms, and attitudes that affect their full social inclusion. The social context can either support or hinder an AT user's participation. Understanding social mores as they relate to effective use of AT systems like AAC is part of the social context.

The **cultural context** involves systems of shared meanings (Bruner, 1990; Jonsson & Josephsson, 2005) that include beliefs, rituals, and values that are broadly held and that do not change as quickly as socially held attitudes and practices. Although similarities exist among social and cultural contexts, cultural beliefs transcend social settings and are formed as part of membership in a group, such as a religious or ethnic group, rather than living in a particular social context. The perception of time and space, rights and responsibilities of different members of a group, independence and autonomy, and beliefs about the causality of life situations such as disability are all dependent on the cultural context and influence actions and attitudes (Jonsson & Josephsson, 2005).

The final element of the context is the **institutional context**. This component refers to the systems, services, and policies that directly or indirectly affect the lives of persons with disabilities. For example, legislation may directly relate to persons with disabilities, such as the Americans with Disabilities Act (1990) in the United States. Systems and services, such as those relating to transportation, may indirectly affect persons with disabilities if they ignore the needs of these individuals. On the funding side, legislation, regulation, and policy define who and what are eligible for funding and the process whereby funding is obtained.

Assistive Technology

AT in the HAAT model is viewed as an **enabler** for a human doing an activity in context. This component has four aspects: the **human/technology interface** (HTI), the **environmental sensor**, the **processor**, and the **activity output**.

Interaction with the human is through the HTI, which forms the boundary between the human and the AT. A two-way interaction occurs at this boundary (i.e., information and forces are directed from the human to the technology and vice versa). Some assistive technologies (e.g., speech-to-text apps) must also be capable of detecting external environmental data. The environmental sensor accomplishes this function. The technology supports activity performance through an activity output, which is specified in the HAAT model as cognition, communication, manipulation, or mobility.

The HTI, the environmental sensor, and the activity output are linked by the processor. The processor translates information and forces received from the human and environment into signals that are used to control the activity output. It also interprets and formats data from the device and the environment to present it to the user. Not all assistive technologies have all of these components. However, all of them have at least one of these components, and most have two or three.

Assistive technologies can be considered on a continuum that identifies technology produced for the mass market, or **mainstream technology**, to technology that is created for a single individual (see Fig. 1.3). As will be seen in Chapter 2, increasingly individuals with disabilities can use technology that is mass produced, intended for a wide consumer audience. In particular, information and communication technologies are now accessible for individuals with a wide range of abilities. Mass-produced devices are typically easier to obtain and less expensive than devices that are produced specifically for individuals with disabilities. At the other end of this continuum are devices that are created for a single individual (or a very small number of people), that meet very specific needs of that person. These devices tend to be more expensive and more difficult to obtain because they are custom made and produced in very low numbers. On the midrange of the continuum are products that are produced for individuals with disabilities that are usually used "off the shelf" with minimal or no modifications necessary.

The complexity of the technology is another consideration of this component of the HAAT model. A continuum of

Fig. 1.3 Continuum illustrating the progression from mainstream to custom-made technology.

complexity ranges from simple to complex in terms of ease of use and the configuration of the AT hardware. Devices that are simple to use tend to be more acceptable to the user and less likely to be used incorrectly. However, they often have less functionality and reduced value to the user.

Another way of considering complexity is by describing technology as low tech or high tech. Low-tech devices are simple to operate and construct, often are manually driven, are easy to acquire, and are low cost. Examples of low-tech devices are mouth sticks, adapted utensils, and computer keyguards (see Chapter 11). In contrast, high-tech devices are more complex to use; frequently are electrically powered or feature electronics; have multiple functions, including functions that are defined by the user; and are more expensive. AAC devices, power wheelchairs, electronic aids to daily living, and robotic devices are all examples of high-tech devices.

A final distinction is made between assistive products and AT services. **Assistive product** refers to the actual device, such as computer hardware or software, an AAC device, or a mobility device. In contrast, **assistive technology services** refer to less tangible aspects that support the selection, acquisition, and use of an assistive product. These include service delivery systems, encompassing assessment methods and instruments, concept formation, and decision-making skills when recommending or purchasing a product or procurement and provision of assistive products. They also include training in product use, to develop the strategies that allow a person to make the most of the assistive product. Initially, a new user or clinician may depend heavily on external resources, such as this textbook, to learn about device use. With greater confidence and knowledge, additional strategies and flexibility are applied to device use and to the service delivery process. Finally, AT services also include follow-up to ensure the product continues to meet the user's needs in the long run.

Reassembling the Human Activity Assistive Technology Model

The HAAT model describes a complex and dynamic framework for understanding the place of AT in the lives of persons with disabilities, guiding both clinical applications and research. It includes several different elements that affect the use of AT. The dynamic nature of the model reminds us that these elements interact and influence each other and that the degree of influence changes. For example, in the summer, the weather, which is part of the physical environment, may have little influence on the outdoor mobility of a person who uses a device that supports mobility. However, in the winter, when snow, ice, and cold are present, the physical context has a much greater influence on outdoor mobility. The institutional context supports activity participation via AT use when public funding is provided for device acquisition but becomes a hindrance when devices are not funded at a sufficient level or perhaps not at all.

Collectively, the elements of the human, activity, and context affect the selection and success of the AT as an enabler of human activity. The HAAT model leads to a consistent process for product design and recommendation that recognizes the importance of understanding the activity the person wants or needs to perform, the capabilities of the individual, and the influence of the different aspects of the context on device acquisition and use. Understanding the activity ensures that the assistive product will support the performance of something useful. Understanding individuals results in knowledge about not only their abilities, skills, and knowledge but also their stage in life, their experience with technology, the roles they enact, and the meaning they hold for the activity, their disability, and use of AT. Understanding the context results in knowledge of how the physical, social, cultural, and institutional contexts individually and collectively support or limit activity participation of an individual with a disability, as well as the acquisition and use of AT.

Client- or user-centered approaches are primary themes in the application of the HAAT model. It is important to understand the person's goals and perception of their own needs as a starting point in the service delivery and research process. Technology that does not meet the person's needs or expectations will not be useful in supporting the person's full potential. Most of us probably have devices that we thought would be useful when purchased, but that did not meet our expectations and were put aside. In the case of AT, particularly for devices that are acquired with public funds, such device abandonment has greater implications if the user's activity performance is compromised or scarce health care funds are wasted.

In the next chapter, the different elements of the model are presented individually in greater detail, and then their mutual interactions are described. Although we do separate the components in order to discuss the key ideas of each, it is important to understand that the model is intended to be considered as a unit, with each element contributing to the desired outcome of activity performance and community participation of the technology user.

Other Ecological Models of Assistive Technology

Two other models were developed specifically to address AT assessment and service delivery: the Matching Person and Technology (MPT) model (Scherer & Glueckauf, 2005) and the Comprehensive Assistive Technology (CAT) model (Hersh & Johnson, 2008a, 2008b). Both of these models incorporate elements of the person, the environment, and the technology. CAT also incorporates the activity component.

The MPT was developed to support an AT assessment process that is goal directed, client centered, and designed to facilitate the identification of AT that is most likely to be used by the individual. The model incorporates three key elements: person (preferences and needs), milieu (elements of the environment that affect AT use and function), and AT (features and function) (Scherer & Glueckauf, 2005).

Several assessments are available that are based on the model. Commonly, these assessments require input from both the potential user or client and the professional assisting with the identification of appropriate AT. The assessments include evaluation of current use of technology and a series of tools that evaluate the attitude and experience with general, educational, and workplace technologies. These assessments are discussed in Chapter 5 on service delivery.

The MPT approach is consistent with HAAT in that it considers a complex situation (use of technology), identifies critical elements that affect the situation, and understands that making changes in one element will effect change (positive and negative) in other elements. The MPT does not specifically discuss activities, which are explicit in the HAAT model; however, links to the WHO Activities and Participation categories have been made with different MPT measures (Scherer & Glueckauf, 2005).

The CAT model is closely connected to the WHO ICF and was primarily designed to categorize and describe different features that influence the use of AT. Design specification, initial assessment, and outcome evaluation are identified as the prime applications of CAT (Hersh & Johnson, 2008a). The model is organized in a tree-and-branch structure, with different options of display (e.g., chart, table, and flow diagram), depending on the user's needs and preferences. The main categories are activities, human, context, and AT, each branching into several subcategories over two sublevels.

Hersh and Johnson (2008b) demonstrate the different applications of the model, with the benefits of identifying key elements to consider when designing, selecting, or evaluating AT. They show how the model can be used to describe relevant features for a specific purpose.

Conceptually, the CAT model is very similar to the HAAT model because it contains very similar main categories. Both models can be used for similar applications of device design and development, guidance of the service delivery process, and outcome evaluation. The main difference between these models is in the supporting description—whereas the HAAT model posits a more dynamic interaction among the different components, CAT seems to provide more description of the individual categories in a situation rather than describing an interaction among these categories.

APPLICATION OF THE HUMAN ACTIVITY ASSISTIVE TECHNOLOGY MODEL

The HAAT model has four primary applications: (1) clinical assessment, (2) outcome evaluation (including both individual and collective outcomes), (3) product research and development, and (4) product **usability** studies. The general process for each of these is similar: identification of the desired activity, consideration of the individual or collective user characteristics, and determination of the contextual factors that influence the device acquisition and use all precede consideration of the AT.

Clinical Assessment

The AT assessment process is described in greater detail in Chapter 5. Basically, it involves identification of the need to be addressed by AT use (the activity), evaluation of key aspects (human and context), synthesis of the evaluation results, and device recommendation (the AT). The HAAT model thus guides the clinician in the necessary steps for a comprehensive AT assessment. Recall that the HAAT model is described as person, engaged in an activity, within a context, using AT. This framing of the model guides clinical evaluation to consider the collective influence of the activity, person, and context on the performance of daily activities before making a recommendation for AT to support function.

Outcome Evaluation

Outcome evaluation refers to assessing AT use. It can be done at an individual level, to check whether the AT is, in fact, meeting the particular user's needs. Ideally, it occurs at several points after acquisition of the device: immediately after acquisition and short- and long-term follow-up. In reality, the possibility of conducting these evaluations depends on funding, institutional policies, and clinician workload. Unfortunately, often the only time a clinician is able to follow up with the client is at the time the device is delivered, which limits the ability to evaluate how well the device has been integrated into the client's life.

Outcome evaluation can also be done at a group of users level, often framed within a formal research study with the purpose of building an evidence base related to the AT use to support clinical decisions, influence policy, or justify new and continued public funding. In this case, the focus is more on showing the ability of the device to meet the intended need and obtaining feedback on device design for future development.

The HAAT model is a useful framework for both outcome evaluation purposes. It focuses the attention on the user(s) that is (are) doing something in context using AT, shifting it away from the assistive product. It is irrelevant if the assistive product is performing as it was designed to perform if it does not meet the needs of the end user. Proper outcome assessment needs to consider the activity, the human, and the context to evaluate AT use.

Product Research and Development

Products that are developed without consideration of the activity, human, or contextual needs and influences are less likely to meet the needs of the user. For this reason, we advocate

conducting preparatory studies that investigate these needs before a product is designed. Two of the foundational principles of this book—AT design and service delivery processes that are person centered and function based—are influential here. The lived experiences of individuals with disabilities are critical parts of the AT research and development process to support identification of the need for a product and to evaluate the success of each design iteration to meet that need.

Usability

Fisk et al. (2009) distinguish between device utility and usability. Whereas utility describes how well the device meets its intended function, usability describes how well the user is able to access the device's functionality (Fisk et al., 2009). They identify five key features of usability:

1. Learnability: All functions of the device are easily learned. We would add consideration of the effectiveness of assistive services to support learning here.
2. Efficiency: The user meets the intended goals of device use in a reasonable amount of time with minimal frustration and effort.
3. Memorability: How the device is used can be easily remembered, particularly when a function has not been used over a long period of time. An example of memorability involves programming a particular function on a mobile phone. When the programming process is easily retained or retrieved from memory, this aspect of usability is satisfied.
4. Errors: This aspect refers to incorrect actions the user makes or actions that are omitted that limit or prevent a device from functioning as intended. It is important that errors can be recognized, that the effect of an error is minimal, that feedback is given to signal an error is made, and that the user can repair an error made.
5. Satisfaction: The user has a positive experience when using the device, which we interpret as satisfaction with how the device functions as well as the image that the device use conveys to the user (Miller Polgar, 2010).

The HAAT model provides a framework for assessing the usability of AT. It acknowledges the dynamic interplay between the activity, the human, the context, and the AT, which are key factors on which usability should be evaluated.

SUMMARY

Technology is ubiquitous in the performance of our daily activities. Very few activities are performed without the support of technology. AT is defined formally as technology and related services and systems used by individuals with disabilities to maintain or improve functioning and independence, and thereby promote well-being. AT encompasses technologies designed specifically for people with disabilities and mainstream technology; low-tech and high-tech products; not only the assistive products but also the systems and services that support selection, acquisition, and use of the assistive products.

Several key principles guide the design, assessment, and evaluation of assistive technologies. These principles include (1) person-centered processes, (2) function as the outcome, (3) use of an evidence-informed process, (4) use of an ethical process, and (5) provision of AT in a sustainable manner. These key principles can be used by professionals involved in device design and development, clinical applications, and policymakers to ensure that devices meet their intended functional goals, are accepted by the intended users, and are congruent with the context in which they are used.

The HAAT model is the framework applied in this book. It describes a human doing an activity in a context using AT. It has four main components: (1) activity, (2) human, (3) context, and (4) AT. The model is based on ecological and transactional constructs, emphasizing the dynamic and integrative nature of its components. We claim that the HAAT model is useful in clinical assessments, outcome evaluation, research and development, and device usability processes.

The next chapters of this book describe the HAAT model in detail, provide a global perspective on AT, and discuss ethical and service delivery issues relevant to AT. These chapters make the application process of the HAAT model explicit. Then the book focuses on specific applications of AT. Each chapter is organized to reflect the HAAT model, starting with the activities that are supported by the AT discussed, attributes of the human user of that particular category of technology, and contextual considerations. The bulk of each chapter is devoted to the description of the technology that is currently available as well as emerging technology. When relevant, assessment, training, and outcome evaluation considerations for the particular AT are included. This organization is deliberate to illustrate the process inherent in the HAAT model and to provide sufficient detail about the different technologies to support their clinical application.

STUDY QUESTIONS

1. Contrast the concept of disability as understood from a medical versus social and rights-based models. Describe how each influences AT and assistive product use.
2. Discuss how the presence of a disability influences the life circumstances of a person with a disability.
3. Identify the elements of formal definitions of AT.
4. Discuss how the HAAT model is influenced by the ICF, CMOP-E, and PEOP models.
5. Describe each of the five principles that guide AT service delivery. Give an example of each.
6. Describe each component of the HAAT model and give an example of each.
7. Describe each of the four contextual components. Give an example of each.
8. Identify and describe each of the four applications of the HAAT model.

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2

The Human Activity Assistive Technology Model

LEARNING OBJECTIVES

On completing this chapter, you will be able to do the following:

1. Define assistive technology (AT) and assistive products.
2. Describe the activity, human, context, and assistive technology components of the Human Activity Assistive Technology (HAAT) model.
3. Describe the individual elements that comprise each of the primary HAAT model components.
4. Discuss how each of the HAAT model components affects AT service delivery, use, and product design.
5. Discuss how the individual HAAT model components interact to affect AT service delivery, use, and product design.
6. Describe the major applications of the HAAT model.

CHAPTER OUTLINE

KEY TERMS

Activity
Activity Analysis
Activity Output
Capacity
Context
Control Interface
Co-occupation
Cultural Context
Environmental Sensor
Expert
Free and Appropriate Public Education (FAPE)
Human Activity Assistive Technology (HAAT) Model
Human Technology Interface
Individualized Education Plan (IEP)
Institutional Context
International Classification of Functioning, Disability, and Health (ICF)
Leisure
Lifespan
Linguistic Competence
Mainstream Products
Meaning
Mechanisms
Novice
Occupation
Occupational Engagement
Occupational Performance
Occupational Satisfaction
Operational Competence
Participation
Performance
Physical Context
Processor
Productivity
Reasonable Accommodation
Self-Care
Self-Efficacy
Social Context
Social Competence
Strategic Competence
Universal Design
Usability
User Display

INTRODUCTION

As stated in Chapter 1, the **Human Activity Assistive Technology (HAAT) model** describes a human doing something in a context using assistive technology (AT). In this chapter, we deconstruct the elements of the human, the **activity**, the **context**, and the AT describing them in detail. However, as you can see from Fig. 2.1, the HAAT model is depicted as an integration of the human, activity, and AT, embedded in the context. Consequently, the chapter concludes with a reconstruction of the model elements to describe and understand how the activity, human, and context elements affect doing and their collective influence on the use and utility of AT. Although it is possible to discuss each element in isolation, it is only in uncovering their connections that the complexity of the place of AT in a person's life is revealed.

The order in which the HAAT elements are presented in this textbook is deliberate. Whether applying the HAAT model to device design, assessment resulting in AT recommendation, or outcome evaluation, the order of consideration and integration of the HAAT elements is consistent. The activity or need is identified first, followed by the aspects of the human that affect the ability to perform and engage in the activity. The contextual influences that affect the human's performance of that activity are then considered. The AT design and recommendation come last, signifying technology's place to enable activity participation and engagement.

THE ACTIVITY COMPONENT

Classifications of Activity

International Classification of Functioning, Disability, and Health

The **International Classification of Functioning, Disability, and Health (ICF)** (World Health Organization [WHO], 2001) is a well-known system for coding and classifying elements of the person, activity, and environment that influence health. The activities and **participation** components are useful for identification and organization of activities that a person needs or wants to do. Furthermore, the ICF provides a common language for communication around these activities.

The ICF defines *activities* as "the execution of a task or action by an individual" (WHO, 2001, p. 10) and *participation* as "involvement in a life situation" (WHO, 2001, p. 10). In addition to the identification of different domains of activities and participation, the ICF includes two types of qualifiers that assist the characterization of the person's involvement in the activity and participation domains: **performance** describes what the person actually does, and **capacity** describes the person's potential optimal performance given favorable and supportive circumstances.

The major ICF activity and participation domains include:

- Learning and applying knowledge
- General tasks and demands
- Communication
- Mobility
- Self-care
- Domestic life
- Interpersonal interactions and relationships
- Major life areas
- Community, social, and civic life (WHO, 2001)

Each of the domains and subdomains is defined to provide a consistent understanding, which is intended to make the ICF transferable across professions, organizations, and cultures. Table 2.1 provides examples of subdomains in each of these areas.

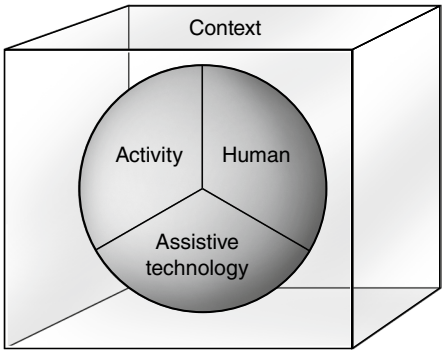

Fig. 2.1 The Human Activity Assistive Technology Model.

Occupational Therapy Classifications

Occupational therapists classify activity or **occupation** into areas of self-care, productivity, and leisure. Other professional groups may use similar categories. Typically, **self-care** occupations include activities of daily living (ADLs), often understood as routine daily activities like dressing, and meal preparation, and instrumental ADLs (e.g., banking, use of transportation, shopping); **productivity** includes occupations at work, school, or in nonpaid activities that contribute to society or are important to the person; and **leisure** are activities done for recreation (American Occupational Therapy Association [AOTA], 2002; Townsend & Polatajko, 2002, 2013).

The HAAT model includes four activity output areas to organize our discussion of AT in this book: mobility, manipulation, cognitive abilities, and communication. Table 2.2 compares the HAAT classification of activity outputs with selected domains and subdomains of the ICF. Fig. 2.2 shows the HAAT model with the elements of the activity component identified.

Activity Analysis

Activity analysis has been a foundational skill of occupational therapists for decades. It is complementary to methods used by human factors engineers in the analysis of tasks, hierarchical task analysis being one example (Fisk et al., 2009; Stanton, 2006). These methods of analysis begin with a deconstruction of the activity to understand the different steps necessary to complete it. A hierarchical task analysis may produce a flowchart that depicts the process of doing an activity, showing different paths resulting from different choices that can be made. An occupational therapy activity analysis provides a narrative of these steps.

Additional background information that contributes to the analysis includes listing the materials and equipment that are used to do the activity, describing the context in which it is

TABLE 2.1 International Classification of Functioning, Disability, and Health (ICF) Activities and Participation Domains With Examples

ICF Domain	Examples Relevant to Assistive Technology
Learning and applying knowledge	• *Basic learning skills,* such as learning how to read, write, and do arithmetic operations; skill acquisition • *Applying knowledge,* such as reading, attending to a learning situation, thinking, writing, problem solving, doing arithmetic operations, and decision making
General tasks and demands	• *Performing a single task,* which involves steps required to do one thing, including acquisition and organization of materials; initiating, maintaining, and completing task; sequencing the task; and the place, space, and pacing • *Performing multiple tasks,* including skills and knowledge required to perform many tasks either concurrently or consecutively • *Performing a daily routine,* involving performance of all the activities that make up one's day • *Handling stress or other psychological demands;* involves the ability to deal effectively with stress, demands, and distractions of daily tasks
Communication	• *Reception of communicative messages,* including spoken, written, signed language, or other means • *Expression of communicative messages,* including oral, written, signed, or other means • *Conversation and use of communication devices and techniques;* classification includes use of telephones and writing implements but not devices that would necessarily be considered assistive technology

Mobility	• Ability to move from one position to another (e.g., sit to stand) or maintain one position
	  • Transfers from one surface to another
	  • Lift, hold, handle, and carry objects, including use of both upper and lower extremities for this purpose; upper extremity classification includes manipulation
	  • Activities of the hands and arms, including motions such as reaching, grasping, pinching, and rotating
	  • *Walking and moving,* including walking or moving by other means such as crawling or running in different environments and using equipment such as skates as well as a wheelchair or walker
	  • *Use of transportation for mobility,* including transportation use as a passenger or driver as well as use of an animal for transport

Self-care	• Includes basic activities of daily living, such as bathing, eating, dressing, toileting, and personal health promotion activities
Domestic life	• *Acquiring necessities,* including securing a place to live; obtaining necessary goods to support daily life; and performing home management activities as well as providing assistance to others, such as child care
Major life areas	• *Education,* including formal and informal educational opportunities • *Work and employment,* including work training, job acquisition, and remunerative and nonremunerative work • Management of personal finances
Community, social, and civic life	• *Community life,* including participation in formal and informal organizations such as service clubs • *Recreation and leisure,* including participation in organized or informal play, leisure, or recreational activities • *Religion and spirituality,* including both formal and informal activities • *Human rights,* including participation in rights as identified in declarations such as the United Nations Convention on the Rights of Persons With Disabilities; excludes rights related to political life and citizenship • *Political life and citizenship,* includes participation in all forms of political activity and rights accorded to persons with citizenship status in a particular country

From: World Health Organization. (2001). International classification of functioning, disability and health. More information on the International Classification of Functioning, Disability and Health is available on the World Health Organization's website at https://www.who.int/standards/classifications/international-classification-of-functioning-disability-and-health.

completed, and identifying who is doing the activity. The occupational therapy analysis process involves describing the different performance components (e.g., cognitive, physical, sensory, perceptual, communicative, and affective) that are used to perform each step of the activity. These analyses are useful for two main purposes: (1) understanding the performance of an activity generally (i.e., detailing the performance process) and (2) understanding how a specific individual or group of individuals completes an activity.

An analysis is useful in the process of determining appropriate AT, as it assists the clinician in determining the skills and abilities possessed by the person to complete the task and those that require supplementation or replacement by AT for successful performance. This process is time consuming, so it is recognized that activity analysis, as presented here, is rarely completed in clinical practice for a single, isolated activity. However, possessing a framework for such an analysis of a single activity supports the clinician during the assessment and evaluation processes to understand the activities in which the client needs and wishes to engage and the skills and abilities that are required for successful performance of those activities. While it may not be realistic to complete activity analysis for every activity a person does, practicing this skill helps you change the way you think about activity, so you become more adept at recognizing the necessary skills and abilities. Several schemes for conducting an occupation or activity analysis are found in the literature (e.g., Hersch et al., 2005).

Understanding Activity Beyond Its Classification

Using the ICF or other systems that classify activity or occupation helps name and organize what a person does. However, a simple classification does not provide the full picture. When the consideration of activity stops at classification, other factors that influence doing activity are lost. The personal **meaning**

TABLE 2.2 Comparison of ICF and the HAAT Model

ICF	HAAT Model
Learning and applying knowledge	Cognition Communication
General tasks and demands	Cognition
Communication	Communication
Mobility	Manipulation Mobility
Self-care	Cognition Communication Manipulation
Domestic life	Cognition Communication Manipulation Mobility
Interpersonal interactions and relationships	Cognition Communication Manipulation Mobility
Major life areas	Cognition Communication Manipulation Mobility
Community, social, and civic life	Cognition Communication Manipulation Mobility

ICF, International Classification of Functioning, Disability, and Health; *HAAT,* Human Activity Assistive Technology Model.

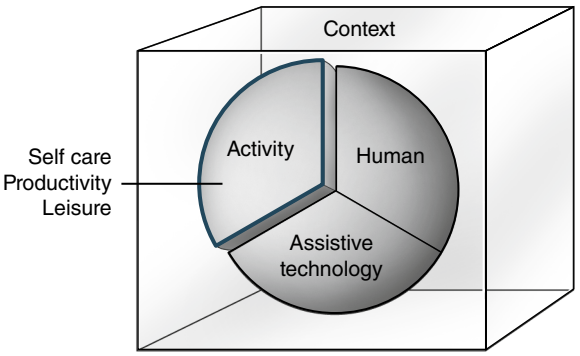

Fig. 2.2 The Human Activity Assistive Technology Model with elements of the activity component identified.

attributed to doing activity, its complexity and flow, and the situated nature of doing within a context (i.e., that doing does not exist in a vacuum, but always in reference to a context) are not evident within a classification system. A number of questions help further define the activity. These questions guide the gathering of information about the performance of the activity as well as how its performance relates to engagement in other activities.

Why is this activity performed? Here a distinction is made between a person wanting to do an activity versus needing to do an activity. Some occupations, such as working, going to school, or parenting, are things a person needs to do. Conversely, other occupations, often leisure or volunteer occupations, involve more choice (i.e., the person wants versus needs to do them). Because individuals themselves have some influence on required versus chosen activities, we will return to this idea when we discuss the meaning of the activity.

Even within required activities, there is an element of choice. For example, for most children younger than a certain age, as defined by local legislation, attending school is a required occupation. There is no choice. However, choice is exerted (at least by older children) around how much or to what extent required school activities are completed. Similarly, at work, specific activities are expected as part of the requirements of the job; however, people may exert choice in which jobs they take on or feel are most suited to them.

How is the activity performed? Is it important for the client to perform the activity independently, or will the person accept assistance from others or technology? When people do not accept assistance from others, it is important to determine whether this assistance is provided by family, friends, or a personal care attendant. If the activity is a sensitive one, such as toileting, people may be very particular about from whom they will accept this assistance. Another aspect of this question is whether the activity is performed alone or with others. For example, reading is something that can be done alone, but having a conversation requires a minimum of two people. The concept of a **co-occupation** (Pierce, 2009) is a relatively new idea from occupational science that explores performance of an occupation by two or more people. This concept is explored in more detail in the section that integrates the HAAT components.

Temporal aspects. Timing issues related to activity performance give guidance about how frequently the person engages in that activity. It is useful to ask how long it takes the person to complete the task and whether that person is willing to invest that amount of time required to do it without assistance. Similarly, does the time to complete the task take away from time available for other activities? For example, a client may be able to dress themselves by adapting the activity but only with much effort over an extended period of time. This amount of time can be problematic when they are getting ready for school or work, because if dressing takes a long time by doing it themselves, it either means getting up very early to dress or risking being late for some commitment. Similarly, this length of time means they are not able to do other activities.

A final consideration relates to the client's preference of frequency with which an activity is performed. Individual preference often determines how frequently an activity, such as exercising or bathing, is performed. A change in abilities that affects cognitive, communicative, manipulative, or mobility skills can alter the ability of a person to exercise choice regarding the frequency with which certain activities are performed. For example, when a person lives in a skilled nursing facility, the institutional routines dictate the frequency of many activities, including personal care activities. The resident has limited opportunity to exercise choice over this temporal component.

Where does the activity take place? We will explore the implications of place on activity when we discuss context. Here we identify the considerations required when considering place. An activity may be performed differently in a public versus a private place.

The presence of others in the place where the activity occurs can mean that there are individuals available to provide assistance. The opinion and knowledge of others about AT may hinder or enable its use. Place may also limit the choice of AT because some technologies that use voice input or activation may be obtrusive in a quiet place, and their use may restrict the privacy of the user. The physical aspects of place may also enable or hinder the performance of the activity.

What other activities are supported by the performance of a given activity? The performance of complex activities depends on the ability to perform more basic ones. For example, the ability to sit supports many other activities a person does to look after themselves, socialize with others, volunteer, or engage in work or educational activities. Similarly, the ability to speak and manipulate materials are basic skills used in more complex activities.

Seeking the answers to these questions moves beyond simply knowing what activities a person needs or wants to do. They also assist the clinician in understanding other elements of the performance of an activity and how they will enable or hinder the use of any AT.

THE HUMAN COMPONENT

ICF Body Structures and Functions

The ICF (WHO, 2001) is a good starting place to understand the human user. The classification provides a useful way to organize the functions of the human body that affect the ability to perform an activity, engage in the community, and use AT. The ICF defines body functions as "the physiological functions of body systems (including psychological functions)" (WHO, 2001, p. 10). In this chapter, we cover the classifications of body functions that support AT applications as described by the human component of the HAAT model. Fig. 2.3 shows the elements of the human component of the HAAT model. Relevant classifications of body functions are discussed in greater detail in individual chapters.

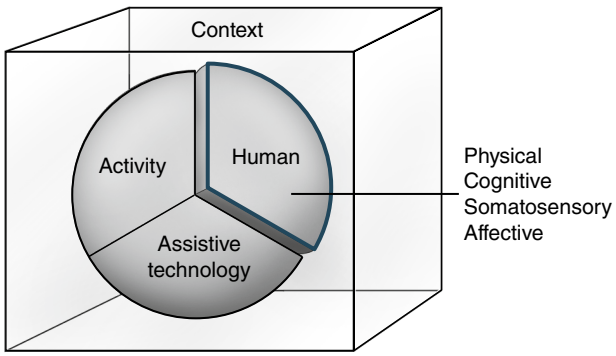

Fig. 2.3 The Human Activity Assistive Technology Model with elements of the human component identified.

Mental Functions

Mental functions include cognitive abilities that enable the individual to be alert and focus on their environment, perceive and interpret sensory phenomena, feel and regulate emotions, and perform higher-level cognitive functions that enable them to organize and control their behavior and action and to learn, reason, and synthesize information (WHO, 2001).

At a very basic level, mental functions involve a level of consciousness (being able to attend to one's surroundings); orientation to place, person, and time; and general intellectual functions that enable an individual to process, remember, and understand information. The ability to perceive and interpret sensory stimulation, including auditory, visual, tactile, and visual-spatial, are basic functions that help a person organize and respond to their world (AOTA, 2002; WHO, 2001).

Higher-level cognitive functions enable the individual to synthesize and integrate information and to reason and learn. These executive functions enable a person to regulate and organize their behavior and to exercise judgment. Mental functions as they relate to written and spoken language, mathematical functions, and the ability to organize and sequence movement (praxis) form part of this category. The ICF also includes classifications of personality and temperament here (AOTA, 2002; WHO, 2001).

Seeing Functions

Seeing classifications involve functions related to vision. Acuity is the ability to see clearly, including monocular and binocular near and distant vision (AOTA, 2002; WHO, 2001). This visual function is probably the one with which most people are familiar. Individuals who are nearsighted can see objects up close but perceive distant objects as blurry. Farsighted vision is the opposite. As individuals age, the ability to focus on objects up close declines. You might hear a middle-aged person saying their arms are too short, referring to the fact that they must hold materials at a distance to be able to read them.

Visual field describes the span an individual is able to see when the eyes are fixed in a certain direction, including visual information that is directly in front and in the peripheral field (WHO, 2001). The quality of vision relates to the ability to detect color, sensitivity to light, and visual contrast.

Light sensitivity refers to the amount of light that is required to be able to see clearly; with age, individuals often require a greater amount of light to see clearly. It also refers to the reaction to light. Some individuals with light sensitivity problems have difficulty seeing clearly in extremely bright conditions, for example, on a sunny day in the snow or on the beach.

Light contrast refers to the amount of contrast required between a figure in the foreground and the background to enable a person to distinguish the figure from the background. Light contrast is particularly important for AT with a visual display interface.

Hearing and Vestibular Functions

The functions of hearing include both auditory elements related to perception and discrimination of sound. At the most basic level, these classifications involve detecting that a sound has

occurred and discriminating among sounds that are in the environment (e.g., the ability to focus on a conversation in a noisy restaurant).

Localization of sound is the ability to determine where a sound is coming from. It refers to the less precise ability of determining whether it is coming from the right or left side. Hearing includes the ability to discriminate between sounds that are language and those that are not (e.g., laughing, crying) (WHO, 2001).

Vestibular sensory functions of the inner ear have implications for balance, movement, and position in space (WHO, 2001). The structures of the inner ear detect movement and position relative to gravity to assist a person to move through space and to maintain balance (WHO, 2001). They enable people to detect whether they are upright or not and assist them to retain body alignment in terms of keeping their head in an upright position, regardless of the body position, to maintain a useful line of sight. The ability to detect the body's movement through space and whether the body is supported on a flat or tilted surface assists with balance and movement. Think about the difficulty a child has retaining an upright position after spinning; in this situation, the vestibular apparatus and visual information are not providing consistent information to enable the child to maintain balance. Another example of vestibular function (or dysfunction) is the phenomenon of motion sickness. When the vestibular input and the visual input conflict, a person might feel nauseous. For example, sitting in a moving vehicle or on an amusement park ride, where the body is not moving relative to the car but the visual information conveys movement, can result in motion sickness because of the disconnect between vestibular and visual stimuli.

Additional Sensory Functions

The ICF identifies several other sensory functions, although we are only including the sensations here that are pertinent to the scope of this book. Tactile functions involve the ability to detect various physical stimuli, including temperature, vibration, pressure, and noxious stimuli. Proprioception is the ability to sense the position of body parts in relation to each other. For example, if you close your eyes and your friend flexes your elbow to 90 degrees, proprioception is what tells you that your arm is bent and not straight. The ability to detect movement of the parts of the body is called kinesthesia. Sensations associated with pain are a separate classification in the ICF (WHO, 2001).

Voice and Speech Functions

Voice and speech functions refer to the production of different sounds in order to speak or vocalize. It involves enunciation of various sounds and articulation of phonemes. The rhythm of speech, fluency, speed, and intonation are included here. Vocalizations such as babbling, crying, screaming, producing musical notes, and humming are also included (WHO, 2001).

Neuromusculoskeletal Functions

The final body function classification that we will present describes neuromusculoskeletal and movement-related functions. Several of these classifications involve functions that are necessary for the production of movement, such as bone and joint functions (mobility and stability around a joint and bone mobility, which refers to the mobility of specific joints in the body, including the scapular, pelvic, carpal, and tarsal joints) (WHO, 2001, p. 95).

Muscle functions include muscle tone, power, and endurance (AOTA, 2002; WHO, 2001). Movement-related functions include reflex and other involuntary motor reactions and involuntary movement such as tremors, tics, and simple to complex voluntary movements, including gait (WHO, 2001).

Lifespan Perspective

The ability and desire to use technology is not the same across the **lifespan.** Although it is important to remember that chronological age does not necessarily have the strongest influence on activity performance or AT use, it certainly has an effect and deserves consideration.

Infants and Children

Children are acquiring skills that affect their ability to perform activities and use AT. Young children and infants have limited abilities to express themselves, control their movement for mobility and manipulation, and perform cognitive functions. AT that is aimed at children must take into account their ability to interact with and control it.

Technology that is complex to use, involving multiple steps to operate, may be beyond the ability of a young child. The experience a child has with performing different actions or activities can also affect their ability to use AT. Age should not be a restriction to the use of AT. Rather, AT should support a child to engage in activities in which their peers are also participating. For example, as children start to explore production of language, simple language boards can help very young children begin express themselves. Similarly, a powered wheelchair can give a young child mobility, although perhaps not at the same time as their peers (Rosen et al., 2017).

Parents enable activities with children, and the meaning of AT use for the child may not be the same as for the parent. Children do not carry the same viewpoint as their parents of how activities are performed or whether there is stigma in how they engage in activity when they use some form of device. Parents, on the other hand, may view AT as a visible sign that their child has a disability. AT might be fun and interesting to a child, but the stigma of its use may make it difficult for a parent to accept it for their child.

Adolescents

Adolescence is an interesting age for most young people; it is a time when they seek independence from their family, at least to some degree, and think about their future as a worker and a partner and their place in community. It is also a time when they explore their identity, often striving for a sense of belonging with a certain group. Adolescence can be a time when a child with a disability becomes aware that they are different from their peers, although often this awareness comes at a younger age (King et al., 2003). If a particular device, which is useful to them, becomes a symbol to them that they are different, then it

might not be used. On the other hand, if the AT enables them to do the activities they want to do, such as communicate with friends with an augmentative and alternative communication (AAC) device or with computer access technology or go out with friends with the use of a wheelchair, device use is more likely.

Older Adults

At the other end of the age spectrum, older adults have changing needs that affect their ability to use AT (Fisk et al., 2009). The WHO World Report on Ageing and Health (2015) reports that older adults account for the highest proportion of individuals who have a disability, and as they get older, they are likely to experience more than one impairment. Vision, hearing, mobility, cognitive impairments, and pain all affect the ability of older adults to perform activities and use AT (WHO, 2015). These age-related impairments are introduced here and discussed in greater detail in later chapters.

The most common causes of low vision in older adults are age-related macular degeneration, cataracts, glaucoma, and diabetic retinopathy, although these disorders can also occur in younger people (see National Eye Institute, n.d.). Low vision is defined by the level of vision in the "better" eye, when measured with the best possible corrective lenses. Best corrected vision of 20/200 means that features an individual with low vision can see from a distance of 20 feet, an individual without vision loss can see from a distance of 200 feet. Corrected vision between 20/200 and 20/400 is considered severe visual impairment and constitutes legal blindness in the United States. Loss of peripheral vision is also used to identify low vision with restriction of less than 20 degrees wide forming part of the definition of legal blindness (American Optometric Association, n.d.).

Hearing impairment associated with aging is sensorineuronal hearing loss. In this situation, damage occurs to the cochlea or the auditory nerve, which limits the ability of the person to hear sounds. Sounds that are perceptible may seem muffled. This situation is not treatable and requires the use of hearing aids as the condition progresses (WHO, 2015).

The most common causes of mobility impairment in older adults are musculoskeletal conditions, such as osteoarthritis and other forms of arthritis. Mobility can also be impaired by neurological conditions such as stroke, Parkinson's disease, and multiple sclerosis. Mobility is also impaired through loss of coordination, balance or stability, and decreased strength and range of motion. Pain may be a contributing factor for limited mobility (WHO, 2015).

Cognitive impairment in older adults is frequently the result of some form of dementia, most commonly Alzheimer's dementia (Marshall et al., 2015). An individual may be diagnosed with mild cognitive impairment when others notice problems with memory, behavior, and executive functions. When mild cognitive impairment progresses to a dementia, these problems become more evident and restrict the ability to engage in activity to a greater degree. At the onset, devices that assist memory can be useful; however, as the disease progresses, even simple activities such as dressing and other self-care activities are a challenge to perform (WHO, 2015). Other causes of cognitive impairment in older adults include stroke, traumatic brain injury, and multiple sclerosis.

How an older adult performs in each of these areas is a consideration in the assessment process as well as in the AT design process. The ability of an older adult to see the screen on a display interface, to generate the force required to propel a manual wheelchair, or to see or hear instructions or feedback provided by the device are essential considerations for both assessment and design.

The presence of disabilities can magnify the effects of age-related impairments. Individuals who are aging with disabilities experience secondary impairments, such as osteoarthritis, that affect their ability to function and use AT. These secondary impairments can result in age-related changes that occur earlier in individuals with a congenital impairment or one acquired as a child or young adult. Common related impairments are osteoporosis, joint immobility, and contractures as a result of limited movement and weight bearing. Increased pain is also common. Furthermore, individuals aging with disabilities are at greater risk of obesity because of fewer opportunities to exercise (Klingbeil et al., 2004).

The meaning of technology use for older adults may reflect loss, diminishing of abilities, and perhaps generate a feeling of being less capable or valued. Not only does the use of an assistive product signal a person is no longer able to perform activities in the manner with which they are familiar, but it may also limit the ability to engage in desired activities when the use of the device is not supported in a particular environment. For example, an older person who enjoys attending musical theater may find themselves unable to continue to engage in this activity if they require the use of a wheelchair for mobility and the theater is not accessible. Similarly, another adult may choose not to engage in activities if it means they must use AT. A common example here is the use of a hearing aid; some older adults may choose not to go into a social situation because of the stigma of using a hearing aid.

A final consideration with older adults is prior experience with technology use. It is not appropriate to assume that an older person will not wish to use technology or is unable to learn to use new technology. Many older adults thrive with the use of a computer, using it to keep in touch with family and to explore information and ideas on the Internet. Stereotyping older adults as nonusers of technology limits their potential for continued engagement in and new possibilities for activity.

Novice Versus Expert

Another human characteristic important in the selection or evaluation of AT is whether a person is a **novice** or **expert** user of the specific technology. The term *novice* describes a user of an AT system who has little or no experience with that particular system or the task for which it is used. A novice user may have no idea of the possibilities for performing activities that have become difficult or impossible because of injury, illness, or some other condition. Although devices such as wheelchairs and hearing aids are common in most areas, AT such as alternative and augmentative communication systems, computer access systems, and electronic aids to daily living (EADL) devices are

Fig. 2.4 A skilled assistive technology user will use technology in complex and challenging ways, shown here as the ability to perform a wheelie, a challenging wheelchair skill.

not as familiar. If a person has a newly developed impairment, the lack of knowledge of different types of AT can be a limiting factor in regaining function.

Another aspect of a novice user is the tendency to use the device in a limited manner because of the lack of familiarity and experience with its use. For example, a new user of a mobile telephone may restrict themselves to the functions of the telephone that are familiar, easy to learn to use, and most useful. A novice is more likely to use the system in prescribed ways, relying on assistive services (e.g., instructions or others with expertise) to use it effectively. Novices are less likely to generalize use of the system from one task to another and may use more conscious effort to control it.

As a user practices and gains more experience, they may become an *expert* user, that is, they may demonstrate a high degree of skill in the use of the system. An expert takes more risks with the equipment in terms of stretching how it is used and trying new activities with the system (Fig. 2.4). For example, skilled users of a manual wheelchair may take their chair up or down an escalator rather than use an elevator or perform a wheelie. Skilled users of communication aids will develop strategies to increase their rate of communication.

An expert user of technology also knows how they want a device to perform and what they want it to do. An expert has an opinion on how the technology should look; how fast it performs; and, with devices like seating and mobility technology, how it should fit. An expert also feels comfortable modifying the technology and often has ideas about how to improve the technology, building on their familiarity and experience with using a device in many different situations.

Light (2003) describes several types of competence associated with AT use. She originally developed her categories for AAC systems (see Chapter 14), but most of the concepts apply more broadly. The first level of competence to be achieved is called **operational competence**, which is the ability to use the AT for the intended purpose. Included in this category are basic operations such as understanding how to use a joystick on a power wheelchair to drive. Turning the device on and off, recharging batteries, and general maintenance are all part of operational competence.

Coexistent with the basic operation of a device is the development of **strategic competence** (Light, 2003). This category includes more subtle elements of using an AT device. For the wheelchair example, it might include developing skill at selecting the appropriate speed for an empty hallway versus a crowded restaurant and techniques for navigating a snowy sidewalk. For a manual wheelchair user, it might be learning how to jump curbs when there is no curb cut available. These strategies come with training and practice.

The third type of competence is **social competence** (Light, 2003). This category applies more to certain types of ATs than others. For a user of AAC, social competence is required when selecting what vocabulary to use. For example, the words and formality of a conversation with a best friend are not the same as with a teacher or parent. Likewise, a user of a cognitive AT device may need training in the social expectations of using such a device.

Light also includes **linguistic competence** (Light, 2003). Although this competence was originally proposed to describe the process of developing sufficient vocabulary to use an AAC system, it can also apply to other ATs. A novice wheelchair user needs to have vocabulary that describes spatial concepts and operational concepts such as speed, acceleration, and force for a manual wheelchair. Users of cognitive AT devices need to have sufficient vocabulary to operate the devices and to understand their output. For example, a device for navigation in the community requires understanding of the language concept for it to be used successfully.

Understanding the differences between a novice and expert user has important implications for teaching people how to use a system and the development of strategies. An expert user exerts less conscious effort in the operation of the system because they do not need to do so. Analysis of the strategies of an expert user and translation of these into teaching programs can be an effective means of assisting a novice to become an expert user of a system.

THE CONTEXT COMPONENT

The HAAT model uses the term *context* rather than *environment,* which is the term other similarly constructed models (e.g., WHO ICF, Canadian Model of Occupational Performance and Engagement, and the Person-Environment-Occupational Performance Model) use to describe the contextual components that influence doing. The term *context* was deliberately chosen to convey a broader understanding of the external influences on a person doing an activity using AT. The word *environment* has the popular connotation of natural, physical elements and spaces, often related to pollution and climate change. This meaning does not capture the complexity of this element of the HAAT model and may result in exclusion of social, cultural, and institutional aspects that influence performance of an activity. By explicitly including these latter elements as components of the context, the HAAT model recognizes their contribution

to doing with AT. The contextual influence on doing with AT can be understood from the perspective of how participation is enabled by physical, social, cultural, and institutional means and how that participation is sustained over a length of time (Mirza et al., 2012).

Over the past several decades, the models used to describe disability and the disablement process have changed dramatically (McColl & Jongbloed, 2006; Whalley Hammell, 2006). Prior to the last century, disability was seen as the result of divine punishment or the result of some moral lack on the part of the person or their family. In the 1950s, a medical model was dominant that viewed the "problem" as something intrinsic to the person with disabilities that prevented them from participating in work, play, education, and ADLs. This problem was "in the person," that is, it was strictly the result of the impairment, which was then used as a rationale to exclude persons with disabilities from many different aspects of life.

More recently, there has been an increasing awareness that the difficulties experienced by individuals with disabilities result as much or more from contextual factors as from the impairment itself, what we described as the social model in Chapter 1. Initially, this contextual focus was limited to the physical or built environment, with much effort to make curb cuts, install elevators, and so on. As individuals with disabilities participated more fully in society, it became evident that the social and attitudinal barriers were just as great as the physical ones. The social model of disability emerged in which the attention was shifted away from the impairment to the social, political, and environmental disadvantages forced on people who have disabilities (Jongbloed & Crichton, 1990; Whalley Hammell, 2006). The social model has advanced to include social and attitudinal barriers that limit participation by individuals with cognitive, learning, neurodivergent, mental health, and other disabilities.

Bickenbach et al. (1999) conceptualized disability in a different way. In their view, disability is a universal experience if a person lives long enough. This "universalism" concept advocated for broader social justice and policies that were inclusive of persons with disabilities, actions that benefit a broader segment of society. From this perspective, problems of societal participation were no longer attributed to the impairment of the person with disabilities. Rather, lack of participation in society was viewed as resulting from limitations in the social, cultural, institutional, and physical environments. The emphasis on participation in the ICF is indicative of the move away from a "problem in the person" concept to a "problem in the environment" model. When AT is viewed from this perspective, its purpose is reframed from minimizing personal limitations to minimizing restrictions that are created by the context in which a person lives and functions (Borg et al., 2011).

In the HAAT model, we have captured these external influences in the *context.* As shown in Fig. 2.5, the context includes four major elements. These are the (1) physical context, including natural and built surroundings and physical parameters; (2) social context (e.g., with peers, with strangers); (3) cultural context; and (4) the institutional context, including formal legal, legislative, and sociocultural institutions such as religious institutions. The **context** in which the human carries out the activity

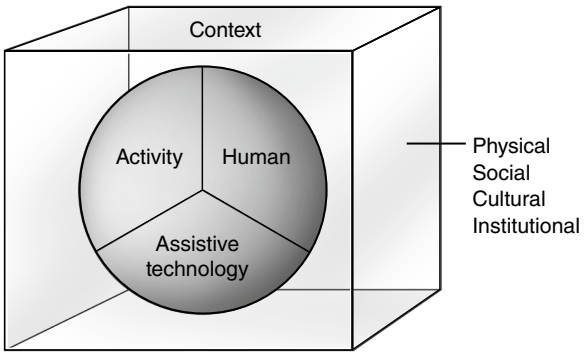

Fig. 2.5 The Human Activity Assistive Technology Model with elements of the context identified.

can be determining factors in whether the person successfully uses AT. The supports and barriers in these environments are important considerations in the selection and evaluation of AT.

One further distinction is important in the consideration of context: the level of environment. Three levels of environments have been described in the literature: microenvironment, mesoenvironment, and macroenvironment (Fougeyrollas & Gray, 1998; Townsend & Polatajko, 2002). The microenvironment refers to the closest, most intimate environments in which a person functions, such as their home, school, or work setting. Here the person and their abilities are well known. The mesoenvironment describes settings in which a person functions less frequently and includes various community facilities such as community centers, shopping malls, and churches. The macroenvironment refers to the broader social and cultural contexts that impose a legislative and moral behavioral framework on the person (Townsend & Polatajko, 2002). Each of these environments influences the use of AT systems. It is useful to understand how each aids or hinders the use of technology.

Physical Context

Perhaps the easiest contextual component to understand is the **physical context**. This context involves the physical attributes of the environment that enable, hinder, or affect performance of activities, either with or without AT. It is the physical context that limits individuals with disabilities from engaging in occupations when they cannot access the places, materials, or persons to do so or that enables occupations by making them accessible for a wide range of users (e.g., a playground featuring equipment that can be used by all children, including those who use mobility devices).

A distinction is made between the built and natural environment, which simply refers to human-made and non–human-made environments. Accessibility features can be integrated into both environments. Assessment of the physical context for selection or evaluation of AT begins with articulation of the activities the person wants or needs to do in key locations such as the home, workplace, or shopping mall. Within buildings, people need to enter and exit the building; access various locations, possibly move between levels; and perform a variety of activities, such as using the toilet. Some of the physical aspects of the environment that should be considered include the width

of hallways or doorways, distances between locations that people must navigate, surface (e.g., carpet, transitions, floor surfaces), and height and weight of devices and objects (e.g., door) the person must manipulate.

Physical accessibility from a visual perspective involves way finding in an environment and locating key pieces of information. An individual with a visual impairment is assisted with movement throughout an environment with appropriate lighting, with hallways and other areas free of clutter, and with a perceptible warning of hazardous situations, such as a change in elevation (e.g., stairs) (Sanford, 2012). Modification of the environment through the use of signage that is perceptible by an individual with a visual impairment, such as through the use of Braille or using an appropriate color contrast, or converting visual information to auditory or tactile (e.g., adding tactile ground surface indicators), enables function in that environment.

From a cognitive perspective, accessibility means signage that is easy to interpret, using simple symbols whose meaning is readily understandable. Providing signage or other forms of marking that indicate paths in large buildings is another way the physical context can be modified to support someone with a cognitive impairment. For example, some hospitals use colored lines to mark a path from a main entrance to select locations (Sanford, 2012). As with many features that are associated with accessibility, these lines are useful for all people, since hospitals are typically hard to navigate.

Physical safety is an important consideration when assessing the environment. In the event of an emergency, the physical environment must support the ability of people with disabilities to safely move away from a dangerous situation and quickly exit the building, if needed. Such safety measures include strategies to assist people with mobility or visual impairments to move from one floor to another when elevators cannot be used or providing an alternate alarm system for deaf individuals who cannot hear an audible alarm.

Three commonly measured parameters of the physical environment—temperature, light, and sound—most directly affect the performance of ATs. Many materials are sensitive to temperature and are affected by excessive heat or cold. For example, the properties of foams and gels used in seat cushions can change under conditions of very high or very low temperatures. Displays may be affected by temperature, as well as by ambient (existing) light. Some emit light and are better in conditions of reduced ambient light, but others reflect light and are better used in bright light. For example, direct sunlight often renders reading from screens on telephones, tablets, and computers difficult, if not impossible. Low-light conditions also affect the ability to read a screen and can affect the function of devices designed to assist persons with low vision.

Ambient sound (including noise) can interfere with the function of voice-activated devices or AAC systems with speech output when ambient noise levels are high. Sounds generated by assistive products, such devices as Braille printers, power wheelchairs, voice output communication aids, and auditory feedback from computer programs, can be disruptive to others.

Often a person wants or needs to use the same assistive product in multiple contexts. In some cases, a product will work in one context but not in another. Voice recognition software is an example of a product that does not readily transfer from one context to another. In the relative quiet of an individual's home, voice recognition software may be an excellent alternative to direct input of computer keystrokes. However, it may not work in an office environment where noise interferes with the software, and its use may interfere with the work of colleagues in close proximity to the individual. Another example is an individual who propels their wheelchair in both a natural and built environment. Wheelchair tires that are appropriate for indoor use are often much less useful when used in outdoor conditions, particularly when propelling over grass or through sand or snow. Transportation of the device is another consideration when it is used in multiple contexts. For example, consideration must be made of who will be transporting the wheelchair, and whether it can fit in a personal vehicle or must be transported in an adapted vehicle (see Chapter 9 for a fuller discussion).

Social Context

The **social context** refers to individuals and groups who interact with the individual using AT, either directly or indirectly. This context can be understood from two perspectives. The first perspective involves individuals with whom a person interacts in contexts that are usually more familiar, local, and frequented. These occur in the micro- and meso-environments that were identified earlier. Contact with individuals in these environments tends to be direct rather than indirect. The second perspective is the larger, societal one, the macro-environment that tends to have an indirect effect on the individual through the expression of societal mores, values, and practices. It is closely related to the institutional context.

Hocking (2011) poses several questions that inform the understanding of how the social contextual influences a person's doing an activity. She asks: (1) in a social context, who else is involved? Do they enable or hinder participation in activities? (2) Are there disparities among who is able to participate in an activity and who is not? Which social factors support or reduce these inequities? (3) What specific actions, societal norms, and traditions affect the possibility of performing the activity? These questions will be used to guide the discussion of the social context.

Who Is in the Social Context?

If you think about the people with whom you come into contact on a regular basis (daily, weekly), you can cluster these individuals into different groups, for example, family, friends, peers at school and work, or service providers (e.g., a personal trainer at a gym, religious leader, personal support worker). For the most part, these are people with whom we are very familiar. This familiarity results in certain mutual expectations for behavior, knowledge, attitudes, and so on. These individuals will have a direct influence on participation in activities.

A framework that is helpful in categorizing direct interactions is based on the circle of friends concept (Falvey et al., 1997). There are five circles surrounding the individual. The first

circle represents the person's lifelong social partners. This group consists primarily of immediate family members. The second circle includes close friends (e.g., people to whom you tell your secrets). These are often not family members. Acquaintances such as neighbors, schoolmates, coworkers, distant relatives, bus drivers, and shopkeepers are included in the third circle. The fourth circle is used to represent paid workers such as a physician, speech-language pathologist or a physical or occupational therapist, teacher, teacher assistant, or babysitter. Finally, the fifth circle is used to represent those unfamiliar partners with whom the person has occasional interactions. This circle includes everyone who does not fit in the first four circles. Thus, the familiarity with partners decreases as we move from circle one to five, which impacts the use of AT. For example, the modes of communication required to communicate with people in each circle will vary, influencing use of AT for communication.

Indirect contact involves individuals who are physically present in a context but are separated from others, perhaps by position or practices that support the separation. Examples here include the president or executive members of a large company, a school principal, or the executive director of a professional organization. These individuals exert power in the context in which they function; however, they do not come into direct contact with all of the other members in that context. A last group includes individuals with whom there is no expectation of direct interaction but whose actions have significant influence over the activities of others. This group includes people in positions of authority (WHO, 2001) such as politicians and policymakers who create and enforce legislation and administrators who create policies and procedures for organizations. The actions of this group have widespread influence over others in their social contexts.

How Do They Influence Participation and Use of Assistive Technology?

The beliefs and values, attitudes, and actions of others affect behavior and engagement in activity. Here, beliefs are considered to be worldviews, deeply held values that are foundational to how a person lives. The ICF defines attitudes as "the observable consequences of customs, practices, ideologies, values, norms, factual beliefs and religious beliefs" (WHO, 2001, p. 190).

Attitudes and actions are rooted in a person's beliefs, which are viewed as higher-order, more entrenched viewpoints. Beliefs express how a person understands their position in the world relative to others. For example, someone who believes all persons are equally valuable will express very different opinions and actions than another person who believes that the possession of certain traits makes one group of people better or worse than others.

Similarly, deeply held values may lead one person to believe that all people have the same rights and responsibilities, while another believes the opposite. Considering the different groups described in the previous section, it is apparent that as others become further removed from the individual, the influence and consequences of their beliefs on that individual are related to the power they hold in the social context. At all levels, there is great potential to enable or hinder the activities of persons with disabilities and their access to, and use of, AT.

Inclusive attitudes of others support activity participation and the use of AT. These attitudes recognize the person with disabilities for attributes that may have little to do with the presence of an impairment. For example, the person is recognized as a child, a parent, or a teacher, or as someone with a good sense of humor or perhaps a less desirable trait such as a quick temper. The point here is that the presence of the impairment does not define the person for these individuals with whom they interact. The presence of the impairment does not influence their behavior toward that person.

Awareness and acceptance of alternate ways of doing is another expression of an inclusive attitude. Recognition that use of a communication aid is just another way to talk or use of a wheelchair as just another way to move leads to actions and behaviors that make it possible for persons using these devices to engage in their communities and desired activities.

On the other hand, exclusionary attitudes and prejudices limit the capabilities (Nussbaum, 2011; Sen, 2009) of persons with disabilities. As Fougeyrollas (1997) points out, social influence on individuals is related to what is considered normal or expected. Individuals who have disabilities may be stigmatized because of their disability. A frequent comment by persons with disabilities is that it is often the social environment, the attitude of others, that creates more of a disability than the physical barriers in the environment. When policies and practices do not recognize the needs of individuals with disabilities, these individuals are excluded from social participation in the areas the policy governs. For example, when a building is constructed with accessibility features that support the needs of persons with mobility impairments only, individuals with other impairments that affect movement in that building (e.g., a person with low vision) may be excluded, limiting their access to the services in that building. Public transportation that does not provide options for individuals with cognitive impairments denies them community mobility and participation.

A paternalistic attitude conveys to the person with disabilities that they need to be protected and that they are not capable of looking after themselves or making decisions about their own life. Policies and procedures that restrict the choices of a person with disabilities often derive from a paternalistic perspective. This perspective is apparent in health care practices when treatment is recommended without regard to the person's lifestyle or when the view of patient means decisions are made for someone (Jongbloed & Crichton, 1990). Often persons with disabilities or chronic illness are referred to as patients even in nonmedical spheres, so the protective and diminishing attitudes pervade past discharge from any medical care. First-person narratives by persons with disabilities frequently recount interactions in which the behaviors of others suggest that they see the presence of an impairment as generalizing to other capacities. The possession of one trait that limits performance in one body function is generalized to performance of other functions (Whalley Hammell, 2006). Two common examples are when others speak louder to a person with low vision or with a communication

impairment thinking that increased volume will facilitate the conversation or when others assume a cognitive impairment goes along with the use of a wheelchair. These generalizations can result in one partner assuming diminished capacity in the other and acting accordingly.

Actions of Others in the Social Context

Participation in activities and in the community is supported or hindered by the actions of others based on their understanding of their role in enacting this participation. Two actions that support participation are enabling performance and advocating for inclusion.

In the first instance, enablement is achieved by fostering a social context that supports participation of individuals with disabilities doing an activity with technology. This enablement includes meaningful partnership with individuals with disabilities to determine that the needs identified are relevant and that solutions created are usable. For example, the need for accessible washroom stalls is met with the creation of such stalls, but if someone who needs to use the stall cannot access them because the door to the washroom is heavy or the path to the stall is not clear, then the accessible stall is not useful.

Advocacy involves championing for the right to full participation for all members of a community or society. However, true advocacy occurs with the participation of members of groups who experience exclusion or marginalization to achieve results that are meaningful and relevant. Rather than advocating *for* a person or group, advocating *with* the person or group achieves a more inclusive result. Advocacy on a large scale involves championing full participation for a group; for example, current advocacy efforts in some countries to ratify the United Nations Convention on the Rights of Persons With Disabilities (United Nations, 2006).

The actions of others in the social environment may be a source of stigma, which is defined as a mark of shame, an attribute that discredits the person who possesses it (Goffman, 1963). Certain devices such as hearing aids and power wheelchairs seem to convey greater disability than others such as eyeglasses or manual wheelchairs. Consequently, persons with disabilities may choose not to use a particular AT in a social environment because of the stigma it conveys. Consider an office worker who has the capacity to use a manual wheelchair but who might choose to use a power chair because of the energy savings it affords. The behavior of certain colleagues in the office suggests that they perceive the office worker to be less competent in performing their job tasks than they actually are. The office worker's reaction may be to minimize the appearance of their disability through use of a manual wheelchair, although this choice might result in negative consequences such as excessive energy expenditure and fatigue in the short term and shoulder injury in the long term. Stigma and other aspects of the social context are discussed form the ethics point of view in Chapter 4.

Cultural Context

Culture is an intangible concept that can be cumbersome to define. Davis suggests that it can be understood as:

> *A unique and ever-changing constellation [that] we recognize through the observation and study of . . . language, religion, social and economic organization, decorative arts, stories, myths, ritual practices and beliefs and a host of other adaptive traits and characteristics. The full measure of a culture embraces both the actions of a people and the quality of their aspirations. No description of a people can be complete without reference to the character of their homeland, the ecological and geographical matrix in which they have determined to live out their destiny.*
>
> ***(Davis, 2009, pp. 32–33)***

This rich description of culture highlights the influence of the collective on the individual's perception and use of AT, that is, the shared beliefs that influence the person's worldview will similarly influence their readiness to incorporate AT into their daily occupations. It further suggests that in addition to beliefs, aspects such as collective aspirations, time, place, and space are all relevant to the AT design, selection, and use. These far-reaching philosophical ideas may seem quite distant from the selection of AT. Yet cultural beliefs can be a major factor in the acceptance and use of a device, particularly when the client and clinician do not share cultural beliefs and experiences.

To illustrate these ideas, consider a clinician who was raised and educated in southern Canada who assumes a clinical position in the far north of that country. The cultural beliefs and experiences of this clinician and their clients are not shared for common occupations. In the south, travel from one location to another is most commonly accomplished with a car on paved roads. In the far north, vehicles such as an automobile are not as effective, and movement from one location to another is easier in the winter when the land is frozen to allow use of snowmobiles or dog sleds. Play for a child in the north is less dependent on electronics than it is in the south because of access issues. Food preparation and other household occupations differ. Indeed, access to many amenities such as a reliable source of electricity or fresh, affordable food is limited in many remote communities in the north (MacLachlan, 2010). The clinician is not able to rely on their own cultural experiences but must accommodate their clinical reasoning to ensure that the recommendations made will be meaningful and appropriate for the cultural (and other) context in which they practice. In simpler form: clinical recommendations that are appropriate in the **cultural context** in which they were raised and educated may be highly inappropriate in the context in which they practice.

What are some of the cultural aspects that may influence the readiness to accept and use technology? Beliefs about independence versus interdependence have implications for how the person accepts assistance. Western culture places high value on independence, which might reinforce use of technology or restrict it. If the technology use is interpreted by the person and others as a sign of disability, vulnerability, or some other undesirable attribute, the device is more likely to be rejected or abandoned. On the other hand, technology that is valued, is seen to enable independence, or that, in the eyes of the user and others, confers a positive status is more likely to be accepted and used.

Cultural beliefs that value interdependence may cause the client to accept assistance from others and consider technology as unnecessary. Of course, it is not usually this black and white; many clients use a mix of technology and personal assistance in addition to using their own abilities (Miller Polgar, 2010).

Beliefs about disability, occupational or social justice, and the rights to choice and control over occupational engagement also influence technology selection and use. A client and others who hold the view that a disability is some form of punishment and that those with a disability do not have the right to engage in or are not included in community or civic activities may not see the need for technology that enables these occupations. Views about personal space may influence the acceptance of technology, such as a wheelchair or some EADLs that place a physical barrier between the person and others in their environment.

Culture, although a somewhat nebulous construct, is an important aspect in the consideration of appropriate AT. Time spent understanding the cultural beliefs and experiences of the person and significant others is necessary to facilitate the most appropriate AT recommendation. The process of developing cultural sensitivity is one of personal and professional growth, which includes increasing knowledge of cultural differences, engaging with different cultural groups, and reflecting on the role one's own culture plays in their thinking and behavior (Balcazar et al., 2009).

Institutional Context

The **institutional context** refers to larger organizations within a society that are responsible for policies, decision-making processes, and procedures. Institutional aspects of legislation, regulation and policy, funding at a state or provincial level, and policies at more local levels, such as municipalities, school boards, health care institutions, or other community agencies, are of particular importance to provision of AT. The Canadian Model of Occupational Performance and Engagement includes economic, legal, and political components, such as government-funded services, legislation, and political regulations and policies in the institutional element (Townsend & Polatajko, 2002). The Person-Environment-Occupational Performance model situates institutional concepts of the external environment in the social and environment systems (Baum & Christiansen, 2005).

The ICF chapter that categorizes institutional aspects is labeled "Services, Systems, and Policies" (WHO, 2001). Services are "benefits, structured programs and operations in various sectors of society" that meet the needs of individuals (WHO, 2001, p. 192). Systems are the administrative and organizational layer at all levels of government or other authorities that plan, implement, and monitor services. Policies are "rules, regulations, conventions and standards" that regulate systems and, again, exist at all levels of government or other organizations (WHO, 2001, p. 192).

Legislation

Legislation in many countries establishes laws, policies, and regulations that enable persons with disabilities to engage in activities in various contexts within their local communities and beyond. Other legislation specifically addresses AT provision and service delivery. These laws specifically comment on environmental access issues; modifications required in employment, educational, and other community settings; and the responsibility of the employer or educational system to provide accommodations for eligible individuals, including the provision of AT.

Hocking (2011) again offers key questions that guide understanding and critique of how the institutional context influences participation in activities. She poses the question of how policies and legislation affect participation and directs us to identify the sectors and institutions that explicitly or implicitly affect participation. When considering the institutional context of legislation and policy, it is useful to identify the aim or purpose of a piece of legislation or policy, key definitions (e.g., definition of a person with a disability, AT), conditions of enactment of the legislation, and related regulations. Furthermore, it is useful to identify not only what is included in legislation, regulation, or policy but also what is not. For example, in the funding area, often items such as wheelchairs or communication aids are included, but other devices such as EADLs are not. While legislation, policies, and so on that explicitly address individuals with disabilities appear to be most relevant to AT use, others relating to broader communities will also affect how a person is able to do something with AT. Jónasdóttir et al. (2018) reported that community policies related to snow removal, ramped access to public venues, and signage placed on sidewalks limited mobility and community engagement for persons using wheelchairs. Similarly, policies concerning accessible transit prevent riders from engaging in leisure activities due to scheduling rules.

Legislation in the United States predates the release of the United Nations Convention on the Rights of Persons With Disabilities (UNCRPD). It has provided an example for other jurisdictions in their development of similar legislation. For this reason, we include an expanded discussion of relevant US legislation.

Rehabilitation Act of 1973 (Amended). The Rehabilitation Act of 1973 in the United States established several important principles on which subsequent legislation in that country has been based. The most far-reaching of these principles are nondiscrimination and **reasonable accommodation**. Section 504 of the Rehabilitation Act prohibits any activity receiving federal funds from discriminating solely on the basis of disability. To remedy discrimination, federally funded activities and programs must offer reasonable accommodations to facilities, programs, and benefits to ensure that people with disabilities have equal access and equal opportunity to derive benefits.

The Rehabilitation Act was amended in 1986 (PL 99-506), 1992 (PL 102-569), and 1993 (PL 103-73). Together these amendments include several provisions involving AT. First, the amendments require that each state includes provisions for AT within its vocational rehabilitation. It also requires that provision for acquisition of appropriate and necessary AT devices and services be included in Individualized Plans for Employment.

A third Rehabilitation Act provision with important AT implications is Section 508. This section was developed to ensure access to electronic office equipment by persons with

disabilities who work for the federal government. Although restricting the provision of the Act to the federal government may seem to severely reduce its impact, because the federal government is such a large purchaser of computers and other office technology, several manufacturers included such technology in the basic designs of their computer systems, increasing access outside of government departments.

Americans With Disabilities Act of 1990. The Americans With Disabilities Act (ADA, PL 101-336) prohibits discrimination on the basis of disability in employment, state and local government, public accommodations, commercial facilities, transportation, and telecommunications. To be protected by the ADA, an individual must meet the following ADA definitions of disability: a person who has a physical or mental impairment that substantially limits one or more major life activities, a person who has a history or record of such an impairment, or a person who is perceived by others as having such an impairment. The ADA does not specifically name all the impairments that are covered. The ADA has four main titles: Title I (employment), Title II (state and local government agencies and public transportation), Title III (public accommodations), and Title IV (telecommunications). Only those sections that specifically refer to AT will be described here (Title III does not mention AT).

Title I of the ADA requires that employers make reasonable accommodation to the known physical or mental limitations of otherwise qualified individuals with disabilities unless it results in undue hardship to the employer. Such accommodations frequently involve AT. The application of Title I to employee benefits protects employees with disabilities and family members with disabilities from discrimination in the provision of health insurance benefits, which is an important funding source for ATs.

Title II requires that state and local governments give people with disabilities an equal opportunity to benefit from all their programs, services, and activities (e.g., public education, employment, transportation, recreation, health care, social services, courts, voting, and town meetings). These opportunities are achieved through modification of the physical environment and use of devices to support communication of individuals with hearing, vision, or speech impairments.

Title IV addresses telephone and television access for people with hearing and speech disabilities; this section has wide AT implications because emerging and developing technologies in the telecommunications and television fields are changing at a rapid pace. Title IV requires common carriers to establish interstate and intrastate telecommunications relay services 24 hours a day, 7 days a week. Telecommunications relay service enables callers with hearing and speech disabilities who use text telephones and callers who use voice telephones to communicate with each other through a third-party communications assistant. Title IV also requires closed captioning of federally funded public service announcements.

Individuals With Disabilities Education Act, Amendments of 2004. The Education for All Handicapped Children Act of 1975, PL 94-142, later amended by the Individuals With Disabilities Education Act (IDEA) of 1990 and the IDEA Amendments of 1997 (IDEA 97), PL 105-17, establish the right of every child with a disability to receive a **free and appropriate public education (FAPE)**.

The centerpiece of the IDEA is an **individualized education plan (IEP)** that describes each student's current educational performance and outlines the program of specially designed instruction (special education) and supplemental (related) services each child with a disability is to receive as part of their FAPE. Assistive devices and training in their use have long been recognized as components of a FAPE. In the 1997 IDEA Amendments PL 105-17, schools were directed to consider the AT needs when formulating every IEP for students with disabilities.

The impact of this law has been far reaching. Devices ranging from sensory aids (visual and auditory) to AAC devices to specialized computers have been used to provide access to educational programs for children with disabilities. Lack of local services or lack of funds is not sufficient reason to deny services or devices justified in the IEP.

Assistive Technology Act of 1998. Designated as PL 105-394, the Assistive Technology Act replaced the Technology-Related Assistance for Individuals With Disabilities Act of 1988 (PL 100-407) and the amendments to that law (PL 103-218) enacted in 1994. The Assistive Technology Act extends funding to the 50 states, the District of Columbia, Puerto Rico, and outlying areas (Guam, American Samoa, US Virgin Islands, and the Commonwealth of the Northern Mariana Islands) that received federal funding under the Technology Act. The purposes of the Assistive Technology Act include the following:

1. Support states in sustaining and strengthening their capacity to address the AT needs of individuals with disabilities
2. Support the investment in technology across federal agencies and departments that could benefit individuals with disabilities
3. Support microloan programs to individuals wishing to purchase AT devices or services

The Assistive Technology Act is divided into three parts: Title I, State Grant Programs; Title II, National Activities; and Title III, Alternative Financing Mechanisms.

Title I provides grants to states to support capacity building and advocacy activities designed to assist the states in maintaining permanent, comprehensive, consumer-responsive, statewide programs of technology-related assistance. These include public awareness, interagency coordination, technical assistance, and training to promote access to AT and support to community-based organizations that provide AT devices and services or assist individuals in using AT.

Title II provides for increased coordination of federal efforts related to AT and universal design. Title III requires the secretary of education to award grants to states and outlying areas to pay for the federal share of the cost of the establishment and administration of or the expansion and administration of specified types of alternative financing systems for AT for people with disabilities.

The primary changes in the 2004 amendment include the repeal of the provision that allows the law to expire on an annual basis. It includes the provision of AT for individuals of all ages and attempts to make the provision of AT and access to AT

services more consistent across the states and other US jurisdictions (Association of Assistive Technology Act Programs, n.d.). The 21st Century Assistive Technology Act is a reauthorization of the 2004 Act, with minimal changes to the main provisions that are described here (Association of Assistive Technology Act Programs, n.d.).

Legislation in Other Countries. The UNCRPD requires that members states who are signatories of the convention agree to develop and implement legislation, regulation, policy, and so on to support the named rights. The UNCRPD is explained in more detail in Chapter 3. At the time of writing, 186 countries or "regional integrated governments" have ratified the UNCRPD. Hocking's (2011) questions described previously are useful for readers to apply when exploring and understanding the legislation in their own jurisdictions.

Funding Regulations

Funding policies and regulations establish who is eligible to receive assistance for the purchase of devices, which devices are supported in funding schemes, and who (i.e., which professional group) serves as the funding gatekeepers.

Medicaid. Medicaid is a US federal program created in 1965 and codified as Title XIX of the Social Security Act (42 U.S.C. §1396 et seq.). The primary goal of Medicaid is to provide medical assistance to persons in need and to furnish them with rehabilitation and other services to help them "attain or retain capability for independence or self-care" (42 U.S.C. §1396). It is an income-based or means-tested program, so eligibility depends on a person's income level.

Medicaid programs are the largest funding source for AT—both assistive products and services—in the United States. However, its program vocabulary was established decades before the term *assistive technology* was coined, so reference to AT in Medicaid means access to items of durable medical equipment or prosthetic devices. Additionally, Medicaid language reveals a dated medical model of disability. Reference to services means access to occupational, physical, or speech-language pathology or audiology services. An individual who seeks Medicaid funding for any of these items or services must generally meet a three-part test: (1) the individual must be eligible for Medicaid, (2) the specific device or service requested must be one that is covered by the Medicaid program, and (3) the individual must establish that the device or service requested is required.

Medicare. The Medicare program was also created in 1965. Although Medicaid is focused on the needs of those who lack the financial means to meet the costs of necessary health care, Medicare initially was focused on the needs of elderly adults, defined as individuals aged 65 years and older. It was believed that this population was less wealthy and less healthy and had access to less health insurance than younger individuals and therefore needed assistance meeting the costs of their health care needs. Medicare subsequently was expanded to serve individuals with disabilities who are younger than age 65 years.

Funding in Other Jurisdictions. Across the globe, funding for provision of assistive devices varies widely, with no funding provisions in some jurisdictions. Again, the reader is advised to review the regulations and policies in their own jurisdiction to learn who is eligible for funding, what AT is eligible for funding, how funding is obtained, identification of gatekeepers, and other relevant provisions.

Assistive Products Standards

A final influence of the institutional environment on AT is legislation and standards that govern product design, function, and safety standards. For a product to be marketed and for it to be included as a device for which funding assistance is provided, the developers or manufacturers must ensure that testing and other measures have been undertaken to ensure that the product meets certain technical standards. The International Standards Organization and the American National Standards Institution/Rehabilitation Engineering and Assistive Technology Society of North America organization develop these standards. In Europe, the CE marking ensures that a product complies with the European Union directives. Standards for individual types of ATs are discussed in later chapters.

THE ASSISTIVE TECHNOLOGY COMPONENT

We now consider the last element of the HAAT model: the AT. At this point, we have discussed key aspects of the person, the activity and context that influence the choice, the design, and the use of AT. In both the clinical and design processes, understanding and integrating the first three elements leads to an informed recommendation for an AT that has the potential to meet the needs and be used by individuals and groups.

This book focuses on AT or "the application of organized knowledge and skills related to assistive products, including systems and services" (WHO, 2022, p. 6). We discuss several assistive products, that is, "external product[s] (including devices, equipment, instruments or software), especially produced or generally available, the primary purpose of which is to maintain or improve an individual's functioning and independence, and thereby promote their well-being" (WHO, 2022, p. 6). It is important to note that *assistive technology* refers to knowledge and skill necessary for the development and use of assistive products and includes systems and services that support the acquisition, training, regulation, and so on of assistive products. It is also relevant that this relatively recent definition by the WHO, unlike earlier ones, does not explicitly state that assistive products are intended for persons with disabilities. Rather, the wording is inclusive, recognizing that the technology and products are supportive of function for all.

Early development of AT was specially designed to meet the unique needs of people with disabilities (Cook & Hussey, 1995). Over time, many of the special adaptations developed for people with disabilities have become standard features incorporated into mainstream products. A partial listing of these features and both their AT and mainstream uses is shown in Table 2.3. Likewise, many devices that we commonly use today were initially developed to support abilities of persons with disabilities. For example, the typewriter was produced for a blind Italian countess, the ballpoint pen was created for people who could not use a pen with a point because of poor manual skills, carpenters' miter blocks were made for those who could not use two hands

TABLE 2.3 Application of Sample Technology Across Assistive and Mainstream Use

Technology Name	Assistive Use	Mainstream Use
Closed captioning	Textual translation of voice and sounds on TV for people who are deaf or hard of hearing	Television screens in lounges and gyms (more used here than by people who are deaf)
Voice recognition	Text entry for those who are unable to use their hands to type on a keyboard	Anyone wanting to enter text faster than they can type; widely used by lawyers; telephone prompt systems
On-screen keyboards	Text entry for those who are unable to use their hands to type on a keyboard	Tablets and mobile telephones; many computing platforms do not have a keyboard attached and require the use of an onscreen keyboard for text entry
Speech synthesis	Computer-generated speech used to communicate for those unable to speak using their own voices	Voice prompt telephone systems; many software applications where verbal feedback is provided
Digitized speech	Computer-generated speech used to communicate for those unable to speak using their own voices	Voice prompt telephone systems; many software applications in which verbal feedback is provided
Computer keyboard equivalents	Keyboard access and control of menu items for people who are unable to use a mouse or see the screen	Shortcuts to save time by anyone (e.g., Control-S to save)
Mouse keys	Control of the cursor via the numeric keypad for people who are unable to use the mouse	Graphic designers who wish to move the cursor a single pixel at a time and have difficulty doing so with a mouse
Sticky keys	Assist one-handed typists in accomplishing key combinations, such as Shift-A	Anyone who is a two-finger typist (and there are many) can use this feature
Word prediction	Speed text entry for people who are unable to use their hands to type on a keyboard	Used everywhere from spreadsheets to language learning software; word completion and word prediction help speed text entry for everyone
On/off push button toggle switches	Ability for people with limited motor control to turn on/off computers (instead of the traditional rocker switches in the rear)	Now almost every computer made uses this type of switch because it is simply easier for everyone
Callout control descriptions	Allow people who are blind to have the description of a control icon read to them via speech synthesis	Anyone wondering what a certain toolbar icon is supposed to mean can now dwell over it and get the text description
Screen enlargement	Allows people with low vision problems to more easily see the screen of the computer	Often used during presentations or in kiosks to make certain parts of the computer screen more viewable by the public
Head-tracking devices	Allow someone without the use of their hands to control the cursor	Gamers who are using their hands for other things such as firing buttons can still control the cursor; also used by database entry clerks and other computer operators who must have their hands on the keyboard at all times; used in hazardous environments where the computer is behind a window yet can still be controlled
Single-switch hardware interfaces	Allow people with physical disabilities who are unable to use a pointing device or keyboard to control the computer using a single switch	Used as a simple data acquisition solution for anyone needing to plug a switch into a computer; one known example: changing PowerPoint slides
Swype text input for touch screens	People who have difficulty using a standard keyboard (e.g., people with spinal cord injury, learning disabilities, amyotrophic lateral sclerosis) can enter text using head tracking or touch much faster than traditional uses of on-screen keyboards	Mobile telephones and the proliferation of touch-screen devices (e.g., iPads) do not have keyboards; Swype is used for all people using these devices to enter text much faster than alternative methods

for sawing, and cassette tapes and long-playing records were developed to support talking books for the blind. The introduction of the telephone was originally intended to help individuals who were hard of hearing, but its impact was felt mainly in the mainstream population, ending up marginalizing those who had difficulty hearing (Emiliani, 2006). However, the same technology that made the telephone possible was also useful in hearing aid amplification and telephone lines were later used to transmit digital data via modems, creating a visual substitute for auditory information. A number of material and manufacturing techniques originally intended for people with disabilities have also been contributed to the mainstream of design concepts, materials, and approaches. Pullin (2009) describes how plywood manufacturing techniques developed for splints during World War II led to the design and mass manufacture of unique furniture in the 1940s and 1950s.

This diffusion of features from ATs to the mainstream technology world has contributed to the development of two larger concepts. The first is **usability** (Fisk et al., 2009), already discussed in Chapter 1. The second is **universal design**: "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" (Sanford, 2012, p. 66). Principles of universal design are shown in Box 2.1. In this design approach, features that make a product more useful to persons with disabilities (e.g., larger knobs, displays in visual and auditory form) are built into the product. Universal design can be less expensive than modifying a product after production to meet the needs of a person with a disability. However, design and production of products following universal design principles can still increase the manufacturer's costs. The increased emphasis on economic sustainability and profit worldwide has caused a level

BOX 2.1 Principles of Universal Design

- Equitable use: The design is useful and marketable to people with diverse abilities.
- Flexibility in use: The design accommodates a wide range of individual preferences and abilities.
- Simple and intuitive use: Use of the design is easy to understand regardless of the user's experience, knowledge, language skills, or current concentration level.
- Perceptible information: The design communicates necessary information effectively to the user regardless of ambient conditions or the user's sensory abilities.
- Tolerance for error: The design minimizes hazards and the adverse consequences of accidental or unintended actions.
- Low physical effort: The design can be used efficiently and comfortably and with a minimum of fatigue.
- Size and space for approach and use: Appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility.

of skepticism in industry regarding the cost-benefit ratio of universal design (Emiliani et al., 2011).

Today, ATs that assist individuals with disabilities come from two main sources, **mainstream products** and those designed specifically for individuals with disabilities. Mainstream products, especially those developed with universal design and usability principles, can often meet the needs of individuals who have a wide range of abilities. Fig. 2.6 shows examples of mainstream technologies useful for persons with disabilities.

Incorporation of accessibility features into mainstream products has opened new opportunities for people with disabilities. However, recognition of universal design principles and understanding product usability reveals that the need for products specifically designed for the needs of an individual still exists. Universal design does not completely eliminate the need for specially designed ATs because the variety and complexity of individual needs are too great for inclusion in a single product (Emiliani, 2006; Emiliani et al., 2011).

Mainstream and specially designed technologies are often combined in what are known as modular systems (Emiliani et al., 2011). The basic idea of a modular design is to assemble an assistive product system as a set of distinct components that can be developed independently and then plugged together. For example, a mainstream computer can be connected to an eye-tracking system making it accessible through eye gaze. "Modular-based solutions can provide the individual with optimum usability as the solutions can be adapted exactly to the needs and requirements of the individual" (Björk, 2012, p. 121).

A continuum of technologies useful for persons with disabilities was presented in Chapter 1. There we described mainstream technologies, designed without any particular user in mind, and custom-made AT, produced for individuals with complex and/or very specific needs. Mainstream technologies are easily available from physical or online stores. While a mainstream technology can be taken off the shelf, with little to no input from a professional, a custom-made assistive product needs to be designed and developed by an

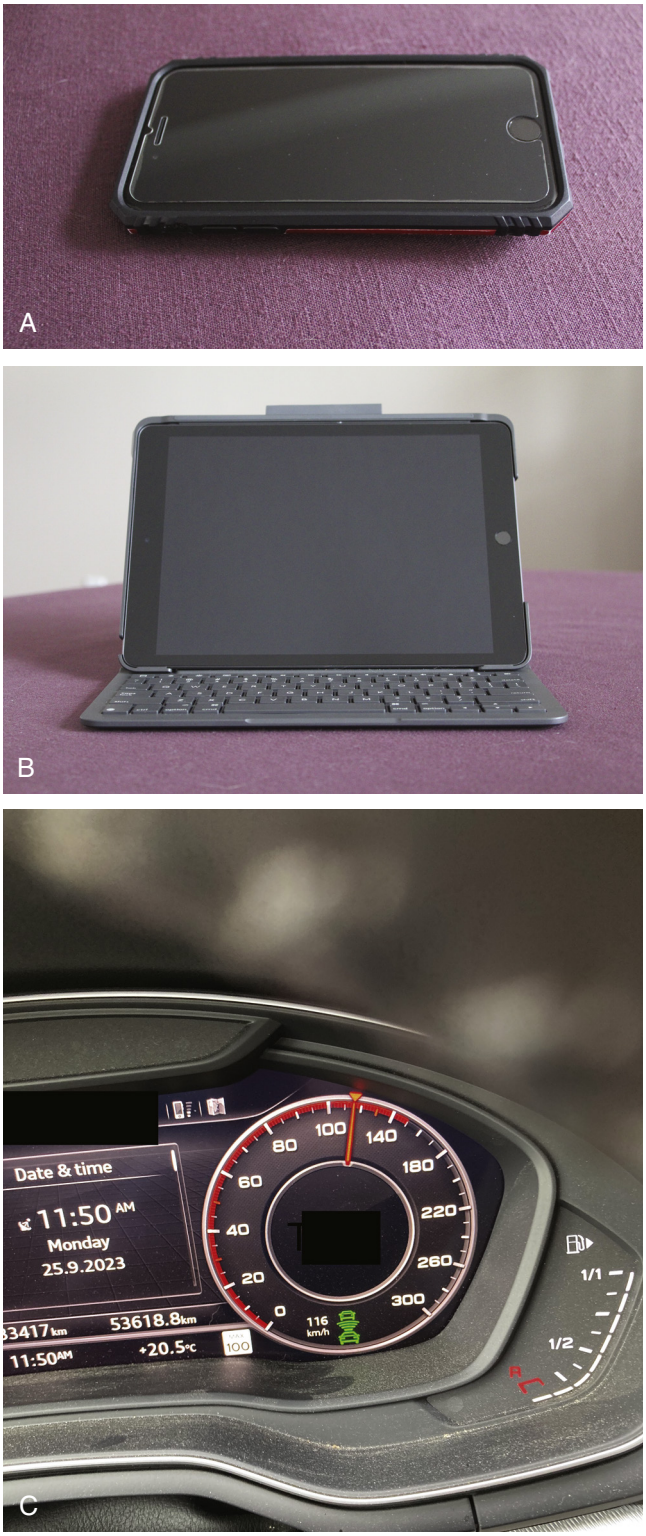

Fig. 2.6 Advances in mainstream technologies that make them more usable by individuals with disabilities of all ages (A) There are many more options for all types of mobile technologies like cellular telephones. (B) Mobile devices like tablets are becoming more and more user friendly. (C) Mainstream automobiles with more options that help individuals with disabilities. (All photos courtesy J. Polgar.)

expert team. Therefore, when moving along the continuum between mainstream and custom-made technology, usually we go from no mediation in access to a team of mediators to assess the particular needs of the person, and then we design and develop a product that meets those needs. Mainstream technology, since it can be mass-produced, is often less expensive when compared with custom-made AT. However, the cost the person bears may go in the opposite direction, depending on the funding schemes available. It may be the case that mainstream technology is not eligible for government or insurance funding, while custom-made AT is.

To illustrate these ideas, let us consider the example of wheelchairs and cushions. Basic wheelchairs and cushions are available from many in-person and online sources. A consumer can purchase these devices simply with the assistance of the store personnel, and they are typically obtained without any modifications made. If the consumer's needs are more complex or specific, wheelchairs that have more modifications or features are required, often necessitating purchase in a store that specializes in health care or mobility technology. For example, an individual who requires a power chair or a pressure distribution cushion will need to obtain this device at a specialized store. Often the purchase of these devices is in collaboration with a health care professional. If the person's seating or mobility needs cannot be met by commercially available technology, a solution needs to be found through clinics or wheelchair manufacturers. Examples of this type of technology are chairs that require mounting for a ventilator, that are interfaced with AAC systems or EADL devices, or chairs with seats that move forward and to the floor to enable independent transfers.

Assistive Technology Systems and Services

AT includes the human areas of decision making, strategies, training, concept formation, and service delivery. Without these, assistive products may not reach those who need them or be used successfully. AT systems and services can be much harder to obtain because they are highly dependent on human knowledge and experience and institutional policies, procedures, and funding, rather than tangible devices that can be purchased. This knowledge is obtained slowly through experience, formal training, and textbooks such as this one.

In many places of the world, people have access to health care systems that encompass the provision of assistive products to support basic body functions such as seeing, hearing, or mobility. Labor, social affairs, and educational systems are often involved in the provision of AT to enable participation in all life domains. While systems and services have different levels of coverage and efficacy in these locations, there are other places of the world where there are no formal AT systems or services. In Chapter 3 we discuss global initiatives aiming at universalizing access to AT.

It is paramount to understand that the goal of AT systems and services should not be limited to the assessment of needs, procurement, and provision of assistive products. In fact, an assistive product per se may not enable the participation of a person. One critical aspect is the fitting of assistive products to meet the needs of individual users. For example, most current wheelchairs (see Chapter 9) have flexible configurations, with several components on the wheelchair being adjustable. Some adjustments and settings are made in the factory before shipping, but typically the provider of the wheelchair will need to make modifications to fit the chair to the user after it arrives from the factory. Adjustments to the wheelchair can make a difference in user comfort, safety, and performance.

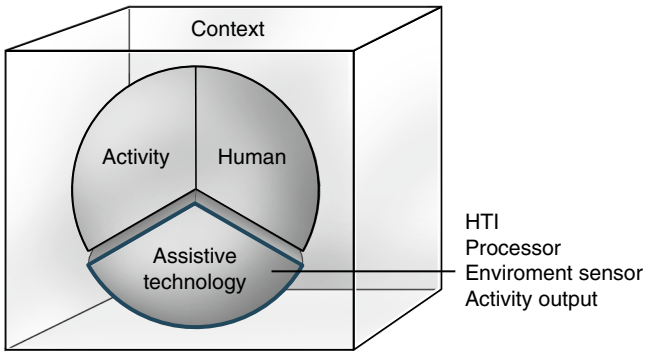

Fig. 2.7 The Human Activity Assistive Technology Model with elements of the assistive technology identified. *HTI*, human/technology interface.

Another critical aspect is training of the user to successfully use the assistive product. The development of effective strategies of use has a major effect on AT system success. Initially, the formulation of these strategies may rely heavily on the knowledge, experience, and ingenuity of the AT clinician or provider. With growing experience, the AT user develops their own strategies for successful device use.

Follow-up is a third critical area of AT services. Only through periodic outcome assessment can one ensure the assistive product continues to meet the user needs and does not get abandoned. Fitting, training, and follow-up in AT service delivery systems and services are discussed in detail in Chapter 5.

Assistive Products

Regardless of whether the assistive product is based on a mainstream device or is specially designed for people with disabilities, we can conceptualize its functionality in a systematic way. Fig. 2.7 illustrates the elements of an assistive product: the human/technology interface,[1] the environmental sensor, the activity output, and the processor.

The Human/Technology Interface

The boundary between the human user and the assistive product is called the **human/technology interface** (HTI). Examples of an HTI include a device keyboard and monitor, wheelchair pushrims, wheelchair seat cushions and other postural support, hand control knobs on a vehicle, and voice recognition software. The interaction between the human and the assistive product through the HTI is bidirectional. The human acts on the assistive product, often to control it; the assistive product provides feedback to the human, including

[1]We follow here the common terminology in which the term *technology* identifies a product (tangible, as a computer, or intangible, as an app).

visual, auditory, or tactile information, and forces that act on the human.

An essential feature of the HTI is enabling the user to control the device. You will be familiar with many of the means of device control. For example, a smartphone can be controlled through voice commands or by selecting an icon on the touch screen; the direction, speed, and acceleration/deceleration of a wheelchair can be controlled through forces exerted on the pushrims or a joystick. The device through which the user sends commands to the assistive product is the **control interface** (see Chapter 7). Examples are keyboards, remote controllers, eye-tracking systems.

Feedback is provided by the HTI to the user of the product about the effect of their control input, current mode of operation, alerts or alarms, or environmental information. For example, the **user display** shows the person whether they have input information correctly or not (as I am typing, the word processing program identifies spelling errors that I make); the visual display of a power wheelchair provides details on the current mode of operation and the remaining battery power; an obstacle detection system may signal the proximity of an object through a sound or vibration.

Interaction from the assistive product to the user through the HTI does not include only the provision of information. The assistive product can also act on the user. An HTI can provide postural support either directly, through positioning devices such as wheelchair seat cushions, backs, and other components, or indirectly through mounting devices that position the device in an optimal location for use. We discuss seating technologies in Chapter 8, wheelchair components in Chapter 9, and mounting devices in Chapter 6.

Environmental Sensor

An **environmental sensor** is the component that can detect various forms of energy. Examples include light sensors (cameras), sound sensors (microphones), motion sensors (accelerometers), pressure sensors, and location sensors (GPS receivers). Environmental information captured by these sensors may be useful for an assistive product. A camera can be used to convert text to speech; a microphone to convert speech to text; an accelerometer to detect falls; a pressure sensor to alert a person to change position; and a GPS sensor can be used to assist a person navigating.

Activity Outputs

Assistive products generate outputs that are appropriate to the chosen activity. We call this the **activity output.** Types of activity outputs considered in this book are mobility (see Chapters 9 and 10), manipulation (see Chapters 11–13), cognitive processing (see Chapter 13), and communication (see Chapter 14).

The Processor or Mechanism

In many AT systems, the input from the HTI must be altered in some way to generate an activity output. For electronic AT applications, we refer to this component as the **processor**. The HTI provides a signal from the user that the processor combines with the environmental sensor input to generate an activity output. For example, it is the processor in a mobile telephone that converts the touch of a finger on the screen to an action such as opening an app, while the light sensor information is used to set the screen brightness. Typical processor functions are listed in Table 2.4.

Some mechanical assistive products have no need for any processing (e.g., simple everyday technologies that serve as aids to daily living such as adapted cutlery). For other mechanical assistive products, there are processor-like functions that we refer to as **mechanisms.** The linkages that connect the hand rims on a manual wheelchair to the wheels are an example of an assistive product mechanism. Another example is the linkage between the gripper and the claw end

TABLE 2.4 Typical Processor Functions for Electronic Assistive Technology

Function Name	Description	Examples
Transformation	Conversion from one type of energy (e.g., electrical) to another (e.g., mechanical) or visual to auditory or tactile or vice versa	Braille reader that converts visual information from a camera to tactile information on a Braille display (see Chapter 7)
Amplification	Increases the strength of the required mechanical or electrical energy	Screen magnifier (see Chapter 7), power assist wheelchair rims (see Chapter 9)
Managing information	Storage and retrieval of data from internal or cloud-based sources	Vocabulary for augmentative communication (see Chapter 14), configurations for individual users of mobile telephones (see Chapter 7), stored functions in controller for power wheelchair (see Chapter 9) or for electronic aids to daily living (see Chapter 12), maps, or routing information for navigation (see Chapters 13 and 14)
Configuration	Loads user profiles that include ideal parameters for a particular user	Setup for computer access or controller for power wheelchair
Output	Generates control signals for activity outputs	Motor control signals sent to power wheelchair motors based on an internal controller
Manipulate data	Apps that perform functions necessary to process sensory information and generate appropriate outputs	Optical character recognition apps for screen readers, automatic speech recognition apps, and digital processing of sound in a hearing aid to separate speech from noise; powered wheelchair motor speed control based on joystick input

TABLE 2.5 Typical Mechanism Functions for Mechanical Assistive Technologies

Function Name	Description	Examples
Transformation	Converts one type of mechanical energy (e.g., translation) to another (rotation) to accommodate for motor abilities	Lever arms used for manual wheelchair propulsion
Augmentation	Increases mechanical advantage	Relative size of push rim diameter to wheel diameter determines "gearing" like a bicycle hub
Linkage	Connects the user action to the desired output	The internal linkage in a mechanical reacher that converts user grip to reacher end effector grasp

on a mechanical reacher. Some typical mechanism functions are shown in Table 2.5.

REASSEMBLING THE HAAT MODEL

To this point, the HAAT elements of activity, human, context, and AT have been discussed separately. This separation was useful to provide clarity to each of the elements to the model. However, the model as a whole describes a person doing an activity in a context with the use of AT, which requires an understanding of the intersectionality of these items and how it affects engagement and participation. To fully understand the combined influence of all the HAAT elements is not an easy task given the complexity and subjective meaning of the interaction between all elements. To help in this undertaking, we discuss three key concepts: (1) meaning of the activity, (2) meaning of AT and its use, and (3) occupational performance.

Meaning of an Activity

The performance of an activity holds meaning to an individual. When you think about all the activities a person performs in a typical day, across the span of a week, or on special occasions, some will quickly come to mind as very important, and some will seem so insignificant that they may even be difficult to recall. Humans perform a vast number of activities daily; some, such as brushing hair, take almost no time at all, but others take long periods of time, such as driving between two distant points or reading a book. Humans give meaning to each of these activities.

The human-centered aspect of meaning is the self-determined perspective of an activity or the personal, preexisting "lens" through which a person views an activity (Reed & Hocking, 2013). Personal meaning is drawn from previous experience with doing an activity along with the "in the moment" feelings generated by engaging in an activity. The sense of competence or accomplishment and the perceived challenge of an activity similarly contribute to personal meaning (Csikszentmihalyi, 1997). The blending of previous and current experiences of an activity invokes a dynamic, fluid nature of self-perceived meaning of activity. For example, someone who was previously skilled at dancing, who gained great satisfaction from this occupation, may derive less satisfaction if their dancing skills decline with age or if an injury limits their ability to dance for a time.

The occupation of riding a bike is used to illustrate the different meanings that can be ascribed to the same activity. A novice bike rider might perceive bike riding as something scary and uncomfortable because their limited skills will not prevent them from falling. Alternately, a novice bike rider might perceive the activity as a sign of growing up, performing an activity that is demanding. With experience and competence in bike riding, the perception of the activity changes, becoming something that is fun, freeing, or providing a sense of adventure. The perception may change further if riding becomes cycling and a form of exercise or if it becomes transportation, an alternative to driving a motor vehicle. Although the essential activity is the same, bike riding in this example, the meaning attributed to it is not static, changing with the development and skill acquisition or decline of the rider and with the purpose for the use of the bicycle (e.g., exercise versus transportation).

What do these ideas mean for our discussion of the activity, the human, AT, and the context? Let us consider the experience of a person who uses a speech-generating device for oral communication who is eating at a restaurant. First, let us think about the situation when they are eating a meal with friends. The meaning that they bring to this situation, based on past interactions with these friends, might be that they will enjoy a good meal and good conversation and that their use of a communication device is simply recognized as how they talk to their friends. However, they and their friends are not alone in the restaurant. The wait staff may be unaccustomed to the use of a communication device and ignore the woman, asking others at the table what the user of the device would like to eat. It is possible that other patrons may not accept the use of the communication aid, perhaps commenting that the quality or the volume of the auditory output of the device affects their ability to enjoy their meal. The meaning of this initially pleasurable experience shifts, perhaps becoming stressful or threatening as a result of the behaviors and attitudes of others in the restaurant. This example demonstrates the dynamic and fluid nature of a context and its ability to affect the perception of an experience.

Meaning is constructed through our engagement with different contexts, people, and objects in the world (Reed & Hocking, 2013). Context influences the meaning of doing; this meaning may change in different contexts. Doing may be more satisfying in one context than in another, or it may feel more comfortable in one context than another. A bird-watcher who is at a park with a group of other birders probably feels very comfortable wearing clothes that designate them as a birder, carrying binoculars and cameras around their neck, looking up into the trees or in the bushes for birds, and talking about exciting sightings. In this situation, the bird-watcher feels like they belong. Imagine now the same person dressed as a bird-watcher displaying similar behaviors but in a park or on a beach where others are doing other activities such as swimming, sunbathing, or playing

beach volleyball. In this context, the bird-watcher's behavior is uncommon, perhaps considered odd, which then changes their perception to feeling like an outsider. Doing the activity of bird-watching might be less satisfying in a context where the person feels they do not belong.

This discussion conveys, in part, the danger of making assumptions about the meaning an activity holds for an individual. An activity that might be considered work for one person is considered leisure for another. One person might view an activity such as reading as something they are forced to do, for homework as an example, but another seeks out reading as a desired activity. Understanding the meaning that participation in an activity holds for an individual is useful knowledge for the clinician when uncovering the necessary, important, and desired activities to be enabled through AT use.

Meaning and Assistive Technology

When we introduce the use of AT into the doing, the meaning may be influenced in different ways depending on whether the context supports, or not, the use of technology, through physical, social, cultural, or institutional structures. In these situations, the meaning of using AT when performing an activity becomes an important consideration.

AT may enable or hinder participation in activities; the influence of the human and the context may result in the same assistive product enabling activity participation in one situation and hindering it in another. For example, a wheelchair enables mobility where features like ramps and elevators/lifts exist but hinders it where they do not. Miller Polgar (2010) identified several themes illustrating the meaning individuals with disabilities have for their use of AT. As an enabler, AT was simply seen as a tool, just another way of doing an activity. AT was seen as a way of leveling the playing field by eliminating or, in some situations, masking a disability. Commonly, this latter idea was related to computer and other electronic technology use.

In contrast, AT was seen as a barrier, in some cases a physical barrier, and as a contributor to stigma. Equipment such as a wheelchair or communication devices mounted on a wheelchair create a physical barrier between the AT user and others. Similarly, the arrangement of assistive products can cause a physical barrier, as when a computer is placed so that it creates a barrier between the user and others in an environment such as a classroom (Miller Polgar, 2010).

Likewise, assistive product use is seen as a visible sign of disability. Indeed, signage that designates accessible facilities typically features a wheelchair. Rather than a physical barrier, AT as stigma creates a social barrier, an "othering" that makes it difficult for someone using an assistive product to feel a sense of belonging and worth (Miller Polgar, 2010).

Occupational Performance

Occupational performance describes how a person does an occupation (AOTA, 2002; Chapparo & Ranka, 2005; Townsend & Polatajko, 2013). The manner in which the occupation or activity is completed, where, when, the frequency, and other temporal aspects discussed earlier are important to **occupational performance**.

Fig. 2.8 The activity of playing a guitar demonstrates the intersection of skill level, motivation, and satisfaction with performance. (Courtesy J. Polgar.)

The level of skill and skill acquisition affect occupational performance. A novice is bound by procedures and rules as they develop the skills necessary to perform an occupation. Complex motor tasks may be under cognitive control as the performer learns how to complete them. Consider the example of a guitar player (Fig. 2.8). A novice player may need to think about the fingering needed to play a specific chord or use music to provide cues for finger placement. The tune is played as it is set out in the musical score. As the player gains expertise, the ability to play chords becomes much easier, no longer requiring cognitive control. The player gains confidence to deviate from the musical score to change how the tune is played. With expertise comes a degree of freedom allowing the person to experiment, take risks, and perform the occupation in novel ways. A similar experience may occur as an individual learns to use AT and incorporate it into their daily life.

Occupational performance is influenced by personal preferences; preferences may be expressed temporally (when and how frequently an occupation is performed), spatially (in a certain location), and through the manner in which an occupation is completed (Baum & Christiansen, 2005; Kielhofner, 2007).

An individual who is motivated to perform an occupation may have a higher level of performance than if they are not motivated. Motivation comes from both internal sources (e.g., a student who chooses to study because they are interested in learning the material) and external sources (e.g., a student who studies to get a good grade and gain recognition from others). Self-determination and self-efficacy are related to motivation. An individual's sense of self-determination affects whether they perceive themselves as capable of engaging in an activity and completing it with a degree of competence (Deci & Ryan, 2008). **Self-efficacy** is the personal sense of how well one can perform an activity in an anticipated situation (Bandura, 1977). An individual may feel efficacious in certain situations but not in others. For example, a person may feel very comfortable speaking in front of a large group of people when they are reading from a script but less efficacious about speaking in front of a similarly sized group when they are speaking impromptu.

Another concept related to occupational performance is **occupational engagement**, which refers to the degree to which a person is engaged with or involved in a particular occupation (AOTA, 2002; Townsend & Polatajko, 2013). Most people can think of times when they have participated in an occupation but have not been particularly engaged in it. Perhaps they have accompanied a friend to a movie or sports event that does not really interest them. Perhaps they are participating in a meeting that has gone on for too long. In these situations, a person is physically present, perhaps performing the activities that comprise the occupation, but is not actively engaged in the occupation, perhaps daydreaming or doing something else like responding to emails on a mobile telephone or tablet. The context or the lack of a means to participate in an activity, such as can be provided by AT, affect engagement. Participants in the study by Jónasdóttir et al. (2018) described the inability to fully engage in the occupation of going to a movie due to the limited hours of accessible transit, which meant they were unable to view the entire movie.

Occupational satisfaction is derived from performing an activity. It describes the affective aspect of occupational performance (Townsend & Polatajko, 2013). Satisfaction is derived from the perceived level of performance, a sense of accomplishment, and support received for the performance. The ability to choose the occupation and control the context in which it is performed affects satisfaction, with greater satisfaction gained when an occupation that is chosen is performed in a context or manner over which the person has some control (Miller Polgar & Landry, 2004). AT can enable a sense of satisfaction and control, providing contextual elements that facilitate rather than inhibit occupational performance and engagement.

Changes in skill level can affect satisfaction with occupational performance. An individual who has lost skill because of trauma or illness may experience less satisfaction with their occupational performance because they are unable to perform at a previous level of competence, which may result in discontinuing the occupation or changing how it is performed, depending on the meaning of the occupation held by the individual.

Social and cultural contexts influence the perception of satisfaction with performance. For example, a person who excels at an occupation that is highly valued by society (e.g., professional athletes or actors) constantly has their performance critiqued in public forums. An athlete with strong internal motivation and high self-efficacy will be less influenced in terms of satisfaction with performance than one who is more externally motivated, with lower self-efficacy. The intersection of the personal belief in self and social expressions of performance or ability contributes to satisfaction with performance (Deci & Ryan, 2008).

Many of the occupations that we perform are not done individually. Occupational scientists have studied groups of individuals working together in a common occupation such as meal preparation. These types of occupations are termed *shared occupations* when they involve two or more people acting together (Pierce, 2003). We now turn to a particular shared occupation, co-occupation, to understand how these shared occupations influence AT use.

The concept of **co-occupation** is an idea that describes an occupation in which two or more people are involved and cannot be done by one person alone. For example, a conversation requires at least two people who interact with each other and take turns speaking and listening. The concept helps us understand the complexity of engagement in occupations and requires us to think about the shared occupations of a collective. Pierce describes co-occupations as highly interactive and reciprocal, with each partner making an equal contribution (Pierce, 2009). Pickens and Pizur-Barnekow (2011) extend these ideas by discussing the implications of shared physicality, emotionality, and intentionality in the performance of co-occupations. Participants have reciprocal motor actions, are responsive to the emotional tone of others, and understand the roles others play in completing the occupation as well as their purpose for engaging in it. Shared meaning (Bruner, 1990) comes about through this confluence of shared physicality, emotionality, and intentionality achieved through co-occupation.

Many examples of co-occupations can be described. A simple example is a parent reading to their child and asking the child to point out certain items in the book being read. In response to the verbal request to point out an item, the child makes the necessary movement. If the reading occurs at bedtime, the parent may be attempting to create a quiet space and mood to prepare the child to sleep. A quiet tone is, hopefully, perceived and shared by the child. Both the parent and child understand this shared bedtime routine.

AT's role in engagement in co-occupations is to facilitate one or both partner's participation. In this example, a child who is unable to use reliable auditory communication may use a communication device to indicate their response to the parent's request. It demonstrates how the introduction and use of AT change the dynamics of co-occupations by changing how one or more partners complete the occupation.

APPLICATION OF THE HAAT MODEL

Finally, we briefly consider the application of the HAAT model in the clinical and product research and development contexts. More in-depth clinical applications are found in Chapter 5 and the individual chapters on specific assistive technologies. Our discussion of product research and development is minimal, intended to highlight how the intersection of all the elements of the HAAT model apply to this aspect of the AT field.

Client Assessment and Outcome Evaluation

The service delivery process includes both assessment for the provision of AT and evaluation of the outcome of AT use. Chapter 5 describes AT service delivery in four stages: (1) selection, (2) fit, (3) training, and (4) follow-up. Selection involves identification of the activities the person wants and needs to do along with influence of key others such as parents, children, or spouses. It further involves assessment of relevant cognitive, sensory, motor, communication, and emotional aspects. During this assessment, a discussion about the meaning of the technology and concerns about the use of technology is beneficial to identify less tangible factors that will affect whether a device will be used and under what circumstances.