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How Practically Usable are Assistive Technology Devices for Users with Disabilities in Singapore?

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Abstract : *Although much research has already been done, written and published on assistive technology (AT) as well as the rapid proliferation of such devices, very little has been discussed about how practically usable AT is with individuals, who vary in disability type, degree of severity, and age as well as their capacity (innate) and ability (acquired) to perform that constitute their level of competence and their capability, which is their level of performance. The AT Universal Usability ("usable by all") – whose concept of universal usability is advocated by Ben Shneiderman – refers to the design of such devices that are usable for everyone regardless of his or her age, disability and severity. In fact, Universal Usability (UU) is closely associated with the concepts of Universal Design and Design for All. However, in this paper, the authors have chosen to use the term "Practical Usability" instead of UU. Their main aim is to make sure that an AT device is not only applicable or usable but must be useful and practically usable to a user whose specific needs and challenges can be different from others. The authors have designed a simple and easy-to-use AT Device Practical Usability Questionnaire to help those currently using AT devices or planning to buy such devices to make informed decision if these are really needed or useful to them.*

Keywords: *Assistive Technology, Disabilities, Practical Usability, Special Education, Universal Design*

I. Introduction

Over the past several decades and more so as we enter into the new millennium, technologies have evolved rapidly and revolutionized the way agriculture, business, communication, education, politics, pharmacy and medical treatment … the list can go on and even battles are being conducted today. Today, technology has become a vital part of our daily living, playing an important role in mass communication and rapid dissemination of information even via handheld devices such as, smartphones and tablets [1]. In this paper, the focus is narrowed down to assistive technology (AT), which refers to any device, system or service that helps to improve the functional capacity of people with disabilities (PWDs for short) – also known as individuals with special needs – used in special education as well as by individuals with special needs after they have left school.

According to McKnight and Davis [2], one major challenge, taking from the perspective of technology, is that "there are clearly a large number of technological approaches to assistive learning technologies being investigated, and there is perhaps a tendency for research to focus on the technology rather than its uses" (p.3). For instance, the use of virtual reality technology (e.g., the use of avatars) and robotics (especially the socially assistive robots or SAR for short) have been found to benefit children with autism spectrum disorders learning to communicate and interact with others.

Another major challenge, taken from the perspective of users, is to determine the most appropriate approaches customized to meet and support the specific demands of specific impairments, but also, an urgent need for a greater understanding about issues relating users with such impairments. Today, there is a call for better operating definitions of learning disorders and disabilities (as well as other developmental impairments) in order to decide on the choice and operational application of appropriate strategies including AT devices to manage such learning and/or behavioral challenges (see [3]).

The next major challenge encountered in the field of AT research is often the lack of involvement of users of AT devices, especially when there are still "disagreements as to the extent and nature of participation of AT users that should take place" (p.2; italicized words added by us) [2]. One reason that has been noted is the need to consider the sociocultural contexts of AT use involving parents and teachers as well as individuals with special needs. Another reason noted is the difficulty in obtaining informed consent from AT users to participate in a study. McKnight and Davis [2] have argued that to find an effective solution, there is a need to consider the following three key factors that are essential to AT research (see Figure 1):

- The needs, capacities (inborn/innate) and abilities (learned) – both constitute the level of competence – of the AT users;
- The capabilities (it refers to the extremes of ability or the level of performance) of the AT to perform the required tasks; and
- The context of use that AT aims to support.

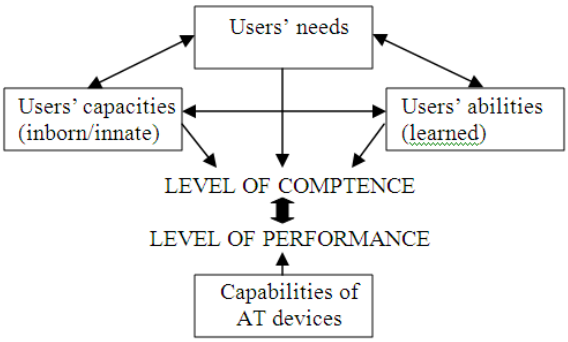

Figure 1 Key Factors for Consideration in AT Research

The term assistive technology (AT) is generic and may be used interchangeably with assistive learning technology throughout this paper to mean the same thing, i.e., it covers a wide variety of products and services, and hence, there exist many different definitions of AT. For instance, in the United States, the Technology-Related Assistive Act of 1988 defined AT as "any item, piece of equipment or product system whether acquired commercially off the shelf, modified or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities" (p.4) [4]. This definition of AT was included in PL 100-407 and was later modified slightly in the federal regulations for the Individuals with Disabilities Education Act of 2004 (PL 101-476) to be more applicable to children with disabilities.

Raskind [5] has chosen to provide a more detailed definition of AT in terms of its aims: "In some instances the technology may assist, augment, or supplement task performance in a given area of disability, whereas in others it may be used to circumvent or by-pass specific deficits entirely. AT is not intended to teach or instruct. Furthermore, it strives to accentuate strengths rather than weaknesses, to enable expression of abilities at a level commensurate with intelligence, and ultimately, to enhance the quality of life of persons with learning disabilities" (p.153).

The Foundation for Assistive Technology [6] has defined AT as any kind of product or service that is designed to enable independence for the disabled as well as the elderly. In the United Kingdom, the now-defunct British Educational Communications and Technology Agency [7] defined AT as software and technology that helps people with disabilities to overcome additional barriers they encounter in communication and learning.

Blackhurst and Lahm [8] have further elaborated the definition of AT to "include mechanical, electronic, and microprocessor-based equipment, non-mechanical and non-electronic aids, specialized instructional materials, services, and strategies that people with disabilities can use either to (a) assist them in learning, (b) make the environment more accessible, (c) enable them to compete in the workplace, (d) enhance their independence, or (e) otherwise improve their quality of life. These may include commercially available or home-made devices that are specially designed to meet the idiosyncratic needs of a particular individual" (p.7).

II. Assistive Technology for Individuals with Special Needs

AT is a very broad field ranging from the very simple to the very complex. It should be viewed as a continuum ranging from high-tech to no-tech devices as described in Table 1 below:

Table 1 Continuum of High- to No-tech Devices

High-tech devices	These are incorporate sophisticated electronics or computers.
Medium-tech devices	These are relatively complicated mechanical devices (e.g., wheelchairs).
Low-tech devices	These are less sophisticated and can include devices (e.g., adapted spoon handles, non-tipping drinking cups, and Velcro fasteners).
No-tech solutions	These are those that make use of procedures, services, and existing conditions in the environment that do not involve the use of devices or equipment. These might include services such as physical therapy, occupational therapy or the services of other specialists.

There is still a keen conflict between designing special purpose AT devices that suit individual users' specific needs, capacities and abilities, and in designing mainstream technological devices so as to be more appropriate for a wider range of users (McKnight & Davies, 2013). This issue calls for the attention to the seven

well-known principles of Universal Design – coined by Ronald L. Mace [9] – or UD for short that has been adapted here for the use of AT devices as shown in Table 2 below:

Table 2 The Seven Principles of Universal Design adapted for the Use of AT Devices

Principle #1	Equitable Use	An AT device that has to be useful and marketable to individuals of diverse capacities and needs.
Principle #2	Flexibility in Use	The AT device should accommodate a wide range of individual choices and abilities.
Principle #3	Simple & Intuitive Use	The AT device that is easy to understand, regardless of an individual's experience, knowledge, language skills, or current attention-concentration span.
Principle #4	Perceptible Information	The AT device can communicate essential information effectively to the user, regardless of ambient conditions or the user's sensory abilities.
Principle #5	Tolerance for Error	The design of the AT device minimizes problems of its usage or adverse consequences of accidental or unintended actions.
Principle #6	Low Physical & Mental Effort	The AT device can be applied efficiently and comfortably with minimum physical as well as mental fatigue.
Principle #7	Size & Space for Use	Size and Space for using the AT device must also be provided and carefully considered in terms of its approach, reach, manipulation, and application regardless of the user's body size, posture and/or mobility.

Currently, the best practice to prescribe appropriate AT devices for use by PWDs as well as to measure the outcomes of such devices being used is to take a multi-disciplinary approach. This means a collaborative partnership involving feedback from regular interaction sessions and over time, building a strong engagement among parents, professionals (e.g., occupational therapists and special education teachers) and para-professionals (e.g., teacher aides and AT technicians). For instance, casual conversations with parents or PWDs concerning their everyday experiences in using AT devices will create a better awareness among the professionals and para-professionals of the benefits as well as the challenges encountered in the use of AT devices. Commercially available instruments such as the Individually Prioritized Problem Assessment and the Canadian Occupational |Performance Measure have been used by professionals to help them identify key problems and levels of functional challenges in order to make a better informed decision on the appropriate AT devices for use by PWDs.

III. Assistive Technology Devices In Special Education

One of the greatest potentials for the use of AT devices is in the education of individuals with disabilities or special needs (also known as special education). Blackhurst [10] proposed a variety of AT devices that could be developed and used to enhance the learning, working, behavior and independence (including physical mobility) of individuals as a variety of disabilities.

In Singapore, AT is becoming more and more important, not only for PWDs, but also to meet the needs of an ageing population that the country is experiencing now and more so in the coming years. The population of elderly people can be classified into two categories: the elderly disabled, i.e., those PWDs who have grown old and are above the age of 65 years – the defining age for the elderly that has been accepted by most developed countries though it is somewhat arbitrary; and the disabled elderly, i.e., those elderly people with medical or health problems as a result of old age.

According to Lee [11], "[W]ith those aged above 65 making up one in five Singaporean residents by 2030 – marking a three-fold rise over 15 years in the number of seniors – there will be an increased demands for aged-care services as the workforce shrinks" (p.4). Hence, the Singapore Ministry of Health has to constantly innovate and improve the delivery of aged-care services that also include provision of AT devices to the elderly PWDs and disabled elderly individuals who need them. As a result, from August 2015, the Singapore Government opens the Assistive Technology Fund (ATF), which used to be open only to PWDs for education and work purposes, to cover PWDs of all ages and for all purposes including those who are in supported workplace employment, therapy or rehabilitation, or trying to become more independent in their daily lives.

In fact, the seven UD principles (see Table 2 above) have been applied in Learning (also known as UD for Learning or UDL1 for short), in Instruction including curriculum design and development (also known as UD for Instruction or UDI for short), in Living (also known as UD for Living or UDL2 for short), and transition from learning to living as well as from living to independence (also known as UD for Transition or UDT for short). However, the application of the seven UD principles does not stop here. They have also been further incorporated into UD for Independence (or UDInd for short) that has been used in job coaching as well as daily life mentoring for PWDs as shown in Figure 2 below.

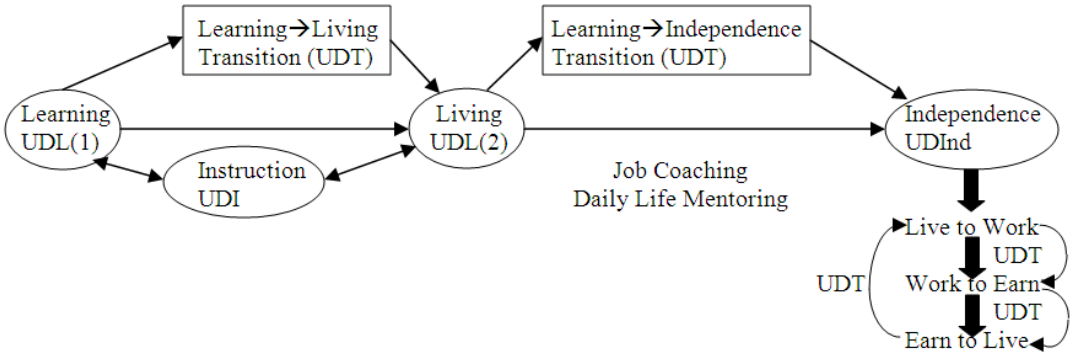

Figure 2 Application of the UD Principles from Learning/Instruction to Learning to Independence

The application of the seven UD principles from UDL1→UDI→UDL2→UDInd via UDTs as shown in Figure 2 above illustrates the importance of these principles that permeates across how the current special education system in Singapore is preparing a student with special needs to be ready for life. It has also helped to shape how AT devices should be designed and developed (Phase 1: Design and Development of AT Devices) as well as the way they are being used or applied (Phase 2: Use and Application of AT Devices) by PWDs and others including students with special needs attending either special or mainstream school. It is important to take note that there is a difference between use and application of AT devices. When we talk about use of an AT device, we refer to the benefits gained from an AT device. When we talk about application of the AT device, the focus is on how the AT device works in different situations/contexts and how it is used in each of these situations/contexts to produce the benefits it has been originally designed to perform. Next, how useful or usable these AT devices are to the users and whether they are really beneficial constitutes the Phase 3: Usability and Practicality of AT Devices. The two terms usability and practicality mean different things. By usability of an AT device, we refer to how effectively, efficiently and satisfactorily the device can be used by a user to perform the task and attain the goal it is designed and developed to do [12]. The other term practicality refers to what an AT device can really perform, likely to succeed reasonably to meet the user's needs (rather than what it is designed and/or developed to do but fails to help the user at all; in other words, it is nothing more than a white elephant) and that it is appropriately suited for the actual use. This third phase requires us to examine closely the Universal Usability (UU) of AT devices, i.e., these AT devices must serve their purposes for which they are designed and developed to benefit the users. In this paper, instead of using UU, we have borrowed its concept but chosen to replace Universal with Practical, i.e., Practical Usability. Our main aim here is to make sure that an AT device is not only applicable or usable but must be useful and practically usable to the user whose specific needs and challenges are different from others, since no two users, more so with PWDs, are the same in every aspect. These three phases constitute what we have termed as ATogogy, where -ogogy is a Greek derivative "to lead", i.e., to lead by assistive technology (see Table 3 for a summary of the three phases), a form of technogogy. It is not within the scope of this paper to discuss about ATogogy or technogogy.

Table 3 The Three Phases of ATogogy

Phases	Description
1	Design and development of AT devices
2	Use and application of AT devices
3	Usability and practicality of AT devices

IV. Assistive Technology Device Practical Usability Questionnaire

According to Collins and Halverson [13], we are currently going through what is termed as the digital revolution, in which the technology in designing educational or training programs are more readily available and accessible to everyone with or without disability than before. This means that more can be done, using AT devices, to educate and train individuals with special needs so that their potential can be maximized. This, in turn, can prepare them, hopefully, in the long run, to lead an independent life: live to work, work to earn and earn to live. However, AT varies significantly in terms of "cost from one device to another and sometimes can be too expensive for families or schools to afford" (p.19) [14]. Funding is certainly required to make AT devices readily available and accessible to those who need them most. Hence, in Singapore, the Government has made AT Fund via SG Enable – a Government-supported agency dedicated to enabling PWDs – available to all who need to get AT devices.

Another important criterion, according to Almahdi [14], in deciding on the appropriate type of AT device required by a PWD is to do a user's needs analysis in order to determine the right choice of AT device for the user. This is to ensure that the selected AT device assigned to the user must serve its purpose well, not

only being just useful but must also be practically usable. Whether or not users need some training to show them how to use an AT device depends on two factors: (1) the complexity of the selected AT device; and (2) the capability, capacity and ability of each user to be trained to use the device. Hence, it is important to take note if the selected AT device actually meets the seven UD principles to be useful and usable.

We have devised the following AT Device Practical Usability Questionnaire (see Table 4) to help parents, teachers and users in deciding if an AT device to be chosen for use is of practical usability.

Table 4 The Assistive Technology Device Practical Usability Questionnaire

Who is the user? What are the user's needs (based on the results taken from the user's needs analysis)?	
Before Using the AT Device	
The AT Device	The User
What is the selected AT device? What is the selected AT device designed/developed to do for the user?	What are the user's challenges that will hinder in the use of the AT device?
What is the cost of the selected AT device?	Can the user afford to buy, hire or rent for using it? How long does the user need the selected AT device?
What are the benefits to gain from the use or application of the selected AT device?	What is the user's level of capacity (innate level of competence to know and understand how to use a selected AT device)?
Where is the selected AT device being used?	What is the user's level of ability (acquired level of competence to be trained to use a selected AT device)?
How is the selected AT device being used?	What is the user's level of capability (level of performance to use a selected AT device)?
After Using the AT Device	
The AT Device: Issues of Usability	The User: Issues of Practicality
How effective is the AT device in use?	Can the user complete tasks, achieve goals with the AT device, i.e., does what he/she wants to do with the device?
How efficient is the AT device in use?	How much effort does the user require to use the AT device?
How satisfactory is the AT device in use?	What does the user think about the AT device ease of use?

V. Conclusion

The term usability is often used in relations to software applications and websites (see [12] for more detail). Another big concept – Universal Usability – advocated by Shneiderman [15], refers to the design of information and communications products and services that are usable for everyone. The concept of universal usability ("usable by all") is closely related to two other well-known concepts: Universal Design and Design for All.

However, in this paper, we have chosen to use the term Practical Usability in relation to any AT device that is employed by a user to accomplish a given task that would not, otherwise, have been successfully completed. The practical usability of an AT device constitutes the measure of the potential of the AT device to accomplish the goals of the user.

In conclusion, we acknowledge that there is still a need for more studies to be done in the area of practical usability of AT devices, especially for users with disabilities, applied in different phases of lifespan development, and also in different contexts where these devices are used. We hope this paper will serve as a catalyst to excite as well as to attract more researchers to look into the issue of practical usability of AT.

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