A Framework for the Adoption of Assistive Technology

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ABSTRACT

This paper proposes a framework for facilitating the successful adoption of assistive technology tools used by people with disabilities. It identifies the participants in the adoption process: the users, those involved with the user on a daily bases (caregivers), designers and assistive technology specialists. Each of these parties must bring certain attributes to the process in order for adoption to occur. Together, a complex and often difficult collaborative process of designing, selecting, personalizing, learning and integrating must be accomplished.

Keywords: assistive technology, disabilities, technology abandonment, technology adoption, collaboration

INTRODUCTION

There are many assistive tools available on the market today that possess the potential to profoundly empower individuals with disabilities. These devices are often purchased and tried but true success fails because users and their caregivers are unable to integrate the device into their daily lives. There is an adoption process that one must navigate before success can take place. The process involves the development of assistive technology; assessment of needs, desires and equipment; training, customization of the tool and facilitating its use into daily life. Failure in any one of these areas, particularly in respecting the user's goals and preference and keeping the process collaborative, can be detrimental. Because so much is involved in the adoption process, assistive technology tools do not typically become the useful tools we hope them to be.

A framework for analyzing the problem of high frequency abandonment of assistive technologies by users with disabilities and their caregivers has been proposed. The framework is the product of a collaboration between researchers at the University of Colorado's Cognitive Levers Group[1] (Depaula) and an assistive technology specialist from the Boulder Valley School District (Kintsch). The framework identifies recurring features of abandoned technology and how to avoid it derived from a review of empirical studies and direct observations.

ASSISTIVE TECHNOLOGY

Approximately 4.8% of the general population in the United Sates have severe disabilities which includes people with physical, cognitive, auditory, visual and communication limitations (Bureau, 2001; McNeil, 2001). A disability is "any restriction or lack of ability to perform an activity that is generally accepted as [an] essential component of everyday life" [3]. A handicap is a limitation on "the fulfillment of a role that is normal for the individual" (Russel, Hendershot, LeClerer, Jean, & Adler, 1997). A handicapping condition occurs when there is a mismatch between an individual and his environment (Scherer, 1996). However, a disability does not necessarily lead to a handicap or limitation in participation (LaPlante, 1997). Often a handicap can be over come using an external tool, an assistive technology device.

The U.S. Department of Health and Human Services defines assistive technology as any device and other solution that assists people with deficits in physical, mental or emotional

[1] www.cs.colorado.edu/~l3d/clever

functioning. Assistive technology devices provide alternative ways of performing actions, tasks, and activities (LaPlante, 1992). Altogether, more that 13 million Americans use assistive technology devices.

While assistive devices can have a profound effect on a person's abilities, such devices have a high abandonment rate, ranging from 8% for life saving devices to 75% for hearing aides. Approximately one-third of all assistive devices are abandoned (Scherer, 1996; Scherer & Galvin, 1996). There are no studies examining the abandonment rate across all types of assistive devices (Magiera & Goetz, 2001).

Users and their families often have high expectations for an assistive technology device and can be devastated when expectations are not fully met. The abandonment of an assistive technology device may have far-reaching implications. Not only does abandonment mean a loss of potential, freedom and independence, it leads to disillusionment with both technology and the adoption process. Assistive technology tools can be an excessive financial cost for families and its abandonment is an inefficient use of a finite service system (Kolatch, 2001; Parette, 2000).

In this paper abandonment of assistive technology tools is referred to as undesirable. But this is not necessarily the case. Abandonment, because a user no longer needs the device, is a positive event. For example, if a person learns to walk, they will no longer need their wheelchair. A user, while still having a functional limitation, may outgrow a current device. They may now be ready to use a more complex device that will enable them to do even more. While the majority of abandonment occurs for negative reasons, sometimes abandonment is a good thing.

PARTICIPATION OF ALL TO SUPPORT ADOPTION

A user is considered successful when the individual can use the tool with grace and ease in a variety of environments, when the user values and likes their device and when she is empowered by it. The process of adoption is complex. We have organized the components involved in successful adoption into a framework for assistive technology adoption. Among those components, we observed that the informed and active participation of all participants to varying degrees throughout the adoption process is a must. To begin, the user does not function in isolation and decision-making regarding which tool would be most beneficial is not straightforward. Adoption involves a collaborative interaction among four groups: (1) the user, (2) the persons around him/her who support and interact with him/her on a daily bases, including families members, friends, educators, therapists, doctors, and employers, (3) the assistive technology specialists who have knowledge of many tools and who facilitates a collaborative decision making process and (4) the developers of assistive tools [7]. As depicted in Table 1, each participant brings certain contributions and attributes to the process of development, selection, learning to use and integrating the device into user's daily life[2].

Developer Attributes

Developers, in some respects, are the foundation in the development of a useful and usable device. Developers must develop tools with a clear purpose in mind and this purpose must be conveyed and reflect the needs of the user. They must develop tools that are durable, meet user's aesthetic preferences and must are easy to use, while remaining highly customizable (Scherer & Galvin, 1996).

Assistive Technology Specialist Attributes

Working with the user and her caregivers must be at least one person who maintains a large repertoire of information regarding the unique characteristics of different manufacture's products as well as an ability to use and personalize the various devices related to a specific disability need. The Assistive Technology Specialist must guide users and caregivers in learning about the tools that are available and facilitate the selection process in a collaborative manner (Scadden, 1996).

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[2] Whenever possible, the individual with a disability should be in complete control of the assistive technology tool; they should be able to select, set up, personalize, trouble shoot and use it independently. However, with individuals with severe disabilities or young users, this is not always possible. They may need assistance in the selection process as well as support and training when using it. In this case the support system around them: typically family members, teachers, therapists and medical personal are critical to the process.

Involvement with the user and his caregivers by the assistive technology specialist does not end once the device has been acquired. They must be able to teach caregivers appropriate customization techniques, methods for teaching users how to use the device, how ultimately to fuse its use into a user's normal routine. Moreover, they must continue to be available for troubleshooting.

Caregiver Attributes

Obtaining an assistive device is only the beginning. Without an adequate support system the user of the device, particularly users who are children or have more severe disabilities, will not be able to learn to use the device. Often caregivers are unprepared for the responsibilities of programming and learning to use a device as well as learning how to use it in their daily interactions with the user. Yet, the caregivers fill several key roles: assessing, personalizing, instructing the user, and facilitating its integration into daily tasks. Families become used to doing things for the individual with a disability. The added pressure of learning how to customize a tool and then facilitate its use and integration can be overwhelming in an already difficult situation. In most cases the more customizable a device is, the more difficult it is to set-up. Caregivers must approach the new device with the proper attitude and require the user to use the tool to the best of their abilities whenever possible. Just as it may be easier for parents and teachers to do things for the user, so is it for the user (Parette, 2000; Scherer, 1996; Scherer & Galvin, 1996).

User Attributes

	User	Caregivers	A.T. specialists	Developers
Characteristics of successful adoption	Desires change in what they can do. Self-disciplined and has a high frustration tolerance Proud to use the device Willing to the tools use into their daily routine	Able to put forth effort required to learn to use and personalize the tool Support the user in using the new tool Welcome changes use of the tool brings to the social dynamic Understand that customization is not a one-shot deal and may need to continue throughout the technology's life.	Extensive knowledge of assistive technology Willingness to learn about new tools coming out on the market Facilitate a process which is collaborative rather than directive Offer training and support both in programming and integration Sensitivity to family values and cultural differences	Comprehensive understanding of functional limitations Develop customizable tools Develop tools which are simple to set-up Develop tools which are durable Allow for customer's aesthetic preferences Support users with technical support and short repair times

Table 1: Participant characteristics of successful adoption

To be successful the user must feel competent, they must feel that the device has enhanced their life and have opportunities to use the device. Although caregivers must go through their own introduction to the device, users should feel ownership and control of the assistive tool from the beginning. But in order to obtain success the user must bring certain attributes to the process themselves. Most importantly they must desire a

change in the activities they can perform (Scherer, 1996). We have observed that learned helplessness is a powerful and detrimental factor in many individuals' attempts towards independence.

If a user can perceive the discrepancy between the desired situation and the current situation and is optimistic that they will be able to learn to use the new tool effectively they will be more likely to put forth greater effort. They will be able to deal with the frustrations inherent in trying out, adapting and learning to use an assistive technology tool (Scherer, 1996; Scherer & Galvin, 1996). Through interviews with people with disabilities and therapists Scherer (Scherer & Galvin, 1996) found that people with congenital disabilities tend to welcome assistive technology more than those with acquired disabilities for they more readily perceive the enhancement to their abilities. Those with acquired disabilities tend to see assistive technology tools as reminders of what they can no longer do on their own. Too often people with acquired disabilities are prematurely pushed into using assistive devices that they then readily discard.

Good training, a good match, and good technology increase the likelihood that a user will feel capable and empowered. But the attitude and desire an individual with a disability is able to bring to the assistive technology tool is a critical factor in whether a device will be ultimately integrated into the user' s daily life.

ASSISTIVE TECHNOLOGY ADOPTION FRAMEWORK

Not only do each of these groups need to bring essential characteristics to the adoption process, they must follow a difficult and complex adoption process (see Figure 10). Each group will be called upon to bring forth their skills and abilities during different parts of the adoption process. Assistive technology tool designers will clearly need to bring their comprehensive understanding of functional limitations to the development phase. Assistive technology specialists will need to bring their vast understanding of the tools available as well as their skills as facilitators during the selection phase. Caregivers and users will need to put forth great energy in learning how to use the new tool and integrating it into daily life. During this phase the assistive technology specialists and developers will also be called upon to support and train the caregivers and users. The integration phase, will involve an ongoing expansion of activities that the user can complete with the new tool.

Phase 1: Development

While designers are developing tools to be used by people with disabilities, they are also developing tools used by caregivers. Developers of assistive technology can take advantage of the wealth of information on standard design practices, and integrate it with their knowledge in the area of design for people with disabilities. People with disabilities require tools that are durable in a variety of environments atypical of other technologies. Developers also face the challenge of learning not only about users' preferences, knowledge, attitude, goals and abilities, but also those of the caregivers. Caregivers require the simplicity of set-up and programming, while users require unique customization features.

Customization

Just as there is no such thing as the average person (Norman, 1993), there is no typical disability. Many disorders are best described as a spectrum with varying degrees to which a person is affected. There is great variability within each category of disability: cognitive, sensory, and physical. Cognitive disabilities can affect comprehension, expression, fluency of ideas, memory, reasoning, problem solving, hearing, attention, generalization skills, and motor skills. Sensory impairments involving vision can involve acuity, depth perception, color discrimination, peripheral vision, glare sensitivity, orientation and visual attention. Hearing impairments can affect hearing acuity within a range of pitches and frequencies, sound localization and auditory attention. The speed by which one comprehends what one is seeing or hearing and is able to react is also a factor. Physical impairments involve strength, flexibility, gross motor coordination, stamina, fine motor control, reaction time, rate control, speed, multi-limb coordination, and selective attention (Jacko, 2001; King, 1984). Each person's abilities and disabilities combine in a multidimensional fashion, that creates a truly unique condition or a "universe-of-one".

Moreover, the surrounding environment in which the user acts and makes use of an assistive tool further impacts his/her abilities as well as the effectiveness and usefulness of such a tool. Therefore, not only must designers understand the disabilities they attempt to support, but also

they must understand the settings in which their design will be used.

While universal usability argues that technology should be designed "for all," the entire context in which a person with disabilities lives, as well as her abilities and disabilities, make her situation unique. Thus the "one-size-fits-all" design approach is impossible and customization becomes necessary.

Simplicity

In developing an assistive tool, it must be kept simple to set-up, customize and use (DeGraff, 2001; Scherer, 1996). Developers should design set-up to be intuitive and similar to tools with which caregivers may already be familiar. For example, while still complex, augmentative communication tools with dynamic displays, which allow for hundreds of different messages, were designed similarly to the hyperlink structure of a web pages and HyperCard, where the selection of one choice brings you to a new page of further choices.

Durability

Devices must also be durable (King, 1984). Alternative keyboards and touch screens must be able to withstand large amounts of force from users not as able to control the power they use. Prompting systems or communication tools used by individuals who are independently mobile must be lightweight yet able to sustain a fall to the ground without damage. It must be able to go with users outside and experience different sorts of weather and temperature, be usable in different sorts of lighting conditions and where users may be eating. Moreover an assistive device must interface with other "standard" technologies. When devices breakdown, repair must occur quickly. A user can not go without their voice, prompting system or computer access for 6 to 8 weeks.

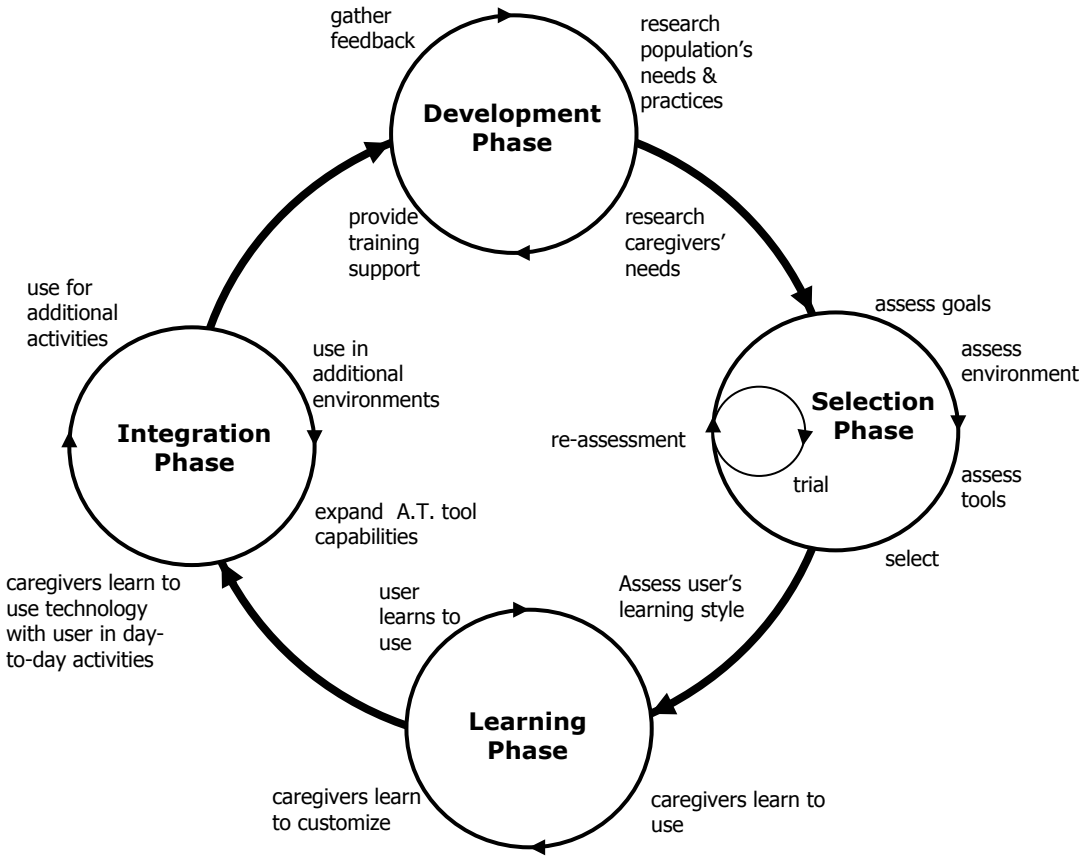

Figure 1: Cycle for Adoption of A.T.

User preferences

Aside from being usable and useful, assistive technology must be aesthetically pleasing, age appropriate, fashionable, and culturally and socially acceptable. Devices that look "handicapped" are not adopted (King, 2001). They should be carefully designed so that users do not feel singled out in their own social environment to the extent possible: they should be transparent [24]. Although a tool may be designed for someone with a severe limitation, this does not mean it should look like it is designed for a young child (King, 1984; Magiera & Goetz, 2001). If they are using computerized speech output such as DECtalk, they will want a voice which sounds age appropriate and of the correct sex (Vitale, 1996).

Recently the Boulder Valley School District Assistive Technology Team had a case of a young girl who was willing to try any augmentative communication device as long as it was red. Yet other individuals do not want tools that look different from what typical people are using. Now, in addition to getting a red e-talk[3], one can get communication devices on standard PDA's and laptop computers[4].

Phase 2: Selection Process

"The overarching factor in abandonment is failure to consider user opinions and preferences in selection" (Scherer & Galvin, 1996, p.4). Too often the expectations that the user has for a tool are not realized because their goals, perceived needs and preferences are not taken into account (Scherer, 1996). The freedoms offered have not resulted in the improved quality of life the user envisioned.

To avoid these problems, the process of selection must be collaborative and participatory. A team effort including the user, families, friends, educators, therapists, doctors, employers and assistive technology specialists must come together and despite age or severity of disability the user must be allowed to show her preferences to the greatest degree possible(Scherer & Galvin, 1996). Then the goals and expectations of the user and the technology must be established with the user and those supporting him, as often the goals of different team members are not the same (Angelo, 1995). For example, some may want the person with a disability to be able to access the computer for writing, while they may wish to access it for video games. In this case the appropriate hardware solution may be different.

Assessment

Not only do assistive technology specialists need to know about a variety of devices, they need to skillfully facilitate the selection process. Once the user's goals are known, the assistive technology specialist and the rest of the team needs to take into account the users' specific physical, sensory and cognitive abilities, in addition to their environment. Where will they be using the device? Does it need to be weatherproof or be able to withstand a spilled drink? Who will be there to help them set-up and learn to use the device? What sort of time commitment can parents and teachers reasonable make? While the user may be capable of using a sophisticated tool, the environment may not support it. For example, an eight message, digitized speech output device for communication requires only that the caregiver finds eight suitable pictures, presses a button and records their voice into the machine. However, dynamic display devices allow caregivers to customize for visual and auditory differences as well as a wider variety of physical access methods and cognitive levels. One can have a screen that includes 1,4,8, or a hundred different messages, which can be highlighted in different colors for visual feedback and can be accessed through direct selection or via auditory or visually scanning cues and some sort of switch. It also takes hours and hours of programming by the caregiver. If this programming is not done, or not done correctly, the sophisticated device may be less useful than the eight-message augmentative communication device.

There are wide range of factors that influence families', teachers', and users' decision making. Families and support personal fail to support new devices for a variety of emotional reasons as well. In a study of families with children with disabilities Parette and VanBiervliet (Parette, 2000) found that parents often worried that the tool was a crutch and that their child would not overcome their disability or that an external tool would make their child look too different or even more handicapped. This was found to be particularly true of members of minority groups who often see being a minority and having a disability as a double stigma. They did not want

[3] e-talk is an augmentative communication device produced by Great Talking Box co.

[4] Such augmentative communication devices are produced by Enkidu Research.

to draw even greater negative attention to their child.

Participation by the user and his family must be emphasized in all cases. Cultural differences must be taken into account. Some families will want to refer to elders or members of the extended family to help to guide them. People from some cultural backgrounds may hesitate to share their knowledge because they see the clinicians as experts. When this occurs, valuable information can be lost during the process (Parette, 2000).

Another aspect that must be considered is the user's personality. What is their frustration tolerance? Will they be able to put forth a lot of effort learning to use the device before they are rewarded? Or, do they require an errorless teaching method? A person's personality and environment has as much, if not more, to do with a specific device's selection, than does their functional limitations.

Once the social needs and preferences of the user and his environment are established, the team must carefully identify the concrete aspects that prohibit a person from using a device successfully. A person's cognitive, sensory and physical abilities must be taken into account to the smallest detail.

Selection

Once the specific goals, desires and limitations are uncovered a detailed analyses of different manufacturers' assistive tools personalization features must be made. By having a clear picture of the needs and the tool's capacities can a team cut down the length of the trial and retrial process.

Trial and re-assessment

The trial of a device is not a "one-shot deal". Not only must different tools be tried out and evaluated, but also different configurations of a tool may need to be attempted. A certain level of fine-tuning, perhaps not to the degree desired for final use, must be attempted to get fair assessment of the device's potential. Because both the caregivers and the user require experience with the tool, families need to be able to try out devices for extended periods of time. Most report that within days they know if a device will be useful, however sophisticated devices can take upwards of three months to evaluate. However, currently assistive technology developers and lending organizations rarely loan items for more than a month. Typically, only a week is offered (Magiera & Goetz, 2001; Scherer & Galvin, 1996).

If a tool is tried and found incompatible with the caregivers' abilities or users' goals and needs, the team must reconvene and decide whether further adjustments should be tried or if another option should be explored. A wise team will examine what specific element or elements did not work with the failed tool as they explore other possibilities. Often it will take many trials, each lasting for several months in some cases, before the correct tool with the correct customization is uncovered.

Phase 3: Learning

Caregivers

To be successful caregivers, preferably more than one, must be well trained in the device's properties. Training is however, not a single event, rather it is an on-going and collaborative process that takes place throughout the entire life of the device (Magiera & Goetz, 2001). Not only do caregivers need to know how to program the device from a technological standpoint but also how to program it from a pragmatic point of view. While the human computer interaction community has stressed for a long time the importance of taking into account these design issues, teachers, therapists, parents and users must learn how to employ them in a meaningful way for that specific user. For example, icons used in a communication or prompting system must mean something to the user. Natural patterns of mapping must be used to the extent necessary. Messages that are used more often should be more easily accessible. Common mistakes in programming include programming a "no" without a "yes" icon and communication systems which use multiple overlays that lack messages which let users say that the message they want to communicate is on a different overlay (King, 1984).

Caregivers, particular those that are not family members, also need to be taught to be aware of gender and ethnic issues as they choose icons and voices. Caregivers need to be made aware that those users using digitized speech probably do not want the same voice as their mother or teacher. The standard digital voice on most devices is male. One may need to re-configure things for a female user. The color black may be used to denote "wrong" or "bad" and thus offensive to many African American users and family members (Parette, 2000). Parette and VanBiervliet (Parette, 2000) discussed a case in

which members of a Navaho tribe wanted symbols and colors that were appropriate to their tribe.

User

Once caregivers feel comfortable with the device they must instruct the user as to how to use it, by first coming together and choosing the best method of instruction. Reasonable, easily attainable goals must be developed and, as they are met, new goals developed. Some users are tolerant of some frustration and can spend time learning without actually reaping many rewards; others must have some sort of instant gratification in order to buy into using the device. Once they have felt some sort of reward they are willing to put forth more effort. Others are very sensitive to feelings of failure and require an errorless teaching method throughout the process. Regardless of a person's learning style, using the new tool should be a rewarding experience.

Phase 4: Integration

Integrating a new device into daily activities is difficult until the user is adept at using the device. Initially tasks take longer than before (Magiera & Goetz, 2001). To begin it will take longer for a quadriplegic to maneuver their wheelchair with a sip and puff switch than it would if they were simply pushed. A plan for using the device must be made which continual expands the people with whom the user uses the device (particularly with respect to communication tools), the environments in which it is used and the repertoires of skills that tool enables the user to complete (see appendix a). For example, a user with a single message recorder may start using the tool to request food from his teacher at snack time, this can progress to asking for drinks at home with his parents, and then saying hello to peers in his class, eventually they may be in charge of an important sound-effect in the school play. The more places and people with which they are required to use the tool, the faster the user will learn and the more easily they will be able to use it in new situations. But to do this caregivers must learn how to find the times and places they can best begin to use the tool. In order to be considered a successful assistive technology user, the user must use his device across all environments.

To be a successful assistive technology user does not mean that one no longer has anything new to learn. As a user masters the current configuration of a programmable communication device, caregivers may work together with assistive technology specialists on modifications that address the new needs of the user so that she can continue on expanding her abilities. This usually requires the learning of new functionalities and the collaborative re-integration of the device into the current settings. Even when caregivers and users are proficient, technology support continues to be necessary as there are always occasions in which things break down.

SUMMARY AND CONCLUSION

With over 1,000 assistive technology products coming to market each year, the task of figuring out what is the best tool for a particular goal and functional limitation can be overwhelming (Scherer & Galvin, 1996). Consideration of all stakeholders, particularly the user, throughout the adoption process is crucial. During the design phase designers must be aware of the two users for whom they are developing. Not only must they hold a deep understanding of the functional limitations of their customers but they must also realize that the caregivers will become the ultimate designers of the product for the user. These caregivers are not necessarily skilled in the field.

The selection phase requires a long trial and error period whose time can only be shortened by detailed articulation of the user's and caregivers' goals and expectations, a thorough understanding of the user's functional limitations, the support environment surrounding her and a detailed and current knowledge of the assistive tools available. Places where caregivers can borrow various assistive tools are instrumental in fostering adoption and reducing abandonment.

The personalization and instruction for the user on how to use the tool is highly dependent on the caregivers' training and time. This task depends in turn on the assistive technology specialist and the developers for training and support. Integration of the new tool is an exciting process of discovering the new activities that the tool can empower the user to do. As the user learns to use the tool in more environments with more activities its use becomes natural, allowing the user to focus on other typical tasks.

As a user grows adept at using a particular tool their desire to accomplish more will increase, leading to a new cycle of the adoption process. As users become increasingly knowledgeable consumers, developers must remain involved.

They must not only keep up with user's increasing desires for independence, which new technologies can afford them, but they must keep their technologies current so that users can continue to interface with technologies on the open market.

The challenge of assistive technology adoption can be daunting but the rewards profound.

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APPENDIX A

Plan of integration for student using an augmentative communication device.

Example 1: Beginning augmentative communication communicator

Goal	Activity	Environment	Interactor
Learn the power of communication using an voice out-put communication device Motivators: Food Oinkers the stuffed pig Glitter wand	Snack time with highly desired foods - say that he is hungry	Special Education Room	Teacher
	Play time – say that he wants a toy	Home – living room	Mother
	Lunch time – make milk choice	School cafeteria	Para-educator
	Dinner – ask for more	Home – dining room	Mother or Father
	Before school – say which toy he is going to bring to school	Home – bed room	Older sister
	Breakfast – choose between bread & jam or cereal	Home – kitchen	Father
	Share/Trade snacks	Regular Education Classroom	Peers

Example 2: Intermediate augmentative communication user

Goal	Activity	Environment	Interactor
Express academic learning Motivators: Wants to be a part of things	Practice answering social studies questions	Speech Language Therapy Room	Speech Language Therapist
	Have regular education teacher ask him similar questions during social studies	Regular education classroom	Regular Education Teacher
	Answer questions about story read to him using specifically designed overlays for homework	Home	Older brother or independently (depending on device capabilities)
	Answer addition problems using manipulatives and	Regular education classroom	Para-educator

	communication device		