Assistive Technology Outcomes and Benefits
Volume 10, Summer 2016, Volume 1 pp 94-110
 ISSN 1938-7261
Available online: www.atia.org/atob

Measuring Assistive Technology Outcomes: A User Centered Approach

Adam Kinney, MSOT [a *]

Dianne M. Goodwin [b]

Lynn Gitlow, Ph. D., OTR/L ATP [c]

a *. Adam Kinney is the corresponding author, and at the time of this study he was a graduate occupational therapy student at Ithaca College, akinney9797@gmail.com

b. BlueSky Designs, Inc.,

651-603-0828, 651-917-0137 (fax), dianne@blueskydesigns.us

c. Ithaca College , Department of Occupational Therapy , lgitlow@ithaca.edu

Abstract

Individuals with disabilities may require mounting systems that provide access to devices they want to use (e.g., a communication device) within reach while they engage in their daily routine. The Mount'n Mover is such a system and was developed with the assistance of users. The purpose of this paper is to demonstrate the benefit of involving users throughout the design and use of an assistive technology (AT) device when evaluating AT outcomes. User involvement in the design process is described and then a retrospective study investigating outcomes is presented, and suggestions for a more rigorous research methodology are provided. This holistic approach to outcomes study suggests that involving users in the entire process can help to ensure that product features relevant to users' functional needs are designed into AT solutions.

Keywords: assistive technology, outcomes, user centered design

Introduction

Assistive technology (AT) professionals are familiar with the challenges of providing evidence to support the efficacy of AT interventions that are available for people with disabilities. Emphasis on documenting outcomes using randomized control studies (considered the gold standard for documenting evidence in a medical model arena), lack of a unified theory guiding systematic research in the field of AT, and inconsistent involvement of all stakeholders are cited as some of the barriers to providing the evidence that is increasingly required by funders in a fiscally constrained environment (Clayback et al., 2014). Consistent with the focus of this journal, and in particular this special edition of the journal focused on "Meeting the Evidence Challenge," this paper describes a collaboration between BlueSky Designs, the developers of the Mount'n Mover and independent researchers at Ithaca College. The first part of the article provides specific details of the user-informed design process which led to the development of the Mount'n Mover. The second part of the paper provides useful product feedback from a small sample of users who responded to reliable and valid outcomes measures and provides suggestions for more empirically sound methods of measuring the impact of consumer involvement in the design process. The paper concludes with a section describing what can be learned regarding the benefits of user input during the design process by using outcomes assessment.

BlueSky Designs Perspective

This section of the paper addresses one company's approach to the development of a new mounting system which attaches various devices such as speech devices, laptops, tablets trays and phones to wheelchairs, beds and tables. Prior to this development project, the founder of BlueSky Designs had worked as a rehabilitation engineer, developing custom solutions for individuals with disabilities. Her approach to product development reflects a rehabilitation engineer's approach to identifying a solution for an individual. First, clearly identify a person's needs and goals. Next, consider whether commercial products address those needs. If it is determined that available technology falls short or does not exist, work with the person to determine the ideal solution. As the design progresses, test it with the person and revise it until you are both satisfied. This approach of involving users is consistent with approaches that are increasingly emphasized by many who engage in product design (ideo.org, n.d.; usability.org, n.d.).

The product development process is similar, but it broadens the scope of audience for the product, and how it will be used. The designer is not only designing for a broad range of end users, but also for family members, attendants, therapists, and AT professionals, and therefore needs their input as well. The design process is iterative and must consider how it will be manufactured, what the cost will be, and how it is distributed and installed. Review sessions by various stakeholders are built into the development plan, in which prototypes are presented to test the form and function. The process continues until users of all types test functional prototypes and are clearly satisfied.

Identifying the Need for a Movable Mount (Pre-R&D effort)

The identification of the diverse needs and the idea for a customizable movable mount came from working as a rehabilitation engineer who was developing custom mounting and positioning solutions for speech devices to meet job accommodations. Existing mounts did not meet the needs of many clients, especially those for whom independence was critical, such as college students or people who worked. Custom solutions often involved movable mounts for tables, wheelchairs, or recliners or beds, such as: a table-mounted phone stand which could easily swing between work areas; rotating turntables to bring different objects within reach; stands with adjustable angles for books, devices or papers; retractable keyboard and laptop trays; a stand attached to an ergonomic chair for a court reporter; and a downward-facing book support that hovered above a person in bed.

Shortcomings of existing mounts (at the time of development):

- Only one operating position:
  - What if the user needs to move the speech device to eat or work, but still needs it within reach, in a usable position?
- Cannot be moved out of the way for independent transfers:
  - A person has to choose between communicating or independent toileting.
- Must be removed for transfers, toileting or pulling up to a table:
  - The person is dependent on others.
  - In restrooms, the user must choose between placing the device and mount in the sink or on the floor.
  - The user is then unable to speak during meals or at work.
- Once removed, most rigid mounts are cumbersome and hard to handle.
- If existing swing-away mounts are swung out of the way:
  - They are not usable (the screen does not face the person)
  - They present a tipping hazard if it is a manual chair (Lange, 1999)
- Armrest-attached trays (another alternative) are confining and carry a stigma.

Client goals <u>unmet</u> by other mounts or trays:

- Use more than one thing concurrently (i.e., book/laptop; tablet/phone)
- Easily and independently reposition a device
- Use it from more than one position (in front, to the side)
- Change devices easily
- Adjust tilt angle for glare, or visual access (for driving, watching television)
- Move it (safely) for transfers
- Repeatable positioning: Move it easily but return to the same secure position

Predecessors to the Mount'n Mover

The case studies below describe clients whose needs and goals were addressed by a movable mount. Their need for a device to be mounted had been met with existing mounts, but the mounts restricted them from achieving other critical goals.

Case 1: LB's school team and her vocational counselor wanted to remove barriers to her education and employment beyond high school. Her vocational goals required that she use a computer workstation. However, her speech device mount kept her from pulling up to the table. If the device was removed, she couldn't communicate. A standard swing-away mount was too difficult for her to operate and it positioned the device such that she could not use it. The idea that she could move her speech device to the side, in a usable position was identified as the optimal solution. A custom, movable mount with two arms and a joint that rotated under the device was designed and supplied. She was able to move it and access it from two positions. No other mounts offered that functionality.

Case 2: An 8-year-old girl with cerebral palsy and her mother wanted her to be able to get out of her chair independently. Then, she could get down on the floor to play, and she could use the toilet herself. At the time, she needed someone to remove her speech device to do this. Even though she had a swing-away mount, when it was swung out in a position from which she could get out of her chair, the weight of the extended device tipped her manual wheelchair. With the custom dual arm system, the device remained closer to the wheelbase and did not present a tipping hazard.

In both cases, the goal of supporting the device (the mount) was important, but there were other equally important goals. The solution, a mount that moved, allowed the two girls to participate more fully in other essential activities. Very importantly, they were no longer reliant on others and could do it when they wanted. The girls' experiences validated the need for and benefits of a movable mount.

The results in the two case studies above motivated the principals at BlueSky Designs to pursue Small Business Innovation Research (SBIR) funding through the National Institute on Disability and Rehabilitation Research and the National Institutes of Health. With SBIR support, BlueSky was able to launch a user-centric research and development effort.

Mount'n Mover Development: User Input in the Development and Testing Process

At various stages of the development process, different types of input were solicited. Sessions were held every 6-9 months, to present new prototypes to testers.

Pre-Focus Group Survey

A pre-focus group survey was used to identify and prioritize consumer priorities and preferences. Questions included which devices they presently mount to their chairs, problems or shortcomings with their existing technology, and the importance of different product attributes. Eleven consumers completed pre-surveys. The consumers were drawn from two organizations, the MS Achievement Center, and Express Yourself Minnesota, a support group for adults who use communication devices.

Of those who completed the survey, the most common devices mounted to the wheelchairs were bags or backpacks (100%), cup holders (91%), trays (45%), and communication devices (45%). Everyone expressed *the need to access multiple devices* from their wheelchair. Individuals rated the importance of twenty factors to consider in a wheelchair mounting system. The top factors, listed in order of importance were durability, proper positioning, wheelchair compatibility, *ability to do other tasks with device in operable position*, device safety, *difficulty moving the device for transfers*, device compatibility, ease of removing the device and mount from the chair, and the effect on the width of the chair. The factors receiving the lowest priority ratings were cost, appearance, and vendor.

In response to questions regarding problems experienced with their existing mounts, 64% reported their mount needed to have frequent adjustment to keep the device in its proper place. Many reported difficulty moving the device out of the way (45%) or back into position (36%). Others reported that devices were not positioned properly to begin with (36%). Only 36% of respondents could move their device out of the way for transfers, yet 64% wanted to be able to do so. Devices were removed from wheelchairs for transfers in 73% of the cases.

Information gathered was incorporated into the design goals and specifications.

Fig 1. Force-testing jig

Phase 1 Focus Groups

In Phase 1, three focus groups were held with different stakeholders, including people who use augmentative and alternative communication systems, people with multiple sclerosis (MS), and professionals who address mounting needs. Early stage prototypes were demonstrated, as were existing mounts.

A simple force-adjustable jig was developed to determine force preferences for actuating the lever and moving the mount (Fig. 1). It could be positioned for downward, lateral or upward activation to determine preferences. It was also useful in observing movement patterns required to access and depress a lever. Observation of individuals using and moving mounts was instructive in determining the ease of use, range of motion, strength and dexterity required for our system and others.

Development of Design Criteria Based on User Input

Consumers and professionals answered questions relating to force and actuation requirements to move, lock, and unlock a device mount; lever operating specifications (up, down, or lateral activation); locking characteristics (preset locking positions, ability to customize, and latching in unlocked position); placement of device in use and storage; ability to lock, unlock, tilt, and move a device; and comparison to existing mounts.

Fig.2. Consumers test prototype mounts

The following design preferences and parameters were derived from input from the focus groups and guided prototype development:

- Dual arm configuration preferred because of flexibility in positioning
- Ability to lock into a specific position very important
- Multiple locking positions for operating, secondary, and storage positions
- Able to mount and access more than one device (i.e. book/laptop)
- Ability to customize locking position
- Release should be with a depression, or a lift; choice would be nice
- Tilt should be a lateral release
- One-handed operation
- Able to depress lever and then push the lever to reposition the mount
- Ability to attach and remove devices without tools (quick release)
- Release force and moving force preferred a pound or less
- Some friction desirable so it doesn't move too easily, or too fast
- Able to have either a single or dual arm configuration
- Able to independently adjust tilt
- Changes or additional requirements identified after trial with prototypes included:
- Option to have a non-locking, friction-only version of the joint positioning mechanism
- Latched unlock option to keep it from locking out in inaccessible position
- Post-located lock release option (so release stays in place when mount moves)
- Lock release levers co-located at the device end

User preferences for the arm length, arm shape, actuation method, and shape of the user interfaces were also determined through developing and testing different options.

Fig. 3. Access multiple devices

Technical development and validation

Technical development involves many different methods and processes, ranging from sketches to 3D computer drawings; from hand-fabricated models for the arms and levers to test concepts, sizes and shapes to 3D computer design models; and then to 3D printed models. Only when the design direction was firmly established and proven with the input of consumers and professionals, was a metal machined prototype created. The investment of time and money increased with each step towards locking down the design. User input guided and validated design decisions and provided the confidence needed to further invest in specific directions. One drawback of the research and development project was that sturdy, load-worthy prototypes were not available for extended user testing. Today's prototyping technologies have made this more affordable and this will be possible in future development projects.

Fig. 4. Iterative design: Operating levers

Usability testing of the lock-setter design

Certain design features do not relate to the end user as much as to the individual setting up a mount, so some usability tests focused on the AT professional or family member. The lock-setting procedure is relatively easy once demonstrated, but it is not immediately apparent. A study was conducted for professionals to assess the usability of the mount and to compare the ease of use of two different lock-setting prototypes. Of lock-setting prototypes, subjects reported the Tab Lock was the preferred mount across all three ranking questions (Ease of Operation, Ease of Setting, and Overall Satisfaction), almost unanimously. It was also the fastest to set, based on the timed task. Subjects liked that a tool was not required to set the lock, that a finger or fingernail could be used. They liked the tactile feedback and that it was visually obvious whether it was set to lock. The tab lock was familiar, similar to a dip switch.


Fig. 5. Twistlet Lock

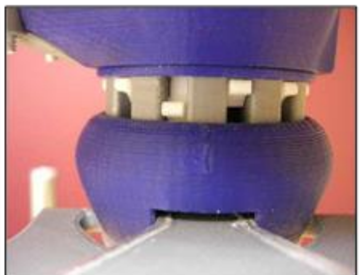
Fig. 6 Tab Lock


Fig 7. Lock setting usability test

Testing of the final prototype

Over 40 individuals, including 25 consumers with disabilities and their family members, and 16 professionals, tested the final metal prototypes. Until this time, the prototypes had not been robust enough to withstand the forces some consumers would exert on it. The results were exceptionally positive, as seen below, especially when satisfaction with their existing mounts was compared with reactions to the Mount'n Mover.

Product testers with disabilities attempted tasks such as moving the arm, rotating the platform, and tilting the device. Many end users, even those with significant disabilities, were able to unlock and move it. A few were unable to, as is to be expected.

It was observed that a number of people who could move the arm had difficulty accessing the tilt handle to unlock it. Once unlocked, many more could change the tilt. Some turned the device to improve the biomechanics, and could then unlock and change it. The tilt handle received the poorest control ratings, so it was modified prior to production.

Results of testing validated the design. 17 consumers, 8 family members and 16 professionals were asked to rate both current mounting systems and the movable mount prototype. When rating the **Positioning Features** of their current systems, they gave negative ratings in 45% of the cases and positive in 45%. No one ranked the movable mount prototype negatively, and 95% gave it positive ratings. Rating results for **Ease of Use** of their current systems resulted in 50% negative and 30% positive. 88% gave the movable mount positive ratings, and 10% gave a neutral rating. The movable prototype received overwhelmingly positive ratings (90%) for **Feeling of Independence**.

Insights based on observation

Through observation, interaction, and surveys, the collective feedback indicated the people testing the mount saw the potential to positively impact a person's independence and abilities.

- Parents were excited about the flexibility of the trays. They saw that they could be used for different things because of the ability to reposition them, for example, for eating and holding books.
- One feature particularly loved is the ability to change angles.
- A young woman in her twenties could not get over being able to change the tilt herself, and to use a phone independently. She was absolutely giddy.
- One product tester who uses a speech device said, "I can eat and talk at the same time!" because he could move his speech device to the side and pull up to a table. He has been using a Mount'n Mover seven years.

Fig. 8. Extended testing

Extended testing with users has the potential to provide critical insights. Unfortunately, the complex design did not permit the production of Mount'n Mover prototypes that were robust enough for extended testing. One prototype was modified for a woman with amyotropic lateral sclerosis (ALS) whose occupational therapist convinced the design team that she needed the product immediately. The client had refused to have a speech device attached to her wheelchair, because she could still transfer to use the toilet herself. She spent much of the day at home alone and made the choice to maintain her ability to transfer. Once she tried the Mount'n Mover prototype and saw that she could transfer, she embraced having her speech device attached and available at all times. She received the very first production unit and is still using it, 10 years after she began her extended use testing.

The Big Leap: Manufacturing and Commercialization

Throughout the development, the design team considered the implications for manufacturing. The choice of production methods greatly affects not only the look, feel and durability of the product, but the tolerances, cost, minimum order quantities, and the up-front tooling investment. Given that the team did not produce any products at the time, this was a very involved process. The design team met with vendors and obtained bids from at least two or three different vendors for each part. Production drawings had to be completed for each part, specifying tolerances and finishing. The team also had to source, order, and stock a wide range of fasteners.

More than 70 custom parts now are made from the following manufacturing processes: magnesium die casting, plastic injection-molding, metal-formed or stamped parts, plastic sheet-formed parts, custom labels, and aluminum extrusions.

The investment in tooling and inventory was significant. Without the investment in the user research to prove effectiveness and the impact of the products, the project might not have gone forward.

During development, discussions were held with the speech device manufacturers to ask that they add the new mount to their line. Infrastructure was developed for manufacturing, production, assembly, and finally, marketing. When prospective users contacted the company to order a Mount'n Mover and asked if it processed insurance, they had to be turned away. The company is too small to process insurance, but it resolved this obstacle by having clients talk to their speech device company or wheelchair vendor to submit funding requests for insurance reimbursement for the purchase of the mount. Our strategy was to develop a network of resellers who could process insurance.

Implications of Outcome and Impact Research Results

A significant barrier to the adoption of new products is reimbursement. To support therapists in their letters of medical necessity, the team decided that it would be valuable to have impartial research demonstrating the impact of the Mount'n Mover on its users. Occupational Therapy (OT) programs who had graduate students were invited to conduct outcomes research.

Another barrier is getting professionals to consider a device other than those they commonly use. The natural inclination of an AT professional in choosing and recommending a mount is to focus on the "device mount", with an emphasis on *device*. If they securely mount the device, they have done their job well. However, they have not necessarily considered the potentially beneficial (or detrimental) overall impact of the mount's characteristics on the person. They often choose "the familiar", a mount they have used for years, and do not consider the more holistic picture and benefits of a movable mount.

The next section, analyzing the impact of using the Mount'n Mover, identifies compelling reasons for a variety of stakeholders to consider options that promote a person's abilities to do more than access a device, but to consider the whole picture. Is it assistive? Is it restrictive? How will each of the available mounts impact their client's ability to do other things?

Outcome Study by Independent Researchers

Integrating user input into the design process as BlueSky Designs did when developing the Mount'n Mover can greatly enhance outcomes of device use. Developers of assistive devices, more specifically non-disabled developers, must use knowledge of a functional deficit that is grounded in the user's lived experience when addressing user need with a particular device. As stated above, therapists and developers may not understand a user's lived experience, thus creating a gap between actual need of the person that the device is intended to assist and the developer's/therapists perception of that experience (Choi & Sprigle, 2011). To insure that the device adequately addresses the user's lived experience, it is vital that outcomes based on the user's perspective are collected. This will insure that the device is serving its stated purpose and will inform further change in design to fulfill that purpose.

Researchers have documented the outcomes of AT devices and services in various ways (Hersch, 2010; Jutai, Fuhrer, Demers, Scherer, & DeRuyter, 2005). Lenker, Scherer, Fuhrer, Jutai, and DeRuyter (2005) described outcome domains commonly found in AT literature. These are device usability, user satisfaction, quality of life, social role performance, functional level, and cost.

Device usability is comprised of factors that include: effort and comfort associated with device use, frequency of device use, and benefits of use. Usability is said to be emerging from interactions between the user, device, and environment during task performance. Common indicators include device usage, safety, and benefits of use. User satisfaction is described as the user's evaluation in response to the AT device and its impacts. Quality of life is often considered to encompass all outcome variables, but it is most often used to describe the user's subjective well-being. Social role performance is often considered a domain of quality of life, and concerns the performance in activities shaped by the roles that the user fulfills (e.g., student or worker) (Lenker et al., 2005). Functional level involves the degree of independence of the user and their functional capacity. Costs may be expressed in monetary value or time expended on behalf of the caregiver or user during AT device use or service (Lenker et al., 2005). While these outcomes vary in scope and purpose, virtually all require the perspective of the end-user.

A member from BlueSky Designs contacted an independent research team in an effort to evaluate the experience of Mount'n Mover end-users. This study aimed to gain that perspective in order to affirm the benefits of integrating user input into the design of assistive devices and to further inform both the users and developer of the functional and psychosocial impact of device use.

Methods

Quantitative assessment of a retrospective case series design was used to investigate the impact that using the Mount'n Mover had on clients who had already been using the device. A convenience sample was recruited by sending an email with a link to an online survey to those who had purchased a Mount'n Mover. The survey was created using the online survey platform Qualtrics (Qualtrics, 2014). The Ithaca College Human Subjects Review Committee approved the study. To gain objective measure of the impact the device had on each client's functional and psychosocial factors, the Psychosocial Impact of Assistive Devices Scale (PIADS) (Day & Jutai, 2003) was selected as one outcome measure.

The PIADS is a 26-item, self-report questionnaire designed to assess the effects of an assistive device on functional independence, well-being, and quality of life. It measures factors intrinsic to the individual, as well as environmental factors, which impact the psychosocial functioning of the person using the device. Participants are asked to rate how the device impacted these intrinsic and extrinsic factors on a scale of -3 (decrease) to 3 (increase) (Jutai & Day, 2002).

The items create three subscales that measure the domains of competence, adaptability, and self-esteem. In the context of this tool, competence is a subscale consisting of items that represent the user's perception of their own performance and productivity; adaptability is a subscale consisting of items that represent the user's willingness to try novel tasks and take risks; and self-esteem is a subscale consisting of items that represent the user's emotional health and happiness. The PIADS has documented reliability, validity, and clinical utility (Jutai & Day, 2002). For this investigation, clients were asked to retrospectively provide information regarding the impact that the device had on their performance following the provision of the device. The user or a caregiver on behalf of the user could fill out the online survey.

Following the completion of the online survey, participants were asked to provide contact information if they were willing to participate in a semi-structured interview. While the PIADS was meant to provide an objective sense of the functional and psychosocial impact of the device, the interview was intended to thoroughly investigate the users' perspective of how the device impacted their performance of activities they consider most important, as well as their satisfaction with that performance. The Canadian Occupational Performance Measure (COPM) was used to structure the interview. The COPM is an individualized and standardized instrument that researchers have used in several studies investigating outcomes of AT (Petty, McArthur, & Treviranus, 2005; Gitlow, Meserve, & Michie, 2006a; Gitlow, Meserve, & Michie, 2006b), and is a reliable and valid measurement tool (Carswell et al., 2004). The instrument asks participants to list the daily occupations they consider most important to them. The participants then describe their performance of and satisfaction with each of these occupations by assigning to each a number from 1 to 10 (one being the least level of satisfaction or performance through 10 being the highest level or satisfaction or performance). Participants were asked to retrospectively complete this interview regarding their performance and satisfaction with the device before and after intervention, which allows an opportunity to capture the perceived impact that the intervention had on a participant's ability to perform occupations most meaningful to them. A change in score of two or more points indicates a clinically significant finding. Due to geographic barriers, the interviews were conducted by telephone, video chat or messaging services.

Finally, users were asked questions that allowed collection of demographic information and information that increased understanding of device use (e.g., "Why do you use the Mount'n Mover?").

Results

Ten respondents completed the online survey (3 females and 7 males) and 4 of them consented to participate in the interviews (1 female and 3 males). Six of the ten online surveys were completed by the client themselves; and three of the four semi-structured interviews were completed by the client. Results revealed that the mount was used to access a wide variety of devices including communication devices, phones, laptops, eating trays, and cameras. The variety of devices used was consistent with information available through the company regarding the diversity of devices accessed using this system (Mount'n Mover by BlueSky Designs, n.d.). When asked the question, "Why do you use the Mount'n Mover?", 90% of respondents indicated that it provided them with better positioning for their device, and 70% indicated that it was easily moved when users needed to approach surfaces.

As one user failed to respond to items needed to calculate the PIADS subscales used to measure the domains of competence, adaptability, and self-esteem, results were calculated for nine of the 10 participants. Table 1 below summarizes the mean change and standard deviation value of each subscale among all nine participants. Values represent the extent to which the device changed users' perception of each domain on a scale of -3 (decreased) to 3 (increased). While the small sample size limits the generalizability of any conclusions drawn, the values suggest that following device use, the users surveyed perceived an increase in factors that contribute to each domain.

Table 1

Descriptive Statistics for PIADS Subscales

Subscale	N	Mean	*SD*
Competence	9	2.12	1.049
Adaptability	9	2.15	1.046
Self-Esteem	9	2.00	1.16

Results of the four COPM interviews provided an in-depth understanding of how the participants used the device, and how the device impacted their performance of activities they consider most important. The participants mentioned 18 total activities that the device had impacted their performance of. These activities varied widely, and included an equal number (*n*=9) of activities directly related to the device they mounted using the mounting system (e.g., using a tablet, photography, or feeding) and activities not directly related to what they mounted (*n*=9) (e.g., playing adaptive baseball, transferring, and shopping).

The rating the participants assigned to their performance of each activity before using the Mount'n Mover was subtracted from that same rating after using the Mount'n Mover to calculate a change in performance score. That same process was used to determine the change in satisfaction score. Table 2 summarizes the average change in performance and average change in satisfaction score along with associated standard deviation values. These values are calculated for all of the activities listed, but are also divided into categories representing activities directly related to what the user mounted (e.g., using a computer) and activities unrelated to what the user mounted (e.g., performing a transfer).

The average change in performance and satisfaction for all activities mentioned represents an increase in those constructs that was well beyond the clinically significant level of greater than 2. While this change was greater in activities directly related to what was mounted to the device, a clinically significant change in performance and satisfaction was found in activities both directly related and unrelated to what the users attached to the device. Again, the small sample size limits the generalizability of any conclusions drawn, but the results suggest that use of the Mount'n Mover resulted in a significant increase in performance and satisfaction with the performance of a wide variety of activities.

Table 2

Descriptive Statistics for COPM Results of Four (4) Participants

Type of Activity	N	Average Change in Performance (SD)	Average Change in Satisfaction (SD)
All Activities	18	6.14 (2.57)	6.22 (2.6)
Related to Device Attached to Mounting System	9	7.39 (2.52)	6.89 (2.67)
Unrelated to Device Attached to Mounting System	9	4.89 (2.03)	5.56 (2.51)

Discussion

The results of this study found that, for the participants, integrating the Mount'n Mover into their daily lives yielded an improved sense of competence, adaptability, and self-esteem. This suggests that, overall, users became more independent in daily tasks, were more willing to seek out new tasks and experiences to engage in, and gained an increased sense of emotional well-being. While these results are encouraging and are useful in determining a general sense of what benefit the device provided, it fails to provide a detailed sense of what the lived experience behind these enhanced outcomes was. The results of the COPM provided increased insight into this mechanism.

The results of the COPM indicated that users experienced a clinically significant (a change greater than 2) change in their ability to perform meaningful activity and a significant change in their satisfaction with their performance. This reveals that the device allowed users to complete activities that were most important to them with increased independence and resulted in an increased sense of satisfaction when completing these activities. Furthermore, the results allowed the researchers to identify how users were using the device. When asked the question, "Why do you use the Mount'n Mover?", the majority of respondents indicated that it provided them with better positioning for their device and it was easily moved when users needed to approach surfaces. This suggests that the device's ability to change positions easily was a feature that users valued because it allowed users to access what they attached to the mount with greater ease and the users could easily move the mount out of the way when not accessing what they attached. The information provided during the semi-structured interview affirmed this suggestion.

The activities mentioned by participants to be most impacted by device use were not limited to activities directly related to what device the mounting system allowed access to. While these activities were mentioned, the users often mentioned activities that were unrelated to what they attached to the mounting system. Examples included transferring, answering technical calls, socializing, feeding, engaging in community service, participating in adaptive baseball, and shopping. Out of the 18 activities mentioned, 50% of them were unrelated to what they attached to the mounting system. During the course of the interviews, many users mentioned the ease with which the mount's position is changed made these seemingly unrelated tasks easier to perform.

The results indicated the importance of considering the user's experience with an assistive device in the context of the performance in all the user's daily activities in a variety of environments, and not just the functional deficit that it is meant to address. Without gaining the user's perspective during the design process and while assessing the impact of the device, the holistic benefits of the features of this device would not be realized. Furthermore, for clinicians who recommend mounts based on the devices to be mounted, rather than user activity and performance, this result was extremely informative.

While these results provided valuable information to the developers and potential users alike, there are limitations that must be discussed. First, the size and nature of the sample prevent generalizations of these results to all potential users. Only 10 participated in the PIADS survey, and only 4 of those participants engaged in the interview. Furthermore, only existing users were involved in the study. This creates a biased sample of those who continue to use the device and may again prevent the results from generalizing to all potential users. The retrospective nature of the study makes assessing the true impact of the device difficult. Some users may have been using the device for an extended period of time, and it may be difficult to recall their functional and psychosocial capacity prior to using the Mount'n Mover.

Time and resource constraints limited the options for methodology for this particular study, and therefore this study should be regarded as a case study from which the developer received confirmation of the utility of the product that was developed by integrating user feedback. For future research, companies may consider developing a similar partnership with academic collaborators but with more comprehensive aims. While the results of this study have important implications for the developer of this particular product, they suggest much wider implications by providing a foundation on which more empirically sound studies can build to measure the impact of involving consumers in the development of assistive devices.

An experimental design that compares the functional outcomes of an experimental group consisting of users of devices that integrated consumer feedback in the design process to outcomes of a device that did not share that design process would allow the impact of consumer involvement in the design process to be measured. While the benefit of consumer involvement in the design of products may seem self-evident to those within the field, it is important to quantify this benefit to provide a deeper understanding on behalf of all relevant stakeholders.

Outcomes and Benefits

These results highlight the importance of user input in the design of an assistive device. User input facilitated a holistic approach to the design of the device, one that took into account the daily routine and activities of the user in addition to the activities that are facilitated by the main purpose of the device (allowing functional access to additional devices). For example, in one of the aforementioned case studies a user was unable to access a computer station to complete vocational goals as a result of the rigidity of her mounting solution for accessing her communication device. By taking into account this user's particular needs while designing the product, it assisted in the development of a custom mount that was easily moved to two accessible positions. This principle can be applied to various assistive devices that target a wide variety of functional needs. Only by gaining the perspective of the user can developers create a product that transcends its primary purpose and becomes a product that impacts the users in a variety of functional and environmental contexts. A product that achieves this use in a variety of functional and environmental contexts will lead to increased functional capacity and increased sense of well-being in the user, which will lead to decreased abandonment of the device.

These functional and psychosocial outcomes are useful in both assessing the impact of a finished product and in assessing the progress of the initial design process. In this case, the outcomes demonstrated the success of integrating user input into the design process by indicating increased functional and psychosocial capacity as a result of device use. Furthermore, it demonstrated the value users attached to using the device in diverse functional and environmental contexts. These outcomes could be equally as important during the design process. Consumer-centered outcomes similar to those used in this study could either affirm the benefits of various device features based on improved functional and psychosocial capacity of the user, or provide valuable information to developers regarding the need to change the design based on underwhelming outcomes.

Integrating user input in the design process and collecting outcomes of device use based on the user's perspective not only benefits the developer, but also the end user. As mentioned previously, using these principles in the design and evaluation of a product will lead to enhanced functional and psychosocial capacity of the user. This will reduce the rate of abandonment for the device and lead to an increased sense of independence and overall well-being of the user.

Target Audience and Relevance

- Developers of assistive devices: Using the principles of integrating user input into the design process and using outcomes to inform the refinement of the design will lead to a product with greater functional implications (and, presumably as a result, greater commercial success).
- Providers of AT devices and end-users: The results of this study demonstrate the benefits of integrating consumer feedback during the design process. In this case, consumer feedback seemed to result in a device that transcended its main purpose and allowed improved independence in a wide variety of functional and environmental contexts for end-users. This information is critical for both providers and end-users during the collaborative process of selecting an AT device.

Declarations

The content is solely the responsibility of the authors and does not necessarily represent the official views of ATIA. The authors obtained Institutional Review Board (IRB) approval for the work described in this article. The author Dianne Goodwin disclosed a financial relationship as an equipment patent owner and company owner and no non-finanical relationship. The authors Adam Kinney and Lynn Gitlow disclosed no financial and no non-financial relationships.

References

Carswell, A., McColl, M. A., Baptiste, S., Law, M., Polatajko, H., & Pollock, N. (2004). The Canadian occupational performance measure: A research and clinical literature review. *Canadian Journal of Occupational Therapy, 71*, 210-222.

Clayback, D., Stanley, R., Leahy, J., Minkel, J., Piper, M., Smith, R. O., & Vaarwerk, T. (2014). *Standards for assistive technology funding: What are the right criteria?* Austin, TX: SEDL, Center on Knowledge Translation for Disability and Rehabilitation Research. Available: http://ktdrr.org/ktlibrary/articles_pubs/Standards_for_Assistive_Technology_Funding.pdf

Choi, Y. M., & Sprigle, S. H. (2011). Approaches for evaluating the usability of assistive technology product prototypes. *Assistive Technology: The Official Journal of RESNA, 23*(1), 36-41.

Day, H., & Jutai, J. (2003). *The Psychosocial Impact of Assistive Devices Scale (PIADS) (Version 4.2b).*

Gitlow, L., Meserve, M., & Michie, K. (2006a). The influence of assistive technology on satisfaction in occupational performance: Part 1. *Technology Special Interest Section Quarterly, 16(3),* 1–4.

Gitlow, L., Meserve, M., & Michie, K. (2006b). The influence of assistive technology on satisfaction in occupational performance: Part 2. *Technology Special Interest Section Quarterly, 16 (4),* 1–4.

Hersh, M. A. (2010). The design and evaluation of assistive technology products and devices part 2: Evaluation of assistive products. In J. H. Stone, & M. Blouin (Eds.), *International encyclopedia of rehabilitation*. Retrieved from http://cirrie.buffalo.edu/encyclopedia/en/article/311/

IDEO.org. (n.d.). *The design kit: A field guide to human centered design.* Retrieved from http://www.designkit.org/

Jutai, J., & Day, H. (2002). Psychosocial impact of assistive devices scale (PIADS). *Technology and Disability, 14,* 107-111.

Jutai, J. W., Fuhrer, M. J., Demers, L., Scherer, M. J., & DeRuyter, F. (2005). Toward a taxonomy of assistive technology device outcomes. *American Journal of Physical Medicine & Rehabilitation, 84*(4), 294-302.

Lange, M. L. (1999). Wheelchair mounting systems for communication devices. *Team Rehab*, *11*, 24-29.

Lenker, J. A., Scherer, M. J., Fuhrer, M. J., Jutai, J. W., & DeRuyter, F. (2005). Psychometric and administrative properties of measures used in assistive technology device outcomes research. *Assistive Technology: The Official Journal of RESNA, 17*(1), 7-22.

Mount'n Mover by BlueSky Designs. (n.d.). *Basics and features.* Retrieved from http://www.mountnmover.com/how-it-works/basics-and-features/

Petty, L. S., McArthur, L., & Treviranus, J. (2005). Clinical report: Use of the Canadian Occupational Performance Measure in vision technology. *Canadian Journal of Occupational Therapy, 72*(5), 309-312.

Qualtrics. (2014). Ithaca College Qualtrics. (Version 54,412). [Data file]. Retrieved from https://qualtrics.com/university/researchsuite/research-resources/other-resources/cite-or- reference-qualtrics/

Usability.org. (n.d.). *User–centered design process map*. Retrieved from http://www.usability.gov/how-to-and-tools/resources/ucd-map.html