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Focused Issue: Knowledge Translation and Technology Transfer in Assistive Technology

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Assistive Technology Outcomes and Benefits (ATOB) is a collaborative peer-reviewed publication of the Assistive Technology Industry Association (ATIA).

Assistive Technology Outcomes and Benefits

Editorial Policy

Assistive Technology Outcomes and Benefits is a peer-reviewed, cross-disability, transdisciplinary journal that publishes articles related to the *benefits* and *outcomes* of assistive technology (AT) across the lifespan. The journal's purposes are to (a) foster communication among vendors, AT Specialists, AT Consultants and other professionals that work in the field of AT, family members, and consumers with disabilities; (b) facilitate dialogue regarding effective AT practices; and (c) help practitioners, consumers, and family members advocate for effective AT practices.

Assistive Technology Outcomes and Benefits (ATOB) invites submission of manuscripts adhering to the format of the *Publication Manual of the American Psychological Association* (5th ed.) and which address a broad range of topics related to *outcomes and benefits* of AT devices and services. Manuscripts may include (a) findings of original scientific research, including group studies and single subject designs; (b) marketing research conducted relevant to specific devices having broad interest across disciplines and disabilities; (c) technical notes regarding AT product development findings; (d) qualitative studies, such as focus group and structured interview findings with consumers and their families regarding AT service delivery and associated outcomes and benefits; and (e) project/program descriptions in which AT outcomes and benefits have been documented.

ATOB will include a broad spectrum of papers on topics specifically dealing with AT outcomes and benefits issues, in (but NOT limited to) the following areas:

- Early Childhood and School-Age Populations
- Research and Product Development
- Outcomes Research
- Transitions
- Employment
- Innovative Program Descriptions
- Government Policy

Regardless of primary focus of any submission, primary consideration will be given by the journal to manuscripts presenting quantifiable results.

Submission Categories

Articles may be submitted under two categories—*Voices from the Field* and *Voices from the Industry*.

Voices from the Field

Articles submitted under this category should come from professionals who are involved in some aspect of AT service delivery with persons having disabilities, or from family members and/or consumers with disabilities.

Voices from the Industry

Articles submitted under this category should come from professionals involved in developing and marketing specific AT devices and services.

Within each of these two categories, authors have a range of options for the type of manuscript submitted. Regardless of the type of article submitted, primary consideration will be given by the journal to work that has *quantifiable results*.

Types of articles that are appropriate include:

Applied/Clinical Research. This category includes original work presented with careful attention to experimental design, objective data analysis, and reference to the literature.

Case Studies. This category includes studies that involve only one or a few subjects or an informal protocol. Publication is justified if the results are potentially significant and have broad appeal to a cross-disciplinary audience.

Design. This category includes descriptions of conceptual or physical design of new AT models, techniques, or devices.

Marketing Research. This category includes industry-based research related to specific AT devices and/or services.

Project/Program Description. This category includes descriptions of grant projects, private foundation activities, institutes, and centers having specific goals and objectives related to AT outcomes and benefits.

In all categories, authors MUST include a section titled *Outcomes and Benefits* containing a discussion related to outcomes and benefits of the AT devices/services addressed in the article.

For specific manuscript preparation guidelines, contributors should refer to the *Guidelines for Authors* at http://www.atia.org/atob/authorguidelines

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Assistive Technology Outcomes and Benefits

Focused Issue, Winter 2015

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Introduction to ATOB Focused Issue on Knowledge Translation & Technology Transfer in Assistive Technology

Joseph P. Lane, MBPA

This focused issue of *Assistive Technology Outcomes and Benefits* (ATOB) contains a set of five papers generated through the work of the Center on Knowledge Translation for Technology Transfer (KT4TT). The Center on KT4TT was established in 2008 at the University at Buffalo (SUNY), under sponsorship of the National Institute for Disability and Rehabilitative Research (NIDRR), within the U.S. Department of Education.

The five papers address broad questions arising at the intersection of two processes: a) the Technology Transfer process, which is concerned with conveying ownership and control over enabling knowledge codified as intellectual property, and b) the Knowledge Translation process which is concerned with successfully communicating the value of enabling knowledge between the knowledge creator and some targeted knowledge user.

The three broad questions collectively addressed in this special issue are presented in order as follows:

Question 1: What must government agencies and organizations conducting sponsored R&D projects – including NIDRR and its Grantees – need to know about the technology transfer process in order to optimize the potential for uptake and use of project outputs by relevant stakeholders?

Three of the five papers address this fundamental question. The first paper recounts the National Institute on Disability and Rehabilitative Research (NIDRR) history of sponsoring projects designed to improve the process of technology transfer (TT), and the subsequent introduction of projects designed to apply the process of knowledge translation (KT), all for the sake of generating beneficial impacts for society. These TT and KT projects were necessary adjuncts to the on-going sponsored research and development programs established through the Rehabilitation Act of 1974, because those programs were not demonstrating competency at transforming their scholarly research outputs into beneficial social impacts. The technology transfer projects (commencing in 1998) and the knowledge translation projects (commencing in 2008), were attempts the fill the gap between the university scholars who receive the bulk of NIDRR funding on one side, and the NIDRR goal of improving the quality of life for Persons with Disabilities (PWD's).

This first paper, *Bridging the Persistent Gap Between R&D and Application: A Historical Review of Government Efforts in the Field of Assistive Technology*, is written by Joseph P. Lane who had entered the Assistive Technology field precisely when technology transfer became a funded priority for NIDRR in 1988. Due to his training in business and public administration he was keenly interested in this topic, specifically because he didn't understand why government funded university-based academics to perform technological product and service improvement tasks normally performed by corporate manufacturers and suppliers. There was clearly some disconnect between the theoretical goal and the operational mechanism to achieve it.

The issue remains unresolved to the present day. However, it is not limited to the field of Assistive Technology nor is it limited to the United States. Governments around the world attempting to address national needs through Science, Technology & Innovation (STI) policies, are following the clearly biased advice of self-proclaimed experts within the academic community to channel available resources to universities rather than to corporations. This advice runs counter to the obvious fact that academic faculty are not trained, equipped or rewarded for generating beneficial socio-economic impacts, nor are universities equipped to deploy and support such benefits within society. The special interests served by the status quo dwell within the public and non-profit sectors while the private sector is excluded from policy setting and implementation (Lane & Godin, 2012).

Despite this obvious disparity between the means employed (academic research studies) and the ends expected (improved AT devices and services), agencies such as NIDRR are forced to follow the government's overall orientation. In an attempt to bridge the gap, NIDRR has invested additional resources over the past twenty-five years in a series of projects tasked with generating models, methods and metrics regarding the transformation of research-based discoveries into beneficial devices and services. For example, the currently funded Center on Knowledge Translation for Technology Transfer (KT4TT) has now created and documented an evidence-based framework for planning, implementing, and managing projects meant intending to generate technology-based outputs in the form of prototype devices intended for transfer to the commercial marketplace through established corporations or through start-up enterprises (Lane & Flagg, 2010; Stone & Lane, 2012; Flagg, Lane & Lockett, 2013).

The resulting framework is called the Need to Knowledge (NtK) Model, because it contains the information that funded academics and entrepreneurs 'need to know' but may not even know they need to know. The NtK Model distills all relevant material into nine essential activity stages and nine critical decision that Grantees 'need to know' and apply to have any chance beyond serendipity to progress through the new product or service generation process. The NtK Model is freely accessible on the website: http://kt4tt.buffalo.edu/knowledgebase/model.php

Since the NtK Model's inception in 2008, many NIDRR Grantees – including most of the principal investigators for the Rehabilitation Engineering Research Centers – have invested time in understanding and applying it. These Grantees encountered numerous steps requiring the performance of technical, business, or marketing analysis. While some analytic tools were familiar, others were not. This impeded the investigators' ability to implement the proper analytic tools either personally or through qualified consultants. In response, the Center on KT4TT project team conducted a thorough review to identify and describe tools appropriate for each required analysis and to provide links to further information. As a result, the web-based NtK Model now contains red toolbox icons as hotlinks to the underlying details concerning these requirements for analysis. The entire process is described in the second paper titled, *Tools for Analysis in Assistive Technology Research, Development and Production*, (Flagg, *et al*, 2015).

The majority of government-sponsored projects intended to generate new or improved AT devices and services are conducted by university faculty or small business entrepreneurs. Providing these investigators with tools to enhance their project planning and management should help them generate outputs viewed as useful by AT manufacturers and suppliers. But enhancing the supply side of research and development is not sufficient to increase uptake and use. There needs to be an equivalent demand for prototypes within the AT industry that can be transformed at little additional marginal cost into new or improved products and services.

The demand-side of the AT equation is largely determined by regulations regarding the third-party payment system. Few Persons with Disabilities (PWD's) or their families can afford to acquire the needed AT through private payment, so reimbursement levels and qualifications represent the majority of sales and services. The survival of AT companies – and the AT industry as a whole – depends on their ability to make a business base to justify investing their limited resources into transforming prototypes into commercial products and services ready and approved for deployment in the marketplace. Government can invest unlimited funds in the supply side, but if it does not provide equal support on the demand side, AT companies simply cannot afford to transfer, integrate and then offer new or improved devices and services.

The current third-party reimbursement system is predicated on medical efficacy rather than on functional necessity. Therefore, the AT industry is working under the same evidence-based medicine standards as corporations providing surgical and pharmaceutical interventions. But AT devices and services are not pills and implants so the field is challenged to generate evidence deemed satisfactory to the regulatory system. For example, the durable medical equipment industry (DME) cannot apply the "gold standard" of double-blinded and randomized controlled trials to wheelchair users. Conversely, the majority of AT devices are not even classified as DME so they don't qualify for any form of third-party reimbursement.

So how can the demand side of the AT industry be stimulated to encourage the uptake and use of government-sponsored project outputs? What criteria should be established or modified to justify current – and even expand – third-party payment for devices and services providing necessary function for independent living and improved quality of life? This issue is explored through the third paper addressing the first question which is titled, *Standards for Assistive Technology Funding: What are the Right Criteria?* (Claybeck, *et al*, 2015).

Question 2: What existing infrastructure might sponsors and grantees leverage in order to efficiently and effectively communicate the findings (outputs) from sponsored scientific research projects to non-traditional stakeholder groups?

Knowledge Translation is viewed by many NIDRR grantees – especially those employed in tenure-track faculty positions – as a new and unfunded mandate that detracts from academic scholarship. To qualify for tenure or promotion, university-based investigators must prepare high quality manuscripts suitable for publication in qualified peer-reviewed journals, and they must do so often under the 'publish or perish' mandate.

Knowledge Translation seeks to increase the uptake and use of findings generated through public funding, by ensuring the findings can be accessed, understood, and adopted by stakeholders beyond the academic community. However, faculty complain that their tenure/promotion committees will not recognize as *productive*, in a scholarly sense, the time and effort required to translate the same findings into language and formats suitable for non-traditional audiences. These non-traditional audiences include individuals and groups who may find value in the findings and thereby have potential to apply them in practice (e.g., clinicians, manufacturers, consumers, employers/educators, policymakers).

On an operational level, faculty members serving as NIDRR grantees question how to make contact with a diverse range of individuals who represent non-traditional audiences. These faculty members are accustomed to sharing their findings with scholarly colleagues through an efficient publication system dedicated to disseminating conference presentation and journal articles globally. This system contains abstracting, referencing and indexing resources that simplifies search, access and linkage between scholars to a few keystrokes. But no such infrastructure exists outside the scholarly community. There is no established system or protocol to identify or reach non-traditional audiences, nor are there established criteria that enables members of these non-traditional groups to recognize and assess the value of findings reported by scholars.

As a response to this dilemma, the Center on KT4TT invoked the practice of Knowledge Value Mapping (KVM) through which one can determine the level of interest that any targeted individual group may have in receiving, reviewing and possibly applying the findings from scholarly research (Bozeman & Rogers, 2002). The project team recognized that professional networks do exist for other stakeholder groups – even though those networks are not devoted to scholarly communications. These networks are organized as national/international societies of career professionals or interested persons in a specific topic area. The project team explored the potential viability of these organizations to serve as networks through which scholars could reach non-traditional stakeholder audiences.

Selected national organizations completed a Knowledge Value Mapping survey constructed to assess and categorize (map) the various ways in which they engaged with new scholarly knowledge (Lane & Rogers, 2011). They surveys were completed by multiple professional organizations, each representing different categories of non-traditional stakeholders as noted previously. The survey process was completed for three sets of professional organizations, one set within each of three topic areas within the AT field; Augmentative & Alternative Communication (AAC); Wheeled Mobility; Recreational Technology.

The survey results demonstrated three things: (a) That professional organizations do exist for each non-traditional stakeholder group across all three AT areas; (b) That these organizations indeed value and apply scholarly research-based findings, and (c) That faculty investigators can collaborate with such organizations to communicate efficiently and effectively with non-traditional stakeholder audiences. The details of the project and its findings are described in the paper titled, *Assessing the Roles of National Organizations in Research-based Knowledge Creation, Engagement and Translation: Comparative Results Across Three Assistive Technology Application Areas*, (Nobrega, et al, 2015).

Question 3: Does the strategy of tailoring and targeting findings from scientific research studies actually increase the level of uptake and use by individuals from non-traditional stakeholder groups?

The precipitating circumstance for Knowledge Translation as a new approach to communicating research findings is the dearth of evidence demonstrating uptake and use of scientific research findings by professionals and lay persons outside of the academic community. The scholarly community assumes that research findings do indeed possess practical utility – although this assumption remains untested. Instead, they think that the lack of uptake and use by others – and therefore lack of evidence of same -- is because the inherent value of their findings is not being clearly explained in language understood by these audiences of non-scholars, nor is it being disseminated in formats and venues accessed by these non-scholars. They conclude that increasing uptake and use is a matter of convincing scholars to simply re-state their findings in language that non-scholars understand, explain why the findings have utility in the context of the target audience's values, and distribute the message through multiple media formats that are familiar to target audience members. This analysis and conclusion forms the basis for Knowledge Translation.

The academic community's assumption that findings from research studies vetted through the peer-review process have inherent value to society is not new. Prior to Knowledge Translation models, proponents of academia relied on the passive diffusion model to explain how scholarly findings contributed to society. That is, a scholar investigates a topic of personal interest, publishes their findings within the scholarly domain, and then the scholar moves on to explore a new topic of interest. With no additional effort from the scholar, the original research findings were thought to circulate (diffuse) through society until eventual read by someone who recognized the findings as relevant to answering a question or solving a problem. Passive diffusion is the ultimate 'trickle-down' model of communication, because it makes no claims about an underlying mechanism, requires no attempt to chart the paths taken by each finding, nor can it be expected to estimate the time and circumstance required to move from initial disclosure to actual application. To rely on passive diffusion to solve society's problems is to ultimately depend on the beneficence of serendipity.

The passive diffusion model may be valid and remain appropriate for what is called basic, fundamental, or curiosity-driven research because by definition basic research includes no expectation regarding uptake and use of findings by others. However, a large proportion of funding for scientific research is classified as applied research. By definition, applied research is initiated with the expectation that the findings from research activity will be put into practice; most likely by stakeholders outside of the scholarly community.

Agencies like the NIDRR exist because Congress and the public expect funded projects to confer beneficial impacts to targeted segments of society. Between its inception in 1974 and the late 1980's, the funded projects appeared to be more focused on advancing scholarly knowledge than on generating beneficial impacts for society. By the 1990s, consumer-oriented leadership in NIDRR called for more diligent efforts to reach audiences who could benefit from research-based findings. NIDRR Grantees were charged with moving beyond passive diffusion models to instead implement active dissemination models. Active dissemination models required NIDRR Grantees to invest time and effort to ensure their project findings were being reported through multiple media channels, were reaching audiences beyond other scholars, and that their findings were being communicated to audiences within the AT field as well as to professionals operating in mainstream product and service fields who also could potentially put the findings into practical use.

Yet, through efforts to apply both passive diffusion and active dissemination strategies models, there remained little evidence of uptake and use of new research findings in practice. The academics continued to assume that their findings had practical value and they did not examine that assumption nor did they make any effort understanding the relative effectiveness of these two existing models (passive diffusion and active dissemination). Instead they concluded that the target audiences simply couldn't perceive the inherent value of their findings, because the findings were reported in scholarly publications and written in scholarly language. Although there was no firm evidence to substantiate yet another model for communicating research findings, scholars went ahead and promoted Knowledge Translation as the strategy needed to increase uptake and use.

NIDRR charged the Center on KT4TT with applying and exploring the emerging Knowledge Translation model, so the project team thought that it appropriate to first establish some baseline of relative effectiveness between the three models. This baseline could then be used in future individual and comparative analyses of the ways through which scholarly findings reach and influence the thoughts and behaviors of non-scholar stakeholders. To set the baseline effectiveness for all three models, the project team designed a study involving random assignment of participants, multiple interventions and a control group. The design was applied to document and compare the effectiveness of all three models, for each of three selected topic areas, and for multiple categories of stakeholders.

Collecting baseline data on the comparative effectiveness of the three models for communicating research findings, required the project team to design and validate an entirely new web-based survey instrument called the *Level Of Knowledge Use Survey* (LOKUS). Psychometric testing demonstrated that the LOKUS instrument is valid and reliable for assessing various levels of knowledge engagement by individuals (i.e., non-awareness, awareness, interest, use), and for differentiating between use of knowledge as originally intended by the investigator or use as modified by the individual (Stone, *et al,* 2014).

The three studies conducted with the randomized and controlled design, and employing the LOKUS instrument challenge the traditional thinking within the academic community that increasing uptake and use is simply a matter of better conveying the assumed utility of the findings to people positioned to apply them. Instead, the actual circumstances surrounding knowledge uptake and documented through the three studies brings to mind the proverb: “You can lead a horse to water, but you can’t make it drink.” That is to say, scholars may put forth efforts to target delivery of their findings to non-traditional audiences, and to tailor the language and formats so the audiences become fully aware of the scholar’s findings, but targeting and tailoring offer no guarantee that the findings have value to the targeted audience.

The assumption among scholars that their findings have value to society is unsubstantiated and unrealistic. In reality, it is the individual audience member who decides whether or not to become interested in any specific finding, and it is the individual who decides to expend the effort necessary to convert conceptual interest to instrumental use. This is the true gap between knowledge and action. Early Knowledge Translation models assume that a research study is underway and the decision is to engage stakeholders either during a study (Integrated KT) or after the study (End-of-Grant KT), while simply ignoring the most obvious and logical approach to increasing uptake and use, which is to engage all relevant stakeholders in assessing the need for a research study, and anticipating the utility of the study’s findings (Prior to Grant KT), as previously discussed in Lane and Flagg (2010). The details of this complex, multi-study effort are fully described here in the paper titled, *Effectively Communicating Knowledge to Assistiuve Technology Stakeholders: Three Randomiszed Controlled Case Studies*, (Stone, *et al*, 2015).

The authors of the papers assembled in this Special Issue trust that readers will find utility in the answers to the three broad questions posed above. These three questions initially arose from the very stakeholders who are the intended audience for the study findings presented here. However, simply presenting the study findings is insufficient because they lack the broader context through which the broad questions arose in the first place. The remainder of this introduction will provide an abridged history of technology transfer activity within the field of Assistive Technology, as guided and sponsored by the U.S. federal government, through its lead agency for this area of national interest, the National Institute on Disability and Rehabilitative Research (NIDRR).

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References

Bozeman, B., & Rogers, J. D. (2002). A churn model of scientific knowledge value: Internet researchers as a knowledge value collective. *Research Policy, 31*, 769-794.

Flagg, J. L., Lane, J. P., Lockett, M.M. (2013). Need to Knowledge (NtK) Model: an evidence-based framework for generating technological innovations with socio-economic impacts, *Implementation Science*, *8*, 21. Retrieved from: http://www.implementationscience.com/content/8/1/21/ .

Lane, J. P., Godin, B., (2012). *Is America's Science, Technology, and Innovation Policy Open for Business? Science Progress, June 12, 2012.* Retrieved from: http://scienceprogress.org/2012/06/is-america%E2%80%99s-science-technology-and-innovation-policy-open-for-business/ .

Lane, J. P. & Rogers, J. D. (2011). Engaging national organizations for knowledge translation: Comparative case studies in knowledge value mapping, *Implementation Science, 6,* 106. Retrieved from http://www.implementationscience.com/content/6/1/106/ .

Lane, J. P. & Flagg, J. L. (2010). Translating three states of knowledge—discovery, invention and innovation, *Implementation Science, 5,* 9. Retrieved from http://www.implementationscience.com/content/5/1/9.

Stone, V. I., Nobrega, A. R., Lane, J. P., Tomita, M. R., Usiak, D. J., Lockett, M. M. (2014). Development of a measure of knowledge use by stakeholders in rehabilitation technology. *Sage Open Medicine, 2,* 1-19 doi: 10.1177/2050312114554331.

Stone, V. I., Lane, J. P. (2012). Modeling technology innovation: How science, engineering, and industry methods can combine to generate beneficial socioeconomic impacts, *Implementation Science, 7.* 44. Retrieved from http://www.implementationscience.com/content/7/1/44/.

Bridging the Persistent Gap Between R&D and Application: A Historical Review of Government Efforts in the Field of Assistive Technology

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Abstract

The United States government funds research and development programs to advance the state of technological innovations across many fields. One targeted field is assistive technology devices and services for persons with disabilities. Although these sponsored programs intend to benefit society, they channel most of their funding to university-based scholars. This approach leaves a gap between the specific project outputs (academic papers, patent claims), and their transformation into products, services and related outcomes capable of delivering beneficial socio-economic impacts. One participant/ observer recounts one government agency's efforts to bridge this gap over the past twenty-five years, by initiating projects addressing the transformational processes of technology transfer and knowledge translation.

Keywords: technology transfer, knowledge translation, assistive technology, knowledge use, scientific research, engineering development, industrial production, product development, market failure, knowledge value mapping, randomized controlled trial, analytic tools, procurement contract, exploratory grant.

The U.S. Government Establishes and Addresses Assistive Technology

The United States government had been addressing the needs of persons with disabilities – including their need for function-oriented devices and services – through medical intervention and military veteran programs since the post-Civil War period in the late 1800's. However, it wasn't until the Rehabilitation Act of 1973 that funding was dedicated to address the full range of functional requirements in the context of education, employment, recreation and daily living. It took another five years to create a government agency devoted to this purpose; the National Institute on Disability and Rehabilitative Research (NIDRR). Recognizing the sector and discipline spanning mission required of this new agency, it was established under the Department of Education, rather than under the medical focus of the National Institutes of Health, or the science focus of the National Science Foundation.

The U.S. Department of Education (2014) describes the broad mandate of the newly created NIDRR as follows:

> NIDRR was established by the 1978 amendments to the Rehabilitation Act of 1973 with the statutory responsibility to ... provide for research, demonstration projects, training, and related activities to maximize the full inclusion and integration into society, employment, independent living, family support, and economic and social self-sufficiency of individuals with disabilities of all ages ...; promote the transfer of rehabilitation technology to individuals

> with disabilities through research and demonstration projects...; ensure the widespread distribution, in usable formats, of practical scientific and technological information ...; identify effective strategies that enhance the opportunities of individuals with disabilities to engage in employment ...; and increase opportunities for researchers who are members of traditionally underserved populations, including researchers who are members of minority groups and researchers who are individuals with disabilities (29 USC §760).

Thus, NIDRR's scope of activity includes science, engineering, medical rehabilitation, educational and vocational support, along with a charge to improve the features and functions of Assistive Technology (AT) devices and services. Assistive Technology is relevant to people of all ages and with all types of disabilities. People may acquire functional impairments through disabling conditions at anytime in their lives, suddenly through a specific circumstance or gradually through the aging process. These functional impairments may affect the person's mobility, sensory, or cognitive capabilities. They may also interfere with activities of daily living and with participation in education, employment, recreation, and daily living. The person's interactions with the built and ambient environments create disabling conditions. The products and services available to persons with disabilities were originally limited to mobility-oriented, low-technology objects such as crutches, wheelchairs, and artificial limbs. In the late 1960s, people with disabilities began to express their needs in the context of civil rights, arguing that they had an equal right to access all domains of function. The Independent Living philosophy began at the University of California, Berkeley and quickly spread into a national movement. The advent of computer and information technologies (ICT) in the 1970s dramatically expanded the range of products and services available to people with disabilities.

The potential for technology to support or supplant the functional capabilities of persons with disabilities continued to expand as technologies become more sophisticated, integrated and intelligent. The U.S. government's creation of NIDRR reflected awareness of new opportunities – made possible by AT devices and services -- in employment, education, and daily living. Since its inception in 1973, NIDRR has been an agile and progressive government agency, sponsoring programs in core AT areas such as wheeled mobility, vision and hearing enhancement, augmentative and alternative communication (AAC), prosthetics and orthotics (P&O), and information and communication technologies (ICT). NIDRR has also readily embraced emerging technologies before they became commonly known. Specifically it sponsored R&D in the areas of Functional Electrical Stimulation (FES) and Universal Design (UD) in the 1980s, it established the first center specifically addressing the functional requirements of older persons in 1991, and NIDRR established the first national center exploring the application of AT for persons with cognitive impairments later that same decade.

Given all of this attention and investment over forty years, one may have expected to see a tremendous expansion of AT products and services, a new cadre of professional service providers, and the widespread adoption and use of AT products and services by citizens who need them. Sadly, this is not the case. Despite all of this forward thinking and acting, NIDRR's instrumental contributions to the lives of Persons with Disabilities (PWD's) have been constrained by a pervasive bias in the U.S. government toward academic research at the expense of industrial commercialization. This bias is not limited to the field of AT, nor is it even limited to the United States of America. Around the globe, countries intending to generate beneficial impacts for targeted populations choose to emphasize generating new conceptual discoveries through scientific research programs, rather than supporting the manufacture, deployment and delivery of existing AT products and services through industrial production. This pervasive governmental bias is recounted in greater detail elsewhere (Lane, *in press*).

Suffice it here to say that the Center on Knowledge Translation for Technology Transfer (KT4TT) is the current iteration of NIDRR's long-standing and deep commitment to helping their university-based Grantees ensure that their scholarly outputs can be transformed into beneficial outcomes and impacts for the target population of Persons with Disabilities. This commitment stands in contrast to the faulty logic of government policies, and bias in those policies that skews the limited available resources towards academic and away from industry. For purposes of this paper, it is important to step back and review why the field of Assistive Technology became a priority for the government, what is being done to support the field for better or worse, and why that support now requires a focus on the dual processes of knowledge translation and technology transfer.

Why is the U.S. Federal Government Involved in the Field of Assistive Technology?

Under the free-market system, private-sector corporations meet most of society's needs for products and services. However, corporate investments in new products or services must satisfy the business case; that is they must generate profit defined as revenue in excess of costs. The margin of profit generated by a company is the source of payment to owners (private individuals or public shareholders), and the source of taxes paid to government. Companies cannot afford to invest in areas that fail to meet the business case, simply because they will go out of business. Companies are different than governments and universities because companies must generate revenue internally.

If an unmet need fails to meet the business standard for generating a profit as a corporate run business, or if the requirements exceed the capabilities of the private sector, the need is deemed to be an instance of market failure. If a government deems that unmet need to be important to society, then the government may intervene by underwriting the cost of addressing the unmet need. These interventions involve the investment of public money through mechanisms that are considered government-sponsored alternatives to the free market system.

When national need requires the immediate delivery of massive quantities of products and services that exceed the capacity of any corporation – such as a world war – national governments typically intervene by applying the contract-procurement system. Under this system, a national government finances the necessary research, development and production capacities at the front end, and then buys the product/service outputs from industrial production at the back end. Under the procurement-contract system, the sponsoring government entity specifies the products/services required, establishes the performance criteria to be achieved, and sets the timeframe for delivery. The procurement-contract system of government sponsorship requires leadership from the industrial sector, because it is experienced in planning and managing product/service production requirements, albeit typically on a smaller scale.

The U.S. government routinely applies the procurement- contract system with great success in fields such as national defense, aerospace, and energy. Companies working in those fields respond to highly profitable government contracts for delivering the required products and services. These contracts increase the profitability and reduce the risk associated with market failures because governments substitute public capital from tax revenues for private capital drawn from individual consumers. The capital supplied through these government contracts allows companies to establish and maintain strong internal R&D capabilities in the area of national need, and permits them to draw upon the expertise in universities and government laboratories when necessary. Once the domestic need is addressed, companies may transform market failures into free market opportunities, by establishing international markets for the products and services originally generated under government procurement contracts.

National needs of a more diffuse nature constitute a different form of market failure prompting government sponsorship. Fundamental scientific research conducted at academic universities is a clear example. Fundamental research does not meet the business criteria for free-market sponsorship, so government's step in to provide the necessary support through public capital. In this example, governments apply a different approach – the exploratory-grant system. The exploratory-grant system requires leadership from the academic sector. University faculty – such as most NIDRR Grantees – receive the government funding up front and without conditions, other than those related to the activity proposed by the faculty investigator and approved for funding through the peer review process. Thus, grantees burdened by the pressure to deliver specific results, reach pre-set milestones or meet particular deadlines. Instead, faculty who conduct scientific research through exploratory grants are rewarded with promotion and permanent employment (tenure), which is judged by their peer scholars. So, the outputs generated through the exploratory-grant system may not have any relevance at all to specific unmet needs within society. The assumption being that the continuous accumulation of fundamental knowledge creates a reservoir from which solutions to future unmet needs can be drawn. To accept that premise as valid, one must recall the now challenged scholarly assumption that all findings from scientific research have implicit value.

There is no debate that governments need to support some level fundamental research in order to gain from the conceptual discoveries it generates. The U.S. government's sustained investments through the National Science Foundation and the National Institutes of Health have established the world's finest university system. However, elected officials, government policymakers, and academic advisors have managed to conflate the exploratory-grant system -- which is focused on scientific research methods – with the procurement-contract system -- which is focused on engineering development methods. Conflating research with development, such as through the phrase "R&D" the government and public are told that scientific research is the methodology and academia is the economic sector chiefly responsible for addressing society's problems.

This position has two effects. First, the academic sector has benefitted from a financial windfall in the form of public funding, at the expense of support for the industrial sector. Second, and more importantly, government's skewed investment is generating a very high level of scholarly publications, but a very low level of technology-based innovations. The scholarly training and incentives for university faculty within the academic sector are simply not congruent with technology transfer, commercial manufacturing, and product/service deployment and support. It is the latter activity that generates new net wealth and therefore forms the basis for quality of life in socio-economic terms.

Developing a truly adequate and efficient response to a nation's demand for innovative solutions requires a shift in understanding and interests. It will require government to stop inappropriate and excessive allocations of public resources to the academic sector. By its very nature, the exploratory grant mechanism is concerned with long-term, intangible and largely unforeseeable discoveries about the natural world. A rational and objective analysis would conclude that any government-sponsored program intending to deliver goods and services to the marketplace, and to benefit society in the short-term and tangible sense understood by the general public, would focus efforts in the corporate industrial sector.

However, those who benefit from the current system (including the allotment of exploratory grants) resist change. Only extraordinary circumstances can challenge their loyalty to the status quo as embodied in current Science, Technology and Innovation (STI) public policies. An economic crisis, for example, might eventually force a careful accounting of returns on investments of public funds. That scrutiny would expose the rationale that sustains this defunct system to be mere rhetoric. Until such time, fields such as Assistive Technology must work within the limits of present circumstances, including the large and persistent gap between university-sponsored activity and beneficial socio-economic impacts.

The Field of Assistive Technology: Attempting to Harmonize Method with Mission

Assistive Technology offered an excellent example of how a national government's intentions – as expressed in the Rehabilitation Act of 1973 – are implemented in practice, and how that implementation determines the outcomes and impacts achieved. The diverse population of Persons with Disabilities (PWD) spans the age range, so it is very expensive to reach all its members with information and marketing materials. A fortunate sub-set of PWD's have sufficient personal wealth to privately purchase AT devices and services. However, the majority of PWD's who need AT to compensate for their functional limitations are either unemployed or underemployed (Barnes, 2012). This majority is dependent on reimbursement for AT purchases through a third-party source (e.g., government agency, insurance company, school district).

In response, government allocate public funds to pay for AT devices and services through the Centers for Medicare/Medicaid Services (CMS) (See: www.cms.gov). The CMS is the U.S. government's third-party reimbursement program. The CMS guidelines restrict reimbursement to AT devices that are deemed medically necessary, called Durable Medical Equipment (DME). This medical limitation eliminates CMS reimbursement for most AT devices and services designed to support PWD's in employment, education, recreation, and independent living activities. This limitation in turn limits industry's incentives for producing and supporting non-DME category AT products and services. Companies operating within the AT industry need someone to pay for their products and services in order to stay in business. There are some additional options for third-party payment but they come with their own restrictions. For example, students are eligible for education-oriented AT through their school districts but that eligibility ends at high school graduation (Mittler, 2007).

As a further restriction on innovation in the AT industry, the sub-set of DME products and services qualifying for CMS payment have pre-determined reimbursement rates set at very low levels. Specifically, this means CMS pays for only the most basic, generic, and minimally useful AT devices, and only for a minimal level of assessment, training and support services from AT professionals (Page, 2013; Driver, 2013). The restrictive nature of the reimbursement caps force AT device companies to keep all production, staffing and marketing costs as low as possible, in order to still generate a profit margin and stay in business. Similarly, AT service professionals are forced to limit the time spent with each client to that amount set through reimbursement schedules, despite the wide range of client needs and varying complexity of their individual cases (Jannenga, 2010).

Operating the entire AT and broader rehabilitation system at a bare bones level has many negative consequences for individuals, organizations and society. The minimal profit margin leaves no money for corporations to finance the focused internal R&D necessary to integrate technological innovations into their existing AT products. The lack of funds for marketing limits consumer awareness of available AT devices and services. Constraints on assessment and training limit the value-added by AT and increases device abandonment by consumers. Is this really the system the public expects and the government investment envisioned?

The AT marketplace is not working for the intended beneficiaries because government's consistently and reflexively apply the wrong system to solve social problems. In the author's opinion, this is because the process of transforming public intent into law involves career government employees and academic advisors who are biased against allocating public money to the private sector. In this case, the statutory language within the Rehabilitation Act of 1973 (as amended) structured NIDRR and its programs under the exploratory-grant model designed to generate new scholarly knowledge through scientific research, with insufficient concern over the equally essential engineering development to reduce new conceptual knowledge to a practical form. Statutory language skewing the focus of government investment away from a problem-solving approach led by industry, and towards an intellectual exercise led by academia is widespread in technology innovation programs across government agencies.

The U.S. government's decision to apply the exploratory-grant strategy resulting in a process that channeled the available public capital to faculty in universities for the expressed purpose of improving the quality of life for persons with disabilities through the generation of new scientific knowledge. However, there is no evidence than any stakeholder in the AT marketplace – not corporations, consumers or their advocates – has ever called for the generation of new scientific knowledge. Instead, AT companies are struggling to market and sell their existing AT devices and services, and PWDs are struggling to find, acquire and apply these same AT devices and services.

The primary barrier faced by both AT producers and AT consumers is the third-party payment system administered by CMS that limits access to existing AT devices and services. If sufficient funds were available to support both supply and demand in AT, companies could afford to sponsor targeted research and development with their own internal funds where necessary. There is no justification for the argument that AT companies need professors, graduate students and entrepreneurs to dream up new and improved devices and service, especially when those same companies cannot afford to design, build and deploy the improvements they already have waiting in the backroom.

Governments could easily remove this monetary barrier by shifting from the exploratory grant approach system led by academia, to the procurement contract approach led by industry. Under a procurement contract orientation government agencies would allocate the majority of available funding between underwriting the design, manufacture and deployment of AT devices by AT corporations, and underwrite proper assessment, training and support of AT by service professionals. This approach could immediately eliminate the CMS reimbursement barrier because AT devices and services would be available upon request at little or no cost to PWDs, eliminating any incentives for fraud as a side benefit.

Applying the procurement contract system to the AT field is analogous to its on-going and highly successful application for military weapons. Every infantryman is issued a rifle owned by the government, and every fighter pilot is assigned to an aircraft owned by the government. These individuals use their issued devices after receiving appropriate assessment and training funded by government, in order to successfully function in their assigned roles. In the same way governments could subsidize the design, testing, and production activities of companies working in the AT field, then buy the resulting AT devices and services, issue them to PWDs with proper assessment and training. Military defense issues and quality of life issues are both appropriate for government intervention because they provide beneficial socio-economic benefits. The current difference is that the military defense goal is congruent with its support system (i.e. procurement contract mechanism) while the quality of life goal is not (i.e., exploratory grant mechanism).

Why is the U.S. Federal Government Sponsoring Exploration in the Topics of Knowledge Translation & Technology Transfer?

Because of government's entrenched bias toward science and away from industry, the public investment in the field of Assistive Technology has historically yielded an increasing supply of scholarly publications, but little evidence of contribution to AT products and services, or to the corporations responsible for delivering and supporting them (Lane, 2008). A recent NIDRR report on Grantee activity (NIDRR, 2014) shows that 80% of Grantees' outputs take the form of scholarly presentations and publications. About 15% of outputs take the form of informational materials in paper or electronic formats. And about 5% of reported outputs -- a very small percentage -- represent AT devices or services. Even this five percent overstates the devices and services categorty because it includes software applications (apps) that are passively deployed simply by posting them on-line.

The great disparity between papers and products should be no surprise. The exploratory grant system's selection criteria favor academics actively engaged in scientific research. Consequently, most NIDRR Grantees are university-based faculty who by design operate within a peer-driven incentive system. A recent survey asked NIDRR Grantees to identify the audiences that were most involved in their work (KTDRR, 2013). The audience category "Other Researchers" led by a wide margin as either primary (50%) or as secondary (16%). The categories "Persons with Disabilities" and "Practitioners/ Clinicians" came in distant second and third, while "Manufacturers" were considered primary or secondary by fewer than 10% of the respondents. The lack of engagement with industry substantiates both the focus on publications within the academic incentive system, and the dearth of Grantee contributions to the AT marketplace.

The NIDRR's management team does recognize the disparity between the paper and product outputs generated by university-based projects. The current NIDRR Long-Range Plan contains a commitment to bring parity between scientific research methods and engineering development methods, including a commitment to establish a Stages of Development structure commensurate to the existing Stages of Research structure (NIDRR, 2013).

Realistically, NIDRR's options are limited. As a sub-agency it lacks the statutory authority to shift the agency-level focus from scholarship to commercialization; to balance the rigor of academia with the relevance of industry. Instead, NIDRR must adhere to the standard practice among those government programs establishing collaborations between academia and industry with the intention of generating socio-economic outcomes (e.g., NSF's Industry-University Cooperative Research Centers; NIH's Industry-Academic Partnerships). Those programs steadfastly focus on sponsoring scientific research at universities (the R in R&D), while engineering development at corporations (the D in R&D) is left unsupported by the available government funding. Instead, industry is expected to invest its own limited resources – at great risk to their corporate survival – to carry forward into outcomes whatever the academics happen to generate as project outputs. These programs are not demonstrating a high level of success due to great disparities in funding, culture, incentives and goals.

In the absence of any seismic shift in government STI policies, NIDRR's management has funded a series of projects over the past twenty-five years to help NIDRR Grantees improve their technology transfer activities and increase their success at contributing to the AT marketplace. Although more band-aid than remedy, NIDRR's efforts reflect its commitment to transforming primarily scholarly outputs from Grantees into marketplace outcomes with potential for beneficial socio-economic impacts.

NIDRR is currently sponsoring the Center on Knowledge Translation for Technology Transfer (KT4TT), which is charged with helping NIDRR Grantee's achieve success in translating and transferring their project outputs into AT devices and services with beneficial impacts for PWDs. As the majority of NIDRR Grantees are university scholars, they typically generate either conceptual discoveries outputs embodied in presentations and publications, or tangible invention outputs embodied in proof-of-concept prototypes and patent claims (Lane & Flagg, 2012). The first type of output (academic publication) is important for advancing the global state of scholarly knowledge, and for generating a base of scientific evidence on which to base health policy and clinical practice decisions in the areas of disability, rehabilitation, and assistive technology. The second type of output (prototype inventions) is important for advancing the global state of proof-of-concept knowledge, and for demonstrating the potential for improving the technology-based features and functions of existing AT devices and services.

However, neither publications nor prototypes are ready for deployment in the commercial AT marketplace as devices or services, so these Grantee outputs simply cannot directly generate beneficial impacts on the target audiences. The majority of resources and effort needed to transform these outputs into AT devices and services lie outside the academic sector's capabilities but inside the capabilities of the industrial sector. The gap between academic outputs and market outcomes chiefly stems from academics not recognizing the downstream activity and not reserving any grant-based funding to support that downstream activity. Instead, they set a priority on achieving their scholarly outputs that meets their professional incentives and obligations.

Even those scholars with the best of intentions don't usually know what they don't know – but need to know -- about the downstream requirements to achieve commercial success. Their naïve actions and decisions early in the R&D process may complicate or even preclude eventual commercial success. Even those Grantees who know something about the downstream activities and do reserve some funds for that purpose report that the amount is likely insufficient to underwrite the full cost of delivering AT products and services to the marketplace. The downstream activity requires substantial investment by private sector corporations. Without prior engagement with – and long-term commitment from – these corporate partners, Grantees are unlikely to attract sufficient support towards the conclusion of their sponsored projects. It is very difficult to secure corporate support for project outputs generated outside their control and ownership, so securing some sense of ownership and control early in the process is critical.

The total costs involved and the need to integrate multiple sectors under a viable management plan focused on market deliverables, explains why governments typically apply the procurement-contract system when unmet need is viewed as of the highest priority and deemed critical to the nation's survival. However, when the need is viewed as less critical – such as such as Assistive Technology devices and services – governments apply the exploratory-grant system which places low or no priority on marketplace deliverables. The funded scholars focus on initiating the scientific research necessary for generating scholarly publications, while any engineering development or corporation collaboration is delayed or indefinitely postponed. The time lost between the project's conception and initiating the post-research downstream activities, limits the options available regarding the actions and decisions that largely determine the results of technology transfer and commercialization efforts. Technology Transfer Offices in universities demonstrate very little evidence of success for this very reason – technology transfer is simply not a priority within the culture of academia's incentive systems. All fields of endeavor tend to get more of what they measure and reward and less of what they don't.

History of Technology Transfer & Knowledge Translation in Assistive Technology

Is the current Center on KT4TT (2013-2018) the First NIDRR initiative to support the technology transfer activities of its Grantees?

No. NIDRR has continuously sponsored projects charged with addressing technology evaluation, transfer, commercialization, and related issues since the late 1980s. The need for such projects is an explicit indicator that something important for resolving socio-economic problems missing from the exploratory-grant system. The procurement-contract system needs no such intermediaries to bridge gaps between the methods applied and the intended results.

Rehabilitation Engineering [Research] Centers on Technology Transfer: 1988 – 2008.

In 1988, NIDRR funded a set of three Rehabilitation Engineering Centers (REC), all for five year periods and each at $500,000 per year. The REC on Technology Transfer center at Rancho Lost Amigos Medical Center, Los Angeles, California focused on addressing the information needs of Grantees or even independent inventors whose R&D activities actually generated concepts or prototypes with commercial market potential (Eveland, *et al*, 1991). The REC on Technology Transfer at the Electronic Industries Foundation, Washington DC, focused on industry standards, performance guidelines, and related issues to help large and small companies generate products that were more accessible and usable (Scadden, 1987). The REC on Technology Evaluation at the National Rehabilitation Hospital, Washington, DC, considered issues of consumer satisfaction and AT abandonment, and generated charts showing the performance of devices within specified AT categories (Philips & Zhao, 1993).

NIDRR took stock of the persistent barriers to success for their Grantees despite the presence of these three REC's focused on the topic area from 1988 - 1993. In 1993 NIDRR decided to combine funding for all three concluding REC's into one 'super center' funded at $1.5 million per year for five years. The Rehabilitation Engineering [Research] Center on Technology Evaluation and Transfer operated at the University at Buffalo from 1993-1998.

Note that NIDRR had modified the program's name by inserting the word 'research.' The name change reflects the compelling influence that that the concept of scientific research has over government programs no matter how practical their intended results. Even this engineering development oriented program had to be re-branded as research, despite the obvious need for such applied projects to shift attention and resources to downstream engineering development methods, and to forge linkages to industrial production methods.

NIDRR's mission for this new RERC was to review AT prototype inventions that had failed to reach the marketplace, from all potential sources (e.g., NIDRR Grantees, clinicians/practitioners, PWDs and family members, independent inventors), and provide whatever support was necessary to help them achieve success (Lane, 1995). This broad mission was based on NIDRR's assumption that the nation's stock of languishing inventions must hold potential value and simply needed a boost to realize this potential.

NIDRR's assumption turned out to be invalid. The RERC's results after five years of intensive effort supported by the leading invention evaluation and commercialization programs existing at the time, showed that virtually all (over 97%) of the hundreds of inventions reviewed had no real commercial value. These inventions were languishing for good reason. They proved to be either re-inventions of existing or even obsolete AT devices, or were so poorly designed that they provided no functional benefit or actually posed a hazard in use. Two-thirds of the inventions initially judged to have potential value were rejected in subsequent reviews which showed their insufficient market size, price point or profit margin for them to be licensed by any AT company. After all of the invention solicitation and screening the RERC was successful in licensing or commercializing on average one prototype invention per year (Lane, 1996).

It turns out that most of the inventors attempting to contribute to the AT field with the best of intentions – including NIDRR Grantees -- simply had no idea how to go about validating a perceived problem, designing a feasible solution to a valid problem, or to collaborating with the AT companies qualified to deploy and support new AT products and services (Lane, 1997). Further, most inventors inside and outside academia comprehended neither the distinctions among roles of inventors, AT companies, and other stakeholders, nor the need to combine capabilities and address all stakeholder requirements in order to achieve beneficial impacts (Lane, 1999). The RERC's results demonstrated that a national program with an open call for inventions could ultimately expect to only commercialize a couple of prototypes per year. The project's feedback to NIDRR was that any future invention review program should limit itself to prototypes vetted for value by experienced AT practitioners, with the remaining resources devoted to partnering with existing AT corporations in order to help them achieve their internal plans for product improvements and market innovations.

In 1998, NIDRR approved a new five-year funding cycle on technology transfer, at a reduced level of $1 million per year, and decided to allow applicants to determine how best to facilitate transfer and commercialization within the AT field. The University at Buffalo won the funding for the 1998-2003 funding cycle. Following their own advice, the RERC team limited invention review to those referred by AT experts, and allocated the remaining resources to parallel projects supporting the AT industry. One project established a market demand-pull orientation which solicited information from AT corporations and clinical practitioners on what technology-based barriers were high priority but unresolved by the capabilities of the AT field. The second project established new collaborations between AT or even mainstream companies and NIDRR Grantees on device development efforts of mutual interest. Some of Corporation Collaboration efforts resulted in crossover commercial products that satisfied both AT niche market as well as broader mass market needs (e.g., Black & Decker's Lid's Off jar opener; White Roger's Blue Series 90 accessible thermostat). By combining projects addressing supply push inventions, demand pull technologies, and corporate collaborations within one program the RERC on Technology Transfer was able to increase its own success rate to five new or improved products licensed or sold per year. A state-of-the-practice journal issue summarized all the lessons learned by the project team during these first ten years of operation (Lane, Bauer & Leahy, 2003).

Demonstrating increased success at deliberate and systematic technology transfer led NIDRR to allocate funding for a new five year funding cycle (2003-2008). The incumbent RERC again won funding through the competitive review process by proposing to continue operating all three approaches (i.e., science supply-push, market demand-pull, and corporate collaboration), in addition to adding a project to assess the efficacy of previously commercialized AT devices. This new project was added in response to individuals in the AT field who challenged the RERC's track record by questioning the quality and value of transferred AT devices. It was designed to test consumer satisfaction by comparing recently transferred inventions to alternative approaches to achieving the same function. Not only were consumers highly satisfied with the RERC-led devices but most were willing to waive a portion of their fee for participating in the efficacy study in order to keep or acquire that newly commercialized device for their own personal use. The commercialized prototypes that represented a cross-over between the AT market and mainstream markets also permitted the project team to identify and articulate the critical factors in successfully linking AT devices to mainstream market opportunities (Bauer & Lane, 2006). This linkage may be of scant interest to academics but represents an opportunity for AT companies to expand the customer base for some of their devices currently sold only in niche markets.

Another project proposed for later in funding cycle was a retrospective study of all other RERC's originally funded in the years 1998 through 2000; twelve in all. Since the five year funding cycles for these RERC's ended no later than 2005, it was an opportunity to study the technology transfer activities in related projects through the end of their internal research and development activity, and out into the post-award timeframe where transfer and license activities often occur. The project's purpose point was to learn not only what technology transfer practices had or had not worked for these other RERC's, and more importantly to understand why their internal efforts at technology transfer had or had not been successful. The retrospective case study methodology was intended to document any evidence of progress from each project's initial proposal language, through initiation and prototype events and out to final project output, and to identify those actions/decisions that either facilitated (carrier) or impeded (barrier) project progress. Evidence of uptake and use of project output by any external stakeholder would constitute a successful transfer. This project considered all types of technology-related project outputs which fell into four categories: 1) Commercial devices; 2) Freeware (hardware or software); 3) Instruments or Tools; 4) Standards or Guidelines.

The retrospective study tracked seventy-eight individual projects. The results showed that few projects achieved the results they had initially proposed, with most ending at or before reaching the prototype stage and some never even being initiated after funding was received (Lane, 2008). Overall, the development and transfer-oriented project tended to run out of time or money before achieving their intended outputs. Either NIDRR Grantees lacked adequate planning and management skills for such complex and long-term projects, or they set too high a priority on conducting their scientific research projects. Either way, government's bias towards exploratory grants led by university faculty was demonstrating an inability to deliver the intended beneficial socio-economic outcomes and impacts to PWD's.

Disability & Rehabilitation Research Center (DRRP) on Knowledge Translation for Technology Transfer: 2008 – Present.

In the same timeframe the RERC on Technology Transfer was operating -- from the early 1990's through the late 2000's – at least four related factors were emerging United States that would influence the way NIDRR funded projects supporting its technology-oriented Grantees. First, the general public and their elected officials were challenging the value of sustained funding for scientific research – not questioning the long-term benefits from expanding the general knowledge base, but instead questioning whether scientific research was demonstrating evidence of the claimed beneficial impacts for society. Second, policy-makers and professionals working in the medical and health-related professions were questioning why findings from controlled laboratory studies were not being applied to improve practice at the clinical level. Third, systematic review programs intended to gather and reconcile findings from across all prior studies in selected topic areas (i.e., Cochrane Collaboration; Campbell Collaboration) found that most scientific research studies did not meet the minimum threshold criteria set for rigor in study design, and so were excluded from their analysis. Fourth, the United States government instituted performance-based budgeting polices which meant that each sponsored program would have to demonstrate evidence of successfully achieving its intended results, and would have to provide such evidence at the level of the entire program, rather than offering a convenience sample of those projects demonstrating the best results.

NIDRR's internal monitoring showed that while a few Grantees were successful in attaining their technology transfer goals, most were not. Demonstrating success at the program level, to satisfy new guidelines for future agency funding and benefit the intended target audiences, would require more broad-based support for all Grantees. All of the national factors prompted NIDRR's management to call for both increased rigor in Grantee project methodologies, and increased relevance in Grantee project outputs. Ensuring proper rigor in funded projects was a matter of NIDRR setting more prescriptive criteria within new calls for proposals, and ensuring that proposal review committees contained experts in study methodologies. As in the past, NIDRR focused on increasing the rigor in scientific research, but still neglected the parallel requirement for rigor in engineering development or in technology transfer best practices. The new government performance standards were oriented towards results rather than process, so NIDRR focused additional attention on project output relevance, to ensure that Grantee's could demonstrate evidence of external uptake and use of project outputs.

NIDRR's management became aware of a new approach for encouraging the application of science-based knowledge by non-scholars called Knowledge Translation (Sudsawad, 2007). As mentioned earlier in this paper, the Knowledge Translation (KT) approach involves identifying and engaging targeted stakeholders to ensure the findings are captured and presented in the specific language, format, and media most relevant to each stakeholder group (Graham, et al, 2006). Presenting project findings in the context of each stakeholder group's values, culture, and task domains is expected to facilitate stakeholder awareness, interest, and implementation of the findings. For example, medical researchers expecting to alter the standard practices of nurses or therapists should fully understand the context in which clinical services are provided.

Unfortunately, Knowledge Translation does not truly offer a new approach to moving new knowledge into action, particularly for programs intending to benefic society. The prevailing academic mindset concerning the application of knowledge is science-driven, embodied by the concept of passive diffusion where the new knowledge is disclosed by the producer in written form, which then finds its way into practice through some trickle-down effect. Under this concept, the potential knowledge user is responsible for encountering the new knowledge, assessing its utility, and then formulating a strategy for assimilating the knowledge into practice. Similarly, the Knowledge Translation conceptualization perceives knowledge engagement, uptake, and use through the same supply-push lens; namely, scholars may assume their new knowledge has relevance and value. Knowledge Translation is all about communicating the assumed value of the new knowledge to various audiences either because they lack access to the scholar publications, or they are unable to perceive its value to them because of the scholarly format in which it is initially presented.

Thus, knowledge translation considers two options and two options only: 1) *End-of-grant KT* where the producer considers engaging target audiences after the knowledge is produced; or 2) *Integrated KT* where the producer engages target audiences at some point after the project is initiated but prior to its completion. Both KT options assume that a scientific research project under the direction of an investigator is being sponsored (language cast in terms of "grant") and that it is best for the investigator to determine the point at which target stakeholders should be engaged. Nowhere do the proponents of Knowledge Translation question whether or not the research study's outputs as designed have value to the target audiences, nor do they even question whether or not scientific research is the appropriate methodology for solving the problem addressed. So, the position of Knowledge Translation proponents is that regardless of the circumstances at hand, scientific research will be sponsored by government and undertaken by scholars, and increasing uptake and use of its output's value is only a matter of when to involve the targeted stakeholders in the research process underway.

It is important to recognize that the assumption of knowledge value will remain the key barrier to increasing the application of scientific research findings by non-scholars. If instead government program manager were serious about ensuring that applied scientific research projects are relevant and will generate value to targeted stakeholders, every project's first step would require the investigator to identify, explore and validate the proposed study's relevance to targeted stakeholders. Ideally, this step should occur even before any research study is initiated or even funded, to verify whether or not scientific research is even needed in the first place.

The barrier to success imposed by scholar's assumption of knowledge value is most harmful when the government-sponsored program is justified and funded because it intends to generate project outcomes that result in beneficial socio-economic impacts. Achieving both outcomes and impacts requires some agreement by key stakeholders that the work is worth doing and that the results are worth implementing. Private industry has documented over decades that relevance and value are both determined by the consumer of new products and services, not by the producer. No matter how much the corporation invests in time and money, given any choice in the matter, the target customers always determine where to invest their own time and money as that decision concerns the acquisition of products and services.

The Knowledge Translation approach expects Grantees to do more than generate a scholarly manuscript targeting peer researchers in their field. Under the traditional linear model, scholarly manuscripts are assumed to passively diffuse through the network of scholars and from their out to eventually reach the various stakeholder groups (e.g., clinicians, manufacturers, consumers, brokers, policymakers) who are expected to implement the findings in some practical form. KT requires Grantees to expend more effort on tasks necessary to preparing and communicating project findings to non-traditional stakeholder audiences.

The NIDRR embraced the KT strategy as a means to demonstrate increased success for Grantees within their sponsored programs. In addition to pursuing technology transfer outcomes, Grantees were now expected to apply KT practices where someone with expertise in the field of study is tasked with re-casting the message of the research findings into the language, formats, and values of target (read: non-scholar) audiences. NIDRR's management had sufficient confidence in knowledge translation's ability to facilitate Grantee technology transfer activity that in 2008, NIDRR shifted its call for a new five year Center on Technology Transfer from the RERC program to the Disability & Rehabilitation Research (DRRP) program. This change signaled that the new center funded from Grantee funded for the 2008 – 2013 cycle would be more concerned with helping all NIDRR's Grantees increase their technology transfer success (program level results), rather than having one RERC demonstrate a high level of success (project level results).

The University at Buffalo was again successful in winning the new award through the peer-review process, based on a proposal to apply KT in a novel manner. Given the project team's conviction that an academic mindset does not drive commercial market decisions, they re-cast the application of KT for projects intending to achieve technological innovation outcomes from a science supply push orientation to a market demand-pull orientation. Because it is the stakeholder audience member who determines both the value and utility of new knowledge – not the new knowledge creator -- the project team proposed adding a third approach to KT called *Prior-to-Grant KT* (Lane & Flagg, 2010). This prior-to-grant perspective involves engaging stakeholders prior to initiating a project or even a proposal. No corporation would attempt a new product development effort without intensively exploring the needs and wants of its target market. So it seemed logical for scholars to preemptively build relevance and value into their study designs simply by investigating issues and resolving problems that target audiences deem important. Although relevance is not a necessary pre-condition for basic or fundamental research where no application is intended, projects sponsored with public funds for the expressed purpose of generating products and services are obligated to plan beyond the horizon of scholarly publication output.

The Center on KT4TT completed work in multiple areas during the five year cycle. To recap the details presented earlier for this chronology, the project laid the groundwork for the Prior to Grant KT perspective by characterizing knowledge as existing in three different output states (conceptual discovery; prototype invention; market innovation), each generated through a different yet related methodology (scientific research; engineering development; industrial production), all requiring a comprehensive and coherent strategy from the outset (Lane & Flagg, 2010). Then it applied logic modeling and program evaluation to chart how knowledge flows between the three states of processing and how the eventual output transitions to outcomes and on to impacts (Stone & Lane, 2012). This process modeling culminated in the *Need to Knowledge Model* which serves as a framework for any NIDRR Grantee – or other interested parties – seeking to plan, implement and manage projects intending to successfully complete knowledge translation and technology transfer outcomes (Lane, 2012; Flagg, Lane & Lockett, 2013).

The project also applied the concept of Knowledge Value Mapping as a means through which traditional scholars could work through national organizations to reach non-traditional stakeholders (Lane & Rogers, 2011). It then constructed a new web-based survey instrument called the *Level Of Knowledge Use Survey* (LOKUS), as a means to track the level of awareness, interest and use of new knowledge by individuals within non–traditional stakeholder groups (Stone, *et al*, 2014). The LOKUS instrument was applied within a series of tree studies – all randomized and controlled trials -- to establish baseline measures of the relative effectiveness for three strategies used to communicate new knowledge (passive diffusion, targeted dissemination, tailored translation). The results indicate that stakeholder groups respond to new knowledge in different ways, depending on the importance and urgency of the knowledge to themselves, and that relevance is indeed determined by the stakeholder, regardless of the form and content in which the new knowledge is communicated (Stone, et al, 2014).

While all of this scholarly research was underway, the project team still managed to maintain both invention evaluation and commercialization activity, as well as collaborations between NIDRR Grantees and national/international corporations working to design, test and deploy new or improved AT devices within the commercial marketplace (Leahy, 2012).

Despite government's overall bias towards scientific research, university faculty sponsorship and the exploratory grant system, NIDRR remains committed to investing in projects and activities designed to help their Grantees achieve the AT product and service outcomes and beneficial impacts they propose to accomplish. The Center on KT4TT demonstrated sufficient progress in establishing the models, methods and metrics, and in facilitating the work of all Grantees for NIDRR to allocate funds to support another five year cycle of finding. The University of Buffalo is once again leading this effort during the 2013-2018 timeframe. It is now charged by NIDRR with contributing to Grantees' understanding of, capacity for, and success in, conducting technology transfer activities.

In response to this charge, the Center on KT4TT is conducting the following projects (also identified and described on the Center's website: www.kt4tt.buffalo.edu):

Prospective Case Study – This research study is designed to reveal what works and doesn't work for NIDRR Grantees as they implement the process of transferring their development project outputs to an external stakeholder group. The study will prospectively collect data disclosed by NIDRR Grantees as they progress through the technological innovation process over their funding cycles.

AT Industry Profiles – This research study intends to increase NIDRR Grantees' understanding of industry's opportunities/constraints for participating in TT efforts. Industry is the primary customer for NIDRR Grantee outputs because corporations lead efforts to refine, test, and deliver technology-based outcomes to the marketplace or to related applications. Knowing how to profile potential industry partners is critical for optimizing successful TT outcomes.

Three Variants to the NtK Model – The NtK Model is a framework for projects intended to generate commercial AT devices or services. This research project will create one variant model for each of the three other categories of technology-based project outputs: 1) Industry Standards & Clinical Protocols; 2) Laboratory Instruments & Fabrication Tools; 3) Freeware in the form of do-it-yourself hardware or application store software. NIDRR Grantees requested these NtK Model variants to extend its application to these other categories of project outputs.

Collaborative Commercialization – This development project continues the project team's record of increasing Grantees' success in TT by engaging them in collaborative partnerships with corporations intent on delivering products to the marketplace. The process of learning via participatory demonstration teaches Grantees the value of subordinating personal interests to the shared goal of commercialization.

These four R&D projects follow the prior-to-grant KT perspective through early and continuous engagement with NIDRR Grantees through utilization, dissemination, and technical assistance activities. The Center on KT4TT is also creating a Technology Transfer Planning Template as an interactive guide for planning, implementing and managing technology-oriented projects intending to achieve transfer, uptake and market deployment outcomes.

The Center on KT4TT projects and outputs have application beyond the AT field. Many government programs in the U.S. and in other nations, which like NIDRR are funded for the purpose of generating beneficial socio-economic impacts, are also struggling to bridge the gap created by sponsoring scientific research with scholarly outputs but expecting evidence of stakeholder uptake and use. Consequently, the project team is engaging a wider range of Science, Technology & Innovation (STI) policymakers and program managers, who are increasingly committed to realizing the intended impacts by changing their perspective and approach (Godin & Lane, 2013; Lane & Godin, 2012). These individuals are recognizing the importance of demonstrating evidence of program effectiveness now, in anticipation of future scenarios of contracting budgets and inter-agency contention over the remaining public resources. Demonstrated success will help these programs compete under more difficult economic conditions ahead.

Conclusion

Overall, programs intended to generate beneficial socio-economic impacts in the field of Assistive Technology have demonstrated very little evidence of success, despite decades of public funding invested through government agencies, and allocated to investigators who express the best of intentions in their proposals. The government's response – particularly evident in actions taken by the NIDRR – is to provide guidance and strategies to bridge the gap between the expertise and incentives held by the people and organizations in the academic sector receiving the government funding, and the expertise and incentives necessary to transform project outputs into market outcomes and thereby generate the intended beneficial socio-economic impacts.

The more practical approach would be to allocate the public funding to the people and organizations in the industrial sector who already possess the required expertise and incentives. This approach would substitute the procurement-contract system for the currently unsuccessful exploratory-grant system. Unless and until such a change occurs, programs like the Center on KT4TT will strive to fill the existing gap and at least increase the probability of success for some portion of NIDRR's sponsored projects.

Fortunately, a growing share of academic Grantees recognize the increasing level of scrutiny and accountability over the expenditure of public funds, which increases their engagement with – and level of commitment to – the best practices required to address validated problems with feasible technology-based solutions. The next challenge for government under either the exploratory-grant or procurement-contract system, is working directly with companies doing business within the AT field to ensure they can afford to adopt innovations from NIDRR Grantees – or from any other sources -- for the purpose of offering new or improved AT devices and services.

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References

Barnes, C. (2012). Re-Thinking Disability, work and welfare. *Sociology Compass. 6*, 6, 472-484.

Bauer, S.M., & Lane, J.P. (2006). Convergence of assistive devices and mainstream products: Keys to university participation in research, development and commercialization. *Technology and Disability, 18*(2) 67–78.

Driver, J. (2013). Medicare bidding process slams home medical equipment providers with arbitrary reimbursement rates. *American Association for HomeCare*, February 5, 2013. Retrieved from: https://www.aahomecare.org/press/medicare-bidding-process-slams-home-medical-equipment-providers-with-arbitrary-reimbursement-rates

Eveland, J.D., McNeal, D.R., Rogers, E. & Valente, T. (1991). *Commercialization activities of rehabilitation R&D centers* (Survey Report). Downey, CA: RERC on Technology Transfer, Rancho Los Amigos Medical Center.

Flagg, J.L., Lane, J.P., Lockett, M.M. (2013). Need to Knowledge (NtK) Model: an evidence-based framework for generating technological innovations with socio-economic impacts, *Implementation Science, 8*(1),21.

Godin, B., Lane, J.P. (2013). Pushes and pulls: hi(s)tory of the demand pull model of innovation. *Science, Technology, & Human Values, 38*(5), 621-654. Retrieved from http://sth.sagepub.lcom/content/38/5/621.

Graham, I.D., Logan, J., Harrison, M.B., Straus, S.E., Tetroe, J., Caswell, W., Robinson, N. (2006). Lost in knowledge translation: time for a map?, *Continuing Education in the Health Professions, 26*(1), 13-24.

Jannenga, H. (2010). *Continued medicare cuts and caps will affect therapy patients and providers in 2011*. Retrieved from : http://www.webpt.com/blog/post/continued-medicare-cuts-and-caps-will-affect-therapy-patients-and-providers-2011

KTDRR/SEDL (2013). *Survey results & analysis for nidrr kt centers: Knowledge translation survey.* Unpublished document dated November 18, 2013.

Lane, J.P. & Godin, B. (2012). Methodology trumps mythology. BRIDGES, Office of Science & Technology Austria (OSTA), vol 36. http://ostaustria.org/bridges-magazine/volume-36-december-14-2012/item/6002

Lane, J.P. (*in press*). Aligning policy and practice in science technology & innovation to deliver the intended results: The case of assistive technology, *International Journal of Transitions & Innovation Systems.*

Lane, J.P. (2012). The "Need to Knowledge" Model: An operational framework for knowledge translation and technology transfer, *Technology and Disability, 24*, 187–192.

Lane, J.P. (2010). State Of The Science In Technology Transfer: At The Confluence Of Academic Research And Business Development – Merging Technology Transfer With Knowledge Translation To Deliver Value, *Assistive Technology Outcomes and Benefits, 6*(1), 1-38.

Lane, J.P. & Rogers, J.D. (2011). Engaging national organizations for knowledge translation: Comparative case studies in knowledge value mapping. *Implementation Science, 6*(1), 106. Retrieved August 3, 2014 from http://www.implementationscience.com/content/6/1/106/

Lane, J.P. & Flagg, J.L. (2010). Translating three states of knowledge—discovery, invention and innovation. *Implementation Science, 5*(9), 1-14. Retrieved August 3, 2014 from http://www.implementationscience.com/content/5/1/9

Lane, J.P. (2008). Delivering the "D" in R&D: Recommendations for increasing transfer outcomes from development projects. *Assistive Technology Outcomes and Benefits*, Fall Special Issue, 1 - 60.

Lane, J.P. (2003). The science and practice of technology transfer: implications for the field of technology transfer. Journal of *Technology Transfer, 28*(3/4), 333-354.

Lane, JP, Bauer, SM, Leahy, JA (2003). Accomplishing technology transfer: what works, what doesn't and why?. *Assistive Technology, 15*(1), 69-88.

Lane, J.P. (1999). Understanding technology transfer. *Assistive Technology, 11*(1) , 5-19.

Lane, J.P. (1997). Technology evaluation and transfer in the assistive technology marketplace: Terms, process and roles. *Technology and Disability, 7*(1/2), 5-24.

Lane, J.P. (1996). Development, evaluation and marketing of assistive devices. *Technology and Disability, 6*(1), 105-125.

Lane, J.P. (1995). Rehabilitation engineering research center on technology evaluation and transfer. *Technology and Disability, 4*(2), 137-148. Retrieved August 10, 2014, from http://iospress.metapress.com/content/304j3h51k32430rn/

Leahy, J.A. (2013). Targeted consumer involvement: An integral part of successful new product development, *Research-Technology Management (RTM), 56*(4), 52-58.

Mittler, J. (2007). Assistive technology and IDEA. In C. Warger (Ed.), *Technology integration: Providing access to the curriculum for students with disabilities.* Arlington, VA: Technology and Media Division (TAM).

NIDRR (2014). *Summary of 2013 annual peformance reports from nidrr grantees.* Retrieved from: http://www2.ed.gov/programs/

nidrr/2013aprreportsummaries.pdf

NIDDR. (2013). National Institute on Disability and Rehabilitative Research: Long Range Plan for Fiscal Years 2013 – 2017. U.S. Federal Register, April 4, 2013. Retrieved from: https://www.federalregister.gov/articles/2013/04/04/2013-07879/national-institute-on-disability-and-rehabilitation-research-long-range-plan-for-fiscal-years

Pittman, D. (2013). Medicare's DME bidding program criticized. Retrieved from: http://www.medpagetoday.com/PublicHealthPolicy/Medicare/41184

Philips, B. & Zhao, H. (1993). Predictors of assistive technology abandonment. *Assistive Technology, 5* (1), 36-45.

Scadden, L. (1987). *Stimulating the manufacturing and distribution of rehabilitation products: Economic and policy incentives and disincentives*. Washington, DC: Electronic Industries Foundation Rehabilitation Engineering Center.

Stone, V. I., Lane, J.P. (2012). Modeling technology innovation: How science, engineering, and industry methods can combine to generate beneficial socioeconomic impacts, *Implementation Science, 7*(1), 44. Retrieved from http://www.implementationscience.com/content/7/1/44/abstract.

Stone, V.I., Nobrega, A.R., Lane, J.P., Tomita, M.R., Usiak, D.J., Lockett, M.M. (2014). Development of a measure of knowledge use by stakeholders in rehabilitation technology. *Sage Open Medicine, 2,* 1-19 doi: 10.1177/2050312114554331.

Sudsawad, P. (2007). Knowledge translation: introduction to models, strategies and measures. *The National Center for the Dissemination of Disability Research: SEDL*. Retrieved from: http://www.ktdrr.org/ktlibrary/articles_pubs/ktmodels/

U.S. Department of Education. (2014). *Summary of 2013 annual performance reports from NIDRR grantees*. Retrieved from http://www2.ed.gov/programs/nidrr/2013aprreportsummaries.pdf

Tools for Analysis in Assistive Technology Research, Development, and Production

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Abstract

This paper describes a development project intended to increase awareness and use of new product development (NPD) tools within a specific segment of new product developers: federally funded “technology grantees” who are charged with generating innovations that have socio-economic impacts. To achieve this end, the authors review the creation of a NPD tool repository, designed to improve grantees’ ability to generate outputs that are relevant to industry partners and the marketplace alike. A recently established operational model for NPD, called the Need to Knowledge (NtK) Model, frames this work. Tools specifically concerned with the inclusion and accommodation of user characteristics, particularly those reflecting the principles of Universal Design, are highlighted in order to improve the accessibility of products in the marketplace for all users.

Keywords: New product development, NPD, product design, disability, aging, functional limitations, universal design, UD, Need to Knowledge Model

Introduction

Creating new products and services that meet the needs of people with disabilities is important and challenging work. One group engaged in these efforts is comprised of technology grantees – university-based researchers and small-business entrepreneurs – who are funded by the federal government to generate marketable innovations. As funding agencies expect ever-greater outcomes from projects they support, it is more critical than ever that grantees efficiently allocate their limited resources. To do so, they must be equipped with knowledge about how to plan and coordinate the efforts of the wide variety of stakeholders who are typically engaged in new product development (NPD) activities.

The authors offer the ideas in this paper as a message and a guide. The message is that many time-tested NPD tools are available, and use of these tools can streamline the NPD process to increase the number of products reaching the marketplace. The guide introduces grantees to a selected sample of tools designed to accomplish the various types of technical, marketing and business analaysis required by any NPD project. Where appropriate the list is supplemented by Universal Design (UD) tools, which are designed to consider the requirements of product end users who have functional limitations resulting from disabilities or aging. As a philosophy, UD encourages consideration of end users at each step of the NPD process to improve the usability of products for as many users as possible.

The following sections introduce the Need to Knowledge (NtK) Model and the concept of Universal Design (UD). A description of the tool search process and tool classification scheme, including the designation of tools relevant to UD, is presented in the process section. This is followed by presentation of the project's output, where tools are integrated into the NtK Model, and a discussion of the utility of the output. The paper closes with outcomes and benefits relevant to the assistive technology (AT) industry.

Open Innovation and the Need to Knowledge Model

Technology grantees often attempt to transfer their inventions to industry partners who can bring them to the marketplace. For that reason, many technology grantees are familiar with the concept open innovation. In open innovation, scientific research, engineering development, and industrial production may occur within different organizations or even different sectors. In practice, the role played by technology grantees in open innovation remains loosely defined (Howells, Ramlogan, & Cheng, 2012).

In response to this undefined relationship between technology grantees and industry, the Need to Knowledge (NtK) Model emerged. The NtK Model is a guide for applied researchers and other new product development (NPD) professionals who wish to move project outputs (e.g. prototypes) from the lab to the marketplace through research, development, and production activities. It leverages knowledge translation to facilitate open innovation by considering how outputs generated by one stakeholder (i.e., academic researchers or small business inventors) become inputs for another stakeholder (i.e., larger private-sector manufacturers) (Stone & Lane, 2012).

Importantly, the NtK fosters the generation of needed technology by requiring projects to validate a market need prior to commencing any research or development activity. In fact, the term Need to Knowledge derives from the creator's position that deliberate and systematic technological innovation begins with a feasible solution to a validated need (which are prerequisites for any commercially viable product or service). Beginning with identification of the end users' needs, the NtK Model demonstrates the optimal path that technology grantees should follow to generate a commercial solution to a validated problem.

The NtK borrows elements from three sources, including Ian Graham's Knowledge to Action (KTA) model for knowledge translation (Graham et al., 2006), the Product Development and Management Association's (PDMA) handbook for new product development (Kahn, Castellion, & Griffin, 2005), and the formal research process, as defined by Campbell and Stanley (1963). These foundational components were distilled and stratified along a nine-stage continuum, consisting of 79 activity steps (Flagg & Lockett, 2010).

Table 1 depicts the number of steps and names of stages embedded in the NtK's three major phases, which are named for the outputs resulting from the phases' activities: discovery,

Table 1
Need to Knowledge Model Phases, Stages, and Steps

Phase	Stages	Steps/Stage
Discovery Phase	1. Define Problem and Solution	5
	2. Scoping	3
	3. Conduct Research to Generate Conceptual Discoveries	9
Knowledge Translation to move Discovery Output into Development		7
Invention Phase	4. Build Business Case and Development Plans	13
	5. Implement Development Plan	4
	6. Test and Validate Prototype Invention	4
Technology Transfer to move Prototype Invention into Production		7
Innovation Phase	7. Production Planning and Preparation	13
	8. Launch Product Innovation	4
Commercial Transaction to transfer the Product Innovation to Consumers		7
Innovation Phase Ct.	9. Post-Launch Review	3

invention, and innovation. During the discovery phase, needs are assessed, scoping and research activities are taking place to define the problem (stage 1), ensure that the proposed solution will be viable in the marketplace (stage 2), and generate conceptual findings that will lend to realization of the solution (stage 3). In the invention phase, development activities are occurring. These include establishment of a business case, making contact with potential industry partners, gathering consumer feedback (stage 4), and prototype development and testing (stages 5 & 6). Finally, during the innovation phase, the invention is further refined into a marketable product through activities related to production. For example, creating materials and production plans, conducting test marketing, finalizing distribution, sales, and marketing logistics (stage 7), and the launch of the product into the marketplace (stage 8). The innovation phase then concludes with the provision of service, monitoring, and support to product end users, as well as reviewing product performance against initial expectations. This input helps the manufacturer to determine when to consider making changes to the product, or begin the cycle anew to introduce a new version of the product, or discontinue sales altogether (stage 9). The stages and steps of the NtK model are described in greater detail in a publication by Flagg, Lane and Lockett (2013).

In order to relate to cases typically encountered by technology grantees, where these phases of activity are completed by different stakeholders, Table 1 also highlights three specific opportunities to communicate knowledge in its different forms (concept, prototype, product) between stakeholder groups (Lane, 2012). Each of these opportunities represents an exchange of ownership of the relevant phase's output. First, knowledge translation is used to communicate conceptual discoveries to those who can embody the discoveries within an invention. The conceptual discoveries are typically protected by copyrights from journal publications. Once the invention phase activities have been completed, technology transfer can take place to transfer ownership of intellectual property from one party to another, typically in the form of a license agreement for use of a patented invention. Lastly, when a product is ready for sale in the marketplace, a commercial transaction takes place to transfer ownership to the product purchaser.

Every one of the 79 activity steps related to the nine stages and three opportunities for knowledge communication is more complex and detailed than the steps' short titles suggest (see Table 4 for examples of step names). In order to provide users of the NtK with evidence regarding when, why, and how a step should be completed, a scoping review of academic and practice literature was conducted. Reviewers extracted and coded 1,414 salient excerpts drawn from 229 studies, and associated each excerpt with the NtK Model stage and step to which it was most relevant. A qualitative analysis was completed by grouping the excerpts into common themes, one of which was tools. This process resulted in the identification of 44 tools that could potentially provide users with the finer grain details for step completion.

All excerpts and tools are catalogued within the NtK Model, and are freely accessible on the Center on Knowledge Translation for Technology Transfer's website at http://kt4tt.buffalo.edu/knowledgebase/model.php. A tremendous amount of detail regarding the NPD process and results of the scoping review can be explored on the website by clicking on magnifying glass icons beside the title of each step and stage. All tools can be explored by clicking on toolbox icons.

Three recent publications offer case examples, describing collaborative endeavors between technology grantees and manufacturing partners to highlight examples of NPD and technology transfer in practice and the application of the NtK Model. Flagg (2011) describes the development of an accessible glucose monitoring system and a toaster oven with improved usability; Leahy (2013) discusses the development and testing of an 'electronic ear' application for a cell phone; while Flagg, Lane, and Lockett (2013) describe the commercialization of an automatic jar opener in the context of the NtK Model. Each of these papers offers insights into the NPD process, tools utilized, and the integration of usability considerations, while exemplifying the use of tools that can be found within the NtK Model.

Universal Design

Universal Design is a term attributed to Ronald L. Mace, who defined it thusly: "Universal Design (UD) means the design of products, environments, programs and services to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design" (Center for Universal Design, 1997, para. 1).

In 2006, the United Nations (UN) furthered the definition, adding that "Universal Design shall not exclude assistive devices for particular groups of persons with disabilities where this is needed" (p. 9). The UN definition also articulates General Obligations for governments, including that they must "undertake or promote research and development of universally designed goods, services, equipment and facilities… and in the development of standards and guidelines" (United Nations, 2006, pp. 9-10).

Seven Principles of Universal Design

The Center for Universal Design at North Carolina State University (1997) established *Seven Principles of Universal Design*. The authors of these principles state that "These seven principles may be applied to evaluate existing designs, guide the design process, and educate both designers and consumers about the characteristics of more usable products and environments" (para. 2). The principles are:

- Equitable use
- Flexibility in use
- Simple and intuitive
- Perceptible information
- Tolerance for error
- Low physical effort
- Size and space for approach and use

Each principle corresponds with a set of Universal Design Guidelines used to apply the design principles. Universal Design Principles and Guidelines can be applied at key decision gates and steps in the NPD process. In so doing, new product developers prioritize end-user requirements and preferences throughout the entire NPD process to ensure more accessibility, and usability (Lenker, Nasarwanji, Paquet, & Feathers, 2011).

The output section of this paper indicates the NtK steps in which UD Guidelines can help designers improve the accessibility of their products, thereby increasing their utility to all end users.

Applying Universal Design to Accommodate Extreme Users' Needs

A key advantage for new product developers who apply UD Principles and Guidelines is that they will learn the requirements and preferences of people with disabilities, including persons aging into functional limitations. By leveraging UD as a strategy, and by focusing on extreme users' needs, companies can ensure that their products will be more usable by the broadest range of customers.

UD offers a platform to accommodate the needs of the large, aging cohort of people born after World War II. UD also contributes to the capacity to respond effectively to the fact that people are living longer. According to the United Nations (2001), aging-related population dynamics can be simplified into four succinct points: "1. Population ageing is unprecedented. 2. Population ageing is pervasive. 3. Population ageing is enduring. 4. Population ageing has profound implications" (para. 2-5).

Considering these points, it seems obvious that UD strategies should be pursued to ensure that products are usable by individuals with functional limitations related to aging. However, NPD practitioners must be aware of standards, guidelines, processes, and tools for UD in order to achieve the needed usability.

Global Trends in Universal Design Implementation and Legislation

Universal Design-related initiatives have been appearing in evolving mandates in many countries. For example, the International Organization of Standardization (ISO) and European Committee for Standardization (CEN) offer guidance for stakeholders in standards development work to prioritize the needs of older persons and persons with disabilities (ISO/IEC, 2014). Ireland's Center for Excellence in Universal Design is aligning UD guidelines with the World Health Organization's International Classificition of Function (NDA, 2012). Similarly, authors from many nations are collaborating on design handbooks that integrate UD into mainstream human factors and ergonomic practices (Karwowski, Soares & Stanton, 2011).

Though the international audience promoting UD is relatively small, UD philosophy is expected to increase in priority. Continued advances in modern medicine increase survival rates of those with significant injuries, illnesses, and birth defects. Overall, life expectancy is increasing. As these changes impact population demographics and socio-economic factors, interest in UD will increase (Crews & Zavotka, 2006).

For the time being, however, NPD stakeholders still require operational guidance on how to integrate UD into their work. Models for development – including the NtK Model – can fill this void. Ultimately, prompting designers to give functional limitations as much consideration as they do functional capabilities will result in the creation of products that improve the quality of life for people with disabilities. In so doing, designers are more likely to create products that demonstrate the socio-economic impacts that funding agencies expect.

Process

The authors of this paper are keenly aware of the increasing importance of improving socio-economic outcomes and impacts resulting from federally funded research and development projects (Kamensky, 2011). The principle on which the NtK model is founded is that a structured, well-planned new product development process is more likely to achieve positive outcomes and impacts than an unstructured, unguided process, left to serendipity. The NtK model offers this needed structure. However, feedback from model users indicated that the NtK model's identification of steps, supporting evidence, and tools was helpful, but not sufficient for guiding their new product development processes. In particular, users needed finer grain details regarding the tools that they could use, or could hire an expert to implement, in order to complete the model's steps, and progress their project toward technology transfer and commercialization. Therefore, the authors worked to extend the tool listing to provide details necessary for tool implementation. The following subsections of this article describe the process used to identify and document these tools, introducing a framework of descriptive categories, with a detailed discussion of competency groups and the special case of UD, followed by information regarding the search conducted to populate the tool repository.

Tool Classification and Description

For this project, a tool was considered to be any process, method, software, hardware, template, measure, or guideline that is ready to use, relative to specific points within the NtK, and that makes the NPD process more efficient and effective. For example, during the discovery phase, the method for conducting one-on-one interviews is a tool that can be used for assessing user needs. Similarly, during the invention phase, a software tool such as computer-aided-design may help with completion of product design activities.

The initial scoping review of academic and practice literature, which sought supporting evidence for the NtK's stages and steps, resulted in the identification of 44 tools. The information extracted about these tools was minimal, including only tool names and an identification of where the tool might be useful in the NtK Model. Additional information was needed in order to improve usability of the toolset for those unfamiliar with the tools. For example, users would benefit from a description of what each tool was and how it could be used, identification of the skill sets typically possessed by those who implement the tools, advantages and limitations of each tool, the type of output produced by the tool, target users of the tool's output, and links to resources on where to find additional information for tool implementation.

Upon compiling the expanded descriptions for each tool, it became apparent that many other potentially useful tools were not yet represented in the model, and a much broader set of tools would be required to represent the full range of activities involved in new product development and transfer. In fact, when looking at which NtK steps were represented by those 44 tools, it was realized that many of the model's 79 steps did not have any tools associated with them at all. Therefore, a rigorous investigation specifically focused on tools that were potentially relevant to the NtK Model began.

At the same time, as tool information was being collected, a framework of descriptive categories evolved and was standardized to ensure that each tool's listing would have a common format for ease of display and use.

Table 2
Descriptive Tool Categories

Name of Category	Description of Category	Example
Name of the tool	Common name by which the tool is generically known.	Focus Group
Competency Group	Skill set typically possessed by those applying the tool. Suggests the skill sets one might seek out when hiring a professional to employ a tool for an NPD project.	Business (this tool is commonly employed by people trained in business methods)
Type	Describes the physical nature and/or sub-domain(s) of the tool as a software computer program, hardware piece of equipment, process, tool for mapping or benchmarking, design tool, model, or a measure. More than one label may apply to a tool.	Process
Description	Offers a narrative statement about what the tool is and how it is typically applied.	A focus group is a form of primary market research, where a group of people are asked about their opinions, beliefs and attitudes towards a product, service, concept, advertisement, idea, or packaging…
Citation for Description	Many tool descriptions are quoted from published sources. This category provides reference information regarding the authors of the tool description.	Focus group. (2011). Retrieved from Wikipedia, http://en.wikipedia.org/wiki/Focus_group.
Units	Describes the nature of the tool's resulting output.	Data that can be used to profile the voice of the customer.
Advantages	Describes the merits of the tool, providing reasons for tool application.	Group dynamics play an important role, as one comment may trigger many more. Relatively less time required than one-on-one interviews…
Limitations	Offers an understanding of why a tool might be difficult to obtain or use, and problems that may be encountered in tool application.	One or two people can dominate the discussion, and there is limited time per participant. It is difficult to schedule high level people to take part in a focus group.
Regulations	Provides descriptions of and links to information from and about organizations who approve some aspect of the use of tool or its output. Mainly applies to engineering tools (electrical, mechanical or material science).	When United States Federal funding is used for focus group projects, protocols must be subject to review from an Institutional Review Board to ensure there are adequate human subjects protections in place. For more information, see: http://www.hhs.gov/ohrp/archive/irb/irb_guidebook.htm
Target Audience	This category describes the types of individuals in private sector organizations who would typically receive or use a tool's output. Possible groups include R&D, marketing, engineering, top management, production, accounting/finance, and sales. Understanding the audience helps the person creating an output report to properly tailor their output.	Top management, Marketing, and R&D
Stages and Steps	Lists the NtK Model step numbers where application of a tool is warranted. Most tools are useful for many steps.	1.1 (Assess end user needs); 1.2 (Identify a problem, audience for solution, and context for both); 4.11 (Gather, analyze, and prioritize customer needs).
Free Resource	Offers citations and web links to no-cost information regarding each tool, such as descriptive papers regarding the tool and its use.	Debus, M. (n.d.). Handbook for excellence in focus group research. Retrieved from http://www.globalhealthcommunication.org/tool_docs/60/handbook_for_excellence_in_focus_group_research_(full_text).pdf
Purchase Resources	Offers citations and web links to information available for purchase regarding each tool, such as links to purchase or obtain the tool, or books or journal articles regarding the tool and its use.	None listed for this tool.
Relevant to Universal Design	Yes/No used to indicate if the tool facilitates the incorporation of UD principles into product development activities.	Yes

Table 2 provides the names and descriptions of each category, as well as an example.

The majority of categories used to describe tools are self-explanatory. However, two categories, 'competency groups' and 'relevance to universal design' warrant additional discussion, which is provided in the following sections.

Competency Groups

NPD requires competence in a variety of different skill sets, broadly including business (marketing, management, production, sales); engineering (material science, electrical, and mechanical); and, for purposes of improving product usability, UD. While some of the tools in the repository can be implemented by technology grantees themselves, many of the tools require specialized training to fully understand and use. Therefore, the identification of competency groups suggests the skill sets that a technology grantee would seek out when hiring a staff member or subcontracted professional to implement a tool for them. To provide this information to toolbox users, the authors defined five major competency groups, each related to a different skill set possessed by typical members of a new product development team:

Establishing these five groups enabled the authors to investigate tools commonly employed by professionals in each competency. The competency groups also facilitate an easy-to-understand classification system that directs users of the NtK Model to tools related to each area of expertise. In the case of a product with complex electronics, for example, those tools that require the expertise of an electronic engineer may be identified,

Table 3
Competency Group Descriptions

Competency Group	Description	Example Tool
Electrical/ electronic engineering	Electrical and electronic engineers utilize tools to design, fabricate and test electronic circuits, devices and systems. Tools include measurement systems, design and testing systems, and mass manufacturing tools.	Printed Circuit Board Design Software
Material science	Material science engineers employ tools to evaluate options for a particular manufacturing material. This includes tools to examine whether specific shapes for a particular material have the correct characteristics for making a physical object.	Dynamic and Fatigue Testing System
Mechanical engineering	Mechanical engineers use tools that encompass the generation and application of heat and mechanical power, and the design, production, and use of machines and tools.	Material Requirements Planning
Business	Business professionals utilize tools spanning a wide range of methods, such as gathering consumer input, evaluating business and market potential, and completing open innovation and co-development activities. This category also contains tools related to marketing, process improvement, lean manufacturing, evaluating return on investment, and determining business feasibility.	Competitor Benchmark Matrix
Universal Design	UD professionals employ tools to ensure that the widest possible range of users will be considered in the design process, regardless of users' age, size, ability or disability.	Inclusive Design Toolkit - Disability Simulators

thereby aiding project managers with planning and budgeting activities.

The Special Case of UD and UD-Relevant Tools

Arguably, UD tools could have been stratified among the other competency groups. However, the authors instead assigned UD tools to their own competency group for two primary reasons. First, the tools included in the UD competency group were specifically developed to foster UD in new product development. Second, many of the UD tools actually span multiple competency groups. For example, the Anthropometry tool and Design Exclusion Calculator tool could offer insights to mechanical engineers for design parameters. Marketing personnel could also use them to consider additional target-market segments. The authors were concerned that pigeon-holing tools in one of the other competency groups could cause users to miss opportunities to apply the tools in other areas, and that those tools' explicit focus on usability would be lost.

Importantly, UD was established as its own competency group and as a general category to demonstrate that some tools can be leveraged to implement Universal Design philosophy even though they do not specifically address Universal Design considerations. Therefore tools from all competency groups were designated UD-relevant if they could be used to evaluate a product or service's alignment with the Seven Principles of UD. For example, the project team questioned whether tools recommended or facilitated the consideration of usability and/or incorporated user input into product development.

Of course, all tools included in the UD competency group were deemed UD-relevant. However, the assessment of UD-relevance of those tools not included in the UD competency group is perhaps more important. This linkage demonstrates the degree to which UD intertwines already with many NPD tools that new product developers commonly use. Creating awareness of a tool's potential to improve the usability of a product or service is the first step toward the integration of UD concepts into product development (Lenker et al., 2011).

Tool Research

Because the NtK Model had been based on information gleaned from the PDMA's series of handbooks and toolbooks, the authors began their search for detailed tool information by returning to these resources (Belliveau, Griffin, & Somermeyer, 2002; Belliveau, Griffin, & Somermeyer, 2004; Griffin & Somermeyer, 2007). The authors then continued their searches using online knowledge bases and repositories that had been documented during the scoping review. General resources used to find information on specific tools included publicly available books, journal articles, and online publications, which were primarily located through library web searches and Google Scholar. Sources for information on tools in the Material Science, Mechanical, and Electrical Engineering competency groups included Engineers Edge (http://www.engineersedge.com), the Institute of Electrical and Electronics Engineers Xplore website (http://ieeexplore.ieee.org/Xplore/home.jsp), and material properties data websites, such as MatWeb (http://www.matweb.com/). For tools related to innovation and business, the authors reviewed DRM Associate's Body of Knowledge (http://www.npd-solutions.com/bok.html), which is a repository offering links to more than 100 articles related to new product development; Innovationtools.com, which provided resources on business and innovation; and Bain and Company's 2011 Management Tools guide (Rigby, 2011). Finally, to locate tools related to UD, resources included the websites for the University of Cambridge's

Table 4
Summary of Tools and Relevance to UD Within the NtK Model

Competency Groups	Number of Tools	Number of Tools with Relevance to UD	Most Common NtK Stages and Steps Where Tools are Relevant
Electrical/Electronic tools	13	3	Step 3.5: Conduct research
			Stage 5: Implement development plan
			Stage 6: Testing and validation
Material Science tools	15	2	Step 2.2: Perform preliminary assessments
			Step 4.2: Propose draft solution
			Step 4.3: Outline preliminary business case
			Step 4.12: Identify features and specifications
			Step 7.1: Draft preliminary bill of materials
			Step 7.2: Develop materials plan
Mechanical Engineering tools	4	2	Step 7.4: Develop production and capacity plan
			Step 7.5: Plan and schedule engineering
			Step 7.6: Plan and schedule tool and process design
Business tools	40	31	Step 1.1: Assess needs from relevant stakeholders
			Step 1.2: Identify problem, audience, and context
			Step 1.3: Propose plausible solution
			Step 4.6: Initiate co-development practices
			Step 4.11: Gather and analyze customer needs
			Step 6.3: Test beta prototype with consumers in field
Universal Design Tools	7	7	Step 2.2: Perform preliminary assessments
			Step 4.2: Propose draft solution
			Step 4.12: Identify features and specifications

inclusive design tools, (http://www.inclusivedesigntoolkit.com/betterdesign2/) and North Carolina State University's Center for UD (http://www.ncsu.edu/ncsu/design/cud/). No sources were specifically excluded from the search, but the focus remained on those resources where information about multiple tools could be captured.

During the search process, informal personal interviews were conducted with electrical, electronic, mechanical, and material engineering experts with knowledge of the NPD process from the Dublin Institute of Technology. Similar interviews occurred with UD experts from both the Center for Excellence in Universal Design in Dublin, Ireland, and the Center for Inclusive Design and Environmental Access, Buffalo, New York. During the interviews, the listing of tools was shared, and the source repositories were discussed to determine if the experts could contribute suggestions for additional resources or tools. Some of the sources mentioned in the previous paragraph were included in the search as a result of these interviews. The experts were also asked to make suggestions regarding where the tools would be most useful in the

NtK framework. Their suggestions are reflected in the steps and stages to which the tools are linked. Project team members with more than 20 years of experience in NPD and technology transfer also reviewed the tool repository for completeness, offering additional input regarding any potentially

Table 5
Complete List of Tools Sorted by Competency Group

Electrical Engineering	Material Science	Mechanical Engineering	Business Tools	Business Tools (cont.)	Universal Design
Digital Logic Design Software	Density Measurement	Computer Aided Design (CAD)	Affinity Diagrams	Information Technology	Anthropometry (Human Size)
Electronics Simulation Software	Dynamic and Fatigue Testing System	Computer Integrated Manufacturing (CIM)	Analytic Hierarchy Process (AHP)	Internal Idea Capture System	Design Exclusion Calculator
Emissions Testing	Electrical Resistivity	Material Requirements Planning (MRP)	Beta Testing	IP Agreements	Guideline for Addressing Accessibility in Standards (ISO/IEC Guide 71:2014E)
Home Printed Circuit Board Manufacturing	Finite Element Analysis Tool 1: ALGOR	Six Sigma	Brainstorming	Lead User Analysis	Inclusive Design Toolkit - Disability Simulators
Immunity Testing	Finite Element Analysis Tool 2: Ansys		Brand-Equity Analysis	Market Structure Maps	SWiFT 9:2012 Universal Design for Energy Suppliers
Industrial Printed Circuit Board Manufacturing	Hardness Measurement		Business Process Re-Engineering	Multiple-Attribute Decision Analysis	Transgenerational Tools
Measurement of Inductance and Capacitance	Heat Capacity		Clinical Trials	Net Present Value	Universal Design Product Evaluation Tools
Measurement of Voltage, Current and Resistance	Impact System		Competitor Benchmark Matrix	Netnography	
Pick and Place Machines	Pull Tester		Concept Testing	One on One Interviews (customer visit teams)	
Printed Circuit Board Design Software	Static Hydraulic System		Conjoint Analysis	Open Innovation	
Robotic Electronic Circuit Board Testing Equipment	Strain Measurement		Critical Path Analysis	Patent Mapping	
Safety Testing	Stress Measurement		Customer Idealized Design	Product Benchmark Matrix	
SPICE (Simulation Program with Integrated Circuit Emphasis)	Thermal Conductivity		Delphi Method	Quality Function Deployment	
	Thermal Expansivity		Empirical Methods for Feasibility Testing	Suh's Design Axiom	
	Toughness Measurement		Ethnography	Surveys	
			Failure Mode Effects Analysis (FMEA)	Team-Based Knowledge Work	
			Field Testing	Technology Road Map	
			Focus Groups	TRIZ	
			Human Performance Technology (HPT)	University Research Centers	
			Idea Generation (Wildest Idea, Morphological Analysis, Metaphor Use)	University-Based Industrial Extension Services	

missing tools and steps and stages where the tools might be most useful.

As a final step, once data collection was completed for all tools, the data was independently vetted by three of this article's authors, who reviewed all descriptions for completeness and attribution to correct sources, confirmed that appropriate steps and stages were associated with each tool, and checked web links to resources for function and accuracy. Discrepancies were resolved through discussion.

Output

In this project, the authors identified, described, and catalogued existing new product development tools related to the domains of electronic engineering, material science, mechanical engineering, business, and UD. Important attributes of each tool were extracted from a wide range of resources and categorized. Tools specifically concerned with the inclusion and accommodation of user characteristics were identified as aligning with the principles of UD.

Table 4 lists the five competency groups, the number of tools in each group, the number of tools in each group that are relevant to UD, and finally, the NtK stages and steps that are most frequently associated with the tools in each competency group.

Authors identified a total of 79 tools at the completion of this project. Among them, 45 were deemed to be relevant to UD. That is, they could be used to prioritize the needs of end users in the product design, and/or directly involve end users in the use of the tool.

Table 5 provides the full listing of tools, sorted by competency group. Those (45) that are relevant to UD appear in gray boxes with white lettering.

Tools that were not considered relevant to UD (those in white boxes in Table 5) are those where end users do not need to be directly involved. In particular, many electrical engineering tools and material science tools require no user input. In these cases, user input can even skew test results. However, it is incumbent on engineers performing the tests to derive meaning from the results, which designers will rely on when considering end-user interactions with a product. For example, the requirements for tests and tools such as printed circuit board manufacturing, heat capacity measurements, and hardness measurements will be influenced by end-user needs; however the tests themselves will not involve end users.

Integrating the NtK and UD

The NtK Model is a framework or path that acts as a step-by-step procedural guide; UD can be described as a philosophy, a process, and a set of principles (Steinfeld & Maisel, 2012). The UD philosophy complements and enhances the user-integrated design approach that is vital to the NtK Model. The identification of NtK Model steps where tools relevant to UD can be applied creates awareness of how to integrate UD into activities that product designers perform.

Table 6 summarizes the 20 NtK Model steps where the UD competency group's seven tools could be applied. For example, the Guideline for Addressing Accessibility Standards applies to two NtK steps: 4.2 (propose draft solution) and 5.1 (build alpha prototype model).

The six remaining tools in the UD competency group are: Anthropometry Data Sets, which relates to 7 NtK steps; UD Product Evaluation

Table 6
NtK Steps Associated With UD Tools

		UD-Specific Tools						
NtK Stage	NtK Step	Anthropometry (Human Size)	Guideline for Addressing Accessibility Standards	UD Product Evaluation Tools	SWiFT 9:2012	Transgenerational Tools	Inclusive Design Toolkit	Design Exclusion Calculator
1	1.2: Identify Problem	x		x	x			
2	2.1: Define Innovation Opportunity	x		x	x			
2	2.2: Valuability Assessments	x		x	x	x	x	x
4	4.2: Propose Draft Solution	x	x	x	x	x		
4	4.3: Outline Preliminary Business Case	x		x	x			x
4	4.11: Gather, Analyze, and Prioritize Customer Needs	x		x	x	x		
4	4.12: Identify Device/Service Features and Specifications			x	x	x	x	x
4	4.13: Complete Business Case					x		x
5	5.1: Build Alpha Prototype Models	x	x					x
5	5.2: Monitor Development Process						x	
5	5.3: Test Alpha Prototype Models			x	x	x		
5	5.4: Refine Models							x
6	6.1: Test Beta Prototype with Consumers			x	x	x		
6	6.2: Refine Beta Prototype Models							x
6	6.3: Test Refined Beta Prototype with Consumers			x	x	x		
6	6.4: Refine Beta Prototype Models Further							x
7	7.10: Finalize Marketing and Sales Activities			x	x			
7	7.11: Develop Post-Launch Evaluation Plan			x	x			
8	8.2: Monitor Performance			x	x			
9	9.1: Continue Production, Monitoring and Support			x	x			

Tools (refers to the seven UD Principles and their associated guidelines), which is applicable to 14 NtK steps; SWiFT 9:2012 (UD standards for energy suppliers), which relates to 14 NtK steps; Transgenerational Tools, which relates to 8 NtK steps, the Inclusive Design Toolkit, which relates to 3 NtK steps; and the Design Exclusion Calculator, which relates to 8 NtK steps.

Tools with relevance to UD were represented in the majority of all NtK steps (42 out of 79). Those areas where UD tools were not highly reflected consisted of either steps within the research stage where end-user input would be inappropriate, steps related to knowledge communication, or steps related to administrative aspects of NPD such as intellectual property and resource allocation.

The graph in Figure 1 depicts NtK steps with which five or more UD-relevant tools are associated. Each horizontal bar in the graph accounts for two types of UD-relevant tools. The left side of each bar (white portion) quantifies tools specifically designed for UD and belonging to the UD Competency Group. The right side of each bar (shaded portion) quantifies tools that are not specific to UD but which are UD-relevant and therefore applicable to UD philosophy.

This chart provides a quick view of the steps in which UD-relevant tools are most prevalent. It also enforces the finding that many tools that do not belong to the UD competency group nonetheless demonstrate relevance to UD.

Using the Tools

All of the tools have been embedded into the interactive NtK Model and linked to the stage or step with which they are associated, making it easy for technology grantees to know which tools to consider using when trying to complete any given step. To view results, users can visit the Center for Knowledge Translation for Technology Transfer's Knowledge Base at http://kt4tt.buffalo.edu/knowledgebase/model.php. Users can find the tools within the

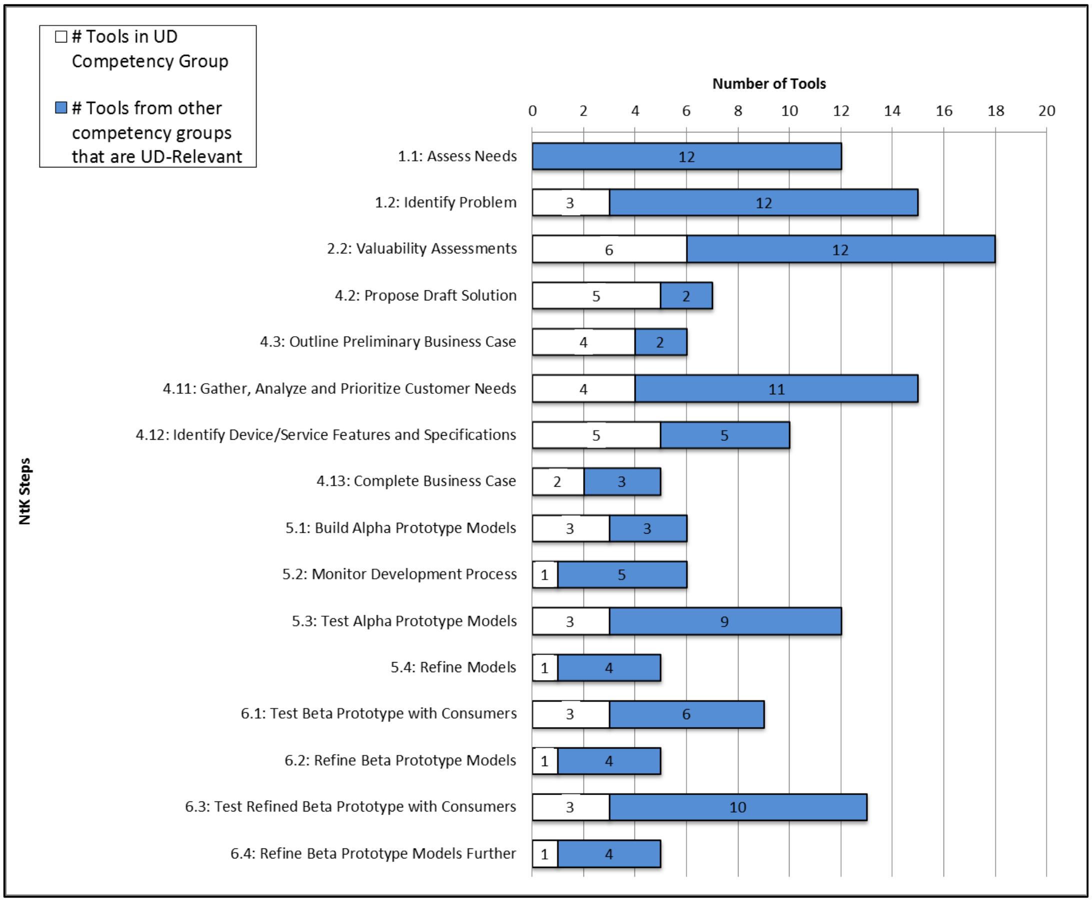

Figure 1. UD-relevant tools sorted by NtK Model steps. This figure depicts NtK steps and associated UD and UD-relevant tools.

plain-text version of the NtK Model by clicking red toolbox icons at the end of each step or stage. Figure 2 shows an example of the type of information that appears on the website. Information in each of the descriptive categories depicted by this figure is available for each of the 79 tools identified.

Home > Knowledge Base > Six Sigma: Toolbox entry

Six Sigma

Type: Process

Description: Six Sigma is a comprehensive business management strategy focused on reducing defects to help lower costs, save time, and improve customer satisfaction. It is typically employed by large companies with more than 500 employees, and may have to be adapted to create value in smaller organizations. It seeks to improve the quality of process outputs by identifying and removing the causes of defects (errors) and minimizing variability in manufacturing and business processes. It uses a set of quality management methods, including statistical methods, and creates a special infrastructure of people within the organization ("Black Belts", "Green Belts", etc.) who are experts in these methods. Each Six Sigma project carried out within an organization follows a defined sequence of steps and has quantified financial targets (cost reduction and/or profit increase). A variety of quality management techniques can be used together to implement a six sigma program, including check sheets, scatter diagrams, cause and effect diagrams, Pareto charts, flowcharts, histograms, and statistical process control to name a few.

Citation: Six Sigma. (2011). Retrieved from Wikipedia, http://en.wikipedia.org/wiki/Six_Sigma. AND Heizer, J. & Render, B. (2011). Operations Management. Pearson Education Inc., Upper Saddle River.

Advantages: Ensures that the process is working at its most efficient. Minimal waste and lower costs. Usually implemented company wide, which makes the process familiar across departments.

Limitations: Can be expensive.

Regulations: ASQ: The Global Voice of Quality

Groups: Management, Marketing, R&D, Engineering, Production, Accounting/Finance, Sales

Steps: 1.5, 2.2, 4.1, 4.7, 4.10, 4.11, 4.12, 4.13, 5.3, 6.3, 7.1, 7.2, 7.3, 7.4, 7.5, 7.6, 7.7, 7.8, 7.9, 7.10, 7.11, 8.2, 9.1

Free Resources

- iSix Sigma: New to Lean Six Sigma
- Lean 6 Society

Purchase Resources

- George, M., Rowlands, D. & Kastle, B. (2004). What is Lean Six Sigma? New York, NY: McGraw-Hill.
- Tuppas - Lean Six Sigma Software with Artificial Intelligence

Figure 2. NtK Model webpage example of the tool *Six Sigma*.

Discussion

This project's output, a synthesis of new product development tools with an emphasis on Universal Design, provides additional operational-level detail to the NtK Model. Grantees that are working on NPD teams can leverage the tool repository to more effectively consider the end user as a priority at every stage of the NPD process. In the short term, the NtK Model's tool repository should improve communication among NPD team members, particularly in cross-sector, open-innovation projects. In the longer-term, the repository's emphasis on UD and UD-relevant tools that can be used to incorporate UD principles into the NPD process should increase awareness of how UD can be applied to NPD projects. This will broaden the market share for products and services that emerge as demographics in national and global markets change.

For government-sponsored programs led by university-based researchers, the NtK Model should help screen projects at the front end, guide planning and management during implementation, and ease monitoring and evaluation overall. At the same time, the tool repository will provide the resources to facilitate all of these activities. The effectiveness of the work that this paper describes is to be trialed and documented in the coming years.

Outcomes and Benefits

Public funding agencies expect greater and more observable socio-economic benefits to result from the projects they fund. Thus, grantees' research and development efforts must yield improved marketplace outcomes and quality-of-life impacts.

The purpose of this paper is twofold. First, the presentation of a set of practical tools that accompanies the step-by-step NtK Model is intended to help grantees deliver viable and useful products to the marketplace. Second, the authors hope to make the concept of Universal Design seem more accessible to NPD practitioners by pointing out commonly used NPD tools that have UD attributes along with some UD-specific tools.

The NtK Model's recommended iterative method of keeping in mind a product's or service's users, including considerations of varying ages and ability levels, is an important human-centered advancement for NPD in general. Furthermore, the integration of UD into the NPD process can improve business viability (Aragall & Montana, 2012). Ultimately, as the accessibility and usability of products in the marketplace improve, end users with functional and environmental limitations will experience an improved quality of life.

Declaration of Interest

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References

Aragall, F., & Montana, J. (2012). *Universal design: The HUMBLES method for user-Centred business.* Burlington, VT: Gower Publishing.

Belliveau, P., Griffin, A., & Somermeyer, S. (Eds.). (2002). *The PDMA toolbook 1 for new product development*. New York: John Wiley & Sons, Inc.

Belliveau, P., Griffin, A., & Somermeyer, S. (Eds.). (2004). *The PDMA toolbook 2 for new product development*. New York: John Wiley & Sons, Inc.

Campbell, D., & Stanley, J. (1963). *Experimental and quasi-experimental designs for research*. Chicago: Rand-McNally.

Center for Universal Design. (1997). *The principles of universal design*. Retrieved from http://www.ncsu.edu/ ncsu/design/cud/about_ud/udprinciplestext.htm

Crews, D. E., & Zavotka, S. (2006). Aging, disability, and frailty: Implications for universal design. *Journal of Physiological Anthropology, 25*(1), 113-118.

Flagg, J. (2011). Expanding product accessibility with primary market research techniques. *Assistive Technology Research Series: Everyday Technology for Independence and Care, 29*, 971-978.

Flagg, J., Lane, J., & Lockett, M. (2013). Need to Knowledge (NtK) Model: An evidence-based framework for generating technological innovations with socio-economic impacts. *Implementation Science, 8*(1), 21.

Flagg, J. L., & Lockett, M. (2010). The Need to Knowledge model: A roadmap to successful outputs for NIDRR grantees. *FOCUS: Technical Brief 28*. Retrieved from http://www.ktdrr.org/ ktlibrary/articles_pubs/ncddrwork/focus /focus28/Focus28.pdf

Graham, I. D., Logan, J., Harrison, M. B., Straus, S. E., Tetroe, J., Caswell, W., & Robinson, N. (2006). Lost in knowledge translation: Time for a map? *The Journal of Continuing Education in The Health Professions, 26*(2), 13–24.

Griffin, A., & Somermeyer, S. (Eds.). (2007). *The PDMA toolbook 3 for new product development*. New York: John Wiley & Sons, Inc.

Howells, J., Ramlogan, R., & Cheng, S. L. (2012). Universities in an open innovation system: a UK perspective. International *Journal of Entrepreneurial Behavior and Research, 18*(4), 440-456.

International Standards Organization / International Electrotechnical Commission (2014) *Guide for addressing accessibility in standards*, ISO/IEC Guide 71:2014E. Retrieved from: http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=57385

Kahn, K. B., Castellion, G., & Griffin, A., (Eds.). (2005). *The PDMA handbook of new product development* (2nd ed.). Hoboken: John Wiley & Sons, Inc.

Kamensky, J. M. (2011). *GPRA Modernization Act of 2010 Explained: Part 1*. Retrieved from http://www.businessofgovernment.org/blog/business-government/gpra-modernization-act-2010-explained-part-1

Karwowski, W., Soares, M. & Stanton, N. (2011). Human factors and ergonomics inconsumer product design: Methods and techniques. Boca Raton, Florida: CRC Press.

Lane, J. P. (2012). Tracking evidence of knowledge use through knowledge translation, technology transfer, and commercial transaction. *FOCUS Technical Brief 34*. Retrieved from http://www.ktdrr.org/ktlibrary/articles_pubs/ncddrwork/focus/focus34/Focus34.pdf

Leahy, J. (2013). Targeted consumer involvement: An integral part of successful new product development. *Research Technology Management, 56*(4), 52-58.

Lenker, J. A., Nasarwanji, M., Paquet, V., & Feathers, D. (2011). A tool for rapid assessment of product usability and universal design. *Work: Development and preliminary psychometric testing. 39*(2), 141-150.

National Disability Authority (2012). The application of the ICF and related resources to improve universal design guidance standards. Retrieved from: http://universaldesign.ie/Products-Services/Universal-Design-Guidance-and-the-ICF/

Rigby, D.K. (2011). *Management tools 2011: An executive's guide*. Boston: Bain & Company, Inc.

Steinfeld, E., & Maisel, J. (2012). *Universal design: Creating inclusive environments*. Hoboken: John Wiley and Sons.

Stone, V. I., & Lane, J. P. (2012). Modeling technology innovation: How science, engineering, and industry methods can combine to generate beneficial socioeconomic impacts. Implementation Science 7(1), 44. Retrieved from http://www.implementationscience.com/content/7/1/44/abstract

U.N. General Assembly, 7th Session. (2006). Report of the Ad Hoc Committee on a Comprehensive and Integral International Convention on the Protection and Promotion of the Rights and Dignity of Persons with Disabilities. Retrieved http://www.un.org/esa/socdev/enable/rights/ahc7docs/ahc7report-e.pdf

U.N. Department of Economic and Social Affairs, Population Division. World Population Ageing: 1950-2050, (2001). Retrieved from http://www.un.org/esa/population/publications/worldageing19502050/

Standards for Assistive Technology Funding: What are the Right Criteria?

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Abstract

Assistive technology developers, manufacturers, and service providers face new third-party payor requirements to demonstrate supporting evidence about the effectiveness of Assistive Technology (AT). The level of evidence being required is comparable to standards of evidence used to support interventions in the medical arena, known as evidence-based medicine. The gold standard for this level of evidence is generally produced through conducting randomized controlled trials (RCTs). However, the RCT is rarely practical or appropriate for showing the true effectiveness of assistive rehabilitation technologies for persons with disabilities. Therefore, alternative options for evidence of AT effectiveness must be identified and accepted.

In this paper, we address the expectation of an evidence-based standard to determine AT product efficacy, and the impact of this standard on the transfer, use, and payment for assistive technologies designed for persons with disabilities. Discussed are alternative options for evidence of AT effectiveness, recommendations on how to develop a useful and workable outcomes-reporting system to further demonstrate evidence of AT efficacy for AT funding, and pending and proposed federal legislative changes. Unless addressed, the lack of documented AT outcomes may limit future innovation as well as limit access to existing rehabilitation and assistive technologies for those who need it most.

Keywords: Assistive Technology; third party-reimbursement, level of evidence, product registries, evidence-based medicine, evidence-based funding, CMS coding trends, big data, complex rehab technology legislation

Introduction/Background

Assistive technology developers, manufacturers, and service providers face new third-party payor requirements to demonstrate supporting evidence about the effectiveness of Assistive Technology (AT). The level of evidence being required is comparable to standards of evidence used to support interventions in the medical arena, known as evidence-based medicine.

The gold standard for this level of evidence is generally produced through conducting randomized controlled trials (RCTs), although other study designs can provide acceptable evidence depending on the clinical situation. Unfortunately, the RCT, or gold-standard level of evidence, is rarely practical or appropriate for showing the true effectiveness of assistive rehabilitation technologies for persons with disabilities. This is because target populations for most AT devices are small and often widely scattered, making it difficult to find homogeneous groups to participate in studies. Perhaps, more importantly, RCTs require control groups who are denied an intervention, creating a potentially unethical situation. Can a researcher justify providing a power wheelchair to one quadriplegic and deny it to another for purposes of a controlled trial? Nonetheless, as a prerequisite for use by persons with disabilities as well as acquisition through third-party payers, evidence of effectiveness is needed to justify funding reimbursement for new and existing Assistive Technology (AT) products. The negative impacts of misapplying these rigorous standards to determine efficiency of AT products have been felt over the past several years, resulting in reduced access to AT by people with disabilities. Alternative options for evidence of AT effectiveness must be identified and accepted. Evidence currently consists of peer-reviewed journal articles and case studies that document the efficacy outcomes of AT devices. This level of evidence certainly supports the medical benefits of and need for AT, given the variability and small populations typically served by assistive technology products, as well as the small business financing that dominates assistive technology developers. However, to further demonstrate evidence of AT efficacy, innovative study designs or widely representative AT product registries could be considered for the future. Both persons with disabilities and practitioners want to know what assistive technology devices work best in a given situation. Unless addressed, the lack of documented outcomes may limit future innovation as well as limit access to existing rehabilitation and assistive technologies for those who need it most.

While RCTs remain the focus and preference of most evidence-based medicine decision-making bodies, newer applications of methodologies such as the use of registries or N =1 crossover trials are surfacing in the literature as alternative research strategies. This corroborates that innovative research methodologies are possible and that they show promise for providing needed justification for future health-related funding decision-making by third-party payors.

Again, while journal articles and case studies on the efficacy of AT exist, the need for more rigorous evidence of AT outcomes remains. The lack of evidence of effectiveness continues to apply to most assistive rehabilitation devices, and policy and research bodies continue to perceive the evidence in the field with apprehension. Third party reimbursement in the wheelchair industry, for example, serves as a representation of the problem. For many people with mobility limitations, a wheelchair is the primary means of mobility.

Individualized wheeled mobility systems, those that are designed and manufactured to meet the specific needs of an individual, are expensive. Approximately 70% of people with long-term disabilities who need these systems are unemployed, and many do not have the discretionary income necessary to afford these systems (Wheelchair Industry Profile). Thus, many people who depend on wheelchairs for daily mobility in order to function do not pay for their own systems. Wheelchair purchasers rely on a third-party payment system that funds wheelchairs for many people who require, but cannot afford, them. This third party payment system is now demanding demonstrated evidence of effectiveness to justify funding reimbursement for new individualized wheeled mobility system purchases.

Understanding the third-party payment system and the impact of government policy on the reimbursement of wheeled mobility devices is critical to understanding the industry. Providing individualized wheeled mobility systems to people who require them in a third-party payment system can be very difficult as customers' seating and mobility needs must be met in a way that ensures effective mobility, maximizes function and comfort, and maintains or improves users' health. Manufacturers and suppliers work to meet the needs of the customer who uses the system, the medical professionals who prescribe them, and third-party payers who establish the coverage and payment policies for these devices. For a vast majority of persons with long-term mobility limitations, a government-sponsored program provides these benefits. The three major government programs that routinely fund durable medical equipment (DME) and of which wheelchairs are a part are:

- *Medicare Part B* – This federal medical insurance program provides coverage for persons older than 65, for persons under 65 years old who have contributed to Social Security and have been unable to work for at least two years due to injury or illness, and for persons with chronic kidney failure.
- *Medicaid* – This state-administered medical insurance program provides coverage for people or families who are judged indigent based on household income. Eligibility requirements vary by state. However, non-income-related variables also factor in the decision to provide Medicaid to an individual. These variables include whether an individual is pregnant, disabled, blind, or aged, for example.
- *Veterans Administration* (VA) – This federal medical insurance funds DME for veterans.

Private medical insurance is also a significant source of payment for wheelchairs. Many employers offer private insurance in the form of managed care plans as a benefit to their employees to cover the cost of medical care. Many people who are self-employed, or who do not receive employer-provided plans, purchase private insurance out-of-pocket. These policies may or may not include a DME coverage option. Private payment, though infrequently exercised, is always an option for people with mobility impairments who have sufficient discretionary income to pay for wheeled mobility systems.

In this paper, we address the expectation of an evidence-based standard to determine AT product efficacy, and the impact of this standard on the transfer, use, and payment for assistive technologies designed for persons with disabilities. The National Institute on Disability and Rehabilitation Research (NIDRR) funded the Center on Knowledge Translation for Disability and Rehabilitation Research (KTDRR) in 2012. The KTDRR in turn created a diverse working group whose purpose was to delineate current reimbursement issues and provide suggestions for methodological standards of evidence for assistive technology reimbursement. Each member of the working group represents a respective stakeholder group: AT Consumers, AT Service Providers, AT Researchers and Methodologists, AT Manufacturers/Product Developers, and AT Payors and Policy Makers. These key stakeholder groups comprise the entire system of manufacture, prescription, application, funding, reimbursement, and efficacy research within each field of AT devices and services.

During working-group conversations, members discussed the current Medicare Coverage of Wheeled Mobility and Seating devices, Competitive Acquisition Policy (competitive bidding) and its impact, the impact of Medicare Policy on consumers and industry, and the expected future of Medicaid coverage. In addition, the working group investigated current reimbursement regulations for assistive technology devices, explored and interpreted recent changes to health care reimbursement policy, and documented anticipated changes in health care reimbursement with the implementation of the Health Care and Education Reconciliation Act of 2010. Lastly, the working group was tasked by the KTDRR with making recommendations on how to develop a useful and workable outcomes-reporting system for Assistive Technology funding. This paper summarizes the results of this effort.

Five Target Populations

This section describes the need for a comprehensive AT outcomes system from the perspective of the five target populations: AT Consumers, AT Clinicians/ Practitioners/ Suppliers, AT Researchers and Methodologists, AT Manufacturers and Product Developers, and AT Payors and Policy Makers.

AT Consumers

An individual with a disability has unique personal characteristics, unique environments, and specific activities to which they apply technology devices and require AT services. People with disabilities (PWD) of all ages, their families, and their caregivers increasingly need personal empowerment to assist in decision-making, purchasing, and acquisition as they relate to assistive technology devices (ATDs) and services (ATSs). It has been documented that as much as 40% of AT, primarily lower-cost technology, is purchased by the user themselves (DeRuyter, 1995; DeRuyter, 1997). As medical practice heads toward a more person-centered model, individuals will be more involved in their own healthcare decision-making, including using the evidence of effectiveness when selecting AT devices for their own use. Data are needed to assist them with their product decisions.

AT Service Providers (Clinician/Practitioner/Supplier)

Currently, objective data to assist with AT product recommendations are sparse and scattered. When studies are published, they are often group studies with normative inferential statistics whose population context may not fit the specialized needs of a client or be too general to be informative. Clinicians are often left to rely solely on their personal expertise and judgment, which may not align with the outcome efficacy needed for funding provisions. Along with AT consumers, AT service providers (clinicians/practitioners/ suppliers) who want the best outcomes for their clients may be in the best position to gather needed outcome-based data. (Albeit, because practitioners can easily inject bias, reliable and valid data-collection methods must be applied.) Today, objective measures are not systematically available for use. The field needs adequate mechanisms to document AT outcomes for later review or sharing. However, AT service providers need reliable, systematic, and objective methods by which to quickly document AT-related performance outcomes and make AT outcome inquiries. Service providers' lack of standardized terminology for coding AT interventions and outcomes contributes to the problem. When combined with barriers in communication due to service-specific terminology, this further complicates consistent and compatible documentation. Ultimately, lack of consistent documentation results in abandonment, inappropriate provision of AT devices, and inefficient use of resources (D. Carlson, et al. 2002; J.W. Jutai, et al 2005; R. Smith, 1998; R. O. Smith, 1996; R. Johnson, 2006). It is imperative that AT Service Providers be a part in designing the solution to address their needs.

AT Researchers and Methodologists

It is the mandate and essential work of AT researchers to provide meaningful assistive technology outcomes (ATO) tools and databases for use by all of the aforementioned stakeholders. Three general types of research need to be done:

1. *Safety and Effectiveness for Product Development* - to describe the problem a product is designed to address and how safely and effectively it addresses the problem. New products need this early evidence.

2. *Outcome Measurements for Evidenced-Based Practice* - for users and clinicians to have objective guidance in determining which interventions are likely to be successful over time and how they should be used to maximize effectiveness for an individual. For example, power tilt/recline wheelchair seating systems are prescribed to maintain skin integrity. In those tilt/recline systems, users and clinicians must know at which angle of tilt/recline users can produce pressure relief, how often users should perform pressure-relief tilts, and for what duration users should maintain pressure-relief tilts to achieve the desired result of the lowest incidence of skin breakdown.

3. *Device Design and Targeted Population Use* - this research is necessary because not all assistive technology works for everyone the same way. While general outcomes knowledge is needed for broad policy decisions, the science of successfully applying assistive technology devices depends on a multitude of variables, many of which might be unique to the individual. Understanding the specific interactions of technology, person, activity, and environmental variables is necessary to match the appropriate technology to the person and situation.

The need for comprehensible usable ATO data remains essentially unmet despite strong efforts by researchers over several decades. This can be explained by several factors impacting research: high variation of needs specific to the specialized nature of AT devices and services that challenge study design; need for a mechanism to establish functional equivalence or research methodology to mitigate the need for multiple studies based on diagnosis, age, gender or other criterion; funding for AT research that aligns with the needs of policy makers and payors as well as clinical decision makers, and perhaps most critical, the need to examine the "best-evidence" hierarchy that currently guides evidence-based medicine research efforts and subsequent interpretation. It is widely accepted among policy makers that RCTs are the gold standard for evidence in certain areas of healthcare. Population size and variables, even among study populations whose members have the same diagnosis, that may influence outcomes, makes RCTs with large numbers of participants impractical, unreasonable, cost prohibitive, and most importantly, may not offer the necessary information to answer the questions policy makers and clinicians making technology recommendations need to have answered. Reasons for this are both theoretical and practical.

Consider the recent publication of a meta-analysis on AFOs (ankle-foot orthoses) for post stroke individuals, Archives of Physical Medicine and Rehabilitation (Scherer & Glueckauf, 2005). The full text of 43 articles was reviewed and 13 trials involving 334 patients that met the inclusion criteria were included. A significant challenge in analyzing these studies occurred secondary to the varieties of AFOs. Thus, the meta-analysis needed to select one type of basic AFO for its target. The overall findings said that it appears that this particular selected standard AFO is beneficial, at least in the short term. The authors go on to say:

> However, although clinically relevant, it is at an insufficient level to fully inform clinical practice, and many crucial questions remain unanswered. Clinicians need to know the best type of AFO to prescribe, for whom they should be prescribed, the optimal time to prescribe one, how long they should be used, the adverse effects, and the factors influencing acceptability and adherence to their use. It is particularly important that these factors are investigated in the long term, because most patients are prescribed an AFO for long-term use. These are complex questions, the answers to which probably differ according to the patients' level of, and combination of, impairments (pg. 1384).

Efficiency of research is an issue. The expense and time supporting the necessary studies and meta-analyses would be substantial. Even when traditional RCTs and meta-analyses are used in the field of AT, products are so sharply individualized that group inferential type methodologies often result in studies with relatively little value. This meta-analysis about AFOs provides little information to help practitioners make better decisions about what AFOs to use in practice. Nor does it, in the long run, help other stakeholders make appropriate decisions of major impact. That said, however, studies such as this, based on investments of hundreds of thousands of dollars, could eventually result in third-party funding agency's willingness to pay for standard AFOs for the specific population. Unfortunately, the number of similarly funded and published investigations can only meet a small fraction of the evidence needs of service providers. Furthermore, the types of evidence secured by classical investigations have lengthy timelines when AT devices are emerging and requiring rapid decisions in very short time frames. For example, in a relatively few short months the entire Augmentative and Alternative Communication (AAC) field needed to make decisions about how to adopt iPads and other mobile device technologies and infuse them into AAC decision-making and interventions. Parents were bringing iPads to the clinics with newly installed and untested AAC apps asking AAC professionals to consider implementing their use for their children. Due to the rapid development of these interventions no evidence was available to help service providers make appropriate decisions. The only recourse for service providers in this circumstance was to use best judgment and apply sensible assessments and evaluations in their immediate intervention planning. To assist researchers, the field needs to consider rapid report research strategies, review and annotate accepted evidence hierarchies as to how they relate to assistive technologies, prompt and provide advice around the spectrum of potentially appropriate methodologies, and begin considering widespread implementation of ongoing assistive technology outcomes systems.

AT Manufacturers/Product Developers

Manufacturers and AT product developers have their own unique needs for AT outcome data (Brown-Triolo, 2002). Manufacturers need guidance from the Coverage and Payment community with regard to a mechanism by which they can establish effectiveness. There needs to be transparency in the criteria used to determine coverage, based on both an agreed upon standard for demonstrating effectiveness as well as pricing and payment methodology. Exacerbating the challenge for manufacturers to acquire and cite outcomes data is the fact that the AT field is extremely small with minimal R&D, testing, financing, or research infrastructure. AT manufacturers need efficient methods for collecting and managing device testing data, and obtaining outcomes data. Many research methods require substantial infrastructure. This disenfranchises the AT industry in its ability to compete, not against other companies, but in its survival within a policy structure that requires documented evidence of health-related outcomes while doing little to work with manufacturers and providers to define the nature of the evidence required for individualized products.

AT Payors and Policy Makers

These stakeholders rely on the best available evidence that researchers provide. Many indications show that evidenced-based practice (EBP) is leading towards evidence-based funding (EBF). As the quality and quantity of the evidence is so limited, resulting decisions by AT payors can be disastrous. Stories are increasingly emerging in which funding agencies have limited or substantially delayed paying for AT devices and services due to the lack of acceptable documented successful outcomes even when what is considered an acceptable outcome has not been defined or disclosed. A recent example is Wisconsin Medicaid virtually shutting down reimbursement for AAC devices due to a lack of evidence of effectiveness. In this case, the minimal evidence available suggested that AT devices were predominantly abandoned. That served as rationale to cease provision. Obviously a critical need exists to provide reputable AT outcome data to these parties. Processes that require appealing to third party payors a large percentage of devices to obtain authorization for payment becomes not only inefficient but also impossible to continue in the long term. A faster mechanism must be available for funding authorization for specific and unique situations. In common with other stakeholders, funding agencies seek evidence of positive outcomes. The problem is that while successful individual patient outcomes occur, documentation of them is unavailable. An effort must be undertaken to systematically record these outcomes. Otherwise, researchers, funders, and the AT industry have virtually no way to summarize the evidence.

Current Use of Evidence-Based Medicine

Evidence-Based Practice (EBP)

From 1993 to 2000, the Journal of the American Medical Association published a series of 25 articles on evidence-based medicine that launched a paradigm shift (National Institutes of Health, 2013). Evidence-based medicine (EBM) developed into evidence-based practice (EBP) and launched similar concepts in education including the U.S. Department of Education special education programs promoting “What Works” (Computer & Information Sciences & Engineering, 2013). Interestingly, the methodology of EBP has evolved to recognize an important concept related to disability and AT. The fourth issue of the 25-issue series presented a hierarchy of the level of evidence methodologies. Group data with inferential statistical outcomes were considered the state of the science, with RCT placed atop of the hierarchy. Twenty-one issues later in the last issue of the series (The White House, 2013), the hierarchy was revised with a significant caveat. The authors of the evidence-based medicine JAMA series placed N=1 RCT at the top of the hierarchy, thereby acknowledging an extraordinary point. The authors explain and, place in context, that individuals have differences and are sometimes not represented in groups, group data or group designs. This, in no way undermines the importance of the group RCT gold standard. But it clearly highlights the challenge in AT outcomes documentation due to the extraordinary variability of people with disability.

However, double-blinded RCT studies using N=1 design are virtually impossible in rehabilitation and AT because individuals obviously know what the intervention is, and it can be difficult to blind the researchers to the ATD as well.

Designs using N=1, that do not require double-blinding may be an ideal method for providing experimental evidence in the AT field. As mentioned above, N=1 trials, as indicators that the intervention works for the individual, may also provide the most important clinical evidence. While N=1 is not appropriate for pharmacologic medical models (World Health Organization, 2001; Chang, et al. 2013), no methodology is better suited to a unique individual using a unique AT. Recently, protocols for conducting robust Single Case Experimental Designs (SCED) have emerged (Smith, 2006; Smith, 2005). Further, meta-analysis techniques for SCEDs are emerging that could allow large collections of SCEDs to gain standing as legitimate evidence for AT outcomes.

Evidence-Based Funding (EBF)

Third-party funding agencies have quickly embraced the concept of evidence-based practice (EBP) and operationalized decision-making around evidence-based funding (EBF). However, cases are proliferating throughout the nation depicting situations where funding streams are being virtually shut off due to the lack of the most robust level of evidence to support the success of using any given AT intervention. Interestingly, EBF has had an impact not only on the funding of devices for people with disabilities at the final stages of the provision of effective technology. It also has affected the policy side of funding that authorizes certification, billing codes, or approval protocols. This negatively impacts the entrepreneurial R&D cycle of the AT industry. On the delivery side, service providers and consumers are directly affected through the reduced access to innovative AT products built to address the needs of the target population and manufacturers. R&D operations are affected on the product development side. As nationwide constraints in funding increase the need for accountability and documentation of outcomes related to AT device provision and services, all of us need to be cognizant of how the demand for the most robust standards of evidence extensively affects all stakeholders in the field.

Case Example

Coding Trends

To illustrate difficulties that manufacturers, clinicians and consumers are experiencing, consider the following example of a current Centers for Medicare and Medicaid Services (CMS) coding trend that highlights the difficulty in obtaining a new Healthcare Common Procedure Coding System (HCPCS) code for a new AT product. A negative impact of this trend is that many products cannot be reimbursed at the proper level, and without proper coding and reimbursement, the product is not available to the broad market that relies on third-party payment. The example of this is the Natural Fit Rims case study. This product is an ergonomically designed handrim for a wheelchair. It is designed to offer a conservative (non-surgical) treatment for the wrist pain experienced by wheelchair users who have Carpal Tunnel Syndrome (CTS) due to injuries incurred through their use of the traditional, round shaped push rim over many years. In 2005, CMS denied establishing a new code for this technology and stated, "Testimonials and summaries of articles provided by the applicant do not demonstrate a significant therapeutic distinction between the category of items described by E2205 and the item in the coding request." The company, Three Rivers, was advised to use existing code *E2205 - Handrim any type without projections*, *replacement only*. From 1993 until December 2004, there were three HCPCS codes to address different handrim technology; *K0059- Plastic coated*, *K0060- Steel*, and *K0061- Aluminum*. The aluminum handrims were the only ones that were not separately billable with the wheelchair. In 2005, CMS cross-walked these three codes to E2205, creating a code that essentially grouped all handrims without projections in the same code and eliminated the opportunity to bill any additional amount for these handrims.

In 2007, following the completion of a clinical trial (requested by CMS in 2005 and reported in a peer-reviewed journal) documenting the effectiveness of the handrim in obviating CTS symptoms, the company applied for a fourth time to obtain a unique HCPCS code for the Natural Fit Rims. The CMS workgroup decision again was that the E2205 code was adequate for this technology and stated in their preliminary decision, "Clinical information provided by the applicant does not include evidence that would support a claim of superior clinical outcome when using this device, as compared with other devices categorized at E2205." However, this time CMS took an additional step; it revised the definition of code E2205 to *Handrim without projections, any type, (including ergonomic or contoured, e.g. Natural Fit) replacement only* (Dieruf & Boninger, 2008).

Merging of multiple codes into single codes and adding "any type" to code definitions creates an access barrier to important technologies, and it reduces access to unique products. This is especially true when these types of coding changes eliminate all opportunity to bill for an item.

It is important to understand the critical need to separately codify disparate technology that serves different clinical needs. This is necessary to facilitate development of appropriate coverage and payment policies. In addition, without a mechanism within the HCPCS code set for identifying and distinguishing technological differences that are designed to serve different clinical needs, it becomes extremely difficult to support comparative effectiveness research. It is unreasonable to expect studies to be conducted to compare every product within a code. Without clear delineation and definitions of products, it is impossible to design studies that provide the evidence needed by medical professionals or policy makers to make informed decisions.

Recommendations of the KTDRR Working Group

NIDRR Funded RERC on Assistive Technology Outcomes

Currently, with NIDRR moving from the US Department of Education to the Department of Health and Human Services (HHS), NIDRR has an opportunity to provide guidance to the AT community on the standards of AT device efficacy needed for AT reimbursement. This effort would provide HHS with the data it needs on which to base its ongoing and future coverage and policy decisions. HHS is now the overarching agency that has oversight over both CMS and NIDRR. With this agency restructuring, our group recommends that NIDRR fund a Rehabilitation Engineering Research Center (RERC) on Assistive Technology Outcomes to address this void.

Through our discussions on data analysis of current trends and future projections, we agreed that the restructuring offers a new opportunity for intra-agency dialogue. Such dialogue would result in a research agenda and framework through which HHS coverage and payment policies are based on NIDRR driven research and outcome measurements.

One tool/methodology that the working group believes is a viable option within the field of Assistive Technology is the development of a database of assistive technology usage and outcomes. This database would impose a standardized and systematic collection of before and after information inputted by clinicians and researchers. Once the outcomes of assistive technology can be aggregated, there will be a greater likelihood of research acceptance/funding. Regarding the format of this database, we suggest using a minimal data set for the data collection. A 10-question format would suffice, for example. While the minimal data set would be required, there would also be places for individuals to expand on their information. In addition, we strongly feel that the process should include both pre and post assessments. The post assessment should be recorded at least 30 days after the equipment is given. This would allow enough time for the consumer to use and understand the benefits and drawbacks of the equipment. To ensure these assessments occur, outcome data should be part of the process, as it is in the state of Ohio. There, the Special Education Department offered to fund assistive technology devices for students but only if pre and post assessments were part of the process.

Managing Repeated Measures Data

An additional consideration for use of the ATO database is data collection for research purposes. When users select this option they will be required to register their intent to conduct a research study whether it be pre/post, single case experimental design (SCED) - also known as single-subject design in this field, repeated measures, or RCT. These applications will require additional data fields to properly describe the data (e.g., phase reporting) and this required flexibility will be explored during development.

Security & Privacy

The author of said database must, at minimum, comply with the HIPAA requirements for covered information. Though ideally, this author should seek to provide even higher levels of security and privacy. All communication with the cloud servers should be performed using HTTPS so that it will be encrypted in transit. In addition, data will be encrypted at rest (e.g., server drives and backups). Privacy controls will be designed into the database layer, such as storing personally identifying information (e.g. name, SSN, address) in separate tables or even a different database. All data access will be logged to create an audit trail, allowing effected users to be contacted in case of a security breach.

However, there are some issues surrounding the use of the database. First, in addition to CMS, other third-party payors must buy in. It will be necessary to work with third-party payors to ensure that the correct data is being collected and that it will be sufficient evidence so that reimbursement will be possible. A second possible challenge will be for service providers and consumers to input the information into the database. However, we feel that through altruism and interest in contribution to the field this will not be an issue for the service providers. Perhaps most importantly, the information that will result from the data collection will streamline the therapists' job, thereby providing enough payback to justify a therapist taking the time to input the data. For consumers, we feel that for a short information request they will not need an incentive because of the benefits to the field.

For more detailed information, a small monetary incentive may be required. In addition, it is important that the details of the information are properly recorded to ensure similar conditions when aggregating the data.

Big Data

AT devices and services, as previously discussed, have numerous variables that affect their outcome. This wide spectrum of variables makes AT outcomes so difficult to quantify. From a scientific standpoint, covariates are enticing to work with when data are collected on the variables and large data sets are available. Given the uniqueness of people with disabilities and the AT systems they use, sufficient aggregate data sets are not only elusive but often completely impractical given today's data collection methodologies and research financing. However, as previously presented, the data-collection methodologies have dramatically shifted on a paradigm level, creating the potential of aggregate data sets that are large and can compile data from individuals who are geographically disparate and seemingly unique. Sophisticated databases can identify like individuals and users of AT systems with a sufficiently sophisticated data collection methodology. This concept of big databases is not entirely new. NIH and NSF have indicated their interest in the usefulness of big databases through the launch of extensive research initiatives (Lenker, et al. 2012; Smith, et al. 2005). This is in part due to the increased capacity of researchers to evaluate complex, multi-factorial, high quality data sets to examine relationships. Statisticians and methodologists have developed new quantitative-analysis systems and data-mining methodologies, and are in the process of continuing to improve these analyses. The supercomputing era and the need for complex variable decisions and reporting (such as weather-related catastrophes) have helped move this science forward. The White House has identified the importance of big data for understanding and discovering important phenomena that affect people throughout the nation (Bauer, et al. 2011). The importance of big data for understanding AT outcomes is that the complexity of variables for individuals creates small data sets for the many thousands of AT interventions. Consequently, researchers tackling an AT intervention must accumulate research groups of participants that may only consist of five, 10, 30, or 50 widely scattered individuals. This makes it not only unlikely but almost impossible for many research questions to be answered considering feasible funding levels. The concept of big data collected by individuals throughout the nation and the world using 24/7 mobile data collection devices enables a new AT outcomes methodology that has never been possible before.

While the immediate advantages are apparent for researchers and scientists, this also becomes a boon for service providers and consumers who may wish to evaluate similar situations to learn what types of interventions have been used and how successful they have been. While numerous websites and apps have recently emerged, including federally supported programs such as AbleData that solicit consumer feedback on ATDs, these systems have only been used minimally. (AbleData notes are available on less than half of 1% of products with usually only one entry.) And these systems provide minimal data regarding user context or elicitation of common coding variables for comparison. The environment is ready for a more accessible and complete approach toward data collection.

Emersion of Community Participation as an Outcome Measure

The International Classification of Functioning, Disability and Health (ICF) (ISO, 2011) provides an important framework for characterizing functional limitations and intervention outcomes. The model is comprised of three non-hierarchical levels, which are influenced by mediating factors. The levels of the model are 1) body functions and structures, which considers impairments in anatomical structures and functions; 2) activities, which considers execution of a particular task in an idealized context; and 3) participation, which considers engagement in real-life situations. Each level can be influenced by contextual factors (personal and environmental) specific to the individual. Numerous measures are emerging that use community participation as an outcome measure for AT use (AbleData, 2004). The ICF classification allows for coding that can be applied to many different assessments and measures, and can be seen as a lingua franca for disability researchers who wish to compare data.

These elements of change have created an environment of possibility that can allow the field to revolutionize the way it collects, aggregates, and reports AT outcome data. While the ICF provides a new framework that goes a long way to embrace the need for a Medical-Social Model to describe and ultimately measure the effectiveness of goods and services designed to meet the needs of persons with a disability, current third-party payor policies are restricted to meeting the needs a of person 'in the home' and only covered if 'medically necessary' – without description of 'functional need.'

Legislation

As a potential solution, we feel that federal legislation can be one of the vehicles to accomplishing this goal of providing public policy that supports the framework of the ICF – supporting health, function, and community participation. This legislation would include the creation of the database as explained above. In addition, we would look for our elected representatives to change CMS policy. For example, this process could begin with an entity such as the RESNA Government Affairs Committee (GAC) performing a comprehensive study of HCPCS coding. The HCPCS codes should be well-defined and written to distinguish products that have unique features, while grouping homogenous products within the same code. We are aware that there are large numbers of requests for different HCPCS codes and that evidence is needed before a new HCPCS code can be considered. However, if the GAC more efficiently groups products, the number of such requests may decrease. From this study, legislation could be created, or direction from Congress could be given, to mandate the use of new more appropriate, separate HCPCS codes.

Example of Recommendations for a Specific AT Technology Sector – Complex Rehab Tech

Legislation has been introduced in Congress related to Complex Rehab Technology (CRT). CRT products and associated services include medically necessary, individually configured devices that require evaluation, configuration, fitting, adjustment, or programming. These products are subject to the same issues seen with other AT devices. For purposes of this document, CRT refers to individually configured manual wheelchair systems, power wheelchair systems, seating and positioning systems, and other adaptive equipment such as standing devices and gait trainers. Individuals with disabilities and medical conditions face significant challenges that threaten their access to CRT products and the supporting services. Those challenges include coding, coverage, and payment problems. Such challenges have increased over the past several years and, without meaningful change to these policies, will only become greater in the future.

A primary factor responsible for these challenges is that this group of individually configurable products has no distinct category. Instead Medicare classifies it within the broad category of Durable Medical Equipment (DME). To improve and protect access to CRT products and services, targeted changes and improvements are proposed by a broad based group of CRT stakeholders that includes consumers, clinicians, providers, and manufacturers.

These changes have been embodied in Congressional legislation entitled "The Ensuring Access To Quality Complex Rehabilitation Technology Act of 2013" (S-948 and HR-942). The legislation will develop clearer and more consistent coverage policies that appropriately address the unique needs of individuals with complex disabilities, obtain formal recognition of the product-related services and costs involved to allow for appropriate funding, and provide future payment stability to ensure continued access to medically necessary CRT products.

This legislation will also foster an environment that encourages product innovation and technological solutions and produces an improved coverage and payment system that can serve as a model for Medicaid and other payers to follow. Proposed changes are as follows:

Proposed Changes Relating to Products and Coding

- Existing HCPCS codes, as appropriate, will be classified as CRT codes and will only be available through accredited CRT companies.
- New codes will be created where existing codes contain both CRT products and non-CRT products in order to segregate CRT products from other DME.
- New codes will be created for 'uncoded' CRT products that are routinely provided but currently have no assigned code.

Proposed Changes Relating to Coverage and Documentation

- Coverage criteria for CRT will be based on a determination of the beneficiary's functional abilities and limitations, rather than on specific diagnoses or other highly prescriptive and limiting criteria.
- A pathway will be established to require that beneficiaries who seek wheeled mobility devices and who have certain diagnoses and/or clinical presentations receive a CRT Evaluation to ensure they receive the most appropriate equipment.

Proposed Changes Relating to Supplier Quality Standards

- The CRT Company (CRTC) must employ at least one qualified rehab technology professional (RTP) per location, and this individual will be required to show additional evidence (in addition to the Assistive Technology Professional credential) of competency in the provision of seating and mobility. A reasonable transition period will be provided to allow individuals to secure this new qualification.
- The CRTC must have the capability of repairing what they sell and must communicate in writing the availability of repair services to the consumer.

The support of consumers with disabilities, their advocacy groups, physicians, physical therapists, occupational therapists, and others will be critical in communicating to Congress and the CMS the issues and needed resolutions. Only through these combined efforts can the ultimate goal of improving and protecting access to CRT products and services for individuals with significant disabilities and medical conditions be achieved.

Outcomes and Benefits

In conclusion, our AT working group discussed the current situation as well as issues surrounding the reimbursement of assistive technology for each of the five major stakeholder groups. Because of the lack of sufficient research needed for reimbursement, we feel that:

1) An intra-agency HHS conference with agencies who determine coverage and payment policy (CMS) and who can provide research data (NIDRR) is needed to consider and define the hierarchy of evidence required to:

    a) Determine safety and effectiveness,
    b) Determine best clinical practice guidelines,
    c) Establish the appropriateness and practicality of data collection methods for the field to collect evidence.
    d) Potentially utilize and promote a national AT outcome database.

2) Legislative action is needed to define the types of assistive technology that are designed to meet the long-term needs for persons with a disability separate from the policies governing broad Durable Medical Equipment to allow improved recognition and policies. Legislative action is also needed to shift the AT reimbursement model's emphasis from a purely medical model to a model that considers the social and functional context of the AT user, using the ICF.

3) Research funding agencies need to support projects that address the scientific and practical challenges of obtaining and reporting sufficient evidence to make appropriate coverage, coding, and payment policies for a small field that has a historical life-changing impact on people with disabilities.

If the recommendations of our working group are enacted upon, the resultant outcomes will provide for the equitable payment for and reimbursement of Assistive Technology, The benefits resulting from those outcomes will positively affect the health, well being and quality of life for people with disabilities. This paper has provided the necessary background information and suggestions for conceptual models that can be used to implement these proposed changes.

Participation

The KTDRR created a working group comprised of: Don Clayback, Executive Director of the National Coalition for Assistive and Rehab Technology (NCART) (AT Industry Representative); Rita Hostak, Vice President of Government Relations for Sunrise Medical (AT Industry Representative); Jean Minkel, Senior Vice President of Rehab Services for Independence Care System (AT Service Provider); Margaret Piper, Senior Investigator for Kaiser Permanente Center for Health Research (AT Payor Representative); Roger Smith, Professor of Occupational Sciences & Technology and Director of the Rehabilitation Research Design & Disability Center at the University of Wisconsin-Milwaukee (AT Researcher); Todd Vaarwerk, Director of Advocacy and Public Policy at Western New York Independent Living (AT Consumer Representative) and led by Jim Leahy, Co-PI and Technical Assistance Director of the Center on Knowledge Translation for Technology Transfer (KT4TT). Each of these individuals is a representative for their respective stakeholder group, which are the five key groups that are involved in the development, provision, and funding of AT devices and services.

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References

AbleData Website (2004). Retrieved from: http://www.abledata.com/abledata.cfm?CFID=67284000&CFTOKEN=6b638aa003857ed0-950C5460-DD8C-3707-914EFA2FCF1B7FEF

Bauer, S.M., Elsaesser, L.-J., & Arthanat, S. (2011). An assistive technology device classification based upon the world health organization's international classification of functioning, disability and health. disability and rehabilitation. *Assistive Technology, 6*(3), 243-259.

Brown-Triolo DL. Understanding the person behind the technology. In: Scherer, M.J. (Ed.), . *Assistive technology. Matching device and consumer for successful rehabilitation.* Washington, DC: American Psychological Association; 2002. pp. 31–46

Carlson, D, & Berland, B. (2002). Highlights from the NIDRR/RESNA/university of michigan survey of assistive technology and information technology use and need by persons with disabilities in the united states. .

Chang, F., Coster, W.J. & C.A. Helfrich (2013). Community participation measures for people with disabilities: A systematic review of content from an international classification of functioning, disability, and health perspective. *Archives of Physical Medicine and Rehabilitation, 94*, 771-781, 1384.

Computer & Information Sciences & Engineering. (2013). *Big Data Research Initiative.* Retrieved from: http://www.nsf.gov/cise/news/bigdata.jsp

DeRuyter, F. (1995). Evaluating outcomes in assistive technology: Do we understand the commitment? *Assistive Technology, 7*(1), 3-8.

DeRuyter, F. (1997). The importance of outcome measures for assistive technology service delivery systems. *Technology and Disability, 6*(1-2) 89-104.

Dieruf, K., Ewer, L., & Boninger, D. (2008). The natural-fit handrim: factors related to improvement in symptoms and function in wheelchair users. *The Journal of Spinal Cord Medicine, 31*, 578–585.

Johnson, R. (2006). *The impact of assistive technology on goal achievement for consumers of the division of vocational rehabilitation services, in Occupational Therapy*. Milwaukee: University of Wisconsin-Milwaukee.

ISO. ISO9999:2011. (2011). Assistive products for persons with disability -- Classification and terminology. Retrieved from: http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=50982

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.

Lenker, J. A., Shoemaker, L. L., Fuhrer, M. J., Jutai, J. W., Demers, L., Tan, C. H., & DeRuyter, F. (2012). Classification of assistive technology services: Implications for outcomes research. *Technology and Disability*, *24*(1), 59-70.

National Institutes of Health. (2013). *Big data to knowledge.* Retrieved from: http://commonfund.nih.gov/bd2k/.

Scherer, M. & Glueckauf, R. (2005). Assessing the benefits of assistive technologies for activities and participation. *Rehabilitation Psychology, 50*(2), 132-141.

Smith, R. (1998). Accountability in assistive technology interventions-measuring outcomes. *RESNA Resource Guide for Assistive Technology Outcomes: Measurement Tools*, 1, 14-42.

Smith, R.O. (1996). Measuring the outcomes of assistive technology: Challenge and innovation. *Assistive Technology, 8*(2), 294-302.

Smith, R.O. & Rust, K.L. (2005). Matching assistive technology interventions to the ICF. in 11th North American Collaborating Center Conference on ICF2005, June.

Smith, R.O., et al. (2005). ATOMS Project technical report: Models and taxonomies relating to assistive technology. *ATOMS Project Technical Reports 2005*. Retrieved from: http://www.r2d2.uwm.edu/atoms/archive/technicalreports/fieldscans/tr-fs-taxonomiesmodels.html

Smith, R.O., Jansen, C., Seitz, J., & Longenecker Rust, K. (2006). The ICF in the context of assistive technology (AT) interventions and outcomes. *ATOMS Project Technical Report*. Retrieved from: http://www.r2d2.uwm.edu/atoms/archive/icf.html.

Wheelchair Industry Profile. (2012). Retrieved from: http://kt4tt.buffalo.edu/publications/ResourceMaterials/index.php

The White House. (2013). *Big Data is a big deal*. Retrieved from: http://www.whitehouse.gov/blog/2012/03/29/big-data-big-deal.

World Health Organization. (2001). *International classification of functioning, disability and health: ICF2001*. Geneva, Switzerland: World Health Organization.

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Assessing the Roles of National Organizations in Research-based Knowledge Creation, Engagement and Translation: Comparative Results Across Three Assistive Technology Application Areas

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Abstract

Research and development projects funded by scholars and government agencies are increasingly expected to demonstrate evidence of impact resulting from their efforts. Scholars traditionally relied on passive diffusion to spread their study findings out among broader communities. However, scholars are now being held accountable and are required to actively support and track the post-output paths of their research projects. Therefore, they must reach non-traditional stakeholder groups extending beyond their scholarly community. Mapping the value systems of organizations representing diverse stakeholders (i.e. Knowledge Value Mapping) is explored as a means to improve knowledge translation, thereby increasing impact. This paper expounds upon a prior analysis conducted in augmentative and alternative communication to two additional assistive technology application areas: Recreational access and wheeled mobility. The purpose is to determine the extent to which the original findings can be generalized. Results indicate that 1) findings from the initial study are, in fact, generalizable to various assistive technology fields of application; 2) national organizations are an appropriate channel for translating and disseminating new research-based knowledge to diverse stakeholders; 3) national organizations engage with knowledge mechanisms at different levels and in different capacities. These results suggest that researchers should identify organizations representing the stakeholder groups most relevant to their own area of study, and then conduct the Knowledge Value Mapping process with those organizations to identify the best approach to knowledge translation.

Keywords: Knowledge value mapping, Knowledge translation, Assistive technology, Augmentative and alternative communication, Recreational access, Wheeled mobility, Stakeholders

Assessing the Roles of National Organizations in Research-based Knowledge Creation, Engagement and Translation: Comparative Results Across Three Assistive Technology Application Areas

Scholars and government agencies that sponsor research and development (R&D) projects within programs intending to generate social benefits are increasingly expected to demonstrate evidence of the outcomes and impacts resulting from their research-based outputs (i.e., concepts, papers, patents, prototypes). According to the United States Government Performance and Results Act of

1993, it is the responsibility of government programs, including sponsored R&D projects, to ensure that they efficiently and effectively accomplish their intended results.

Assessing these downstream outcomes and impacts within the social and healthcare arenas necessarily considers the *reach* and *utilization* of knowledge-based outputs by various stakeholder groups outside of the traditional academic context (Barwick, 2011; Glasgow, Klesges, Dzewaltowski, Estabrooks & Vogt, 2006; Glasgow, Vogt & Boles, 1999). The movement of knowledge outputs from research and development activities into the hands of non-traditional stakeholder audiences is increasingly recognized as a short-term indicator of long-term impacts (NCDDR, 1996; Ottoson & Hawe, 2009). This is particularly true of projects that extend an empirically based concept into a tangible artifact (e.g., prototype, product or service) that is expected to achieve transfer and uptake outcomes. Such engineering development projects often require an array of legal and professional mechanisms that are more complex than traditional scholarly studies customarily require. This is because transfer and uptake involves multiple external stakeholder groups. The link between project outputs and beneficial impacts for society justifies the investment of public money in specific government sponsored research and development programs. This justification is increasingly important as government programs vie for available funding within contracting national budgets (Stone & Lane, 2011).

Traditionally, scholars relied on passive diffusion mechanisms to gradually spread their study findings out among broader communities. However, the recent expectation that scholars actively support and track the post-output trajectories of their research projects presents new challenges for scholars. They must reach non-traditional stakeholder groups beyond their scholarly community. A key question arises: What is an effective method for communicating research knowledge to stakeholders from diffuse and diverse groups, so that such individuals can be made aware of and ultimately apply research and development outputs? Given that it is not always feasible to communicate research knowledge directly to potential stakeholders on a one-to-one basis; the author's speculate that national organizations representing the targeted stakeholder audiences could be a viable pathway for knowledge translation and dissemination.

A recent study (Lane & Rogers, 2011) explored a strategy of identifying national organizations representing the target stakeholder audiences and assessing the extent to which those national organizations saw value in engaging the research community. That study focused on organizations and stakeholders involved in the field of augmentative and alternative communication (AAC). This subsequent paper extends that prior analysis to two additional assistive technology application areas: Recreational access and wheeled mobility. The purpose is to determine the extent to which the original findings can be generalized.

Knowledge Translation as a Tailoring Strategy and Value Mapping as a Targeting Strategy

Knowledge translation (KT) as a communication strategy is gaining acceptance in health-related fields that seek to move knowledge from laboratory bench to clinical bedside and out to the community. According to the National Institute on Disability and Rehabilitation Research (NIDRR), knowledge translation plays a pivotal role in enhancing the quality of life of individuals with disabilities as evidence-based knowledge. In KT, technologies and services are translated to relevant stakeholders in order to inform policy and improve practice (Tingus, Berland, Myklebust & Sherwood, 2004). When scholars devote the additional effort necessary to describe their research findings in the context of a particular user group, they are emphasizing the finding's relevance to that group. This is a form of tailoring the findings to a target audience. It is best to consider relevance to users prior to initiating the study in any applied field, but it is not too late to do so even after the study is completed and the findings are revealed.

In knowledge translation, scholars are expected to take the additional step of identifying the media most appropriate for reaching specific user audiences, and preparing materials appropriate to those media and audiences. This is called *targeting*. Targeting provides researchers and their sponsors a trail of evidence for tracking knowledge transitions from output to impact, because they know what materials were prepared, where those materials went, so it is possible to track who accessed the materials and what resulted from that access. Such tracking is built into the scholarly citation system but absent for non-traditional audiences.

KT strategies may differ depending on the nature of the research conducted, the outputs generated, and the unique needs of various stakeholder groups. Structured KT approaches − such as the Knowledge to Action (KTA) model − identify milestones deemed necessary to bridge the persistent gap between research (knowledge generated) and practice (actions taken) (Graham, Logan, Harrison, Straus, Tetroe, Caswell, & Robinson, 2006). According to the KTA model, researchers may choose to engage stakeholders once their study findings are generated -- called *end-of-grant KT* -- or involve stakeholders during the conduct of the study itself – called *integrated KT* (CIHR, 2009; Graham, et al.). The authors of this paper have offered a third approach – called *prior-to-grant KT* (Lane & Flagg, 2010). This third option is recommended for technology-oriented research projects where sponsor and investigator intend for the study findings to be applied in the creation of prototype inventions and eventually transformed into products/services in the marketplace. Such transformations require substantial investment and commitment from external stakeholders, so it seems only reasonable to engage them and their interests prior to initiating the precipitating research study. The absence of such proactive engagement may readily explain the limited evidence for uptake and use at present.

KT strategies involve tailoring the message and targeting the audience. The next step is to determine the extent to which the target audiences want to learn about the findings, and what communication channels will be effective in reaching them. Knowledge value mapping (KVM) is an approach used to explore the values stakeholders hold toward research, so that information about new research findings can be tailored to connect with those values and targeted to reach those who hold the values identified (Bozeman & Rogers, 2002). The knowledge value mapping process involves characterizing the values held by a target group (e.g., people who think research findings are useful), determining how they apply those values (e.g., people who strive to improve their professional skills), and tracing the pathways through which they receive new knowledge (e.g., people who read certain magazines). The KVM technique is quite congruent with knowledge translation goals.

Applying Knowledge Translation and Knowledge Value Mapping to Facilitate Communication within Assistive Technology

This paper discusses the application of knowledge value mapping techniques to facilitate knowledge translation in the field of assistive technology (AT). This is an applied field where technology-oriented research and development projects are expected to generate outputs that improve products and practices. These technology-oriented outputs encompass commercial devices and services, freeware applications, instruments and tools, as well as performance standards and clinical protocols (Lane, 2008).

Demonstrating the utility of knowledge translation and knowledge value mapping to this particular field is important because it spans many different academic disciplines and clinical professions, and engages a wide range of otherwise unrelated stakeholder groups. A gap between what is known and what is done persists partly because of these disparities, and the limited resources available to connect them. Mapping the value systems of organizations representing these diverse stakeholders is explored as a means to improve KT results. This exploration of KT and KVM occurred within a broader investigation that examined the effectiveness of three communication strategies on stakeholder use of research finding (Stone, *et al*, 2015; in this issue). The subject matter for that investigation was drawn from three AT areas where the outputs from intensive research and development projects were expected to be put into practice by the stakeholders in these three areas.

Augmentative and alternative communication. The field of augmentative and alternative communication (AAC) serves both individuals who have complex communication needs and their professional intermediaries. Estimates of the number people using AAC varies widely (between 8 to 12 people per 1,000) because the level of impairment ranges from very mild to severe (ASHA, 2008; Beukelman & Ansel, 1995; Matas, Mathy-Laikko, Beukelman, Legresley; 1985; Light, Beukelman & Reichle, 2003). However, those with severe language difficulties rely on speech-generating systems for all of their communication functions, so while some view AAC as a niche market, it is critical to sustaining life and contributing to society for those who use it. Professor Stephen Hawking is the world's foremost example of both.

Recreational access. Although still considered an AT area, recreational access targets both dedicated (e.g., auditory baseballs) and mainstream (e.g., swimming pool lifts) devices and services enabling persons with or without disabilities to engage in fitness and sporting activities. Settings for recreation include the home, school, health club or a town park. The challenge for recreational facilities is to accommodate people with all levels of functional ability in a safe and productive manner. Weight machines allow the user to vary the resistance level by moving a pin, because a fixed weight would be too light for some and too heavy for others. Similarly, the recreational access area strives to permit all people to access and use the same facilities and equipment.

Wheeled mobility. The wheeled mobility industry is larger than the AAC marketplace; an estimated 3.3 million individuals over the age of 15 use wheelchairs, according to the U.S. Census Bureau's Americans with Disabilities report (2005). However, its devices and services also fall within a niche customer market. Manual wheelchairs, power wheelchairs, seat cushions, customized seating/positioning systems are all assessed, provided and supported by a range of manufacturers, suppliers and clinicians, and all accommodate the mobility and access needs of individuals in the home, school, workplace and community (Louisiana Tech University, 2013).

Communicating Efficiently and Effectively With Diverse Stakeholders

Scholars conducting research in any of these three AT areas traditionally share their findings with other scholars through the scientific journal publication and citation system. However, scholars working in such applied areas are now expected to demonstrate evidence of communicating with non-traditional audiences – those stakeholders involved with learning about and applying the research findings for the purpose of improving the quality of life for persons with disabilities. But how? No scholar or group has the capacity to create an entirely new communication infrastructure, nor can they devote sufficient time to reach non-traditional stakeholders individually. It happens that while these stakeholder groups may be non-traditional targets for scholars, they are already core constituents within national organizations for their particular topic areas. So, a possibility exists for scholars to engage national organizations as a mechanism for effectively communicating with stakeholder groups. However, it is first necessary to determine if those organizations even about communicating research findings to their members. This paper employs the KVM technique to explore the extent to which national organizations are willing and able to communicate research findings to the targeted stakeholder groups, and therefore serve as conduits for knowledge translation strategies. The paper summarizes and compares the results drawn from multiple national organizations across the three AT areas.

The KVM study reported here investigated three research questions:

1. Can the results from the initial KVM survey of national organizations in the AAC area (Lane & Rogers, 2011) be replicated in other AT areas and thereby generalized beyond AAC?
2. Are national organizations an appropriate channel for translating and disseminating new research-based knowledge to stakeholder groups from various fields of application?
3. Are there differences in levels of knowledge engagement for organizations in each of three different areas of assistive technology?

Method

Participants

Generic stakeholder categories. The study needed to identify national organizations relevant to each AT area. Doing so first required the study to identify the stakeholder groups relevant to each AT area. Previous studies identified six generic stakeholder categories representing people likely to have an interest in the application of technology-oriented outputs from research and development projects *in any* field or area of application, to include the AT field and areas of application (Lane, 1999; Bauer & Flagg, 2010):

- Researchers in related fields of study;
- Practitioners/Clinicians;
- Manufacturers/Suppliers;
- Lay Consumers/Customers;
- Information Brokers (e.g., employers, educators);
- Policy makers/Implementers.

These six generic categories serve as placeholders to remind sponsors and researchers to account for each and every stakeholder group in the context of any field or area. Transforming these generic categories into specifically identifiable groups and representative organizations requires input from experts in that particular field or area.

Defining stakeholder categories in the context of assistive technology areas. The project staff consulted with experts in the national centers conducting research and development in the three AT areas, to define the six generic stakeholder categories as specific stakeholder groups within each of those AT areas, as described here.

- Stakeholder groups in augmentative and alternative communication area:
- Manufacturers of AAC devices that integrate the knowledge into products;
- Clinicians specializing in AAC who recommend the knowledge to clients;
- Researchers who investigate AAC-related issues;
- Brokers in a capacity to refer clinicians or consumers to the knowledge;
- Policy makers or implementers who are concerned with AAC issues;
- Consumers who are AAC users and their family members.

Stakeholder groups in recreational access area:

- Manufacturers who make fitness equipment product development decisions;
- Fitness facility owners/managers who are decision makers that operate fitness facilities;
- Certified fitness trainers/specialists who work with and guide/monitor fitness facility clients;
- Researchers who investigate issues related to fitness and exercise science;
- Fitness facility architects and access consultants who facilitate/advocate for the use of research to improve fitness facilities and equipment;
- Consumers who are individuals with mobility limitations that either use, or are considering the use of fitness facilities.

Stakeholder groups in wheeled mobility area:

- Manufacturers who make product development decisions about power wheelchair seating and positioning technologies;
- Suppliers who provide consumers with access to power wheelchairs;
- Prescribers and therapists who provide power wheelchair users with clinical guidance about seating and positioning;
- Researchers who investigate issues related to wheeled mobility technology;
- Nurses who are involved in the care of power wheelchair users;
- Consumers who use power wheelchairs.

National organizations in each assistive technology area. With the stakeholder groups identified in the context of all three AT areas, the project team again consulted with experts from the national centers to identify specific national organizations representing one or more of the defined target audiences. These national organizations served as the subject pool for recruitment into the KVM survey study. The content experts identified thirteen different national organizations as representing all eighteen defined stakeholder groups across the three AT areas of interest, as follows:

National organizations representing AAC stakeholder groups:

- Manufacturers: Assistive Technology Industry Association (ATIA), http://www.atia.org/i4a/pages/index.cfm?pageid=1

- Clinicians: American Speech-Language Hearing Association (ASHA), http://www.asha.org/
- Consumers & Researchers: International Society for Augmentative and Alternative Communication (ISAAC), https://www.isaac-online.org/english/home/
- Knowledge Brokers: Association on Higher Education and Disability (AHEAD), http://www.ahead.org/
- Policy maker/implementers: Office of Special Education and Rehabilitative Services (OSERS), http://www2.ed.gov/about/offices/list/osers/index.html
- Cross Stakeholders: Rehabilitation Engineering & Assistive Technology Society of North America (RESNA), http://www.resna.org/

National organizations representing recreational access stakeholder groups:

- Manufacturers: International Health, Racquet & Sportsclub Association (IHRSA), http://www.ihrsa.org/
- Fitness Facility Owner/managers: International Health, Racquet & Sportsclub Association (IHRSA), http://www.ihrsa.org/
- Certified Fitness Trainer/Specialists: American College of Sports Medicine (ACSM), http://www.acsm.org/about-acsm
- Researchers: Rehabilitation Engineering & Assistive Technology Society of North America (RESNA), http://www.resna.org/; American College of Sports Medicine (ACSM), http://www.acsm.org/about-acsm
- Fitness Facility Architect and Access Consultants: National Council on Independent Living (NCIL), http://www.ncil.org/
- Lay Consumers: Paralyzed Veterans of America (PVA), http://www.pva.org/site/c.ajIRK9NJLcJ2E/b.6305401/k.BCBB/Home.htm

National organizations representing wheeled mobility stakeholder groups:

- Manufacturers & Suppliers: National Coalition for Assistive and Rehab Technology (NCART), http://www.ncart.us/
- Prescribers/Therapists: American Physical Therapy Association (APTA), http://www.apta.org/
- Researchers: Rehabilitation Engineering & Assistive Technology Society of North America (RESNA), http://www.resna.org/
- Knowledge Brokers: Association of Rehabilitation Nurses/Rehabilitation Nursing Foundation (ARN/RNF), http://www.rehabnurse.org/about/content/Rehab-Nursing-Foundation.html
- Lay Consumers: Paralyzed Veterans of America (PVA), http://www.pva.org/site/c.ajIRK9NJLcJ2E/b.6305401/k.BCBB/Home.htm

The identification process revealed some overlaps in the interests of national organizations (i.e., the RESNA organization was able to represent researchers as a target audience across all three AT areas), and some overlaps in the stakeholder groups represented (i.e., The PVA organization was able to represent lay consumers in both the recreational access and wheeled mobility areas).

Knowledge value mapping survey instrument. In order to collect and map the knowledge-related values of the national organizations, the study team created a semi-structured survey instrument. The instrument's content was based on the seminal work on KVM (Bozeman & Rogers, 2002) in direct consultation with that work's author Dr. Juan Rogers. The instrument was designed for telephone interviews with representatives from the national organizations designated as spokespersons. The process for creating and testing the KVM survey instrument is described elsewhere (Lane & Rogers, 2011).

The survey consisted of semi-structured questions, including both forced-choice and open-ended items. The questions explored multiple forms of knowledge engagement and assessed various approached to each form of engagement, such as techniques for encouraging awareness among staff and members, approaches for assessing the rigor and relevance of new knowledge, and strategies for access and dissemination to offer value to members.

The questions in the KVM survey instrument were intentionally structured to follow a progression of six different mechanisms through which national organizations might engage with new knowledge findings resulting from research projects. The six mechanisms follow a progression from the most direct and intensive involvement in research activity to least as follows:

1. *Creating knowledge*: Conducting research internally or funding others to conduct research for the organization;
2. *Identifying knowledge*: Searching for research findings that have already been generated by others;
3. *Translating knowledge*: Paraphrasing research findings to make them more relevant or understandable to the target audience;
4. *Adapting knowledge*: Interpreting research findings to improve their fit within the organization's context;
5. *Communicating knowledge*: Disseminating or demonstrating research findings through various media channels (i.e., publications, presentations, workshops, webcasts);
6. *Using knowledge*: Applying research findings to situations within the organization or its body of members.

Survey interview procedure. The current study's procedures for the AT areas of recreational access and wheeled mobility replicated the procedures of the prior study on the AAC area (Lane & Rogers, 2011). That is, project staff contacted the national organizations and obtained their consent for the KVM survey interview. Each organization identified a representative responsible for identifying and communicating new knowledge to organization members as a spokesperson for their knowledge values. The interviewees were directors of continuing education, conference content supervisors or chief executives. The spokespersons each received a summary of the study's purpose, an explanation of the procedure, along with a copy of the KVM survey to review or complete in advance. Project staff completed an internal copy of the KVM survey instrument during a scheduled telephone interview, which may have been followed by additional telephone calls to clarify or delve deeper into specific responses. Participating organizations received an honorarium at the conclusion of the interview process. All procedures conformed to the study's written protocol as reviewed and approved by the University at Buffalo's Institutional Review Board (IRB).

Table 1
Frequency of Knowledge Creation Through Research

Field of Application	Organization	Frequency Frequently	Occasionally	Rarely	Not Applicable
Augmentative and Alternative Communication	ATIA				x
	AHEAD	x			
	ISAAC	x			
	ASHA	x			
	OSERS	x			
	RESNA		x		
Recreational Access	NCIL		x		
	IHRSA	x			
	PVA	x			
	ACSM	x			
Wheeled Mobility	APTA	x			
	RNF/ARN	x			
	NCART		x		

The raw data collected through the telephone survey's included both written materials returned by the spokesperson and the responses as recorded by project staff. Once the material was compiled within each KVM survey instrument, the document was returned to the spokesperson as an opportunity to review the content for accuracy and to make any final revisions. This step ensured that their responses reflected their organization's engagement with – and valuation of – new knowledge generated through research studies. The final responses collected from each national organization – both quantitative and qualitative – were then entered into a spreadsheet. Data tables were generated to allow comparisons between the thirteen organizations and across the three assistive technology areas. The results from this comparative analysis appear in the following section.

Results and Discussion

The survey results reported here are organized under the six mechanisms through which national organizations may engage with research activity, and presented in the same order as they appeared in the KVM survey instrument – from most to least intensive levels of engagement.

Creating Research Knowledge

Twelve of the thirteen organizations surveyed report engaging directly in the generation of research-based knowledge. Nine organizations engage in the creation of research-based knowledge frequently while three organizations, RESNA, NCIL, and NCART, only do so occasionally (See Table 1.) The thirteenth organization, ATIA, does not conduct research activity because is an industry association oriented toward trade and business practices, it has at least established a committee to explore ways to integrate research-based activities and actors into the organization. Across the three AT areas it is clear that all the professional organizations surveyed value research-based knowledge, and do so to the extent that most participate in generating new knowledge through the research process.

As seen in Table 2, each national organization directly engages in research activities for different reasons. The most cited reasons included efforts to improve practice, service quality, and consumer outcomes as well as to develop and spread awareness of policies, standards and protocols. Participating

Table 2
Purpose of Conducting or Funding Research

		Purpose			
Field of Application	Organization	Evaluate Programs/Services	Improve Practice/ Service Quality	Professional Development	Advance State of the Science
Augmentative and Alternative Communication	ATIA				
	AHEAD	x	x	x	x
	ISAAC		x	x	
	ASHA		x		x
	OSERS				
	RESNA	x	x	x	
Recreational Access	NCIL				
	IHRSA	x	x		
	PVA		x		x
	ACSM		x		x
Wheeled Mobility	APTA		x		
	RNF/ARN		x		x
	NCART	x			

		Purpose			
Field of Application	Organization	Improve Consumer Outcomes	Needs Assessment	Inform/Develop Policies, Standards, and Protocols	Not Applicable
Augmentative and Alternative Communication	ATIA				x
	AHEAD			x	
	ISAAC	x		x	
	ASHA	x		x	
	OSERS	x			
	RESNA		x	x	
Recreational Access	NCIL	x	x	x	
	IHRSA		x		
	PVA	x			
	ACSM				
Wheeled Mobility	APTA	x		x	
	RNF/ARN	x			
	NCART	x		x	

organizations were selected because of their direct involvement with AT stakeholders, so their focus on sponsoring and conducting applied research activity with discernable benefits to stakeholders – rather than basic science – is congruent with their missions.

For example, the NCART represents AT manufacturers/suppliers. It focuses on applying research-based knowledge to advocate for legislation that facilitates the production, delivery and support of AT devices and services for individuals with disabilities. NCART's leaders know that educating policy makers and third-party payers in government agencies about needs AT devices and services -- especially insurance coverage and payment for complex equipment -- requires evidence-based arguments. They also know that these agencies will only consider such evidence if it is derived from carefully designed and conducted clinical trials demonstrating device/service efficacy.

Table 3
Target Audiences for Internally-Generated Research Findings

		Target Audiences			
Field of Application	**Organization**	**Clinicians/ Practitioners**	**Consumers and Families**	**Policy Makers/ Implementers**	**Educators and Employers**
Augmentative and Alternative Communication	ATIA				
	AHEAD	x		x	x
	ISAAC	x	x		x
	ASHA	x		x	x
	OSERS	x	x	x	x
	RESNA	x	x	x	x
Recreational Access	NCIL		x	x	
	IHRSA				
	PVA		x	x	x
	ACSM	x	x	x	x
Wheeled Mobility	APTA	x		x	x
	RNF/ARN	x		x	x
	NCART			x	

		Target Audiences			
Field of Application	**Organization**	**Manufacturers and Suppliers**	**Gym Owners/ Operators**	**Nonmembers**	**Not Applicable**
Augmentative and Alternative Communication	ATIA				x
	AHEAD				
	ISAAC	x		x	
	ASHA				
	OSERS	x		x	
	RESNA			x	
Recreational Access	NCIL				
	IHRSA	x	x	x	
	PVA				
	ACSM	x		x	
Wheeled Mobility	APTA				
	RNF/ARN				
	NCART	x			

At least three organizations identified professional development, needs assessment, and program evaluation as reasons to sponsor or conduct research activity. For example, the NCIL conducts a needs assessment survey every other year to determine members' legislative priorities. It aggregates responses to that survey to determine the top three issues it should address each year. Similarly, the AHEAD conducts surveys to assess program operations and performance evaluation data for benchmarking purposes, which it draws from its program directors' self-evaluations, faculty evaluations, and service quality evaluations from students with disabilities. The IHRSA conducts surveys to collect data on established benchmarks for fitness club operations and financial goals. All of these internal assessment efforts apply research methods to collect and analyze data for management purposes.

National organizations select various combinations of stakeholder groups as audiences for receiving research-based knowledge. These combinations vary depending on the organization's goals within the AT field and between the AT areas studied herein. As Table 3 shows, policy makers/implementers, practitioners/ clinicians, and information brokers (educators/employers) are the three generic stakeholder groups that national organizations most commonly target, regardless of how those stakeholder groups are defined within the three AT areas. Members of these three generic stakeholder groups provide direct services to lay consumers, train and hire service providers, or implement policies that affect both providers and consumers. The twelve organizations directly engaged in research activities may share the perception that new findings from research generated through their internal efforts has high value to the same three generic stakeholder groups. It seems that these twelve organizations also agree that delivering quality AT devices and services to increase beneficial impacts for persons with disabilities may depend on professional practices which are informed by empirical evidence. In order to bridge the gap between optimal and actual practice, these organizations target stakeholders who 1) have an immediate impact on consumers or the laws that govern standards and guidelines and 2) also seek evidence to improve their performance and meet their ethical obligations as service providers.

Identifying Research Knowledge

All thirteen organizations claim they value research-based knowledge produced by others, and they substantiate that claim by expending internal resources to seek out such new knowledge. Ten of the thirteen organizations search for new research-based findings on a frequent basis, as Table 4 shows. The RESNA is distinctive among the organizations that frequently search for new knowledge, because it represents multiple stakeholder groups within and across the three AT areas studied here. RESNA has a large and trans-disciplinary academic membership, so its frequent searches are to provide timely information to diverse members involved in grant writing, reference work and on-going laboratory, clinical and community-based studies.

Two of the organizations that frequently search for research findings represent stakeholder groups in the AAC area of AT. The ASHA searches for new findings in support of three programs: informatics, education, and dissemination. The ISAAC searches for new findings in support of their journals and newsletters and also seeks to keep members informed about new research knowledge. The government agency OSERS also represents AAC stakeholders because it sponsors most of the on-going research and development projects in the AAC area. As such, the OSERS searches continually for new findings to educate staff, support content of grant/contract solicitations, stay abreast of statutes and regulations, monitor contractor performance, and provide policy advice to other government agencies.

Three of the national organizations representing stakeholders in the Recreational Access field frequently search for research-based new knowledge. The ACSM looks for research findings to investigate the relation of exercise to health and sports performance as well as sports injury prevention. The IHRSA searches for research findings to use as a cross-reference to verify and confirm their own research findings. It relies on survey research to gain insights into the motivations and behaviors of health club members, and to identify trends within the health club industry, and to track the industry's performance within the overall business marketplace.

The PVA, representing several Wheeled Mobility stakeholders in this KVM survey, reports a nearly constant search for new research findings. The PVA uses research knowledge as a basis for developing clinical practice guidelines for secondary conditions associated with spinal cord injury. The three other organizations representing Wheeled Mobility also frequently search for research-based knowledge. APTA and RNF/ARN frequently look for research to enhance practice and to aid in the generation of policy and clinical guidelines. NCART searches for research findings to identify the medical benefits of complex rehabilitation technology as evidence for presentation to reimbursement organizations. It also uses research findings to identify differences and similarities in coverage and payment patterns across those reimbursement organizations.

The remaining three national organizations all report searching for new research findings only occasionally. The ATIA, AHEAD and NCIL organizations only do so to maintain a

Table 4
Frequency of Identifying Research-based Knowledge

Field of Application	Organization	Frequency			
		Frequently	Occasionally	Rarely	Not Applicable
Augmentative and Alternative Communication	ATIA		x		
	AHEAD		x		
	ISAAC	x			
	ASHA	x			
	OSERS	x			
	RESNA	x			
Recreational Access	NCIL		x		
	IHRSA	x			
	PVA	x			
	ACSM	x			
Wheeled Mobility	APTA	x			
	RNF/ARN	x			
	NCART	x			

stream of material to share with their members, although it is not a high priority for them or their members. The NCIL, in particular, takes a strategic approach to knowledge use by seeking research-based findings to support their chosen policy positions.

All of the national organizations surveyed report extracting research-based knowledge from a variety of sources. According to respondents, organizations seeking new research findings rely on academic journals, white papers, professional training, scholarly conferences, and individual experts (as Table 5 shows). Few organizations report that they rely on information in newspapers and magazines. They are concerned about the reliability and validity of content. Authors in these media may lack thorough knowledge of the topic and may use personal opinions to support arguments rather than rely on empirically sound data. Even worse from the perspective of national organizations, such articles are likely written by someone other than the original researcher. They are astutely concerned that the contents may lose accuracy through paraphrasing, might lose critical details and may fail to report the limitations of the findings, all of which is typically found in the original scholarly publication.

Most national organizations report a sophisticated level of understanding and a high degree of sensitivity about traditionally academic concerns such as threats to validity in study designs, and reliability in the reported research findings. Some organizations have implemented policies and procedures to assess the data before determining its usefulness and worth. Two organizations rely on either an internal research review committee or methodologist to perform this function. Others inquire about the methodology employed along with sample size, the level of expertise of those conducting the research, the credibility of the journal and of other sources cited. Several of the organizations have no specific written policy for reviewing quality of research. They use individual judgment to determine whether research is credible.

Though most academic work is published in the form of peer-reviewed journal articles, books, or theses, national organizations regard several other avenues to as valid, reliable sources of research-based information. For example, eleven of the thirteen organizations surveyed use white papers and internal reports generated by researchers as sources of new knowledge. Therefore, researchers who typically limit their dissemination efforts to publishing articles in peer-reviewed academic journals may wish to consider expanding their dissemination strategy. Specifically, they could summarize key findings in newsletters, websites, and/or make their unpublished yet relevant work accessible electronically. Exchanging information at trainings and conferences is also highly valued by the organizations. All but one organization (AHEAD) uses these sources as a means of sharing their needs and priorities with the community while also gaining awareness about the work of others.

Although the NCIL did not rely heavily on academic journals as a resource, it was not due to any particular opposition. Instead, the NICL as a consumer-directed and consumer-oriented organization, was concerned that it lacked the resources (staff and time) to both find and more importantly, to interpret, the findings from scholarly research. The NCIL's concern raises a critical issue for researchers seeking to expand the uptake and use of the findings they generate. Undertaking the process of knowledge translation – either by the knowledge creator or by another qualified person – may be necessary to fully interpret and accurately communicate findings in the context of the intended audiences, to include

Table 5
Sources Used to Identify Research-based Knowledge

		Sources					
Field of Application	Organization	Academic Journals	White Papers	Newspapers/ Magazines	Website	Training/ Conferences	Individual Experts
Augmentative and Alternative Communication	ATIA	x	x		x	x	x
	AHEAD	x	x		x		
	ISAAC	x			x	x	x
	ASHA	x	x	x	x	x	x
	OSERS	x	x	x	x	x	x
	RESNA	x			x	x	x
Recreational Access	NCIL		x			x	x
	IHRSA	x	x	x	x	x	x
	PVA	x	x			x	x
	ACSM	x	x			x	x
Wheeled Mobility	APTA	x	x		x	x	x
	RNF/ARN	x	x		x	x	x
	NCART	x	x	x	x	x	x

targeted stakeholders and relevant organizations. This creates a new opportunity for researchers: to provide technical assistance to national organizations that are interested in implementing research-based findings in practice.

Translating Research Knowledge

In order to make new knowledge more comprehensible to their members, some organizations translate (e.g., paraphrase or condense) the research-based findings before disseminating them. Seven of the thirteen organizations surveyed report translating new research-based knowledge on a frequent or constant basis. One organization does so occasionally while four rarely do so (Table 6). Translating findings was reported as not applicable to the AHEAD's organization.

Four organizations (NCIL, IHRSA, PVA, ACSM) of the seven that translate new research-based knowledge frequently or constantly represent stakeholders in the recreational access area. That is twice the frequency reported for organizations representing AAC stakeholders (ASHA, OSERS), or those representing wheeled mobility stakeholders (RNF/ARN, PVA). This may because the issues addressed by research projects concerning recreational access are relevant to broader mainstream audiences in the general population in addition to those stakeholders in the disability and rehabilitation communities. These four organizations appear to be more accustomed to collecting, translating and disseminating findings from research across mainstream topics of recreation, sports and leisure, as well as research addressing access to the built environment in addition to specific AT devices and services.

All the organizations reporting frequent engagement in translating knowledge do so in unique ways. For example, the ASHA, representing AAC stakeholders, communicates information in special formats that involve interpretations of results that fit the needs and context of their audience. In comparison, the OSERS as a government agency distills materials from various sources to communicate findings to internal staff, other government programs, or to incorporate findings into statutes, regulations and requests for external proposals. Meanwhile, the ACSM, which represents the recreational access sector, translates scientific technical manuscripts into lay health and education language on a frequent basis, while the IHRSA tracks articles that support exercise and wellness and economic value, i.e., corporate facilities and exercise benefits.

These organizations share the KT-oriented goal of communicating research findings in language that is relevant to their target audiences. Further KT orientation is found in their focus on reporting the key details deemed most relevant to their stakeholder audiences. This focus is especially important for organizations that represent lay consumers in their membership. The NCIL, for example, views translating as an important part of its role. It summarizes information about what is happening in Washington, D.C. and in state-level legislatures to inform paid and volunteer staff in Centers for Independent Living as well as those people with disabilities receiving services. Similarly, the PVA assists its sponsored researchers in writing lay versions of findings for PVA's monthly publication to community members. The PVA has a communication staff member with experience in clinical science and journalism who works with research to translate medical language into a ninth-grade reading level, which the organization considers to be the best level for their stakeholders to understand. The

Table 6
Frequency of Translating Research-based Knowledge

		Frequency			
Field of Application	Organization	Frequently	Occasionally	Rarely	Not Applicable
Augmentative and Alternative Communication	ATIA			x	
	AHEAD				x
	ISAAC		x		
	ASHA	x			
	OSERS	x			
	RESNA			x	
Recreational Access	NCIL	x			
	IHRSA	x			
	PVA	x			
	ACSM	x			
Wheeled Mobility	APTA			x	
	RNF/ARN	x			
	NCART			x	

RNF/ARN frequently translates research knowledge about bedside nursing at their ARN conference, in their academic journal, and in the ARN bi-monthly newsletter for care providers in the community and family members of service recipients.

The ISAAC reported only engaging in translating knowledge on occasion. They typically rely on ISAAC chapters within different counties to translate knowledge in order to ensure the translations address cultural diversity issues. The ISAAC also provides a summary of the content in its Augmentative and Alternative Communication journal in the e-zine (electronic magazine) that members receive. The ATIA, RESNA, APTA, and NCART organizations rarely engage in translation of knowledge. The ATIA is more likely to invite the originator of the research to present findings to members via webinar or an educational session at an ATIA conference, because they believe that the researcher's themselves should be responsible for translating the message from their research findings. The ATIA recognizes that researchers need to make an effort to reach stakeholder audiences beyond the traditional academic group, so managers work with invited presenters to ensure the material is relevant and understandable to their stakeholder members. The APTA reports having engaged in KT activities only because it usually relies on its clinical stakeholders to paraphrase and interpret research findings. The RESNA and the NCART rarely translate knowledge from research activity.

More than half of the organizations interviewed routinely engage in KT activities. While they recognize the importance of preserving the author's original findings, they are equally concerned with communicating relevant findings in language and formats comprehended by stakeholders who may lack academic qualifications. All of these organizations are careful to ensure that the individuals who are responsible for translating research findings have an appropriate level of academic preparation and meet the qualifications for the task at hand. Individuals designated to translate knowledge typically have a Ph.D. (or a Master's degree in some cases), a background in the field of application or journalism. They typically partner with content experts for editorial review.

Though target audiences for translated knowledge vary depending on the organization, most common audiences include clinicians and healthcare professionals, consumers and their family members and policy makers (Table 7). Appropriately, these stakeholder groups are the same targeted recipients of the national organizations' internally-generated new knowledge. Whether organizations produce research evidence themselves or search for and translate knowledge that has already been conducted by an outside researcher, individuals that have a direct impact on consumer outcomes or the legislation that guides services, and consumers themselves are viewed as important conduits of change. Four of the organizations also targeted manufacturers and suppliers. These stakeholders are critical intermediaries, as they take research-based knowledge and transform it into products and devices.

Adapting Research Knowledge

The national organizations were divided into two camps regarding the adaptation of research knowledge to improve the fit within the context of their own programs and issues. Six organizations engage in adapting research-based findings – although three only report doing so occasionally. Two organizations do not ever engage in adapting research-based findings (APTA, NCART), while five did not perceive this use of knowledge to be applicable to their organization (ATIA, AHEAD, ASHA,

Table 7
Target Audiences for Translated Research-based Knowledge

		Target Audiences			
Field of Application	Organization	Clinicians/ Practitioners	Consumers and Families	Policy Makers/ Implementers	Educators and Employers
Augmentative and Alternative Communication	ATIA	x			x
	AHEAD				
	ISAAC	x	x		
	ASHA	x	x	x	x
	OSERS	x	x	x	x
	RESNA	x		x	
Recreational Access	NCIL	x	x	x	
	IHRSA				
	PVA		x		
	ACSM	x	x	x	x
Wheeled Mobility	APTA	x		x	
	RNF/ARN	x			
	NCART	x	x	x	

		Target Audiences			
Field of Application	Organization	Manufacturers and Suppliers	Gym Owners/ Operators	Nonmembers	Not Applicable
Augmentative and Alternative Communication	ATIA	x			
	AHEAD				x
	ISAAC				
	ASHA				
	OSERS	x		x	
	RESNA	x		x	
Recreational Access	NCIL				
	IHRSA	x	x	x	
	PVA				
	ACSM			x	
Wheeled Mobility	APTA				
	RNF/ARN				
	NCART				

PVA, RNF/ARN). Table 8 provides additional detail regarding these responses.

The ISAAC's position is that findings from research may need to be adapted to permit absorption and use by portions of its membership. This concern refers particularly to the community of persons with communication disorders spanning mild to severe levels, and so have diverse needs as well as diverse ways for applying new knowledge from research. As a government organization, OSERS reports a need to distill knowledge from multiple sources to address its national mission. The OSERS adapts and applies research knowledge to provide evidence on how government-sponsored programs and policies affect persons with disabilities and their quality of life. Similarly, the RESNA prepares position papers, standards/guidelines, quality indicators, and benchmarks when consolidating and adapting research from a wide range of findings.

The NCIL adapts and combines findings from a wide range of academic research studies and government statistical analyses, in a strategic use of knowledge to justify continuing federal and state government support for the national network of Independent Living Centers. Similarly, the IHRSA endeavors to produce reports by interpreting research on consumer behavior, benchmarks, and compensation, all of which it tracks year-to-year.

The ACSM creates professional resource manuals for reference use by members, a task that requires a fair degree of knowledge adaption. It reports having employed authors with both significant knowledge of the research as well as an abundance of practical experience to aid in the adaption process.

Many of the national organizations expressed hesitation about adapting knowledge during the telephone interviews. Specifically, they were wary that efforts to adapt knowledge could stray from the author's intended meaning of the knowledge. This is another indication of an opportunity for researchers to engage national organizations as technical experts.

Communicating Research Knowledge

All thirteen organizations communicate new knowledge from research studies at least occasionally. Eleven do so either frequently or very frequently (Table 9). All thirteen consider their organization's websites as the primary vehicle for disseminating new knowledge to

Table 8
Frequency of Adapting Research-Based Knowledge

		Frequency			
Field of Application	Organization	Frequently	Occasionally	Rarely	Not Applicable
Augmentative and Alternative Communication	ATIA				x
	AHEAD				x
	ISAAC		x		
	ASHA				x
	OSERS	x			
	RESNA		x		
Recreational Access	NCIL		x		
	IHRSA	x			
	PVA				x
	ACSM	x			
Wheeled Mobility	APTA			x	
	RNF/ARN				x
	NCART			x	

their members. The majority of organizations also apply a variety of other media/materials for this purpose, including email lists, print periodicals, conference presentations, and in-person workshops as a means of communicating knowledge to relevant stakeholders. A smaller percentage use white papers, conference proceedings, webcasts, and special interest group interactions. Eight of the thirteen organizations maintain and edit their own peer-reviewed journals as a vehicle for communicating research findings vetted for quality assurance criteria of methodological rigor and subject matter relevance. The organizations and journals listed below represent yet another opportunity through which people engaged in research can efficiently communicate their findings to broader and on-traditional audiences:

- ISAAC: *Augmentative and Alternative Communication*
- ASHA: *Journal of Speech, Language and Hearing Research; American Journal of Audiology; American Journal of Speech-Language Pathology, Language Speech and Hearing Services in Schools*
- ATIA: *Assistive Technology Outcomes and Benefits*
- RESNA: *Assistive Technology*
- AHEAD: *Journal of Postsecondary Education and Disability*
- ACSM: *Medicine & Science in Sports & Exercise Science; Exercise & Sports Science Reviews*
- APTA: *Physical Therapy Journal of the American Physical Therapy Association*

Table 9
Frequency of Communicating Research-Based Knowledge

		Frequency			
Field of Application	Organization	Frequently	Occasionally	Rarely	Not Applicable
Augmentative and Alternative Communication	ATIA	x			
	AHEAD	x			
	ISAAC	x			
	ASHA	x			
	OSERS	x			
	RESNA	x			
Recreational Access	NCIL		x		
	IHRSA	x			
	PVA	x			
	ACSM	x			
Wheeled Mobility	APTA		x		
	RNF/ARN	x			
	NCART	x			

- ARN/RNF: *Rehabilitation Nursing Journal*

Table 10 shows the range of stakeholder groups targeted for dissemination through each national organization. Among the top audiences are clinicians and healthcare professionals, lay consumers and their family members, policy makers, and educators/employers. Six national organizations target manufacturers and suppliers of products and services. The IHRSA focuses specifically on the owners and operators of exercise facilities because it is a trade association serving the health and fitness club industry.

Several organizations take precautions to avoid or control potential problems which could arise when communicating new research-based knowledge to stakeholders. Such precautions include providing disclaimers to avoid audience perception of endorsement for the research study. Another potential complication is the misinterpretation or misapplication of the new findings. The

Table 10
Target Audiences for Communicating Research-Based Knowledge

		Target Audiences			
Field of Application	Organization	Clinicians/ Practitioners	Consumers and Families	Policy Makers/ Implementers	Educators and Employers
Augmentative and Alternative Communication	ATIA	x	x	x	x
	AHEAD	x		x	x
	ISAAC	x	x		x
	ASHA	x	x	x	x
	OSERS	x	x	x	x
	RESNA	x	x	x	
Recreational Access	NCIL	x	x	x	
	IHRSA				
	PVA		x	x	x
	ACSM	x	x	x	x
Wheeled Mobility	APTA	x		x	x
	RNF/ARN	x		x	x
	NCART	x	x	x	

		Target Audiences		
Field of Application	Organization	Manufacturers and Suppliers	Gym Owners/ Operators	Nonmembers
Augmentative and Alternative Communication	ATIA	x		x
	AHEAD			
	ISAAC	x		
	ASHA			
	OSERS	x		x
	RESNA	x		x
Recreational Access	NCIL			
	IHRSA	x	x	x
	PVA			
	ACSM			x
Wheeled Mobility	APTA			
	RNF/ARN			x
	NCART	x		x

IHRSA tries to control this hazard by routinely gathering feedback from members on how they interpret and apply research findings disseminated through the IHRSA or received through other sources.

Another issue of concern to national organizations is that efforts to communicate new research findings may generate unwanted controversy. The ACSM described complications arising from findings on a controversial topic where its' membership included two groups holding opposing views. The ACSM's approach to such internal controversies is to review all of the available evidence and then announce an official position on the topic. In so doing, the ACSM expects that offering an objective synthesis of the research findings contributes to firmer internal policies which in turn tempers the respective positions of opposing members.

The PVA expressed similar difficulty when moral questions arise from the public regarding the organization's position on stem cell research. The PVA strives to keep its constituents informed about issues with significant potential benefit (e.g., cures for paralysis) even if the issue has social, religious, or other moral implications. These strategies raise another key issue for scientific researchers planning to implement knowledge translation. That issue involves questions of how and whether to control or monitor how original research findings are applied, translated, adapted or communicated by and through external stakeholders.

Using Research Knowledge

Ten of the thirteen organizations reported applying research findings to situations within their organization or membership at least occasionally (Table 11). The sources of research-based information varied widely across national organizations. Seven reported using internally generated research-based knowledge. Six identified academic journals as the primary source of the knowledge they applied. Four organizations referenced trainings, conferences and websites. Three reference white papers from academic institutions and two organizations use newspapers and magazines as primary sources.

The NCIL's position is that it lacks appropriate and qualified resources (staff and time) to search for new research-based knowledge so it very rarely has an opportunity to apply such findings internally. The NCIL did acknowledge that such findings could be useful. The ATIA and RNF/ARN indicated that using research knowledge is not applicable to their organizations because the use of new research-based knowledge is not focused internally, but rather externally on their constituents.

As detailed in Table 12, respondents were asked to rank the importance of using various types of knowledge outputs instrumentally – that is, applying the knowledge in a practical way and as intended by the knowledge creator. All organizations reported the practical application of knowledge for creating or revising industry standards or clinical protocols. The majority reported it as the most important use. Applying knowledge to build laboratory instruments or clinical tools was important to half of the organizations but not important or not applicable to the other half. A different mix of organizations was also evenly split between 1) applying knowledge outputs to create free hardware or software for download or access and 2) reporting that use as not important or not applicable. Nine national organizations reported that they applied new knowledge instrumentally in the design of new or improved devices or services within their areas of interest.

Twelve organizations reported other instrumental uses of new knowledge through an open-ended question. These included improving their organization's efficiency, keeping members informed about relevant issues, promoting their field, informing relevant policy makers, and improving professional practice. One organization, ISAAC, offered no response to this question.

Eight of the national organizations describe having follow-up procedures for assessing the extent to which these instrumental applications of knowledge are meaningful and are valued by staff and members alike. These procedures include soliciting feedback through member surveys, special interest groups, semi-structured forums, and even informal communication channels. These activities present scholars with yet another opportunity to engage national organizations. Specifically, they can identify strategies by which to improve the feedback that national organizations receive, initiate new feedback methods (including for the five organizations who currently have none), and establish methods for verifying the utility of research-based knowledge to staff and members.

Table 11
Frequency of Using Research-Based Knowledge

		Frequency			
Field of Application	Organization	Frequently	Occasionally	Rarely	Not Applicable
Augmentative and Alternative Communication	ATIA				x
	AHEAD		x		
	ISAAC	x			
	ASHA	x			
	OSERS	x			
	RESNA	x			
Recreational Access	NCIL			x	
	IHRSA		x		
	PVA	x			
	ACSM	x			
Wheeled Mobility	APTA		x		
	RNF/ARN				x
	NCART	x			

Promoting the Use of Research Knowledge

All thirteen organizations surveyed engage to some degree in generating, identifying, assessing and/or applying research-based knowledge, which shows that they value scientific research. The KVM survey also asked about how their staffs and members value research-based knowledge. Twelve organizations provide incentives to encourage the adoption and application of new knowledge (Table 13). Nine organizations invest in resource-intensive activities such as workshops, webcasts, or pre-conference trainings to communicate new research-based knowledge. For example, ATIA uses strand advisors from affiliated organizations with research expertise to make presentations or to recruit other experts to speak at their conferences. Eight organizations assign Continuing Education Units (CEUs) to conference or webcast materials, enabling professionals to earn credits toward maintaining their professional credentials. Of course, these organizations need recognized experts to prepare and deliver the materials so

Table 12
Ranking Importance Across Various Types of Knowledge Use

	Level of Importance					
	Very Important	Important	Moderately Important	Of Little Importance	Unimportant	Not Applicable
To create or revise industry standards or clinical protocols is…	AHEAD, ASHA, OSERS, RESNA, PVA, NCART, RNF/ARN, APTA, ACSM	ATIA, IHRSA	ISAAC	NCIL		
To build laboratory instruments or clinical tools is…	RESNA, PVA, APTA	ASHA, OSERS	ACSM	ATIA	ISAAC, NCIL, NCART	AHEAD, IHRSA, RNF/ARN
To create freeware (hardware, software) for free download or access is…	APTA	OSERS	ISAAC, ACSM	RESNA	NCIL, NCART, PVA	ATIA, AHEAD, ASHA, IHRSA, RNF/ARN
Designing new or improved commercial devices or services is…	ATIA, RESNA, NCART, APTA	ISAAC, ASHA, OSERS, ACSM	IHRSA		NCIL, PVA	AHEAD, RNF/ARN
For other purposes is… Improve efficiency of the organization; Keep members informed and up to date about relevant issues; Promote AT field; Inform policy or practice	IHRSA, PVA, NCART, ASHA, RNF/ARN, APTA, ACSM, OSERS	ATIA, RESNA, AHEAD	NCIL			

that the content qualifies for CEU credits. This offers yet another opportunity for scholars to collaborate with national organizations in the context of efficient and effective knowledge translation.

Six organizations offer discounts on advanced conference registration to encourage members to commit to participation. Five of those organizations provide certificates of completion/attendance. Some organizations offer incentives for participating in research studies. Those incentives include advancement in fellowship status and monetary compensation (i.e., gift cards).

Measuring Stakeholder Use of Research Knowledge

All of the preceding examples demonstrate the extent to which organizations value and promote the use of research-based knowledge, while simultaneously implementing strategies to motivate their members to use such knowledge. These initiatives offer additional opportunities for scholars to collaborate with national organizations and thereby promote their research findings. At the same time, scholars can gather evidence for the use of their research findings in instrumental and conceptual ways, by national organizations and their stakeholder members. This is particularly relevant to answering the original KT

Table 13
Incentives for Associates to Become Aware/Apply Research

		Incentives				
Field of Application	Organization	Continuing Education Units	Certification of Completion	Discounts on Conference Registration	Offering Workshops, Webcasts, Pre-conference Training	Other
Augmentative and Alternative Communication	ATIA	x	x	x	x	
	AHEAD	x		x	x	
	ISAAC				x	
	ASHA	x		x	x	
	OSERS				x	
	RESNA	x	x	x		
Recreational Access	NCIL					
	IHRSA					x
	PVA		x	x	x	
	ACSM	x	x		x	x
Wheeled Mobility	APTA	x				
	RNF/ARN	x	x	x	x	x
	NCART	x			x	

challenge of reaching non-traditional stakeholders and collecting evidence of their knowledge use.

Measuring awareness, interest, and use of research-based knowledge is a challenge for scholars working in any field of application. This is especially true when attempting to track diverse and diffuse stakeholders who may use research findings in various ways. The KVM survey results revealed that national organizations face similar challenges when attempting to assess the extent to which internal staff or external members apply new research-based knowledge (Table 14).

Six of the organizations have in place no method for measuring knowledge use. However, since the initial survey interview was completed, the APTA reported asking for an allocation of internal resources for the purpose of formally assessing knowledge use among its members. ATIA's annual member satisfaction survey, which covers all aspects of its operation, includes general questions related to use of research findings. ATIA expects its member corporations to conduct their own studies of knowledge use and related outcomes.

Three organizations, ASHA, IHRSA, PVA, administer surveys (typically after conferences,

Table 14
Measuring Level of Awareness, Interest and Use of New Knowledge

		Method					
Field of Application	Organization	No Evaluation in Place	Informal Evaluation	Surveys	Journal Access	CEU Evaluations	Influence of Knowledge on Work Products
Augmentative and Alternative Communication	ATIA	x					
	AHEAD	x					
	ISAAC				x		
	ASHA			x	x		
	OSERS						x
	RESNA		x				
Recreational Access	NCIL	x					
	IHRSA			x			
	PVA			x			
	ACSM	x					
Wheeled Mobility	APTA	x					
	RNF/ARN					x	
	NCART	x					

workshops, or seminars) to gather feedback on their constituents' interest in and application of research-based content. The ASHA administers a "Knowledge, Attitudes, and Practices" survey every three years to track the extent to which members incorporate research-based evidence into practice. Additionally, the ASHA conducts post-workshop and conference surveys to evaluate both the relevance of the materials to attendees' practice and the likelihood that they will apply the information presented. The ASHA and the ISAAC both also track the number of times the articles appearing in their respective journals have been accessed.

The RNF/ARN collects feedback from CEU-related evaluations to monitor member responses interest in applying materials offered through courses, workshops and webcasts. The OSERS asks internal staff members to monitor journals, conferences and product announcements to identify outputs from research and development projects OSERS has sponsored. This allows the OSERS management to take some measure of credit for valuable contributions in their reports to the U.S. Department of Education and to Congress. It also ensures that OSERS staff members are integrating the state of the science in new program initiatives and new project solicitations. The RESNA relies on passive measures of knowledge awareness, interest, and use, such as tracking requests for information from members according to topics, and monitoring the number of times topical key words appears among RESNA's listserv strand posts and discussions.

Recommendations to Researchers for Improving Communication

A final component of the KVM survey asked respondents to recommend ways in which researchers could improve their abilities to communicate with professional organizations and through them to their respective members. Eleven organizations responded by suggesting that researchers immediately increase their engagement with – and involvement in – national organizations that represent relevant stakeholders. These organizations stressed the need – and opportunity -- for researchers to establish continuing relationships as a basis for collaboration, rather than sporadically approach organizations when they seek to disseminate some particular finding.

All of the national organizations confirmed their ability and willingness to serve as knowledge brokers for the purpose of facilitating increased interactions between external researchers and internal stakeholder groups. Respondents emphasized that national organizations can provide a platform for publicizing and promoting new findings from research and can readily deliver interested audiences to researchers. They viewed on-going relationships with individual scholars as an important vehicle for building trust and credibility. This in turn would expedite the transmission of new research findings from trusted scholars out through these national organizations, and thereby efficiently disseminate new knowledge from research to multiple stakeholders. These organizations seem ready and willing to span the gaps between researchers and non-traditional stakeholder audiences.

Respondents viewed the translation of research-based knowledge into the language and context of non-traditional stakeholders as critical to mobilizing knowledge use. As noted previously, most organizations are hesitant to independently translate and adapt knowledge generated by scholars. The ISAAC, for example, even cautioned members against translating the work of others. Instead, ISAAC welcomes active engagement with scholars who are qualified to translate relevant findings while communicating the limitations of those findings based on the original study design, subject sample and intent. This translation work requires substantial effort beyond that applied to the original study, so it might be well served through collaborative efforts involving multiple scholars working within the same topic area. The key message from national organizations is that they prefer to have the original scholars present their study's findings, explain the implications of these findings for the various stakeholder audiences, and provide action-oriented suggestions for implementing the findings in practice.

Several organizations offered their own expectations regarding the utility of knowledge translation as a communication strategy. Most of them agreed that the most critical element was for researchers to summarize their findings in clear and concise language, designed to be "end-user-friendly," for each targeted stakeholder group. The spokesperson for the AHEAD suggests that researchers who translate research-based findings should plan to produce materials that are ready for distribution, and to prepare those materials in multiple print/electronic media formats. These steps would expedite the dissemination by organizations to their staff and stakeholders. They further advised researchers to consider report length and writing style to make them easier to read and comprehend by non-traditional stakeholder audiences who are not exposed to lengthy, scholar-focused content. Any requirement for the organization's internal staff to compose additional formats or revise the reports will only delay dissemination and raise additional barriers related to cost and effort.

The NCART respondent described any direct collaboration between scholars and organizations for the purpose of creating a central repository of related research findings, as an efficient way to capture and share new research findings as they are generated. In fact, the APTA reported having already taken action to create such a repository accessible it is members. It is called "Hooked on Evidence" and it compiles excerpts from research articles pertaining to physical therapy interventions as they appear.

Underlying all the feedback from these national organizations is a shared interest in establishing an effective and convenient means of communicating new research-based knowledge. This message should be welcome news to researchers and their sponsors.

Conclusion

The key point of knowledge translation is to expand the scope and reach of communication activities by researchers who intend for their findings to be applied in practice. The KT process achieves this by identifying the study's relevance to various non-traditional target audiences beyond the peer scholar community and then tailoring the content and format of findings to make them more explicit to each stakeholder group. Knowledge translation is thought to help researchers avoid the barriers to communication that arise from technical jargon, complex terminology, and unintended interpretations. Fewer barriers result in higher levels of knowledge absorption and application by a wider range of potential beneficiaries.

Leading KT proponents recommend that researchers engage stakeholders either during (integrated KT) or after (end-of-grant KT) the research study. This approach may be sufficient for non-oriented research, but technology-based projects funded to generate beneficial socio-economic impacts should engage all relevant stakeholders even before initiating the study (prior-to-grant KT). While it is good to overcome barriers to effective communication, it is even better to avoid creating them.

Researchers who design studies with the socio-economic relevance defined through prior consultation with stakeholders will see more immediate and comprehensive uptake of their findings, than will researchers who must explain to stakeholders the relevance of their findings.

Traditionally, researchers focus more on scientific rigor than on societal relevance. They conduct research that passes the quality criterion set by peer scholars, often producing findings that are only relevant to that circle of peers. However, heightened public expectations for impacts from research – often promised by academic institutions and their lobbyists in response to contracting budget allocations – are changing the rules of accountability. The applied researchers and government agencies monitoring applied programs (e.g., assistive technology research and development), are under increasing pressure to demonstrate their work has social and or economic value. This is a valid requirement for publicly funded programs that exist for the expressed intent of generating beneficial socio-economic impacts. The challenge is in how to communicate effectively with non-traditional stakeholders and then generate evidence that confirms uptake and use of their study outputs by those same stakeholders.

The research community displays a range of responses to this challenge. Some ignore the requirement to communicate more effectively. They view it as overly burdensome or as an unfunded mandate. Many who regard with seriousness the challenges of reaching non-traditional audiences and tracking their use of research findings find it logistically impractical and potentially distracting from their focus on scholarship for professional advancement.

In response to these changing circumstances and challenges, this study explores the potential for national organizations to function as knowledge brokers on behalf of researchers. The study identified non-traditional stakeholders and their affiliations with national organizations, in three topic areas within the technology-oriented field of assistive technology devices and services. The study applied Knowledge Value Mapping techniques to determine the extent to which the identified national organizations valued and used knowledge generated through scientific research projects.

Outcomes and Benefits

The study outcomes answer the three KVM research questions posed at the outset:

Can the results from KVM survey of national organizations in the AAC area (Lane & Rogers, 2011), be replicated in other AT areas and thereby generalized beyond AAC?

Yes, the results are generalizable. Results derived from respondents in the AAC area are consistent with those found in two unrelated Assistive Technology areas. Specifically, national organizations representing the recreational access and wheeled mobility area, reported valuing and engaging research-based knowledge in similar ways. The national organizations consider findings from scientific research studies to be important to meeting their organizations' missions.

They also recognize the material as important to their members, many of whom are non-traditional stakeholder audiences for scientific knowledge. Most organizations report a high degree of respect for scholarly work. However, they avoid paraphrasing research findings. Instead they prefer to obtain summaries of findings directly from researchers, particularly when the summaries point out the utility of findings to organizations and their members.

The KVM survey revealed that the majority of national organizations surveyed here actively generate research, search for new knowledge created by others, and communicate such knowledge to internal staff and external members. They seek new knowledge through traditional scholarly publications, conference proceedings, webcasts, and other print/electronic sources.

These findings suggest that major, largely unexploited opportunities exist for researchers to accomplish the goals of knowledge translation with minimal additional investment of time and effort. By partnering with national organizations to reach the targeted non-traditional audiences, researchers can take advantage of these opportunities.

Are national organizations an appropriate channel for translating and disseminating new research-based knowledge to stakeholder groups from various fields of application?

Yes. Each organization surveyed expressed an interest in working with researchers to better communicate findings relevant to their organization and members. Most of the organizations surveyed target more than one non-traditional stakeholder group for dissemination, which increases the potential return for researchers from the effort they expend to establish ongoing relationships with national organizations. If researchers lead translation and communication efforts, they can efficiently communicate valid, reliable findings to a diverse range of stakeholder groups. Through regular collaboration, researchers could help national organizations enhance their internal capabilities for linking new research-based knowledge to the specific needs of staff or members. That is, researchers can learn how best to adapt their study findings to a partner organization's context, while simultaneously tailoring the material's format, content, and context to increase uptake, absorption, and application by targeted stakeholder audiences.

Are there differences in levels of knowledge engagement for organizations in each of three different areas of assistive technology?

Yes. The survey data detailed in the paper's tables shows different levels of intensity across the six mechanisms for knowledge engagement among the thirteen national organizations that participated in the KVM survey. So, while national organizations do value knowledge they each engage with knowledge mechanisms at different levels and in different ways. These results suggest that individual researchers should identify organizations representing the stakeholder groups most relevant to their own area of study, and then conduct the KVM process with those organizations to know best how to approach them for KT purposes. The results will help researchers tailor their interactions with the identified national organizations, as well as helping tailor the findings to the interests and values of the target stakeholder audiences.

This Knowledge Value Mapping exercise demonstrates that, across at least three application areas within the field of Assistive Technology, national organizations representing various non-traditional stakeholders value research-based knowledge highly. These organizations seek and communicate research-based knowledge that is specifically relevant to their members' interests. And the organizations strive to advance the state of knowledge and the state of practice within their fields.

To expand the scope and reach of their knowledge communication efforts, researchers can partner with national organizations, such as those involved in the KVM survey, as a means to efficiently and effectively disseminate materials tailored to multiple or different target audiences. These materials can be disseminated through white papers, websites, continuing education sessions, professional conferences, and collaborative work with other experts.

By conducting this activity in partnership with national organizations, researchers significantly expand their capacity to share information with a broader range and larger number of potential knowledge users. Opportunities for reciprocal benefits also exist. For example, none of the national organizations report having formal internal programs for systematically tracking and evaluating knowledge use. This is yet another opportunity to engage these organizations. If researchers apply their skills to help create such internal systems, these national organizations could become sources of evidence for knowledge uptake and use among non-traditional stakeholders. This would benefit researchers and sponsors alike because the evidence would meet the growing obligation to demonstrate the value of research findings to society.

This KVM study concludes that national organizations are ready and willing to provide a platform through which researchers can efficiently and effectively communicate their new findings from research studies. Researchers can also receive direct feedback regarding the degree to which their findings are relevant and valuable to a wide range of non-traditional stakeholder audiences. Professional partnerships between researchers and national organizations show great potential value for all parties concerned along with added benefits to society in general.

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References

American Speech-Language Hearing Association. (2008). *Communication facts: Special populations: Augmentative and alternative communication.* Retrieved from http://www.asha.org/research/reports/aac/

Barwick, M. (2011, November). Evaluation use and knowledge translation: An exchange for the future. *Annual meeting of the American Evaluation Association.* Lecture conducted from Anaheim, CA.

Bauer, S.M., & Flagg, J.L. (2010). Technology transfer and technology transfer intermediaries. *Assistive Technology Outcomes and Benefits:*, *6*(1), 129-150.

Beukelman, D.R., & Ansel, B. (1995). Research priorities in augmentative and alternative communication. *Augmentative and Alternative Communication, 11*, 131-134. doi:10.1080/07434619512331277229

Bozeman, B., & Rogers, J.D. (2002). A churn model of scientific knowledge value: Internet researchers as a knowledge value collective. *Research Policy, 31*, 769-94. http://dx.doi.org/10.1016/S0048-7333(01)00146-9

Canadian Institutes for Health Research (CIHR). (2009). *End of grant knowledge translation and integrated knowledge translation.* Retrieved from http://www.cihr-irsc.gc.ca/e/38654.html

Glasgow R.E., Klesges L.M., Dzewaltowski D.A., Estabrooks P.A., & Vogt T.M. (2006). Evaluating the impact of health promotion programs: Using the RE-AIM framework to form summary measures for decision-making involving complex issues. *Health Education Research: Theory & Practice, 21*(5), 688-694. doi: 10.1093/her/cyl081

Glasgow, R.E., Vogt, T.M., & Boles, S.M. (1999). Evaluating the public health impact of health promotion interventions: The RE-AIM framework. *American Journal of Public Health, 89*(9), 1322-7. doi: 10.2105/AJPH.89.9.1322

Graham, I.D., Logan, J., Harrison, M.B., Straus, S.E., Tetroe, J., Caswell, W., & Roninson, N. (2006). Lost in translation: Time for a map? *Continuing Education in the Health Professions, 26*(1), 13-24. doi: 10.1002/chp.47

Lane, J.P. (1999). Understanding technology transfer. *Assistive Technology, 11*(1), 5-19. doi:10.1080/10400435.1999.10131981

Lane, J.P. (2008). Delivering on the 'D' in R&D: Recommendations for increasing transfer outcomes from development projects. *Assistive Technology Outcomes and Benefits*, 1-60. Retrieved from. http://www.atia.org/files/public/ATOBSIF2008.pdf

Lane, J.P., Flagg J.L. (2010). Translating three states of knowledge: Discovery, invention & innovation. *Implementation Science, 5*(9), 1-14.

Lane, J.P., & Rogers, J.D. (2011). Engaging national organizations for knowledge translation: Comparative case studies in knowledge value mapping. *Implementation Science, 6*(106). doi:10.1186/1748-5908-6-106

Light, J.C., Beukelman, D.R., & Reichle, J. (2003). *Communicative competence for individuals who use AAC: From research to effective practice*. Baltimore: Paul H. Brookes Publishing Co.

Louisiana Tech University. (2013). *Seating and Wheeled Mobility*. Retrieved from http://coes.latech.edu/crest/seating-wheeledmobility.php

Matas, J., Mathy-Laikko, P., Beukelman, D., & Legresley, K. (1985). Identifying the non-speaking population: A demographic study. *Augmentative and Alternative Communication, 1*, 17-31. doi:10.1080/07434618512331273491

National Center for the Dissemination of Disability Research NCDDR. (1996). *Dissemination and knowledge utilization*. Retrieved from http://www.ncddr.org/du/products/review/index.html

Office of Management and Budget, Government. (1993). *Performance and results act (GPRA) related materials*. Retrieved from www.whitehouse.gov/omb/mgmt-gpra/index-gpra

Ottoson, J., & Hawe, P. (2009). Knowledge utilization, diffusion, implementation, transfer, and translation: Implications for evaluation. *New Directions for Evaluation Special Issue, 2009*(124), 3-100.

Stone, V.I., & Lane, J.P. (2011). *Measuring reach and uptake of new knowledge from technology innovations. Working Paper I.* Retrieved from http://kt4tt.buffalo.edu/publications/WorkingPapers/Working%20paper%20I.pdf

Stone, V.I., Lane, J.P., Tomita, M.R., Nobrega, A.R., Flagg, J.L., Leahy, J.A., Lockett, M.M., Oddo, C., & Usiask, D.J. (2015). Effectively communicating knowledge to assistive technology stakeholders: three randomized controlled case studies. Assistive technology outcomes and benefits focused issue: knowledge translation and technology transfer in assistive technology, 9(1), 98-160.

Tingus, S.J., Berland, B.J., Myklebust, J., & Sherwood, A. (2004, August). *NIDRR long-range planning update for KDU*. Paper presented at the Knowledge Dissemination and Utilization Projects Meeting: Translating Disability Research into Practice. Pentagon City, VA.

United States Census Bureau. (2005). *Americans with disabilities: 2005*. Retrieved from http://www.census.gov/prod/2008pubs/p70-117.

Appendix

The Knowledge Value Mapping Questionnaire

How does your organization interact with knowledge generated through research studies?

This survey explores how your organization interacts with knowledge generated by research studies. We are profiling multiple national organizations to help researchers understand how to communicate their research findings to people with related interests, and thereby increase the rate at which new knowledge generated through their research studies is used by others. The study is focused on organizations and members interested in rehabilitation and assistive technology devices and services that benefit persons with disabilities.

Name:

Title:

Organization:

NOTE: The survey explores six ways in which your organization may interact with knowledge from research:

1) **Creating Knowledge:** Conducting research internally or funding others to do research for your organization;

2) Identifying Knowledge: searching for research findings that have already been produced by others;

3) Translating Knowledge: paraphrasing research findings to make them more relevant and understandable;

4) Adapting Knowledge: interpreting research findings to improve their fit within your organization's context;

5) Communicating Knowledge: disseminating or demonstrating research findings through various media;

6) Using Knowledge: applying research findings to situations within your organization or membership;

Please answer the following questions to the best of your ability, speaking on behalf of your organization. There will be an opportunity to have questions clarified during our follow-up telephone call.

Question #1. Relative to other activities, how frequently does your organization engage in **Creating Knowledge** through Research activity? That is, conduct or perform your own research or pay/fund others to do research for you? Choose the answer which most closely fits your organization.
[ ] Very Frequently
[ ] Frequently
[ ] Occasionally
[ ] Rarely
[ ] Very Rarely
[ ] Not Applicable – **SKIP to QUESTION #2**

1a) For what purpose are you conducting research or funding research performed by others?

1b) Who conducts the research?
[ ] An internal department or staff member
[ ] An outside service contractor/grantee
[ ] Both an internal department or staff member and an outside contractor/grantee

1c) Who are the main intended users of the research knowledge your organization creates? Please check all that apply.
[ ] Our internal organizational staff
Organizational members who are:
[ ] Clinician/Practitioners
[ ] Consumer/Family
[ ] Policy Makers
[ ] Manufacturer/Suppliers
[ ] Educators/Employers
[ ] Non-members who are (describe below):

Question #2. Relative to other activities, how frequently does your organization engage in **Identifying Knowledge** from Research activity? That is, searching for research findings that have already been produced by others? Choose the answer which you think most closely fits your organization.

[ ] Very Frequently
[ ] Frequently
[ ] Occasionally
[ ] Rarely
[ ] Very Rarely
[ ] Not Applicable – **SKIP to QUESTION #3**

2a) For what purpose or reason is your organization looking for research findings produced by others?

2b) What sources does your organization search when identifying new research knowledge? Please check all that apply.

[ ] Academic Journals (online or print)
[ ] White papers or other in-house reports from other organizations
[ ] Newspapers or Magazines
[ ] Websites
[ ] Trainings or Conference
[ ] Individual Experts
[ ] Other (describe below):

2c) For each source checked in question 2b, please provide names of the specific sources your organization finds credible for providing new research knowledge.

Academic Journals:

Newspapers or Magazines:

Websites:

Trainings or Conferences:

Other: ☐

2d) Please describe any policies or procedures your organization uses to judge the quality of the research findings?

☐

Question #3. Relative to other activities, how frequently does your organization engage in **Translating Knowledge** from Research activity? That is, paraphrasing research findings to make them more relevant and understandable to your organization and members? Choose the answer which you think most closely fits your organization.

- [ ] Very Frequently
- [ ] Frequently
- [ ] Occasionally
- [ ] Rarely
- [ ] Very Rarely
- [ ] Not Applicable – **SKIP to QUESTION #4**

3a) To what extent does your organization typically paraphrase research findings?

☐

3b) Describe the qualifications (training, certificates, experience or education) of the people who are responsible for translating the research findings?

☐

3c) Who does your organization translate research for? Check all that apply.

- [ ] Our internal organizational staff
- [ ] Organizational members who are:
  - [ ] Clinician/Practitioners

    [ ] Consumer/Family
    [ ] Policy Makers
    [ ] Manufacturer/Suppliers
    [ ] Educators/Employers
[ ] Non-members who are (describe below):

3d) Please provide an example of complications that have arisen when your organization translated or paraphrased research findings, and explain how you overcome them?

Question #4. Relative to other activities, how frequently does your organization engage in **Adapting Knowledge** from research activity? That is, interpreting research findings to improve their fit within your organization’s context? Choose the answer which you think most closely fits your organization.

[ ] Very Frequently
[ ] Frequently
[ ] Occasionally
[ ] Rarely
[ ] Very Rarely
[ ] Not Applicable – **SKIP to QUESTION #5**

4a) Please provide some examples of how your organization has interpreted knowledge from research findings to make it fit within the context of your own program or issue?

4b) Why were these adaptations to the existing research findings necessary?

Question #5. Relative to other activities, how frequently does your organization engage in **Communicating Knowledge** from research activities? That is, disseminating or demonstrating research findings through various media? Choose the answer which you think most closely fits your organization.

[ ] Very Frequently
[ ] Frequently
[ ] Occasionally
[ ] Rarely
[ ] Very Rarely
[ ] Not Applicable – **SKIP to QUESTION #6**

5a) What criteria does your organization use to decide which research knowledge is communicated and to whom it is communicated?

5b) What formats does your organization use to distribute research knowledge? Please check all that apply.

[ ] E-mail/Listserv
[ ] Website
[ ] Periodicals (Journals, Magazines, Newsletter…)
[ ] White papers or other in-house reports
[ ] Conference Proceedings
[ ] Conference Presentations/Workshops
[ ] Webcasts/Webinars
[ ] Special Interest Group Interactions
[ ] Other:

5c) Who are the target audiences for your organization's knowledge communication efforts?

[ ] Our internal organizational staff
[ ] Organizational members who are:
    [ ] Clinician/Practitioners
    [ ] Consumer/Family

    - [ ] Policy Makers
    - [ ] Manufacturer/Suppliers
    - [ ] Educators/Employers
- [ ] Non-members who are (describe below):

5d) Please describe any complications or problems that have arisen when your organization has communicated research findings and how you overcame them?

Question #6. Relative to other activities, how frequently does your organization engage in **Using Knowledge** from research activities? That is, apply research findings to situations within your organization or membership? Choose the answer which you think most closely fits your organization.

- [ ] Very Frequently
- [ ] Frequently
- [ ] Occasionally
- [ ] Rarely
- [ ] Very Rarely
- [ ] Not Applicable – **SKIP to QUESTION #7**

6a) Please provide some general examples of how your organization has directly used knowledge from research findings?

6b) What were the sources of that new knowledge? Please check all that apply.

- [ ] Your Organizations own Research (or commissioned/funded research)
- [ ] Academic Journals (Online or not)
- [ ] White papers or similar reports from other organization reports
- [ ] Newspapers or Magazines
- [ ] Websites
- [ ] Trainings or Conference
- [ ] Other (describe below)

6c) Please rate the following five statements in terms of their importance to your organization. Circle or highlight the appropriate importance level 1-5, where 5 = very important and 1 = unimportant.

	Very Important	Important	Moderately Important	Of Little Importance	Unimportant	Not Applicable
a. For my organization, Using Knowledge to create or revise Industry Standards or Clinical Protocols is…	5	4	3	2	1	N/A
b. For my organization, Using Knowledge to produce Laboratory Instruments or Clinical Tools is…	5	4	3	2	1	N/A
c. For my organization, Using Knowledge to develop Freeware such as software to download or instructions for building hardware is…	5	4	3	2	1	N/A
d. For my organization, Using Knowledge to produce New or improved Commercial Devices or Services that will be available in the marketplace is…	5	4	3	2	1	N/A
e. For my organization, using Knowledge for other purposes [described below] is... Please explain: Preparing RFP's and Contracts, Grantee and Contractor monitoring, Communicating to senior policy makers in USDE and other branches of government.	5	4	3	2	1	N/A

6d) Does your organization have a procedure (for example, formal feedback from members; and informal observation of member interactions) for verifying the usefulness of new knowledge? If so, please describe.

6e) Please describe any problems or complications when trying to verify the usefulness of new knowledge.

6f) What information or resources helped your organization overcome these problems?

6g. Please provide one or two specific examples of your organization's use of a new research finding. For each example, include: (i) a detailed description of what the research finding was and how your organization used it; (ii) the source of the research finding and how it was found; (iii) specific groups or individuals who used the new knowledge (internally or externally):

Example 1

(i) Description of finding and how it was used?

(ii) Source of research finding and how found?

(iii) Specific Users of the knowledge:

Example 2

(i) Description of finding and how it was used?

(ii) Source of research finding and how found?

(iii) Specific Users of the knowledge:

Question #7. Please describe any incentives that your organization uses to encourage your internal associates or members to become aware of, or apply new research-based knowledge. Check all that apply.

[ ] Continuing Education Units (CEUs)
[ ] Certification of Completion/Attendance
[ ] Discount on advanced conference registration
[ ] Offering Workshops, Webcasts or Pre-Conference Training
[ ] Other, please describe:

Question #8. How does your organization measure the levels of awareness, interest or application of new knowledge among your members? What is being measured in each case? (For example, post workshop surveys to measure awareness and interest, post conference follow up surveys to measure application)?

Question #9. What percentage of your members have education/training in a research field equivalent to a Masters or Doctoral degree?

____%

Question #10. Can you identify or suggest any ways in which researchers could help your organization facilitate the flow of knowledge from them as the sources, through your organization and out to your members?

Thank you for spending some of your valuable time with our questionnaire. We look forward to receiving your responses by email and to our follow up call to answer any questions and to discuss your organization's engagement with research-based knowledge.

Effectively Communicating Knowledge to Assistive Technology Stakeholders: Three Randomized Controlled Case Studies

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Executive Summary

In healthcare policy and practice, underutilization of knowledge by stakeholders has been a bottle neck in achieving intended end-user benefits from funded research. Knowledge Translation (KT) calls for effective communication of new knowledge to stakeholders as a way of increasing uptake and use of this knowledge. KT poses a unique challenge to R&D projects that generate technology-based new knowledge. The process involves technology transfer (TT) and implies knowledge communication to diverse stakeholders. This paper describes a research project that evaluated the effectiveness of tailor-and-target and target-only approaches designed to communicate new knowledge to multiple stakeholders of Assistive Technology (AT). A series of three randomized controlled studies were conducted focused on knowledge uptake and use respectively by stakeholders in three AT areas: 1) augmentative and alternative communication (AAC); 2) recreational access (RecAcc); and 3) wheeled mobility (WhMob). Each study used the two strategies as interventions that communicated new knowledge. The traditional diffusion method was used as the control. Participants represented five types of stakeholders in each technology area: researchers, clinician practitioners, manufacturers, consumers, and knowledge brokers/consumer advocates.

Method

To develop the intervening strategies, each study selected findings from a peer-reviewed research publication in the respective AT area to be communicated to stakeholders. The *tailor-and-target* strategy tailored the findings to the five types of stakeholders. A contextualized knowledge package (CKP) was developed in five different versions, emphasizing the potential value of the findings to each stakeholder type through concrete examples of how to apply them in their specific living and working contexts, and derive benefit. They were adapted in language and format, reviewed for readability, prepared in print and digital versions, and pilot tested by a representative stakeholder prior to its use as intervention. Additionally, the *tailor-and-target* strategy prepared a tailored webcast to demonstrate application of the findings in the specific stakeholder context, and offered technical assistance upon request. Authenticity of content was maintained by involving the authors of the publications in the development of the CKPs and the webcasts.

For targeted delivery of the material, potential stakeholders were identified by interviewing organizations of their affiliation, and mapping the values and preferences of these stakeholders. The

organizations also helped recruit participants for the studies. The *target-only* strategy used a different approach. The research publication was mailed directly to each individual participant, but without any accompanying tailored material. For targeted delivery, participants were also pre-identified and recruited as described above.

All three studies were eight-months long, and used the same randomized controlled design to evaluate the two strategies. The Level Of Knowledge Use Survey (LOKUS) instrument was developed and used to measure participants' level of knowledge use as evidence of strategy effectiveness. The instrument demonstrated strong validity, reliability, and responsiveness to change. In each study, it identified and placed individuals in one of four levels: Non-awareness, Awareness, Interest, and Use. Participants were assigned randomly to a *tailor-and-target* group, a *target-only* group and a *control* group. All three groups answered the LOKUS instrument three times: at baseline (pretest), follow-up 1(posttest at four months) and follow-up 2 (posttest at eight months). During the interval between tests, the *tailor-and-target* and the *target-only* groups received the corresponding tailored or non-tailored materials as intervention. The *tailor-and-target* group received the CKP in the first four-month interval, and the webcast-plus-technical-assistance-offer in the second four-month interval. The *target-only* group received the research publication in the first four-month interval but nothing afterwards. The control group received no intervention materials at any time.

Responses were analyzed for differences in knowledge use levels among the three groups, using non-parametric statistics. Effectiveness verification included ensuring that changes observed between pretest and posttests in these two groups should surpass testing effect, as detected by any change seen in the control group. Pretest-Posttest data were therefore quantitatively examined to verify the magnitude of these effects. Additionally, data were analyzed separately for the initial four months and the second four months. This allowed for separate and fair estimates of effectiveness of each strategy, given that the *target-only* strategy differed from the *tailor-and-target* strategy in that active intervention occurred in the initial four months, with no additional intervention in the second four months.

Overall effectiveness on the total stakeholder sample including all five types was verified through: 1) within-group analyses to examine pretest–to-posttest changes by each of the three groups; and 2) between-group analyses to examine differences in knowledge use levels among the three groups at each assessment point. Additionally, differential effects on the knowledge use levels of stakeholders were also analyzed. Pretest-to-posttest changes were examined separately for the five types of stakeholder samples.

Sub-analyses of pretest-to-posttest changes included: 1) effectiveness in raising participant awareness by moving them from non-awareness level to the other three levels; 2) effectiveness in persuading non-user participants to move from Non-awareness, Awareness and Interest levels to the Use level; and 3) differential effectiveness of each strategy and its components with the five different stakeholder types.

Results

Participants in the three studies (N_1=207; N_2=288; and N_3=210; where the subscript denotes the first, second, and third studies) represented all five stakeholder types.

The *tailor-and-target* strategy was found effective in all three studies. Pretest-to-posttest changes were significant in the first four months ($p<.001$) but not in the second four months. But changes were significant over the eight-month study period ($p<.001$). The CKP was effective as a stand-alone communication format; the webcast plus offer-of-technical assistance was not. Nor was there any request for technical assistance. Cumulatively however, the strategy was effective.

The *target-only* strategy was also effective in all three studies, based on significant pretest-to-posttest changes in the first four months ($p_1=.001$; $p_2<.001$; and $p_3<.001$). Targeted delivery of the publication was an effective method of communication. No significant change was further observed in the second four months, in any of the three studies, suggesting the adequacy of four months for obtaining the effect.

Thus, each strategy was effective compared to control. But, the difference between the two was not significant at the third assessment point in any study ($p_1=.086$; $p_2=.323$ and $p_3<.615$). Neither strategy was better than the other.

Sub-analyses on awareness-raising corroborated the main results. Over the first four months both strategies effectively moved non-aware participants to awareness, interest and use levels in all three studies ($p_1=.001$; $p_2<.001$; and $p_3=.001$). No further movement was observed in the second four months but the original effect was retained over the total eight-month period in the first study ($p_1<.001$-*tailor-and-target* and $p_1=.001$-*target-only*) as well as in the other two studies ($p<.001$- both strategies).

Both intervention strategies were effective in persuading non-users (i.e., those reporting at the Non-Awareness, Awareness, and the Interest levels at baseline) to use the knowledge, but the results were not consistent across the three case studies. The *target-only* strategy — delivering the original publication to participants — was effective within the initial four-month period across all three case studies ($p_1=.022$; $p_2<.001$; and $p_3<.001$). That is, a significant proportion of stakeholders who reported themselves as non-users at baseline shifted to the Use level four months after receiving the intervention. However, the effect from the *target-only* strategy was not reported as sustained at the Use level at the end of the eight-month period. The results were more complex for the more intensive strategy. The *tailor-and-target* strategy was also effective in persuading non-users to shift to the *Use* level four months after the initial intervention — delivering a plain language summary customized to each stakeholder's interests — but valid only in two of the three case studies ($p_1=.039$; and $p_2<.001$). As with the first intervention strategy, the effect from the *tailor-and-target* was not reported as sustained at the Use level at the end of the eight month period, which was four months after the second intervention — access to customized webcast and offer of technical assistance.

For the stakeholders in these two case studies, the tailored CKPs were persuasive, but the addition of the supplemental webcasts (and technical-assistance-offer) did not help sustain the Use level to the eight-month period, nor was the strategy effective as a whole. Participants in the third case study reported the opposite effect from the intervention strategy. For them, the *tailor-and-target* strategy was not was not significant in moving them to the Use level the first four months, but it was ($p_3<.041$) in the second four months, and also over the total eight-month period ($p_3<.001$). In this third case study, the CKP alone was not persuasive but the addition of the supplemental webcast (and offer of technical assistance) was effective. For this third case study, the *tailor-and-target* strategy as a whole was effective as well. A qualitative assessment of the data for both intervention strategies revealed that overall, the number of individuals reporting a decision to move to the Use level for the knowledge presented — or to maintain the Use level over time — consisted of a very small number of participants across all three case studies.

Discussion

The results supported effectiveness of the two strategies in raising awareness and also in persuading non-users to using the knowledge. Yet the low numbers that changed over time also suggested instability in participants' decisions to use or to maintain such decisions. Contextual and time constraints apart, this points to the user-attributed value to the new knowledge as a factor, and calls for ensuring relevance in the knowledge generation process. Research is needed to clarify effective ways of incorporating user needs in the cycle of a research project.

A limitation of the AT case studies was the lack of provision for a follow-up interview with participants in the design. Learning in-depth about pros and cons of decisions to use the knowledge would have further enlightened the results, which could not be captured well in the self–reported responses of participants and further complicated by recall of information required by repeated testing. Future designs could also include shorter or longer study periods, to know how long after dissemination it is reasonable to expect awareness, interest or use.

Conclusions

Both *Tailor-and-target* and *Target-only* strategies were found to be effective communication methods across the studies, with stakeholders of AAC, recreational access and wheeled mobility technologies. As one strategy was not found to be better than the other, deliberately targeting stakeholders, with or without tailoring the knowledge disseminated, can be said to be an effective method. While the results apparently question the standalone effect of tailoring, significant differential effects were found on stakeholder types that revealed the value of tailoring, especially the CKPs, to specific stakeholder types. Both strategies were clearly effective in raising and sustaining awareness of new knowledge. Results show that the recipient of new knowledge remains the chief arbiter for determining level of use.

This means that investigators need to be as concerned about the relevance of new knowledge to the intended stakeholders, as they are about the scientific rigor of the study itself. At least for those studies that are intended for uptake and use of the new knowledge resulting from scientific research studies. Therefore, new research in knowledge translation should be focused on identifying effective ways to incorporate stakeholder interests and concerns into the knowledge generation process from the outset.

Abstract

Knowledge Translation (KT) proposes to achieve expected benefits for end-users from funded research through effective communication of new knowledge aimed at increased uptake and use by stakeholders. This paper describes a series of three randomized controlled case studies assessing the comparative effectiveness of two interventions designed to communicate new knowledge to members of multiple stakeholder groups: *tailor-and-target* versus *target-only* approaches, as well as comparing them to a control condition of *passive diffusion*. The study participants' level of knowledge use was measured as any of four levels: Non-awareness, Awareness, Interest, or Use, through the validated Level of Knowledge Use instrument. Changes from Pretest to posttest levels were analyzed both for statistical significance and for practical meaningfulness. Across the three studies both intervention were effective with the total samples as compared to control. However, they did not differ from each other suggesting that the added effort involved in tailoring new knowledge might be unnecessary as a general rule. Tailoring appeared to be more effective with some stakeholder types as results showed differential effects between stakeholder groups and across the three studies. The recipient of new knowledge remains the chief arbiter for determining level of use, meaning that relevance is as crucial as rigor in the context of increasing uptake and use of new knowledge from scientific research studies. New research is needed on effective ways for incorporating user needs into the knowledge generation process.

Keywords: research impact, knowledge translation, knowledge use, tailoring, targeting, diffusion, awareness, interest, uptake, assistive technology, LOKUS , randomized, controlled, stakeholders.

Background

The number of Knowledge Translation (KT) efforts has surged in recent years in response to heightening concerns about return on research investment, notably investment in research and development (R&D) projects expressly committed to societal benefits. (Canadian Institute of Health Research, 2013; Sudsawad, 2007). Measures such as the Government Performance and Results Act have led to worldwide concern among scholars about assessing research impact (Donovan, 2011; United States General Accounting Office, 2004; United States Government Printing Office, 2011; United States Office of Management and Budget, 1993; Wholey, Hatry & Newcomer, 2004). As an issue related to research impact, it has long been pointed out that knowledge generated from research is underutilized in practice (Weiss, 1979). Moving research to practice is thus the basic charge for KT. In essence, it calls for effectively communicating new knowledge to interested users as a means of achieving research impact.

The Canadian Institute of Health Research (CIHR) has been the front-runner in taking KT forward as a general solution for all innovative research (Canadian Institute of Health Research, 2013; Sudsawad, 2007). However, the specific context of R&D projects that generate technological innovations is unique and complex. It calls for distinct KT models that involve technology transfer (TT). Including TT in the process invariably signifies close engagement with multiple stakeholders who take knowledge outputs from R&D projects to market in the form of products and services. This step in the process is necessary to ensure that outcomes can impact the beneficiaries who use such devices and services (Lane, 2003). Thus, an integration of KT and TT, or KT for TT, provides the needed conceptual basis for designing KT solutions (interventions) in the case of technology-based R&D projects. The Center on Knowledge

Translation for Technology Transfer (KT4TT), established at the University at Buffalo by the National Institute on Disability and Rehabilitation Research (NIDRR) in 2008, has been addressing the issue of developing KT best practices for technology innovations. As part of its KT intervention research project, this center has since conducted a series of three randomized controlled case studies in AT, which are the focus of this paper. These case studies were carried out during 2009-2012, within three AT areas: (1) augmentative and alternative communication (AAC), (2) recreational access, and (3) wheeled mobility. All three case studies addressed research outputs generated from technology-based R&D projects funded by NIDRR, designed communication strategies to increase uptake of these research outputs by stakeholders, and evaluated these strategies for effectiveness. This paper describes and discusses methods and results from the three case studies.

The context driving the AT case studies is the KT4TT Center's effort to develop KT best-practice models, recognizing a need for these by knowledge producers, such as NIDRR's R&D projects involving AT. Principal investigators of these projects wish to document evidence of impact from their project outputs. They need models which are not only effective in increasing use of new knowledge generated by their projects, but are also practical and easy to implement. Therefore the primary stakeholders of results from the three case studies described in this paper are knowledge producers as described above. On another level, potential users of the new knowledge addressed within each case study form a distinct set of stakeholders. These are knowledge users, and include consumers of AT devices and services (the beneficiaries), manufacturers, clinicians/practitioners, knowledge brokers, policymakers and third-party reimbursers, and other researchers who advance the original research for continued benefits to users. The last five types of stakeholders, together or in some combination, must be involved before the new knowledge reaches beneficiaries in an accessible and usable format, which can then ultimately produce impact. Crucial to the KT for TT process is, at minimum, a strategic communication of knowledge to all stakeholders involved, although it would be ideal to create knowledge for proactively identified needs.

Guiding Concepts

In a recent compilation of scholarly papers on the state of the art in assessing research impact, Donovan (2011) provides an overview of the challenges related to this issue. While knowledge utilization has been recognized as a key indicator of research impact, scholars vary in their interpretation of impacts themselves and the methods and metrics used to measure them. Indicators of impact may be *quantitative*, such as bibliometrics, economic data, and science-technology-innovation indicators. Or they may be *qualitative*, involving narratives that enlighten the quest for broader social benefits. In light of this divergence, there exists a need for both more robust impact-measurement tools and for short-term indicators (Brewer, 2011; Spaapen & van Drooge, 2011). The situation underscores the limited usefulness of generic impact indicators (such as those identified for the macro research context) for application to specific contexts (i.e., R & D projects addressing rehabilitative technologies) where knowledge utilization by the involved stakeholders is a key short-term outcome.

Knowledge utilization has held scholarly attention both in the social sciences and in healthcare. Use of knowledge is implicit in the adoption process described in Rogers' (1983) *Diffusion of Innovations* while KT models have proposed it as a measure of impact that ensues from evidence-based practice (Sudsawad, 2007). The *Knowledge-to-Action* (KTA) model by Graham and colleagues at CIHR conceptualizes knowledge utilization operationally, as it identifies deliberate steps to deliver knowledge to users for whom the knowledge is potentially relevant (Graham, Logan, Harrison, Straus, Tetroe, Caswell, & Robinson, 2006).

It is important to note that views of impact have characteristically been concerned with utilizing existing knowledge rather than creating relevant knowledge by proactively identifying existing user needs. It is often assumed that research will yield impacts, whether as a matter of serendipity or deliberate intervention. "Pushing" existing knowledge for utilization is the embraced solution. When technology is involved, a logical flow of knowledge from research to technology is assumed. However, historically, it has been suggested that technology gives rise to science (Scriven, 2005). A discussion of the issue is beyond the scope of this paper, but we note that alternative "pull" models of technology innovation have also been proposed, which make a case for the creation of knowledge based on pre-identified user needs (Flagg, Lane, & Lockett, 2013; Lane & Flagg, 2010; Stone & Lane, 2012). Notwithstanding, the case studies on KT intervention described in this paper consider the push perspective, given

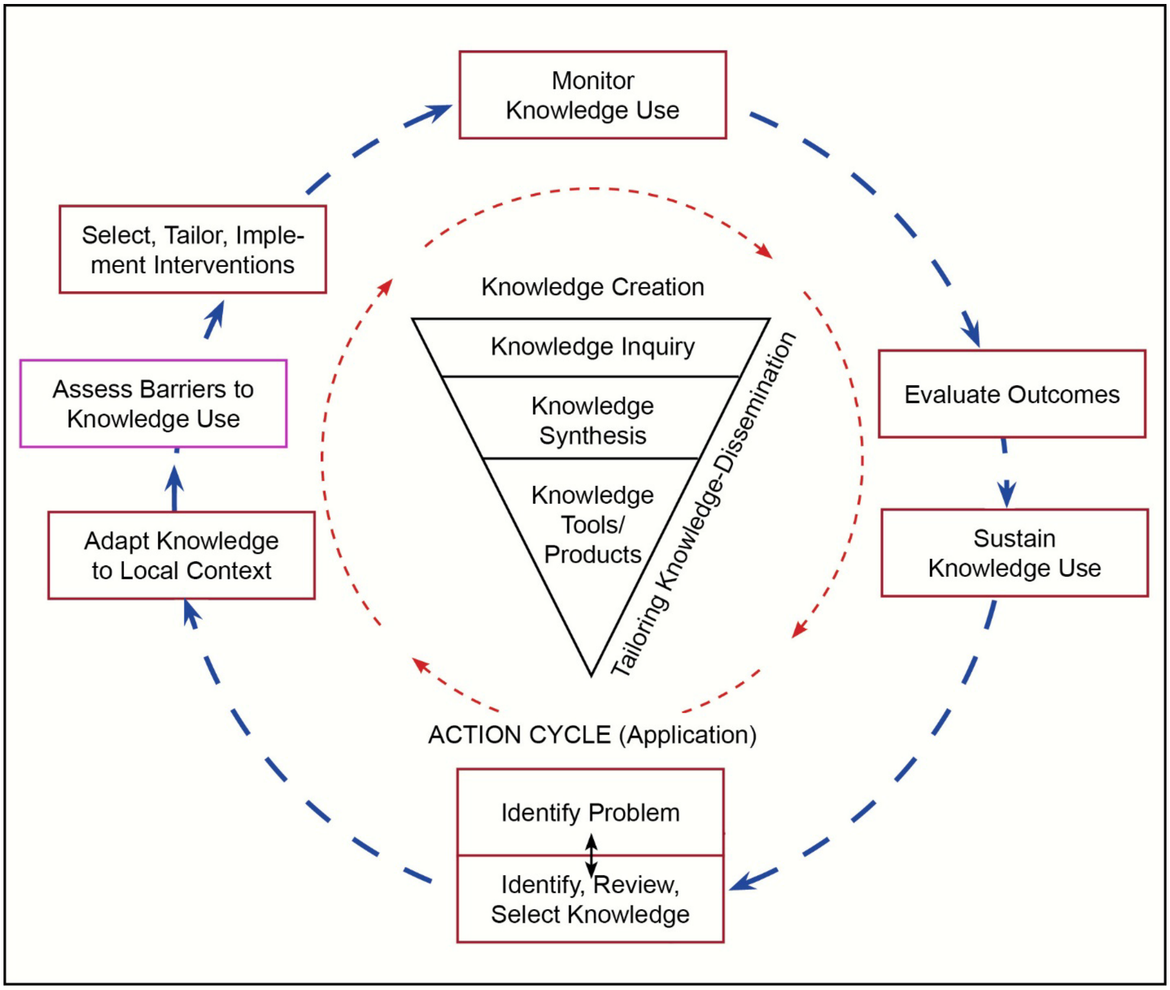

Figure 1. Knowledge-to-Action Model (Adapted from I.D. Graham, J. Logan, M.B. Harrison, S.E. Straus, J. Tetroe, W. Caswell, and N. Robinson, 2006, the *Journal of Continuing Education in the Health Professions,* Vol. 26, No. 1, p. 19. Copyright © 2006, by John Wiley & Sons, Inc. Reprinted with permission.

the urgency of solutions needed for agencies that fund technology-based research to move the accumulated knowledge to the marketplace.

Dissemination or communication of knowledge is key to KT. Its importance has long been recognized by scholars, whether in Rogers' innovation adoption model (1983) or Graham et al.'s KTA model (2006). It is included in the knowledge dissemination and utilization (KDU) efforts by NIDRR through the National Center for the Dissemination of Disability Research (NCDDR). As predecessors to KT in the United States (National Center for the Dissemination of Disability Research, 1996), KDU efforts promoted dissemination to pre-identified audiences, in other words, *targeted* dissemination.

Graham et al.'s (2006) KTA model shown in Figure 1 provided the overall framework for the design of the KT intervention (i.e., knowledge communication) strategies and their evaluation in this case study series. The KTA model consists of two processes: (1) knowledge creation and (2) knowledge application. The knowledge creation process is ongoing. By moving in steps through knowledge inquiry and synthesis, the process yields knowledge outputs in the form of tools and/or products. Tailoring of knowledge dissemination is emphasized within the diagram to convey the importance of tailoring knowledge to the specific context of each knowledge user group. Included in the knowledge application process are seven steps: (1) problem identification and the identification, review and selection of knowledge that can help resolve the problem; (2) knowledge adaptation; (3) assessment of barriers to knowledge use (4) selection, tailoring and implementation of interventions; (5) monitoring intervention and knowledge use by the user; (6) evaluating outcomes; and lastly, (7) sustaining knowledge use. The KTA Model emphasizes the importance of tailoring knowledge to the context of each stakeholder type. The complete KTA intervention can be described as involving *tailored and targeted dissemination* of knowledge, while the first three steps comprise a sub-strategy of *targeted dissemination* of knowledge.

Purpose

The purpose of the three randomized, controlled case studies described here was to evaluate selected knowledge communication strategies for their effectiveness in increasing use of new knowledge by potential users of rehabilitative technologies. Ensuring feasibility of the strategies for use by R&D projects addressing these technologies was also of concern. Research questions investigated both comparative effects of the strategies on five types of stakeholders and differential effects of the strategies on these stakeholder types. Data on knowledge use was collected three times during the eight-month study period: at baseline, at four months (follow-up 1) and at eight months (follow-up 2). It was analyzed using non-parametric tests.

Research Questions

Typically, as research investigators publish their findings and move on to new work, knowledge communication occurs through *passive diffusion*. This raises a question of interest to KT, particularly in the context of Graham et al.'s (2006) KTA model: What is the added value of either of the two strategies – *tailored and targeted dissemination* and *targeted dissemination* – over the traditional *diffusion* strategy? Accordingly, the above three strategies, (1) *tailored and targeted dissemination*, (2) *targeted dissemination*, and (3) *passive diffusion*, comprise the focus of investigation by the three case studies. For this purpose, the three KT interventions for communicating new knowledge are defined as:

1. *Tailored and targeted dissemination* – This refers to publication findings tailored and delivered to targeted stakeholders, through multi-modal channels with the offer of technical assistance. For the sake of brevity, we will refer to this as the *tailor-and-target* strategy.
2. *Targeted dissemination* – This refers to original publication delivered to targeted recipients. It is also referred to hereafter as *target-only* strategy.
3. *Passive diffusion* – This refers to the traditional form of communicating knowledge, and involves no deliberate intervention on the part of the study. It serves as control.

The questions that guided this research were (1) Do differences in effectiveness exist among the three communication methods – *tailor-and-target*, *target-only*, and passive diffusion – in terms of increasing overall levels of knowledge use over time as reported by all stakeholders?; and (2) Are their differences among the stakeholder types regarding change in reported levels of knowledge use over time?

Method Overview

Developing the Intervention: Knowledge Communication Strategies

The *tailor-and-target* and *target-only* strategies were created in three stages. First, researchers selected an innovative research output (peer-reviewed publication) in each of the three AT areas. Second, they identified relevant stakeholders, and third, they generated communication materials in support of the *tailor-and-target* and *target-only* strategies respectively.

Selecting a research output in the three assistive technology areas. In each of the three assistive technology areas, researchers compiled a pool of recent research articles that published new knowledge. A review committee of experts selected one article to represent each area, using the following two selection criteria established by the researchers. The appropriate publication had to have been peer-reviewed (as evidence of quality). It also had to exhibit novelty, feasibility, and utility (as evidence of innovation).

Identifying stakeholders in the three assistive technology areas. The communication strategies were constructed based on presumed stakeholder needs, bearing in mind the potential for knowledge uptake and use. Six generic types of stakeholders were previously identified (Lane & Flagg, 2010): (a) consumers who are the intended beneficiaries of socio-economic impacts; (b) manufacturers of devices and services; (c) practitioners who provide devices and services; (d) brokers such as attorneys or employers; (e) policymakers who regulate provision and payment; and (f) researchers who advance the knowledge base. The six generic stakeholder groups were subsequently defined in the context of each of the three AT areas. National organizations were engaged to identify and recruit participants as described in our prior publications (Lane & Rogers, 2011; Nobrega, et al. 2015). It is important to note that policy makers and implementers were omitted from all three case studies because the project team was unable to recruit a sufficient number of individuals to comprise a study cohort.

Intervention construction. The strategies addressed by the two research questions were structured in the following way for use in each case study.

<u>Tailor-and-target strategy</u>. The strategy involved tailoring the description of the new knowledge selected in each of the three AT areas to the context of each targeted stakeholder type, as well as delivering the knowledge to stakeholders through multimodal channels, as recommended in the literature (Sudsawad, 2007). Contextualized Knowledge Packages (CKPs) were prepared

for each of the specific stakeholder types. These packages aimed to bring out the relevance of the new knowledge to the stakeholder's living and working context. The packages combined the original publication with additional printed materials intended to enhance and illustrate the value of the research findings to the stakeholders' specific work and personal use contexts. Language and format were customized for comprehension and accessibility. The CKPs were both motivational and persuasive. They highlighted the relevance and value of applying the knowledge to stakeholder context. All CKPs were in print format, including textual and graphical content. Each CKP consisted of: (a) an introduction to the identified problem/need area addressed by the selected research article; (b) a summary of the research findings and the potential beneficial impacts of the findings as a solution to the identified problem/need area; (c) additional opportunities and resources for use of the new knowledge; and (d) a CD that included all of the printed components of the CKP to account for accessibility needs. The CKPs were mailed to participants during the first four months of the study period.

To further represent the *tailor-and-target* strategy, the CKP was combined with a tailored webcast for training through multimodal communication of the new knowledge. The participants received an electronic link via e-mail to view the webcast for ease of access during the second four-month period. Closed-captioning was available for each webcast to ensure that all viewers could utilize the information. The webcasts provided a visual and auditory platform in which stakeholder audiences could absorb the new knowledge in

Table 1
Randomized Controlled Pretest-Posttest Design for Evaluating Knowledge Communication Strategies

Group	Publication	Baseline Measure	Intervention (4 Months)	Follow-up 1	Intervention (4 Months)	Follow-up 2
T_1	A	O	$X1_a$	O	$X1_b$	O
	B	O		O		O
	C	O		O		O
T_2	A	O	X_2	O	----	O
	B	O		O		O
	C	O		O		O
Control	A	O	----	O	-----	O
	B	O		O		O
	C	O		O		O

Note: The letter O stands for observations made via the Level Of Knowledge Use Survey instrument administered to participants. A, B, and C denote three published findings included as objects of queries in the instrument. T_1 represents the treatment group exposed to the tailor-and-target intervention, which focused on Publication A. $X1_a$ and $X1_b$ represent the two components of this intervention. $X1_a$ consisted of a contextualized knowledge package. $X1_b$ consisted of a webcast and a message about availability of technical assistance. T_2 represents the treatment group exposed to the target-only intervention, which also focused on Publication A. X_2 denotes this intervention, in which participants received Publication A with no tailoring. Control represents the group that received neither intervention but was assumed to be exposed to passive diffusion.

an alternative modality. Similar to the CKPs, all webcasts introduced an identified problem/need area, the published research findings as a potential solution to the problem, and a call to action, urging the stakeholders to put the new knowledge into use.

In addition, participants could request technical assistance for knowledge implementation by contacting the KT4TT Center. Participants assigned to the *tailor-and-target* group had no obligation to read the CKP, view the webcast or request technical assistance, as conditions for participating in the study. Their only obligation was to complete the *Level Of Knowledge Use Survey* (LOKUS), a web-based measure of self-reported knowledge use, when prompted (Stone, Nobrega, Lane, Tomita, Usiak & Lockett, 2014).

For quality assurance purposes, the project team generated all material for the *tailor-and-target* strategy in close consultation with the authors of the research publications. This ensured fidelity in interpreting the published findings. It also captured the authors' depth of experience in their respective fields within the three AT areas. In addition, the CKPs in draft form were pilot-tested by individuals representing each of the stakeholder types.

Target-only strategy. Unlike the tailor-and target strategy, the *target-only* strategy involved no tailoring. However, it involved targeting members of each stakeholder type assigned to that treatment condition to receive a copy of the original publication along with a cover letter from the author of the publication. The publication and cover letter were mailed directly to the participants during the first four-month period of the study. The participants received no study-related material during the second four-month period. As with the *tailor-and-target* group, participants had no obligation to read the publication or letter as a condition of participation in the study.

Passive diffusion. The control group received no materials during the course of the study, but simply answered the LOKUS instrument at the designated intervals. This group controlled for any substantial changes in level of knowledge use caused by variables other than the interventions during the eight-month study period, except possible previous exposure to the research knowledge through diffusion.

Evaluating Effectiveness of the Knowledge Communication Strategies

Research Design

The three strategies, *tailor-and-target*, *target-only* and passive diffusion used for communicating new knowledge, were evaluated using a randomized, controlled pretest-posttest design. This design is summarized in Table 1.

Procedures

Eligible candidates who fulfilled inclusion criteria were randomly assigned to one of three groups: Treatment Group 1 (T1); Treatment Group 2 (T2); Control Group (C). Those who returned the demographic and consent forms became study participants. Data were collected by the web-based LOKUS instrument, which participants accessed through Vovici, an online software program (Vovici Corporation, 2011). Participants received a link to the baseline survey via e-mail. Four months after completing the baseline survey, participants received a link to the same survey (follow-up 1). Four months after completing the survey a second time, they received a link to complete the survey a third time (follow-up 2). Additionally, the selected publication was mailed to the T_1 group along with the appropriate CKP two to three weeks after baseline testing. However only the published article was mailed to the participants in the T_2 group. During the second four months each participant in the T_1 group received an electronic link to view a tailored webcast specifically designed for the participant's stakeholder type. This occurred nine to ten weeks after they answered the follow-up 1 survey. Participants in the T2 group received no study-related material during this four-month period. During the study, phone calls, reminder e-mails, and additional mailings were sent to survey non-respondents and to individuals who misplaced or discarded materials. Efforts were made to keep participant contact information current. All participants were compensated.

Sampling

Sample size was determined by power analysis based on a prior research publication in the literature (Miller & Spilker, 2003). Considering a power of .80 at an alpha of .05 for an effect size of .24, an *N* of 206 was needed for each of the case studies. For all three case studies, anyone who qualified under the stakeholder definitions relevant to the selected AT area was considered for inclusion. Only individuals 18 years of age or older at assessment were included.

Data Analysis

Effectiveness of the tailor-and target and *target-only* strategies was investigated conducting both *between-group* and *within-group* analyses. Between-group analysis compared the three groups for statistical differences at the three time points. The within-group analysis focused on each group and studied changes in knowledge use levels across the three assessments. Such changes were further analyzed by grouping data in relevant ways. For example, two challenges to KT are (a) reaching (i.e., getting information to) dispersed stakeholders and raising awareness, and (b) getting the stakeholders to actually use the knowledge. The capacity of the strategies to raise awareness was studied by observing frequency changes from the Non-awareness level to all other levels grouped together. Researchers grouped the first three levels of (Non-awareness, Awareness, and Interest) as Non-use. Then they studied changes from this level to the fourth level (*Use*) indicated the extent to which the strategies influenced non-users to actually apply the knowledge.

Data gathered in this investigation consisted of participant frequencies within the four knowledge use levels as measured by the LOKUS instrument. They were essentially nominal although the levels themselves could be considered ordinal. This limited the applicability of parametric statistical tests for analysis. The chi-square statistic was used to test the association between groups and knowledge use levels of participants at any given time point. Kruskal-Wallis one-way ANOVA and the Wilcoxon signed-rank test were used for comparing groups at and across time points on overall knowledge use, assuming the knowledge use levels to be sequential (ordinal). The McNemar test was used for identifying significant changes in knowledge use levels of interest over time (before-after comparisons) in each group. Data were also qualitatively examined to interpret statistically significant results in lieu of their practical significance. Conclusions about strategy effectiveness were guided by two considerations. One, for any significant pretest-to-posttest change observed in T_1 and T_2 groups to be considered true effectiveness, the change should surpass any change seen in the control group, which might reflect an effect due to repeated testing. Two, because active intervention by the *target-only* strategy occurred (through targeted delivery of the published new knowledge) during the first four months of the study period, with no additional intervention during the second four months, any significant changes over the first four months would be a fair indicator of effectiveness of the *target-only* strategy. Additionally, the self-reporting nature of participant responses as well as the requirement to recall facts in repeated

Table 2
Sample Size and Distribution in the Three AT Case Studies

		Case One: the AAC technology study				Case Two: the RecAccess technology study				Case Three: the WhMob technology study			
		Groups				Groups				Groups			
		T_1	T_2	C	Total	T_1	T_2	C	Total	T_1	T_2	C	Total
Stakeholder Type	Broker[§]	23	23	19	65	13	13	14	40	11	7	13	31
	Therapist/ Practitioner[†]	13	15	17	45	19	21	21	61	20	19	20	59
	Industry/ Manufacturer	11	8	7	26	21	16	21	58	17	13	15	45
	Researcher	8	7	6	21	21	22	22	65	7	6	8	21
	Consumer	17	19	14	50	23	21	20	64	17	20	17	54
	Total	72	72	63	207	97	93	98	288	72	65	73	210

Note: T_1 represents the treatment group exposed to the tailor-and-target intervention; T_2 represents the treatment group exposed to the target-only intervention; C represents the control group that received neither of the above interventions, but presumed to be exposed to passive diffusion.

[§] Brokers were represented by college disability service coordinators in Case One; by advocates of independent living in Case Two; and by nurses in Case Three.

[†] Therapists were represented by clinicians in Cases One and Three; and by physical therapists in Case Two.

responses were considered as sources of any possible response distortions.

The three individual case studies are presented in the Appendix which details the methods and results related to each one. All three cases replicated the design and procedures described earlier. They varied slightly depending on the AT area they addressed and on the corresponding stakeholders to whom the knowledge was communicated. The next sections present a cross synthesis of results from all thee case studies and discuss implications for KT and for AT outcomes and benefits.

Synthesis of Results

This foregoing sections of the paper described the rationale and the method overview for the KT4TT project that conducted three case studies in AT, all of which evaluated the *tailor-and-target* and *target-only* strategies to communicate knowledge to multiple stakeholders. These strategies were designed to communicate new knowledge generated by technology-based R&D projects. Each case study focused on a specific rehabilitation technology area: Case One, on AAC; Case Two on RecAccess; and Case Three on WhMob. All three studies replicated a randomized controlled design, which compared groups T_1 and T_2 exposed respectively to *tailor-and-target* and *target-only* strategies to a control group C presumably exposed to passive diffusion that is

Table 3
Overall Effectiveness of Strategies in the Three AT Case Studies: Pretest-to-posttest Changes in Knowledge Use levels (Within-Group analyses)

		Pretest-posttest period		
Case Study	Group	First four months (Baseline to Follow-up 1)	Second four months (Follow-up 1 to Follow-up 2)	Total study period - 8 months (Baseline to Follow-up 2)
Case One: AAC TECHNOLOGY (N=207)§	T_1	$Z=3.826$ ($p_1<.001$)	$Z=0.620$ ($p_1=.536$)	$Z=4.297$ ($p_1<.001$)
	T_2	$Z=3.330$ ($p_1=.001$)	$Z=0.28$ ($p_1=.780$)	$Z=3.206$ ($p_1=.001$)
	C	$Z=0.992$ ($p_1=.321$)	$Z=1.516$ ($p_1=.130$)	$Z=2.100$ ($p_1=.036$)
Case Two: RECREATIONAL ACCESS TECHNOLOGY (N=288)§	T_1	$Z=5.318$ ($p_2< .001$)	$Z=0.118$ ($p_2=.906$)	$Z=5.089$ ($p_2 < .001$)
	T_2	$Z=4.174$ ($p_2< .001$)	$Z=1.132$ ($p_2=.895$)	$Z=4.453$ ($p_2<.001$)
	C	$Z=2.428$ ($p_2=.015$)	$Z=0.41$ ($p_2=.967$)	$Z=2.538$ ($p_2=.011$)
Case Three: WHEELED MOBILITY TECHNOLOGY (N=210)§	T_1	$Z=3.656$ ($p_3<.000$)	$Z=-2.156$ ($p_3=.031$)	$Z=4.741$ ($p_3<.001$)
	T_2	$Z=3.83$ ($p_3<.001$)	$Z=1.115$ ($p_3=.265$)	$Z =3.209$ ($p_3<.001$)
	C	$Z=2.493$ ($p_3<.013$)	$Z=1.534$ ($p_3=.125$)	$Z=3.842$ ($p_3<.001$)

Note: T_1 represents the treatment group exposed to the tailor-and-target intervention; T_2 represents the treatment group exposed to the target-only intervention; C represents the control group that received neither intervention but was presumed to be exposed to passive diffusion.
§Sample includes all five stakeholder types.

typically used for knowledge communication. The results from each AT case study are individually presented, summarized and discussed in the Appendix. This section synthesizes results across all three case studies, followed by a discussion of their overall implications for implementing KT.

Participant samples in each of the three cases ($N_1=207$; $N_2=288$; and $N_3=210$) included five types of stakeholders. Table 2 describes sample distribution by case study and by stakeholder type.

As described under the method overview, temporal changes in the knowledge use levels of participants as measured by the LOKUS instrument was the indicator of strategy effectiveness. Responses were analyzed in two ways. Between-group analyses looked for differences in knowledge use levels among the T_1, T_2, and C groups, checked separately at the three assessment points: at baseline, at four months, and at eight months. Within-group analyses looked for changes knowledge use levels over time, from baseline to four months to eight months, and checked each of the T_1, T_2, and C groups separately. As data mainly consisted of frequencies and percentages, significance of results were based on non-parametric statistics. As described earlier, the results were further reviewed for practical significance through qualitative examination of data. In drawing conclusions about strategy effectiveness, two considerations guided interpretation of results: 1) for a significant effect to be considered true or valid, changes observed between pretest and posttests in T_1 and T_2 groups should surpass any change seen in the control group, which might reflect an effect due to repeated testing; and 2) significant changes over the first four months of the study period were a fair indicator of effectiveness of the *target-only* strategy, given that active intervention (through targeted delivery of the published new knowledge) occurred during this period, and no additional intervention was provided during the second four months. An additional consideration was possible response distortion introduced by the self-reporting nature of participant responses and the requirement to recall facts in repeated responses.

Overall Effectiveness of the Strategies

Table 3 presents results related to temporal changes in knowledge use levels of participants synthesized across all three case studies, for all three communication strategies. The results refer to overall effects on the collective sample of five stakeholder types. As the table shows, both *tailor-and-target* and *target-only* strategies were found effective in all three case studies. Pretest-to-posttest changes were significant in the first four months (p<.001), as well as over the eight-month study period (p<.001) in the case of the *tailor-and-target* strategy. Thus, the CKP was an effective format and the strategy as a whole was also effective. In the case of the *target-only* strategy, there were significant pretest-to-posttest changes (p_1=.001; p_2<.001; and p_3<.001) across all three studies and over the first four-month period, when active intervention had occurred through targeted delivery of the publication. Thus the *target-only* strategy was also shown effective.

Table 4 presents results for the overall effectiveness of the strategies through between-group analyses, comparing the three strategies at each assessment point. Although within-group analyses found both strategies effective compared to control, the between-group analyses found they were not significantly different from each other in any of the three studies (p_1=.086; p_2=.323 and p_3<.615). Neither strategy could be considered more effective than the other for the collective sample of five stakeholder types. Note that both strategies targeted their audience to deliver intervention material, hence tailoring was what differentiated one strategy from the other. The above result then suggests that tailoring new knowledge does not have a stand-alone effect on a sample representing multiple stakeholder types. How cost effective is it then for principal investigators to engage in contextualizing knowledge outputs from their projects beyond an effort of pre-identifying dissemination targets? The next set of results clarify this issue by breaking down the total sample by stakeholder type, to view how tailoring or not tailoring benefited each type of stakeholder.

Strategies and Stakeholder Types: Differential Effects

Results showed that the two strategies were differently effective with different stakeholder types, both within the same case study and also across the three case studies. In interpreting these differences across studies, it is to be considered that the new knowledge presented to the stakeholders could be a factor, since it differed from case to case. First, the state of specific research findings at the time of dissemination and therefore their level of abstraction varied from case to case, along the continuum of a highly abstract concept to a concrete, ready-to-use product. This, together with the stakeholder's own interest in the findings, possibly determined how much of a ready appeal the knowledge held for immediate application in practice. It could be therefore argued that a stakeholder sufficiently interested in the knowledge would find the research publication alone sufficiently motivating, whereas tailoring as an additional persuasive force would be valuable where application of the knowledge in stakeholder context is not straightforward or readily apparent. In other words, the *target-only* strategy would be able to move up knowledge use by some stakeholder types while the *tailor-and-target* strategy would

Table 4
Effectiveness of Strategies in the Three Case Studies: Difference in Knowledge Use Levels at Three Assessments (Between-group analyses)

Case Study	Groups	Assessment		
		Baseline	Follow-up 1	Follow-up 2
		χ 2 (*p*=)	χ 2 (*p*=)	χ 2 (*p*=)
Case One AAC TECHNOLOGY (n= 207)§	T_1, T_2, & C	5.291 (0.507)	6.917 (0.329)	14.013 (0.029)*
	T_1 vs. T_2	.976 (-0.807)	1.352 (-0.717)	6.584 (-0.086)
Case Two RECREATIONAL ACCESS TECHNOLOGY (n=288)§	T_1, T_2, & C	5.722 (0.455)	32.672 (<.001)*	32.672 (.001)*
	T_1 vs. T_2		6.590 (0.086)	3.481 -0.323
Case Three WHEELED MOBILITY TECHNOLOGY (n=210)§	T_1, T_2, & C	6.865 (-0.333)	20.605 (-0.002)*	4.550 (-0.603)
	T_1 vs. T_2		1935.5 (-0.06)	2189.00 (.479)

Note: T_1 represents the treatment group exposed to the tailor-and-target intervention; T_2 represents the treatment group exposed to the target-only intervention; C represents the control group that received neither intervention but was presumed to be exposed to passive diffusion.
§Sample includes all five stakeholder types.

be beneficial, hence cost effective, with other types of stakeholders.

Of particular relevance to principal investigators who wish to undertake tailored dissemination is the effectiveness of the *tailor-and-target* strategy with clinicians/therapists in all three case studies (p_1=.023, p_2=.016 and p_3= .023). These are practitioners who seek out evidence (new knowledge) to guide their practice, and hence a major set of stakeholders. Tailoring in general seems a worthwhile strategy. In particular, the CKP format may be a choice to consider, which was effective (p_2=.005) in the second case study and addressed recreational environment accessibility. On the other hand, the *target-only* strategy was effective with these stakeholders (p_3=.011) in the third case study on WhMob. Clinicians/ prescribers in this area benefitted both from tailored and non-tailored material about tilt-in-space behavior of power wheelchair users – a result that is consistent with their vested interest in the new knowledge and its direct appeal for ready application.

The *tailor-and-target* strategy was effective also with industry/manufacturers in all three case studies (p_1=.016, p_2=.016 and p_3=.040), in particular the CKP (p_2=.010) in Case Two, the RecAccess study. These form another major stakeholder set, whose role is to transform conceptual knowledge into a concrete prototype state in the KT for TT process. These stakeholders benefitted from tailoring related to the new AAC vocabulary set, the recreational accessibility instruments as well as the tilt-in-space behavior of power wheelchair users, in particular persuaded by the CKP about the recreational environment accessibility instruments. The *target-only* strategy was effective with these stakeholders in Case Two, the RecAccess study both at 4 months (p_2=.010) and at eight months (p_2=.007), suggesting interest of these stakeholders in the knowledge and its ready appeal for application by them. In this study, then, tailoring was effective as an additional motivator.

Consumers are important stakeholders of technological innovations, and direct beneficiaries of the KT for TT process. The *tailor-and-target* strategy was effective with these stakeholders in all three studies (p_1=.024, p_2=.006 and p_3=.014), including in particular, the CKP over the first four months (p_1= .017, p_2=.026 and p_3= .024). The *target-only* strategy was also effective with these stakeholders in the first and third case studies (p_1=.013 and p_3=.038) in AAC and WhMob technologies respectively. It suggests their vested interest in the new AAC vocabulary set and tilt-in-space behavior of power wheelchair users. Tailoring was valuable as an additional motivator for these stakeholders in these two cases, whereas it seems to be a needed motivator in the case of the environment accessibility instruments.

Interestingly, neither of the two strategies was effective knowledge brokers in Case One, the AAC study or Case Two, the RecAccess study. Neither the disability service coordinators for college students with disabilities in the AAC study, nor the advocates for independent living of persons with disabilities in the RecAccess study appear to be sufficiently motivated by either strategy. However, the professionals that represented brokers in Case Three, the WhMob study, who were nurses that cared for wheelchair users, were influenced both by the *tailor-and-target* strategy (p3=.007 at four months and p3=.039 at eight months) and by the *target-only* strategy (p3=.034 at four months). While choice of the professional group to represent brokers might be a factor, the results nonetheless suggest that nurses had a vested interest and found ready applicability of the knowledge found in Sonenblum's findings.

Interestingly too, neither of the two strategies had an effect on researchers in Case One, the AAC study or Case Three, the WhMob study;

but both strategies were effective on these stakeholders at four months (p_1=.011; p_3=.038) as well as at eight months (p_1=.038; p_3=.014). This suggests the vested interest of researchers in the AIMFREE instruments as well as the value of tailoring knowledge for them as additional motivation/persuasion.

It should be noted that the between-group analyses among T_1, T_2 and C groups in the WhMob study (See Table 4) registered no overall significance for the total sample of all five stakeholder types. This could be explained by the significant testing effect registered by the control group, large enough to obscure the effect of the *tailor-and-target* and the *target-only* strategies. In turn, a possible explanation of this large testing effect is offered by the differential effects analyses between stakeholder types in this study presented earlier

Table 5
Raising Stakeholder Awareness: Pretest-to-Posttest Changes in the Three Case Studies (Within-Group Analyses)

Case Study	Group	Pretest-posttest period: First four months (Baseline to Follow-up 1)	Second four months (Follow-up 1 to Follow-up 2)	Total study period - 8 months (Baseline to Follow-up 2)
		Exact Sig (2-sided p=)	Exact Sig. (2-sided p=)	Exact Sig. (2-sided p=)
Case One: AAC TECHNOLOGY (n=207)§	T_1	0.001*	0.815	<.001
	T_2	0.001*	1.000	0.001
	C	0.001*	0.267	0.035
Case Two: RECREATIONAL ACCESS TECHNOLOGY (n=288)§	T_1	< .001*	1.000	< .001
	T_2	< .001*	0.607	< .001
	C	0.016*	0.332	0.002
Case Three: WHEELED MOBILITY TECHNOLOGY (n=210)§	T_1	<.001*	1.000	<.001
	T_2	<.001*	1.000	<.000
	C	<.027*	1.000	<.027

Note: T_1 represents the treatment group exposed to the tailor-and-target intervention; T_2 represents the treatment group exposed to the target-only intervention; C represents the control group that received neither intervention but was presumed to be exposed to passive diffusion.
§Sample includes all five stakeholder types.

in this section. In particular, the source seemed to be the clinician/prescribers and the industry/manufacturers samples in the control group, who registered a significant effect.

Raising Stakeholder Awareness

It was noted earlier that a challenge to KT for TT, at the very basic level, is to reach stakeholder individuals with diverse expertise and part of a widely distributed stakeholder population group. Raising their awareness level is an important step before persuading them to uptake and apply the new knowledge. Given that both *tailor-and-target* and *target-only* strategies were effective with total sample of all five stakeholder types, how good were they at reaching non-aware stakeholders and raising their awareness level? In response, Table 5 presents results of within-group analyses

Table 6
Moving Non-Users to The Use Level: Pretest-to-Posttest Changes in the Three AT Case Studies (Within-Group Analyses)

Case Study	Group	Pretest-posttest period: First four months (Baseline to Follow-up 1)	Second four months (Follow-up 1 to Follow-up 2)	Total study period - 8 months (Baseline to Follow-up 2)
		Exact Sig. (2-sided *p*=)	Exact Sig. (2-sided *p*=)	Exact Sig (2-sided *p*=)
Case One: AAC TECHNOLOGY (N=207)§	T_1	0.039	0.549	0.063
	T_2	0.022	0.625	0.092
	C	1.000	0.227	0.18
Case Two: RECREATIONAL ACCESS TECHNOLOGY (N=288)§	T_1	< .001	0.804	< .001
	T_2	0.001	1.000	0.001
	C	0.25	0.687	1.000
Case Three: WHEELED MOBILITY TECHNOLOGY (N=210)§	T_1	<.004	<.041	<.000
	T_2	<.001	0.481	<.021
	C	<.027	0.307	<.001

Note: T_1 represents the treatment group exposed to the tailor-and-target intervention; T_2 represents the treatment group exposed to the target-only intervention; C represents the control group that received neither intervention but was presumed to be exposed to passive diffusion.
§Sample includes all five stakeholder types.

performed by each of the three case studies, on the total sample re-grouped for the purpose. Both strategies effectively moved non-aware participants to awareness, interest and use levels in all three case studies. The effect was observed at four months and was retained over the total eight-month period. The CKP of the target-and-tailor strategy was effective in Case One, the AAC study (p_1=.001), in Case Two, the RecAccess study (p_2<.001) and in Case Three, the WhMob study (p_3=.001). The cumulative strategy effect at eight months was also significant in all three cases (p_1<.001; p_2<.001; and p_3<.001). The *target-only* strategy also effectively raised awareness in all three case studies at four months (p_1=.001; p_2<.001; and p_3=.001). The awareness was maintained at eight months in all three case studies (p_1=.001; p_2<.001 and p_3<.001). Both strategies were effective in raising and sustaining awareness in all three cases.

Persuading Non-users to Use the Knowledge

Persuading stakeholders to apply the new knowledge once they become aware of it and interested in using it is a challenging yet crucial step in KT for TT. Table 6 summarizes the effects of *tailor-and-target* and *target-only* strategies in this regard found across the three case studies. The within-group analyses were performed on the total sample of stakeholders re-grouped to investigate how “non-users” (i.e., those at non-awareness, awareness or interest levels) moved to the Use level (i.e., decided to use the knowledge or maintained such a decision).

Both strategies showed significant effects in moving non-users (i.e., individuals who were non-aware, aware or interested) to the Use level, but the results were not consistent across the three studies. In this regard, both *tailor-and-target* and *target-only* strategies were effective in the initial four-month period in Case One, the AAC study (p_1=.039; p.032), and also in Case Two, the RecAccess study (p_2=.001 for both strategies). But the effect was not retained beyond that point. Same results were observed also in Case Three, the WhMob study, but only for the *target-only* strategy (p_3<.001). The *tailor-and-target* strategy did not move non-users to the Use level initially, but did so over the total eight-month period (p_3<.001). All the same, qualitative examination from the viewpoint of practical significance revealed that data from all three studies consistently showed only a small number of individuals who either decided to use the knowledge or maintained such a decision. For example, about 30 percent of participants in this second case study moved up from Non-awareness levels, whereas about 15 percent of non-users moved up to use levels (i.e. from “knowing” to “acting”).

Discussion

The foregoing results demonstrate the relative challenge of getting non-users to initiate and sustain use compared to raising and sustaining their awareness level. Utility to stakeholder was assumed to be implicit in the knowledge, with the expectation that targeting stakeholders based on best match to their presumed need for the knowledge will result in its automatic uptake. However, to assume automatic uptake after the stakeholder gains awareness and interest is to ignore external conditions and barriers (i.e., funding, reimbursement, and other factors) that one may be faced with (Leahy, 2003).

More importantly, it underscores the importance of ensuring relevance in the knowledge being generated. While uptake and use of new knowledge remains a challenge, it appears that one likely, yet widely overlooked, source of such challenge lies in the lack of perceived utility (relevance) of the new knowledge by the intended user. If stakeholders’ perceived utility of value determines their decision to invest the time and energy for implementing knowledge use – beyond awareness and even interest – then the presumption of utility may be the persistent barrier to knowledge uptake and use. The knowledge creator's approach to communicating new knowledge becomes secondary to the recipient's perception of relevance. In the context of knowledge production for technology innovation, Lane & Flagg (2010) strongly argue for establishing a prior-to-grant approach as a third option under the Knowledge to Action Model, where stakeholder needs would be validated prior to initiating any technology-based R&D projects for increased likelihood of knowledge uptake (Lane & Flagg, 2010).

Differential Effects on Stakeholders and Perceived Validity of New Knowledge

Principal investigators of R&D projects who wish to undertake contextualized tailoring may also note the presence of differences in the level of beneficial effects for different stakeholder types. As noted earlier, the value of tailoring may vary across stakeholder types, depending on the instrumental utility of the knowledge as perceived by the specific stakeholder. Although all three studies presented and discussed in this paper followed the same randomized controlled design and replicated similar protocols, they still represented three individual case studies, and were singular in that they addressed specific research findings of possible interest to certain stakeholder types and not others, both because of presumed contextual relevance and because of feasibility of adoption. Research outputs from NIDRR grantees typically differ with respect to whether they are intended as commercial products/services, hardware instruments/tools, freeware, or guidelines and protocols, and devices. The research output in Case One, the AAC study was the new AAC vocabulary set was available in the form of downloadable freeware, and therefore of free access. Within the concept of age-appropriate vocabulary, the innovative vocabulary set was concrete enough for industry and clinicians to match the set with icons and graphical images to create applications. The instrumental utility was readily apparent at least for simple AAC devices such as communication boards, if not for more sophisticated devices. The findings or new knowledge in Case Two, the RecAccess study was tied to an instrument/tool output, the AIMFREE being available in two administration versions - print and computer. Its instrumental utility was also straightforward to stakeholders because of its sufficiently concrete, prototype format. The findings in Case Three, the WhMob technology study, was conceptual knowledge about tilt-in-space behavior of power wheelchair users, a research output useful within the context of clinical guidelines and protocols. The findings revealed the importance of compliance with appropriate tilt-in-space guidelines, yet lack of it, by wheelchair users. This piece of knowledge, as urgent and important as it was to consumers in relation to health and quality of life, and as significant to clinicians in terms of evidence based practice, was yet not so straightforward to manufacturers and researchers in terms of instrumental utility and immediate application, although they were also among the intended users. This in fact corroborates the differential effects presented earlier on stakeholders in this case study.

The foregoing observations suggest that communication effectiveness may not only be a function of specific stakeholder types, but also of the singularities of each knowledge output that dictate their appeal and utility to these stakeholders. Further research is needed to enlighten the relation between the specific knowledge outputs and stakeholder types. All the same, it points to the difficulty in generalizing across case studies that address unique and different research outputs, even though they replicate the same study protocols to investigate intervention effectiveness.

Relevance versus rigor in knowledge generation. As noted earlier, an issue closely related to the value or utility of the knowledge as perceived by the stakeholder is that of when and how to ensure knowledge relevance in the knowledge generation process. Graham et al's (2006) knowledge-to-action model that provided the basis for the KT strategy evaluation in the three case studies viewed KT as occurring either at the end of knowledge generation (end-of-grant KT) or during knowledge generation (integrated KT) while Lane & Flagg (2010) argued for prior-to-grant KT where the need for knowledge generation itself would be determined by the value of the knowledge to the user. All the same, relevance of new knowledge is a critical part of knowledge generation. Typically however, in their pursuit of valid and reliable cause and effect relations, research endeavors are faced with the challenge of balancing scientific rigor with problem relevance. In this context, it may be worthwhile for investigators to consider the evaluative role that they are called upon to play in the KT process. Considering that the immediate setting for KT is evidence-based practice in a broader context of research accountability and healthcare policy, it is important to recognize that much of implementation research is policy-oriented and evaluative in nature, and that the rigorous research models of investigation are but tools to an end. Much of the efficacy research that R&D grantees conduct are indeed evaluative of the knowledge output they generate. Use is a key tenet of evaluation models, as advocated in evaluation literature (Scriven, 1973; Stufflebeam, 2001; Stufflebeam & Shinkfield, 2007; Worthen, Sanders & Fitzpatrick, 1997) particularly by utilization-focused and responsive evaluation approaches (Abma & Stake, 2001; Guba & Lincoln, 1985; Patton, 2001; Patton, 2008; Patton, 2012). Mutual implications between evaluation and KT are no less significant (Barwick, 2011; Ottoson & Penelope, 2009).

Thus, it is important for KT scholars to consider the quality standards set by the evaluation profession, which endorse *utility* (relevance) and *feasibility* of knowledge on an equal footing with *accuracy* and *propriety* (ethics) of implementation (Joint Committee on Standards for Educational Evaluation, 1994; Yarbrough, Shulha, Hopson & Caruthers, 2011). The sequence by which these standards are presented is a reminder that whatever is worth doing (useful and feasible) is then worth doing well (with accuracy and propriety). Thus, for the field of evaluation research, utility is paramount. Approaches that are both utilization-focused and responsive tend to advocate for stakeholder concerns as the source of questions to be answered.

Limitations of the AT Case Study Series

The logistical and operational processes of the randomized controlled studies were seamlessly smooth and effectively supported the rigor of the design. However, the self-reported nature of the data collected in this case study series posed a limitation, which paradoxically came from a concern with quality assurance. These studies were essentially evaluative so meeting the professional evaluation standards was a priority. Choice of a randomized controlled design ensured *accuracy*; and involving the researchers that produced the new knowledge in developing the CKPs and webcasts addressed *propriety*. Of importance to the case study series was *utility* of results to grantees, our primary stakeholders. We chose workable methods and materials (protocols, intervention packages, and instrument) that were methodologically *feasible* for reaching varied and non-traditional stakeholders (Stone et al., 2014). Thus, a web-based instrument for collecting self-reported data collection seemed necessary. However, follow-up observations of participants to clarify their subjective interpretations would have minimized response inaccuracies. Lack of such a follow-up in the design of the case studies was a limitation of this study series. A further limitation related to the choice of non-parametric statistical tests for inference from data that were nominal (frequencies) or at best ordinal (knowledge use levels).

Conclusions

Cross-case synthesis of results from the three randomized controlled case studies point to four major conclusions about the *tailor-and-target* and *target-only* strategies.

First, both *tailor-and-target* and the *target-only* strategies are effective ways of communicating technology-based knowledge outputs from R&D projects to AT stakeholders. All three case studies found both strategies to effectively communicate the chosen new knowledge to the five major types of stakeholders of the AAC, recreational access, and wheeled mobility technologies; and they did effectively increase uptake and use of the knowledge over an eight-month timeframe.

Second, while both strategies are effective communicators of the chosen new knowledge to the stakeholder samples composed of five major stakeholder types, neither strategy was found more effective than the other. Since targeting was a common feature between the two strategies and tailoring distinguished one from the other, it follows that deliberately targeting stakeholders for knowledge dissemination can generally be an effective method, either with or without tailoring the knowledge. This might offer a cost effective alternative to R&D investigators and sponsors in terms of saving them the added time and effort involved in tailoring their knowledge outputs.

Third, the two strategies were differentially effective with the five different types of stakeholders, considered separately. The effects also varied across the three case studies, which strongly suggested the underlying factor to be a combination of stakeholder type and the given new knowledge presumed to have contextual relevance. In the present synthesis, clinicians/prescribers, industry/manufacturers and consumers benefited from tailoring of all three knowledge outputs - the AAC vocabulary list, the recreational accessibility instruments or the clinical knowledge about the tilting performance of power wheelchair users. In particular, the CKP was effective in the first two cases, as was the webcast plus technical-assistance-offer in the third case. On the other hand, researchers benefited from both strategies as stakeholders of the recreational accessibility instruments (AIMFREE); but from neither strategy communicating the other two outputs. Similarly, knowledge brokers benefited from both strategies as stakeholders of findings about the tilting performance of power wheelchair users; but not from either strategy as stakeholders of the other two outputs. Thus *target-only* strategy might be sufficient to persuade particular stakeholder groups to uptake and use a given new knowledge, either because they have a vested interest in it or because the opportunity for immediate application is readily obvious in the output characteristics. Tailoring can be effective with these stakeholders as an additional motivator, but not essential. On the other hand, tailoring might be essential to motivate stakeholders not strongly vested in the new knowledge, or when the opportunity for immediate application needs to be obviated through contextualized material.

Lastly, both strategies effectively raised and sustained awareness in stakeholders across the three case studies. However, in persuading non users for sustained use, although the effect reached statistical significance, smaller numbers of non-users were persuaded to apply the knowledge. The latter task continues to be a challenge to KT undertaken by R&D sponsors and investigators. As critical as it is to move currently accumulated research knowledge into applications, high expectations about communication strategies in this regard should first ensure relevance to the stakeholder audiences before investing in the rigor of methods that generate the knowledge. It is hoped that investigators and sponsors will seriously consider the implications of these findings for programs intended to generate beneficial socio-economic impacts.

One limitation was lack of provision for a follow-up interview of the participants in the design. The LOKUS instrument called for self -reported responses and required participants to recall information for repeated responses over the study period. So, learning in-depth about the actual use of the findings and the reasons for not using them would have enlightened the results further.

As final note, the foregoing conclusions are based on the three case studies replicated in the AT area. Further research is needed to generalize findings beyond AT to other technology areas covered by R&D in general. Future replications should also consider a follow up component to investigations, considering the earlier mentioned limitation in this case study series. Future designs could also include shorter or longer study periods, to know how long after dissemination it is reasonable to expect awareness, interest or use.

Outcomes and Benefits

The National Institute on Disability and Rehabilitation Research (NIDRR), which funds research and development (R&D) projects to promote outcomes and benefits for persons with disabilities, has identified three major outcome arenas (i.e., key domains of beneficial outcomes) as expected target areas in which to achieve long-term impact from its grantee projects. These are the domains of health and function, employment, and participation/community living (USDE/NIDRR, 2006). Of these, the domain of health and function is particularly relevant to NIDRR's technology grantees, whose projects seek to generate AT innovations, and potentially improve health and functional outcomes for persons with disabilities. Increased function means quality-of-life improvement for individuals with disabilities. Specifically it might then lead to improved employment and increased social inclusion. Eventually it may eliminate disparities with their fellow citizens.

However, the beneficial outcomes expected from the AT innovations generated by the grantees cannot be obtained until these outputs first make it to the marketplace and become available for consumer use. Most often, new knowledge is first released in the form of research findings and exists in a conceptual state (Lane & Flagg, 2010). Moving this knowledge to end-users involves transforming it from conceptual to prototype to product states by engaging multiple stakeholders in a technology transfer (TT) process. These include manufacturers, researchers, clinician practitioners, consumers as well as consumer advocates, knowledge brokers and policymakers, separately or in interaction. For impact to happen, the knowledge should be applied first by each of the stakeholder types in their own context. Evidently, knowledge use by these stakeholders is of key concern to both NIDRR and its technology grantees. It is therefore critical to facilitate TT by these stakeholders through a deliberate KT process (CIHR, 2009; Sudsawad, 2007) which translates the new knowledge into useful and accessible formats and communicates them through effective channels. However, communicating effectively to these diverse and geographically disperse stakeholders is as challenging as it is critical.

This paper focused on testing the effectiveness of two KT strategies that respond to the challenge. The *tailor-and-target* strategy proposed that contextualizing the new knowledge to the living and working environments would help its application by the stakeholder; it also favored multi-channel delivery of the knowledge. The *target-only* strategy focused on direct delivery of the knowledge to targeted individuals with no additional tailoring effort. The three case studies presented in this paper evaluated the two strategies in comparison with the *passive diffusion* strategy that is typically involved when knowledge is mass disseminated through publications where neither targeting nor tailoring is involved. The studies found both strategies effective with multi-stakeholder samples that included five types. Thus targeted delivery of new knowledge might be a cost effective option for grantees. On the other hand, there were differential effects of the two strategies on different stakeholder types, so grantees can choose to do tailoring with specific stakeholders of interest to their projects. The results also showed that both strategies effectively raised stakeholder awareness and interest in the knowledge communicated and also moved non-users to actually use the knowledge. However, the number of non-users that decided to use or to sustain such a decision were very few. Among other things, this points to perceived utility of the knowledge as a possible factor in stakeholder decision to apply it, and to consequent implications for outcomes and benefits to consumers.

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References

Abma, T.A., & Stake, R.E. (2001). Stake's responsive evaluation: Core ideas and evolution. In J.C. Greene & T.A. Abma (Eds.), *New Directions for Evaluation, no. 92* (7-22). San Francisco, CA: Jossey-Bass.

Barwick, M. (2011, November). *Evaluation use and knowledge translation: An exchange for the future.* Keynote lecture delivered at the American Evaluation Association (AEA) conference, Anaheim, CA.

Bozeman, B., & Rogers, J. (2002). A churn model of scientific knowledge value: Internet researchers as a knowledge value collective. *Research Policy, 31*, 769-794. Retrieved from http://archive.cspo.org/rvm/publications/pubs_docs/ResearchPolicy_Churn.pdf

Brewer, J.D. (2011). The impact of impact. *Research Evaluation, 20*(3), 255-256. doi: 10.3152/095820211X12941371876869

Bryen, D.N. (2008). Vocabulary to support socially-valued adult roles. Augmentative and *Alternative Communication, 24*(4), 294-301. doi: 10.1080/07434610802467354

Canadian Institutes of Health Research. (2013). *About knowledge translation.* Retrieved from http://www.cihr-irsc.gc.ca/e/29418.html

Center on Knowledge Translation for Technology Transfer (KT4TT). (2011). *KT intervention study tools –Series A.* Retrieved from http://kt4tt.buffalo.edu/

publications/ResourceMaterials/index.php

Center on Knowledge Translation for Technology Transfer (KT4TT). (2011). *KT intervention study tools- Series B.* Retrieved from http://kt4tt.buffalo.edu/publications/Webcasts/index.php

Donovan, C. (2011). State of the art in assessing research impact: Introduction to a special issue. *Research Evaluation, 20*(3), 175-179. doi: 10.3152/095820211X131185836359

Flagg, J.L., Lane, J.P., & Lockett, M. (2013). Need to knowledge (NtK) model: An evidence-based framework for generating technological innovations with socio-economic impacts. *Implementation Science, 8*(21), 1-10. doi:10.1186/1748-5908-8-21

Graham, I.D., Logan, J., Harrison, M.B., Straus, S.E., Tetroe, J., Caswell, W., & Robinson, N. (2006). Lost in translation: Time for a map? *The Journal of Continuing Education in the Health Professions, 26*(1), 13-24. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/16557505

Guba, E.G., & Lincoln, Y.S. (1985). *Effective evaluation*. San Francisco, CA: Jossey-Bass.

Joint Committee on Standards for Educational Evaluation. (1994). *The program evaluation standards* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Lane, J.P. (Ed.). (2003). The science and practice of technology transfer: Implications for the field of technology transfer. *Journal of Technology Transfer, 28*(3/4), 333-354. Retrieved from http://t2rerc.buffalo.edu/pubs/journals/abstract_2003_lane.htm

Lane, J.P., & Flagg, J.L. (2010). Translating three states of knowledge--discovery, invention, and innovation. *Implementation Science, 5*(9), 1-14. doi:10.1186/1748-5908-5-9

Lane, J.P., & Rogers, J.D. (2011). Engaging national organizations for knowledge translation: Comparative case studies in knowledge value mapping. *Implementation Science, 6*(106), 1-13. doi:10.1186/1748-5908-6-106

Leahy, J.A. (2003). Paths to market for supply push technology transfer. *Journal of Technology Transfer, 28*(3/4), 305-317. Retrieved from http://link.springer.com/journal/10961

Miller, E.T., & Spilker, J. (2003). Readiness to change and brief educational interventions: Successful strategies to reduce stroke risk. *Journal of Neuroscience Nursing, 35*(4), 215-222. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/12942656

National Center for the Dissemination of Disability Research (NCDDR). (1996). *Dissemination and knowledge utilization. A review of the literature on dissemination and knowledge utilization.* Retrieved from http://www.ncddr.org/du/products/review/index.html

Nobrega, A.R., Lane, J. P., Flagg, J. L., Stone, V.I., Lockett, M., Oddo, C., Leahy J.A., & Usiak, D.J. (2015). Assessing the Roles of National Organizations in Research-based Knowledge Creation, Engagement and Translation: Comparative Results Across Three Assistive Technology Application Areas. *Assistive Technology Outcomes and Benefits*. Special Issue on Knowledge Translation.

Ottoson, J.M., & Penelope, H. (Eds.). (2009). Knowledge utilization, diffusion, implementation, transfer, and translation: Implications for evaluation. *New Directions for Evaluation, 124.* San Francisco, CA: Jossey-Bass.

Patton, M.Q. (2012). *Essentials of utilization-focused evaluation.* Thousand Oaks, CA: Sage Publications.

Patton, M.Q. (2008). *Utilization-focused evaluation* (4th ed.). Thousand Oaks, CA: Sage Publications.

Patton, M.Q. (2001). *Qualitative research and evaluation method*s (3rd ed.). Thousand Oaks, CA: Sage Publications.

Rimmer, J. H., Riley, B., Wang, E. & Rauworth,

A. (2004). Development and validation of AIMFREE: Accessibility Instruments Measuring Fitness and Recreation Environments. *Disability and Rehabiliation*, 26 (18), 1087-1095.

Rogers, E.M. (1983). *Diffusion of innovations* (3rd ed.). New York, NY: The Free Press.

Rogers, J.D. (2000). Theoretical consideration of collaboration in scientific research. In J.S. Hauger, & C. McEnaney (Eds.), *Strategies for competitiveness in academic research* (151-177). Washington, DC: American Association for the Advancement of Science.

Scriven, M. (2005, September). Technology and product evaluation. *T2RERC expert seminar series*. Lecture conducted from the University at Buffalo, Buffalo, NY. Retrieved from http://t2rerc.buffalo.edu/news/workshops/scriven/scriven_lecture_2.htm

Scriven, M. (1973). The methodology of evaluation. In B.R. Worthen & J.R. Sanders (Eds.), *Educational evaluation: Theory and practice* (60-106). Belmont, CA: Wadsworth.

Sonenblum, S. E., Sprigle, S. & Maurer, C. I. (2009). Use of power tilt systems in everyday life. *Disability and Rehabilitation: Assistive Technology*, 4(1): 24-30.

Spaapen, J., & van Drooge, L. (2011). Introducing 'productive interactions' in social impact assessment. *Research Evaluation, 20*(3), 211-218. doi: 10.3152/095820211X129413718767

Stone, V.I., & Lane, J.P. (2012) Modeling technology innovation: How science, engineering, and industry methods can combine to generate beneficial socioeconomic impacts. *Implementation Science, 7*(44), 1-19. doi:10.1186/1748-5908-7-44

Stone, V.I., Nobrega, A.R., Lane, J.P., Tomita, M.R., Usiak, D.J. & Lockett, M.M. Development of a measure of knowledge use by stakeholders in rehabilitation technology. *Sage Open Medicine, 2,* 1-19. doi: 10.1177/2050312114554331.

Stone, V.I., Tomita, M.R., & Nobrega, A.R. (2012, October). *Does tailoring knowledge to stakeholder context matter? Replication of an RCT in knowledge translation for technological innovation.* Poster session presented at the American Evaluation Association (AEA) conference, Minneapolis, MN. Retrieved from http://comm.eval.org/eval/resources/viewdocument?DocumentKey=9cf262fa-8c9f-4716-a59b-dd092a1427da

Stufflebeam, D. (2001). Evaluation models. *New Directions for Evaluation, 2001*(89), 7-98. doi: 10.1002/ev.3

Stufflebeam, D.L., & Shinkfield, A.J. (Eds.). (2007). *Evaluation theory, models, and applications*. San Francisco, CA: Jossey-Bass.

Sudsawad, P. (2007). *Knowledge translation: Introduction to models, strategies, and measures*. Austin, TX: Southwest Educational Development Laboratory, National Center for the Dissemination of Disability Research.

United States General Accounting Office. (2004). *Results–oriented government report to congressional requesters. GPRA has established a solid foundation for achieving greater results.* Retrieved from http://www.gao.gov/new.items/d0438.pdf

United States Government Printing Office (2011).*GPRA modernization act of 2010*, PUBLIC LAW 111–352, Retrieved from http://www.gpo.gov/fdsys/pkg/PLAW-111publ352/pdf/PLAW-111publ352.pdf

United States Office of Management and Budget. (1993). *Government performance and results act (GPRA) of 1993*. Retrieved from http://www.whitehouse.gov/omb/mgmt-gpra/gplaw2m

Vovici Corporation. (2011). Vovici 6 [survey software]. Herndon, VA.

Weiss, C.H. (1979). The many meanings of research utilization. *Public Administration Review, 39*(5), 426-431. Retrieved from http://www.ualberta.ca/~dcl3/KT/Public%20Administration%20Review_Weiss_The%20many%20meanings%20of%20research_1979.pdf

Wholey, J.S., Hatry, H.P., & Newcomer, K.E. (Eds.). (2004). *Handbook of practical program* *evaluation*. San Francisco, CA: Jossey-Bass.

Worthen, B.R., Sanders, J.R., & Fitzpatrick, J.L. (1997). *Program evaluation: Alternative approaches and practical guidelines* (2nd ed.). New York, NY: Longman.

Yarbrough, D.B., Shulha, L.M., Hopson R.K., & Caruthers, F.A. (2011). *The program evaluation standards: A guide for evaluators and evaluation users* (3rd ed.). Thousand Oaks, CA: Sage publications.

Appendix: The AT Case Studies

This section presents the three individual case studies addressed by the paper and described in the overview. All three cases replicated the design and procedures described above. They varied slightly depending on the AT area they addressed and on the corresponding stakeholders to whom the knowledge was communicated. The following sections describe the method related to each case one by one, and discuss the corresponding results.

Case One: Communicating Knowledge to Stakeholders of Augmentative and Alternative Technology

Case One: Method

The overall methodological framework was described earlier. This section delineates the development of the intervention materials specific to AAC technology as well as the study procedures used for the intervention evaluation.

Developing intervention materials.

Selecting the knowledge area and the publication. A pool of research articles recently published by NIDRR grantees in augmentative and alternative communication (AAC) was compiled. As per selection criteria mentioned earlier, the publication "Vocabulary to Support Socially-Valued Adult Roles" by Bryen (2008) was chosen as the new knowledge to be addressed.

Identifying stakeholders in the selected knowledge area. The *tailor-and-target* and the *target-only* strategies were designed to communicate the new knowledge to stakeholders with the potential for knowledge uptake and use. Using the generic stakeholder types identified by Lane & Flagg (2010) as a guide, stakeholders were subsequently defined in the context of AAC. For recruiting participants, researchers sought the assistance of national organizations with which the stakeholders were affiliated, after duly extracting a knowledge value map of their membership. (Bozeman & Rogers, 2002; Lane & Rogers, 2011; Nobrega et al, 2015; Rogers, 2000). The stakeholders included as participants in Case One, the AAC technology study, included: (a) manufacturers of AAC devices that integrated the knowledge into products; (b) clinicians specializing in AAC who recommended the knowledge to clients; (c) researchers who investigated AAC related issues; (d) brokers who may refer clinicians or consumers to the knowledge; and (e) AAC users (consumers), and their family members. Although policy makers were identified as a sixth type of stakeholders, this type had to be excluded early during the study because practical constraints rendered their participation and recruitment infeasible.

Materials. The contextualized knowledge packages (CKPs) and webcast interventions used as part of the *tailor-and-target* communication strategy within the AAC technology area presented this treatment group's participants with information about Bryen's adult vocabulary lists. Adults who rely on AAC want the opportunity to work and be valued as contributors to their communities (Bryen, 2008). They want to access to basic and higher education to prepare for the valued roles of adulthood. Furthermore, they want to express themselves as responsible adults and manage their personal activities within multiple social contexts, including those related to healthcare, safety, and transportation. With these objectives, inserting suitably diverse vocabularies into AAC devices and services are important to enhance full participation and achievement of these goals. Many AAC products and services support various communication needs of children but do not address specific adult roles and situations. Bryen's research generated age-appropriate vocabulary and symbol sets (AAVSS) designed for AAC consumers to effectively fulfill socially valued adult roles.

The CKPs and webcasts for each stakeholder type highlighted the relevance of this new knowledge in relation to the stakeholders' context. Manufacturers could use the vocabulary in Bryen's AAVSS to serve as a basis for pursuing funding by small business innovative research (SBIR) or other federal agency. They could create symbols for each of the vocabulary sets, and transform the vocabulary sets into tangible products for use by consumers (Center on KT4TT, 2010, Series A: 3; Center on KT4TT, 2010, Series A: 9). For clinicians, use of these vocabulary sets could enhance their direct service with research-based tools. They would pave the way for participation in further development of AAC resources and support the need for adult service provision in diverse environments. They could provide direction for transition services for transition-age students who use AAC, and advocate for more accessible, efficient, and satisfying AAC communication (Center on KT4TT, 2010, Series A: 2; Center on KT4TT, 2010, Series A: 8). Bryen's vocabulary sets present opportunities for other researchers in the field, including clinical researchers. They could support research needed to advance AAC theory, and to develop AT solutions (Center on KT4TT, 2010, Series A: 4; Center on KT4TT, 2010, Series A: 10). Brokers such as disability service professionals at universities could provide students with information about adult vocabulary sets and encourage students to communicate with their clinicians if they are linked with one, or obtain a clinician to help them program the vocabulary into their devices (Center on KT4TT, 2010, Series A: 1; Center on KT4TT, 2010, Series A: 7). As for relevance to consumers who use AAC technology, the value of the AAVSS can be enhanced by informing them about the benefits of expanding their vocabulary. They could also benefit by guidance on how to access the adult vocabulary sets, as well as on programming the sets into their devices (Center on KT4TT, 2010, Series A: 5; Center on KT4TT, 2010, Series A: 11).

Participants assigned to the *target-only* group received a copy of Bryen's (2008) published article along with a cover letter that provided a brief explanation of her professional background and related interests.

Case One: Study Procedures

Participant Recruitment

After obtaining approval from the institutional review board, individuals presumed to have an interest in AAC-related research were sought through national organizations representing five of the six stakeholder types: American Technology and Industry Association (ATIA) which represents manufacturers, American Speech and Hearing Association (ASHA), which represents clinicians, International Society for Augmentative and Alternative Communication (ISAAC), which represents researchers, National Council on Independent Living (NCIL), which represents consumers, Association on Higher Education and Disability (AHEAD), which represents brokers. Listings of authors published in AAC research journals were also used to recruit researchers. Participants in AAC groups such as Aculog and social networking sites were excluded to avoid potential cross-contamination among participant groups.

Case One: Results

This section describes the sample and the results of the analyses for the two research questions: (1) the effectiveness of the three

Table A.1
Case One[§] Sample by Stakeholder Type and by Study Group (*N*=207)

		Study Group			
		T_1	T_2	C	Total
Stakeholder Type	Broker	23	23	19	65
	Clinician	13	15	17	45
	Manufacturer	11	8	7	26
	Researcher	8	7	6	21
	Consumer	17	19	14	50
	Total	72	72	63	207

Note: T_1 represents the treatment group exposed to the tailored and targeted dissemination of knowledge intervention; T_2 represents the treatment group exposed to the targeted dissemination of knowledge intervention; C represents the control group that received neither of the above interventions, but assumed to be exposed to passive diffusion.

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communication strategies with the total sample and (2) their differential effectiveness with the different stakeholder types (that is, the extent to which they communicate with different stakeholder types).

Sample Distribution and Characteristics

A total of 227 participants, randomized into the T_1 (*tailor-and-target*), T_2 (*target-only*) and C (passive diffusion) groups completed the baseline test. Of these, 214 completed follow-up 1 at four months and 207 completed follow-up 2 at eight months. Table 2 presents the final sample distribution by study group and stakeholder type. As Table A.1 shows, 65 brokers, 45 clinicians, 26 manufacturers, 21 researchers, and 50 consumers completed the study. Of the 207 participants who completed the study, 72 were in the T1 group, 72 in the T2 group, and 63 in the C group. The three study groups were not significantly different regarding demographic characteristics. This refers to: (a) age (F=1.834, p=.162), (b) years of experience (F=1.099, p=.335), (c) gender ($\chi2$= 1.817, p=0.403), (d) race/ethnicity ($\chi2$= 16.776, p=0.158), (e) education ($\chi2$= 4.462, p=0.924), and (f) work status ($\chi2$= 4.107, p=0.662). Overall, 21.3% were men and 78.7% were women, an expected gender difference in the selected knowledge area. The average age was 44.03. The average amount of experience in the knowledge area was 14.15 years.

Effectiveness of knowledge communication strategies. Findings reported in Tables A.2-A.5 address Research Question 1. The tables present results of analyses for the effectiveness of the communication strategies: *tailor-and-target*, *target-only* and *passive diffusion*. As said earlier, between-group analyses compared the knowledge use levels of the T_1, T_2, and C groups, checking for differences among them at the three assessment points: baseline, at four months, and at eight months. Within-group analyses focused on the T_1, T_2, and C groups separately and checked for changes in knowledge use levels from baseline to the four-month and eight-month assessments.

Between-group analyses. Table A.2 shows the participants' self-reported knowledge use levels for Bryen's findings at the three time points: beginning (baseline), at four months (follow-up 1) and at eight months (follow-up 2). In this table, columns labeled Non-awareness, Awareness, Interest and Use show the frequencies (i.e., number of participants)

Table A.2
Frequency Distributions Across Knowledge Use Levels at Baseline, Follow-up 1 and Follow-up 2 in Case One§ (*N*=207)

	N	Levels: Non-awareness	Levels: Awareness	Levels: Interest	Levels: Use	χ 2 (p =)	T_1 vs. T_2 χ 2 (p =)
Baseline							
T_1	72	63 (87.5%)	5 (6.9%)	1 (1.4%)	3 (4.2%)		
T_2	72	63 (87.5%)	3 (4.2%)	2 (2.8%)	4 (5.6%)	5.291 (.507)	.976 (.807)
C	63	54 (85.7%)	1 (1.6%)	1 (1.6%)	7 (11.1%)		
Follow-up 1							
T_1	72	46 (63.9%)	6 (8.3%)	9 (12.5%)	11 (15.3%)		
T_2	72	48 (66.7%)	6 (8.3%)	5 (6.9%)	13 (18.1%)	6.917 (.329)	1.352 (.717)
C	63	50 (79.4%)	1 (1.6%)	5 (7.9%)	7 (11.1%)		
Follow-up 2							
T_1	72	44 (61.1%)	14 (19.4%)*	6 (8.3%)	8 (11.1%)		
T_2	72	49 (68.1%)	4 (5.6%)	8 (11.1%)	11 (15.3%)	14.013 (.029)*	6.584 (.086)
C	63	45 (71.5%)	2 (3.2%)	4 (6.3%)	12 (19.0%)		

Note: T_1 represents the treatment group exposed to the tailored and targeted dissemination of knowledge intervention; T_2 represents the treatment group exposed to the targeted dissemination of knowledge intervention; C represents the control group that received neither of the above interventions, but assumed to be exposed to passive diffusion.
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* Standard residual = 2.7

distributed at these four knowledge use levels as measured by the LOKUS instrument. The frequencies correspond to the three groups shown in the first column from the left. As shown in the column labeled "χ 2 (p =)", the groups were not significantly different in their frequency distribution into the four levels, either at baseline or at four months. But there was a significant difference ($\chi 2$ =14.013; p=.029) observed at eight months. The post-hoc analyses (right-most column) revealed no significant difference between T_1 and T_2 groups at follow up 2 ($\chi 2$ =6.584; p= .086), suggesting that both T_1 and T_2 differed from the C group.

Within-group analyses. Results from between-group analyses are corroborated by results from within-group analyses, which focused on changes in knowledge use levels within each of the three groups across the three time points. Table A.3 reports the within-group analysis done for the T_1 group. In this table, the rows present the frequencies and percentages spread across the four knowledge use levels at baseline. The columns present the same information at follow-up 1. The boxed cells show the number of individuals who stayed at the same level both at baseline and at follow-up 1. The numbers in the cells to the right of the boxed cells represent individuals who changed between baseline and follow-up 1 by moving from lower to upper levels. Those to the left of the boxed cells show changes in the opposite direction, from upper to lower levels. Thus, 23 out of 72 participants reported moving up, while four participants reported moving down. Also, of the 63 who were non-aware at baseline, 30% moved to higher levels at follow-up 1. These changes in the T_1 group were significant (Z=.826, p<.001).

Within-group analyses between baseline and follow-up 1also showed significant changes (Z=3.330, p=.001) in the T_2 group. However these analyses did not show significant changes in the C (control) group (Z= 0.992, p=.321). Thus, both target-and-tailor as well as *target-only* strategies were effective in the first four-month period, compared to control (*passive diffusion*).

However, within-group analyses conducted between follow-up 1 to follow-up 2 detected no significant changes in any group. No new effect occurred in the second four months. Yet, changes were significant between baseline and follow-up 2 both for T_1 (Z=4.297, p<.001) and T_2 (Z=3.206, p=.001), indicating that both strategies were effective over the 8-month period. In other words, the effect achieved during the first four months did not decline but was maintained at eight months. Interestingly, changes were significant over the 8 months also for the C (control) group (Z=2.100, p=.036). In terms of magnitude, this change represented a 14.2% reduction in Non-awareness. If this is taken as a likely testing

Table A.3
Frequency Changes in Knowledge Use Levels Between Baseline and Follow-up 1 for Group T_1 in Case One§ (*N*=207)

			Frequency and Percentage					
			Follow-up 1					
	Group	Levels	Non-awareness	Awareness	Interest	Use	Total	Z (*p*=)
Baseline	T_1	Non-awareness	44 (70%)	5 (8%)	7 (11%)	7 (11%)	63 (100%)	3.826 (<.001)
		Awareness	2 (40%)	0 (0%)	1 (20%)	2 (40%)	5 (100%)	
		Interest	0	0	0 (0%)	1 (100%)	1 (100%)	
		Use	0	1 (33%)	1 (33%)	1 (33%)	3 (100%)	
		Total	46 (64%)	6 (8%)	9 (13%)	11 (15%)	72 (100%)	

Note: T_1 represents the treatment group exposed to the tailored and targeted dissemination of knowledge intervention.

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effect, any effect should be of greater magnitude to be considered a valid effect beyond testing effect. In fact, both T1 and T2 groups registered relatively larger magnitudes (26.4% and 19.4% respectively), which shows that those effects were valid as they went beyond the testing effect. Seemingly, this contradicted the earlier result from the between-group analyses that showed an overall non-significant difference among the three groups at the three assessment points (See Table A.2, last two columns). This apparent contradiction can be explained by considering the changes that occurred in the control group over the eight months. They were likely large enough to obscure the overall difference among the three groups taken together, even though they were smaller in magnitude relative to the other two groups.

Taken together, the results indicate that both *tailor-and-target* and *target-only* interventions were effective in raising the knowledge use levels of individuals compared to *passive diffusion*, at four months. Also, this effect was maintained for the entire study period (eight months), even though the strategies were not effective in the second four-month period. Furthermore, while

Table A.4
Frequency Changes in Non-awareness and Awareness-plus Levels Between Baseline and Follow-up 1 in Case One§ (*N*=207)

T_1 (N=72)		Follow-up 1 Non-awareness	Awareness+	Total	Exact Sig. (2-sided *p*=)
Baseline	Non-awareness	44 (69.8%)	19 (30.2%)	63 (100%)	.001
	Awareness+	2 (22.2%)	7 (77.8%)	9 (100%)	
	Total	46 (63.9%)	26 (36.1%)	72 (100%)	
T_2 (N=72)		**Follow-up 1 Non-awareness**	**Awareness+**	**Total**	**Exact Sig. (2-sided *p*=)**
Baseline	Non-awareness	46 (73.0%)	17 (27.0%)	63 (100%)	.001
	Awareness+	2 (22.2%)	7 (77.8%)	9 (100%)	
	Total	48 (66.7%)	24 (33.3%)	72 (100%)	
C (N=63)		**Follow-up 1 Non-awareness**	**Awareness+**	**Total**	**Exact Sig. (2-sided *p*=)**
Baseline	Non-awareness	48 (88.9%)	6 (11.1%)	54 (100%)	.289
	Awareness+	2 (22.2%)	7 (77.8%)	9 (100%)	
	Total	50 (79.4%)	13 (20.6%)	63 (100%)	

Note: T_1 represents the treatment group exposed to the tailored and targeted dissemination of knowledge intervention; T_2 represents the treatment group exposed to the targeted dissemination of knowledge intervention; C represents the control group that received neither of the above interventions, but assumed to be exposed to passive diffusion.
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tailor-and-target and *target-only* strategies differed significantly from *passive diffusion*, neither was more effective than the other as per post-hoc findings reported earlier ($\chi 2 = 6.584$; $p = .086$).

Raising stakeholder awareness. As mentioned in the data analysis section under method overview, the capacity of the strategies to raise awareness was studied by observing changes from Non-awareness to all other levels grouped together. Addressing the changes occurring in the levels of knowledge use between baseline and follow-up 1, Table A.4 offers an in-depth view of the changes in each group focused on participant movement away from their non-aware state. In Table 5, data are arranged into two broader levels: (1) Non-awareness and (2) Awareness-plus (which combines Awareness, Interest and Use levels). The table compares the pre and post frequencies in awareness versus awareness-plus levels separately in relation to the three groups. The top section refers to the T1 group, where 44 participants were non-aware both pre and post intervention, while seven participants were at awareness-plus level at pre and post. However, 19 participants who were non-aware at baseline moved to Awareness-plus at follow-up 1. Two participants who were aware-plus at baseline moved to Non-awareness at follow-up

Table A.5
Frequency Changes in Non-use and Use Levels Between Baseline and Follow-up 1 in Case One[§](*N*=207)

T_1 (N=72)		Follow-up 1			Exact Sig. (2-sided *p*=)
		Non-use	Use	Total	
	Non-use	59 (85.5%)	10 (14.5%)	69 (100%)	
Baseline	Use	2 (66.7%)	1 (33.3%)	3 (100%)	.039
	Total	61 (84.7%)	11(15.3%)	72 (100%)	
T_2 (N=72)		Follow-up 1			Exact Sig. (2-sided *p*=)
		Non-use	Use	Total	
	Non- use	57 (83.8%)	11 (16.2%)	68 (100%)	
Baseline	Use	2 (50%)	2 (50%)	4 (100%)	.022
	Total	59 (81.9%)	13 (18.1%)	72 (100%)	
C (N=63)		Follow-up 1			Exact Sig. (2-sided *p*=)
		Non-use	Use	Total	
	Non- use	52 (92.9%)	4 (7.1%)	56 (100%)	
Baseline	Use	4 (57.1%)	3 (42.9%)	7 (100%)	1.000
	Total	56 (88.9%)	7 (11.1%)	63 (100%)	

Note: T_1 represents the treatment group exposed to the tailored and targeted dissemination of knowledge intervention; T_2 represents the treatment group exposed to the targeted dissemination of knowledge intervention; C represents the control group that received neither of the above interventions, but assumed to be exposed to passive diffusion.

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1. Applying the McNemar test (last column) showed that the movement from Non-awareness to Awareness-plus level was significant (p=.001) for the T_1 group. The next two sections of this table repeat similar analyses, showing that the movement was also significant for T_2 (p=.001) but not for the C group (p=.289). Thus, both the *tailor-and-target* and *target-only* strategies significantly raised participant awareness.

Similar analyses for participant movement from follow-up 1 to follow-up 2 showed no significant results for any of the three groups. No further increase in awareness occurred in the second four-month period. However, there was significant movement from baseline to follow-up 2 for both T_1 (p<.001) and for T_2 (p=.001), signifying that the groups retained the intervention effect until the end of the eight-month intervention period. The C group also moved up significantly (p=.035) due to the likely testing effect mentioned earlier. (See Table A.3.)

Moving stakeholders from non-use to use level. The ability of the strategies to get non-users to actually use the knowledge was analyzed next. Similar to the foregoing analyses, which re-grouped data into two broad levels, data was reorganized also for this analysis. A *Non-use* level was created by merging data from the first three levels (i.e. *Non-awareness*, *Awareness* and *Interest*). Table A.5 examines pre and post frequencies related to participant movement from the *Non-use* level to the Use level as measured by the LOKUS instrument. Data in Table A.5 are arranged in sub sections one below the other to represent the T_1, T_2 and C groups respectively. As seen in the right-most column, the McNemar test p values are significant for T_1 (p=.039) and T_2 (p=.022) groups but not for the C group (p=1.000). However, these p values were not significant either between follow-up 1 and follow-up 2, or between baseline and follow-up 2. Therefore, both *tailor-and-target* and *target-only* strategies moved participants from *Non-use* to Use level significantly in the first four-month period but the effect was not retained at eight months.

Differential effects on stakeholder types. Results for Research Question 2 appear in Table A.6. They concern differential effects on the knowledge use levels among the five stakeholder types: manufacturers, clinicians, brokers, researchers, and consumers. The table presents both between-group (comparative) and within-group (absolute) differences among the stakeholder types, considering the T_1, T_2, and C groups individually. Results from follow-up 1 to follow-up 2 are omitted, as no significant change was detected within any of the five stakeholder types during this timeframe. The table reports only changes from baseline to follow-up 1 (first four-month period) and from baseline to follow-up 2 (overall eight-month period).

As per the column showing Between–Group difference at baseline in Table A.6, the baseline level differences (Kruskal-Wallis one-way ANOVA) among the five types were significant in all three groups (p =.007; $_2$ =.002; and p<.001). The last two columns in Table A.6 showing within-groups analysis (Wilcoxon signed-rank test) reveal that consumers were the only stakeholders that demonstrated significant change from baseline to follow-up 1 both in T_1 (p=.017) and T_2 (p=.015) groups and also that they retained the change to follow-up 2 (p=.024; and p=.013). Additionally, clinicians and manufacturers in the T_1 group showed significant change from baseline to follow-up 2 (last column in Table A.6).

Case One: Discussion and Conclusions

Overall Effects

These refer to effects on the total sample representing all five stakeholder types. In

Table A.6
Changes in Knowledge Use Over Time by Stakeholder Type and by Group in Case One§ (*N*=207)

	Between Group Difference at Baseline	Within Group Analyses	
T_1		Change from Baseline to Follow-up1	Change from Baseline to Follow-up2
Broker	χ^2= 14.025, *p*= (.007)	*Z*=1.300 (.194)	*Z*=0.577 (.564)
Clinician		*Z*=1.656 (.098)	*Z*=2.271 (.023)
Manufacturer		*Z*=1.282 (.200)	*Z*=2.414 (.016)
Researcher		*Z*=1.841 (.066)	*Z*=1.633 (.102)
Consumer		*Z*=2.392 (.017)	*Z*=2.264 (.024)
T_2			
Broker	χ^2= 16.452, *p*= (.002)	*Z*=1.604 (.109)	*Z*=1.000 (.317)
Clinician		*Z*=1.105 (.269)	*Z*=1.236 (.216)
Manufacturer		*Z*=0.850 (.395)	*Z*=0.680 (.496)
Researcher		*Z*=1.342 (.180)	*Z*=1.134 (.257)
Consumer		*Z*=2.444 (.015)	*Z*=2.490 (.013)
C			
Broker	χ^2= 23.757, *p*= (<.001)	*Z*=1.000 (.317)	*Z*=1.342 (.180)
Clinician		*Z*=1.342 (.180)	*Z*=1.342 (.180)
Manufacturer		*Z*=1.342 (.180)	*Z*=.272 (.785)
Researcher		*Z*=1.000 (.317)	*Z*=1.633 (.102)
Consumer		*Z*=.756 (.450)	*Z*=.131 (.258)

Note: T_1 represents the treatment group exposed to the tailored and targeted dissemination of knowledge intervention; T_2 represents the treatment group exposed to the targeted dissemination of knowledge intervention; C represents the control group that received neither of the above interventions, but assumed to be exposed to passive diffusion.
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drawing conclusions about these effects, it is important to consider that, unlike the *tailor-and-target* strategy which had two distinct intervention components during the first four-month period and the second, active intervention by the *target-only* strategy occurred in the first four month period, with no additional intervention afterward. Thus effects over the first four months carry a special weight as indicator of effectiveness in the case of the *target-only* strategy.

Between-group analyses of responses of the total sample over the study period showed a significant difference in participants' levels of knowledge use among the three groups T_1, T_2, and C. Post-hoc tests confirmed that the difference was between the first two groups and the Control; there was no significant difference between the two groups themselves. Therefore, with respect to the new knowledge in AAC technology addressed by Case One, we can conclude that: 1) both *tailor-and-target* and *target-only* strategies were effective over the total study period, compared to *passive diffusion*; and 2) neither method was superior to the other. The tailored CKP in combination with tailored webcast and availability of technical assistance was an effective method to communicate the value of the innovative vocabulary list to the five types of AAC stakeholders; Targeting stakeholders and delivering the research article that published the innovative vocabulary list was also an effective method.

Within-group analyses of responses from each of the three groups T_1, T_2, and C showed both T_1, T_2 changed significantly in their levels of knowledge use in the first four months, and also over the total period of eight months, but not over the second four months. These changes were beyond those registered by the control group (*passive diffusion*), and represent valid effects from both strategies that went beyond testing effect. We can therefore conclude the following. 1) The *tailor-and-target* strategy had an effect on the knowledge use levels of participants in the first four months, as well as a cumulative effect over the study period (eight months) even though there was no new effect in the second four months. The CKPs were an effective way of knowledge communication, whether used alone (first four months) or in combination with a webcast and available technical assistance (over 8 months), however the webcast and available technical assistance were not effective by themselves (last four months). 2) The *target-only* strategy was also effective – it had an effect over the first four-month period, and the effect was retained to the end. Delivering the publication directly to targeted stakeholders is an effective way of knowledge communication to these AAC stakeholders, which takes effect in four months and lasts at least up to 8 months.

The above results, for both strategies, were consistent with their effect in moving non-aware participants to awareness-plus levels. Within-group analyses in this regard showed significant changes in both T_1, T_2 groups, but not in C. This was true for the first four months and over the total study period. Therefore, both *tailor-and-target* and *target-only* strategies effectively raised stakeholder awareness of the new knowledge in the first months. They also retained the effect over the eight months. We can conclude that, in communicating new knowledge to AAC stakeholders, the CKPs effectively raised their awareness, whether used alone or in combination with the webcast and offer of technical assistance, but just the webcast with available technical assistance did not have the effect. Targeting AAC stakeholders for direct delivery of the knowledge also raised stakeholder awareness in four months and retained it up to 8 months.

On the other hand, results on moving non-users to the Use level showed that the T_1 and T_2 groups effectively did so in the first four months but not over the eight-month period. We can conclude that both *tailor-and-target* and *target-only* strategies effectively moved non-users to the Use level in the first four-month period, but neither strategy was effective in retaining that persuasive effect over the eight-month period. Both the CKPs, as well as targeted delivery of the published knowledge, were able to effectively persuade stakeholders to use the knowledge in four months but were not able to sustain the effect over the 8-month period.

Differential Effects

While the *tailor-and-target* and *target-only* strategies were effective on all five stakeholder types exposed to them, the five types differed significantly in how they changed over time in their levels of knowledge use. Consumers in the T_1 and T_2 groups made significant changes in the first four months and over the eight months, leading us to conclude that exposure to either *tailor-and-target* or *target-only* strategies benefits consumers. As end-users of Bryen's (2008) innovative AAC vocabulary, they benefitted from the *tailor-and-target* strategy as a whole (i.e., CKP, webcasts and availability of technical assistance); the CKPs used in the first four months, as well as the targeted delivery of just the research article. Clinicians and manufacturers also showed significant changes in their levels of knowledge use over the eight-month period but only those exposed to the *tailor-and-target* strategy. We can conclude that the CKPs, in combination with the webcast and availability of technical assistance, is effective with clinicians and manufacturers but the targeted delivery of the published article is not. This is an important result as clinicians and manufacturers are two major players in the process of technology transfer and the result upholds the value of knowledge-tailoring to effectively motivate and persuade these stakeholders for application. Brokers and researchers exposed to either strategy did not reveal significant changes in knowledge use levels. Neither the article alone nor the tailored material was effective with these stakeholders. It suggests a low level of interest in the new knowledge, or its value to their context as perceived by them. Brokers in this case study were disability service coordinators for college students.

Case Two: Communicating Knowledge to Stakeholders of Recreational Access Technology

Presented below are the method and results for the case study on RecAccess technology, which investigated the effects of the same three strategies of communication through replication of the research design described earlier.

Case Two: Method

Within the overall methodological framework, this section describes the development of the intervention materials specific to recreational access technology as well as the study procedures used for the intervention evaluation.

Developing Intervention Materials

Selecting the knowledge area and the publication. For this case study, a pool of recently published research articles related to recreational access was compiled. The publication "Development and Validation of AIMFREE: Accessibility Instruments Measuring Fitness and Recreational Environments" by Dr. James Rimmer and colleagues was selected (Rimmer, Riley, Wang & Rauworth, 2004).

Identifying stakeholders in the selected knowledge area. Stakeholders were subsequently defined in the context of recreational access, and national organizations were engaged to identify and recruit participants. The stakeholders included as participants in Case Two, the RecAccess study, included: (a) manufacturers who made fitness equipment product development decisions; (b) fitness facility owners/managers who were decision makers that operated fitness facilities; (c) certified fitness trainers/specialists who worked with and guide/monitor fitness facility clients; (d) researchers who investigated issues related to fitness and exercise science; (e) fitness facility architects and access consultants who facilitated/advocated for the use of research to improve fitness facilities and equipment; and (f) consumers who were individuals with mobility limitations that either used, or considered using fitness facilities. Eventually during the study, the six types were reduced to five, combining manufacturers and fitness facility owners into one type perceived as fitness industry.

Materials. The contextualized knowledge package and webcast interventions used as part of the *tailor-and-target* communication strategy within the recreational access technology area presented participants assigned to this treatment group with information about Rimmer's and colleagues' instruments that measure fitness and recreational environments (AIMFREE) for accessibility. Fitness facility owners and managers were urged to consider expanding their recruitment efforts to individuals with disabilities and using the AIMFREE instrument to make changes (if necessary) to their facilities to accommodate to individual accessibility needs. Information was provided to owners and managers regarding the Disabled Tax Credit (Internal Revenue Code, Section 44), in which eligible small businesses may take a credit up to $5,000 to offset costs for access, including barrier removal from their facilities, provision of accessible equipment and services. Businesses of all sizes can also take advantage of tax deductions by removing barriers in their facilities. Manufacturers were presented with information regarding a need for creating accessible fitness equipment (Center on KT4TT, 2011, Series B: 2; Center on KT4TT, 2011, Series B: 7). Exercise fitness trainers and specialists could use AIMFREE to increase their understanding of the fitness and access needs of customers, expand expertise in training and fitness programs for persons with special needs, contribute to the development of norms, and provide enhanced programs (Center on KT4TT, 2011, Series B: 3; Center on KT4TT, 2011, Series B: 8) Researchers were encouraged to use AIMFREE to enhance research quality and evidence-based practice and to create and expand AT solutions (Center on KT4TT, 2011, Series B: 4; Center on KT4TT, 2011, Series B: 9). Fitness facility architects and access consultants were provided with information about how to use AIMFREE as a tool to identify architectural barriers in fitness facilities, give dimensions and sizes for spaces such as accessible pathways, determine if facility staff are properly trained to meet the needs of individuals with disabilities, identify needed services and programs, perform disability accessibility evaluations, develop transition plans for fitness centers interested in implementing AIMFREE, and help educate fitness centers to use AIMFREE to do their own self-diagnosis (Center on KT4TT, 2011, Series B: 1; Center on KT4TT, 2011, Series B: 6). Consumers were encouraged to use AIMFREE to advocate for equal access to the gym of their choice (Center on KT4TT, 2011, Series B: 5; Center on KT4TT, 2011, Series B: 10).

Participants assigned to the *target-only* group received a copy of Rimmer et al.'s (2004) published article along with a cover letter that explained his background and related interests.

Case Two: Study Procedures

Participants

After obtaining approval from the institutional review board, individuals presumed to have an interest in recreational access related research were sought through the following national organizations representing the five stakeholder types: 1) Industry/ manufacturers, where International Health, Racquet & Sports Club Association (IHRSA) referred us to manufacturers and International Health, Racquet & Sports Club Association (IHRSA) referred us to fitness facility owners/managers, 2) American College of Sports Medicine

Table A.7
Case Two[§] Sample by Stakeholder Type and by Study Group (N=288)

		STUDY GROUP			
		T_1	T_2	C	Total
Stakeholder Type	Broker	13	13	14	40
	Prescriber/Clinician	19	21	21	61
	Industry/Manufacturer	21	16	21	58
	Researcher	21	22	22	65
	Consumer	23	21	20	64
	Total	97	93	98	288

Note: T_1 represents the treatment group exposed to the tailored and targeted dissemination of knowledge intervention; T_2 represents the treatment group exposed to the targeted dissemination of knowledge intervention; C represents the control group that received neither of the above interventions, but assumed to be exposed to passive diffusion.

[§]The Recreational Access Technology case study.

(ACSM), which represents certified fitness trainer/specialists, 3) Rehabilitation Engineering & Assistive Technology Society of North America (RESNA) and American College of Sports Medicine (ACSM), which represents researchers, 4) National Council on Independent Living (NCIL), which represents fitness facility architects and access consultants and 5) Paralyzed Veterans of America (PVA), which represents consumers.

Case Two: Results

This section describes the sample used and the results of the analyses for the two research questions: (1) the effectiveness of the three communication strategies with the total sample and (2) their differential effectiveness with the different stakeholder types.

Sample Distribution and Characteristics.

A total of 307 participants, randomized into the T_1 (*tailor-and target* intervention), T2 (*target-only* intervention) and C (Control-*passive diffusion*) groups enrolled in the study and answered the baseline test. Of these, 299 completed follow-up 1 and 288 completed follow-up 2. Table A.7 presents the final sample distributed by study group and stakeholder type. As Table A.7 shows, 40 brokers, 61 prescribers, 58 industry representatives, 65 researchers, and 64 consumers completed the study. Of those, 72 were in the T1 group, 72 in the T2 group, and 63 were in the C group. The three study groups were not significantly different regarding demographic characteristics. This refers to: (a) age (F=.209, p=.811); (b) years of experience (F=1.851, p=.159), (c) gender ($\chi2$= 2.893, p=0.235); (d) race/ethnicity ($\chi2$= 10.094, p=0.755); (e) education ($\chi2$= 4.766, p=0.906); and (f) work status ($\chi2$= 4.414, p=0.621). Overall, 53 % were men and 47% were women. The average age was 39.64 and the average amount of experience in the knowledge area was 12.86 years. Compared to Case One, the Case Two sample was younger and was less experienced in the addressed knowledge area.

Effectiveness of the Knowledge Communication Strategies

Findings reported in Tables A.8-A.10 address Research Question 1 and present results of analyses for the effectiveness of the communication strategies: *tailor-and-target*, *target-only* and *passive diffusion* in the case study

Table A.8
Frequency Distributions Across Knowledge use Levels at Baseline, Follow-up 1 and Follow-up 2 in Case Two§ (*N*=288)

	N	Levels				$\chi 2$ (p =)	T_1 vs. T_2 $\chi 2$ (p =)
		Non-awareness	Awareness	Interest	Use		
Baseline							
T_1	97	91 (93.8%)	1 (1%)	2 (2.1%)	3 (3.1%)		
T_2	93	90 (96.8%)	0 (0%)	2 (2.2%)	1 (1.1%)	5.722 (.455)	
C	98	97 (99%)	0 (0%)	0 (0%)	1 (1%)		
Follow-up1							
T_1	97	56 (57.7%)	11 (11.3%)	13 (13.4%)	17 (17.5%)		
T_2	93	69 (74.2%)	4 (4.3%)	8 (8.6%)	12 (12.9%)	32.672 (.001)	6.590 (.086)
C	98	90 (91.8%)	0 (0%)	4 (4.1%)	4 (4.1%)		
Follow-up2							
T_1	97	57 (58.5%)	12 (12.4%)	9 (9.3%)	19 (19.6%)		
T_2	93	66 (71%)	10 (10.8%)	5 (5.4%)	12 (12.9%)	32.672 (.001)	3.481 (.323)
C	98	85 (86.7%)	8 (8.2%)	3 (3.1%)	2 (2%)		

Note: T_1 represents the treatment group exposed to the tailored and targeted dissemination of knowledge intervention; T_2 represents the treatment group exposed to the targeted dissemination of knowledge intervention; C represents the control group that received neither of the above interventions, but assumed to be exposed to passive diffusion.
§The Recreational Access Technology case study.

on recreational access technology. We reiterate that between-group analyses compared the knowledge use levels of the T_1, T_2, and C groups, checking for differences among them at the three assessment points- baseline, at four months and at eight months. Within-group analyses focused on the T_1, T_2, and C groups separately and checked for changes in knowledge use levels from baseline to the four-month and eight-month assessments.

Between-group analyses. Table A.8 displays the participants' self-reported knowledge use levels for Rimmer's findings at the three points: beginning (baseline), at four months (follow-up 1) and at eight months (follow-up 2). Observe that the left-most column in Table A.8 shows the three groups T_1, T_2, and C. The next three columns display participant frequencies corresponding to these groups, distributed at the four knowledge use levels (i.e., Non-awareness, Awareness, Interest, and Use) as measured by the LOKUS instrument. As shown in the column headed by $\chi 2$ (p=), there was no significant association between the groups and their distribution into the four levels at baseline. However, there was a significant difference both at four months ($\chi 2$ = 32.672; p=.001) and at eight months ($\chi 2$ =

32.672; *p*=.001). The post-hoc analyses (last column) revealed no significant difference between T_1 and T_2 groups either at follow-up 1 (χ2 =6.590; *p*=.086) or at follow up 2 (χ2 = 3.481; *p*= .323). This suggests that both the T_1 and T_2 groups differed from the C group but not from each other. This was true at four months and at eight months.

Within-group analyses. Results from the Case Two between-group analyses are corroborated by results from the within-group analyses. The within-group analyses focused on changes in knowledge- use levels in each group across the three time points. Table A.9 shows an analysis that focuses on the T_1 group. The rows in this table present baseline frequencies and percentages spread across the four knowledge use levels. The columns present the same information for follow-up 1. The numbers to the right of the diagonal represent a change between baseline and follow-up 1 from lower to upper levels. Numbers to the left of the diagonal show changes from upper to lower levels. Table A.9 shows that 39 out of 97 participants reported moving up while 2 participants reported moving down. Also, of the 55 participants who were non-aware at baseline, 39.6% moved to higher levels at follow-up 1. The changes in the T_1 group were significant (*Z*= 5.318, *p*<.001). Similar within-group analyses showed the changes were significant in the T_2 group (*Z*=4.174, *p*<.001) as well as in the C (control) group (*Z*= 2.428, *p*=.015). Considering the change in C as a testing effect, the magnitude of such change was further examined, and found to be 7.2%. In other words, 7.2% of participants who were non-aware in the beginning reported moving to higher levels. The magnitude of such change was greater both in the T_1 group (39.6%) and in the T_2 group (23.3%). Thus, the changes in T_1 and T_2 went beyond testing effect and could be considered true effect.

Table A.9
Frequency Changes in Knowledge use Levels Between Baseline and Follow-up 1 for Group T_1 in Case Two§ (*N*=288)

			Frequency and Percentage					
			Follow-up 1					
	Group	Levels	Non-awareness	Awareness	Interest	Use	Total	Z (*p*=)
Baseline	T_1	Non-awarenes	55 (60.4%)	10 (11.0%)	13 (14.3%)	13 (14.3%)	91 (100%)	5.318 (<.001)
		Awareness	1 (100%)	0 (0%)	0	0	1 (100%)	
		Interest	0	1 (50%)	0 (0%)	1 (50%)	2 (100%)	
		Use	0	0	0	3 (100%)	3 (100%)	
		Total	56 (57.7%)	11 (11.3%)	13 (13.4%)	17 (17.5%)	97 (100%)	

Note: T_1 represents the treatment group exposed to the tailored and targeted dissemination of knowledge intervention.
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Within-group analyses detected no significant changes between follow-up 1 and follow-up 2 for any group. However, changes between baseline and follow-up 2 were found, once again, to be significant for all three groups: T_1 ($Z=5.089$, $p<.001$), T_2 ($Z=4.453$, $p<.001$), C (control) ($Z=2.538$, $p=.011$). This suggests that even though no new effect occurred in the second four months, the effect observed for the first four months was maintained at eight months. Again, the change in C suggests the likelihood that a testing effect exists. In terms of magnitude of change, a 13.6% reduction in Non-awareness occurred the C group, any effect of greater magnitude could be considered a valid effect beyond the testing effect. In fact, both T_1 and T_2 groups registered relatively larger magnitudes (38.5% and 26.7% respectively), which indicates that those effects went beyond the testing effect over the study period. Furthermore, there was no significant difference between the T_1 and T_2 groups at eight months ($\chi2=3.481$, $p<.323$). Therefore, both T_1 and T_2 showed higher frequency changes compared to C but did not differ from each other at the end of the study period.

The results indicate that both *tailor-and-target* and *target-only* strategies were effective both over the first four months and over the course

Table A.10
Frequency Changes in Non-awareness and Awareness-plus Levels Between Baseline and Follow-up 1 in Case Two§ (*N*=288)

T_1 (*N* = 97)		Follow-up 1			
		Non-awareness	Awareness+	Total	Exact Sig. (2-sided *p*=)
	Non-awareness	55 (60.4%)	36 (39.6%)	91 (100%)	
Baseline	Awareness+	1 (16.7%)	5 (83.3%)	6 (100%)	< .001
	Total	56 (57.7%)	41 (42.3%)	97 (100%)	

T_2 (*N* = 93)		Follow-up 1			
		Non-awareness	Awareness+	Total	Exact Sig. (2-sided *p*=)
	Non-awareness	69 (76.7%)	21 (23.3%)	90 (100%)	
Baseline	Awareness+	0	3 (100%)	3 (100%)	< .001
	Total	69 (74.2%)	24 (25.8%)	93 (100%)	

C (*N* = 98)		Follow-up 1			
		Non-awareness	Awareness+	Total	Exact Sig. (2-sided *p*=)
	Non-awareness	90 (92.8%)	7 (7.2%)	97 (100%)	
Baseline	Awareness+	0	1 (100%)	1 (100%)	.016
	Total	90 (91.8%)	8 (8.2%)	98 (100%)	

Note: T_1 represents the treatment group exposed to the tailored and targeted dissemination of knowledge intervention; T_2 represents the treatment group exposed to the targeted dissemination of knowledge intervention; C represents the control group that received neither of the above interventions, but assumed to be exposed to passive diffusion.
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of the study period (eight months). The changes surpassed the testing effect as detected in the C group representing *passive diffusion*. Furthermore, while both *tailor-and-target* and *target-only* strategies were effective compared to *passive diffusion*, neither was more effective than the other as per post-hoc findings from between –group analyses reported earlier.

Raising stakeholder awareness. As mentioned earlier in the data analysis section under method overview, the ability of the strategies to raise awareness was studied by observing changes from Non-awareness level to all other levels grouped together. Table A.10 offers a closer view of the changes occurring in the levels of knowledge use within each group from baseline to follow-up 1. In Table AI0, data are arranged under two broad levels: (1) Non-awareness and (2) Awareness-plus (which combines *Awareness*, *Interest* and *Use* levels). The table compares the pre and post frequencies in awareness versus awareness-plus levels separately in relation to the three groups. The top section (first five rows) refers to the T_1 group. Of the 91 who were non-aware at baseline (prior to intervention), 55 participants remained non-aware at follow-up 1 (post

Table A.11
Frequency Changes in Non-use and Use Levels Between Baseline and Follow-up 1 in Case Two§ (*N*=288)

T_1 ($N = 97$)		Follow-up 1 Non-use	Use	Total	Exact Sig. (2-sided *p*=)
	Non-use	80 (85.1%)	14 (14.9%)	94 (100%)	
Baseline	Use	0 (0%)	3 (100%)	3 (100%)	< .001
	Total	80 (82.5%)	17 (17.5%)	97 (100%)	
T_2 ($N = 93$)		Follow-up 1 Non-use	Use	Total	Exact Sig. (2-sided *p*=)
	Non-use	81 (88%)	11 (12%)	92 (100%)	
Baseline	Use	0 (0%)	1 (100%)	1 (100%)	< .001
	Total	81 (87.1%)	12 (12.9%)	93 (100%)	
C ($N = 98$)		Follow-up 1 Non-use	Use	Total	Exact Sig. (2-sided *p*=)
	Non-use	94 (96.9%)	3 (3.1%)	97 (100%)	
Baseline	Use	0 (0%)	1 (100%)	1 (100%)	.250
	Total	94 (95.9%)	4 (4.1%)	98 (100%)	

Note: T_1 represents the treatment group exposed to the tailored and targeted dissemination of knowledge intervention; T_2 represents the treatment group exposed to the targeted dissemination of knowledge intervention; C represents the control group that received neither of the above interventions, but assumed to be exposed to passive diffusion.
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intervention). Of the 6 participants who were at Awareness-plus level at baseline, one participant moved to Non-awareness at follow-up 1. Applying the McNemar test (last column) showed that the movement from Non-awareness to Awareness-plus level was significant (p<.001) for the T_1 group. The next two sections of this table repeat similar analyses, showing that the movement was also significant for T_2 (p<.001). Not surprisingly, it is also significant for C (p=.016), and it corroborates earlier results suggesting a testing effect. Note that the magnitude of changes to awareness in C are smaller, where 92.8 % remained non-aware at follow-up 1. Thus, both the *tailor-and-target* and *target-only* strategies significantly raised participant awareness.

Similar analyses for participant movement from follow-up 1 to follow-up 2 showed no significant results for any of the three groups. No further increase in awareness occurred in the second four-month period. However, there was significant movement from baseline to follow-up 2 for both T_1 (p<.001) and for T_2 (p<.001), signifying that the groups retained the intervention effect until the end of the eight-month intervention period. The C group also moved up significantly (p=.002) reflecting the likely testing effect.

Moving stakeholders from Non-use to Use level. The capacity of the strategies to get non-users to actually use the knowledge was analyzed next. These analyses were based on a regrouping of participant data as shown in Table A.11. These analyses examine baseline and follow-up 1 frequencies related to participant movement from the *Non-use* level (i.e., combining data on Non-awareness, Awareness and Interest) to the Use level as measured by the LOKUS instrument.

Data in Table A.11 are arranged in sub-sections, corresponding to T_1, T_2, and C groups respectively. As seen in the right-most column, the McNemar test p values are significant for groups T_1 (p<.001) and T_2 (p<.001) but not for group C (p=.250). However, these p values were significant neither between follow-up 1 and follow-up 2, nor between baseline and follow-up 2. Therefore, both *tailor-and-target* and *target-only* strategies moved participants from *Non-use* to the Use level significantly in the first four-month period but the effect was not retained at eight months.

Differential effects of knowledge communication strategies among stakeholder types. Research Question 2 concerns differential effects of the three communication strategies on knowledge use among five stakeholder types: brokers, clinicians/prescribers, manufacturers/ industry, researchers, and consumers. Results related to changes on their levels of knowledge use appear in Table A.12. This table presents both between-group (comparative) and within-group (absolute) differences among the stakeholder types, considering the T_1, T_2, and C groups individually. Results from follow-up 1 to follow-up 2 are omitted because no significant change was detected in any of the five stakeholder types during the second four months. The table reports changes from baseline to follow-up 1 (first four-month period) and from baseline to follow-up 2 (overall, eight-month period).

Table A.12 shows that at baseline, there were no significant differences in knowledge use levels among the five types in any of the three groups. The within-groups analysis of data from baseline to follow-up 1 shows that brokers were the only stakeholders that demonstrated no significant change in the T_1 group. The other types changed significantly: prescribers/ certified fitness trainers (p=.005), industry (p=.010), researchers (p=.011), and consumers (p=.026). The right-most column shows that these types also retained the change at follow-up 2 (p=.016, .016, .038 and .006 respectively). In the T_2 group, only industry and researchers showed significant changes by the time of follow-up 1 (p=.010 and p=.038).

Table A.12
Changes in Knowledge Use by Stakeholder Type and by Group in Case Two§ (*N*=288)

	Between Group Difference at Baseline	Within Group Analyses	
T_1		Change from Baseline to Follow-up 1 Z (*p*=)	Change from Baseline to Follow-up 2 Z (*p*=)
Fitness Facility Architect and Access Consultant (Broker)	$\chi^{2} = 2.042$, p =. 728	*Z* = -1.890 (.059)	*Z* = -1.890 (.059)
Certified Fitness Trainer		*Z* = -2.790 (.005)	*Z* = -2.414 (.016)
Manufacturer; Fitness Facility Owner/Manager (Industry)		*Z* = -2.565 (.010)	*Z* = -2.401 (.016)
Researcher		*Z* = -2.539 (.011)	*Z* = -2.074 (.038)
Consumer		*Z* = -2.232 (.026)	*Z* = -2.724 (.006)
T_2			
Fitness Facility Architect and Access Consultant (Broker)	$\chi^{2} = 2.298$, $p = .681$	*Z* = -1.342 (.180)	*Z* = -1.604 (.109)
Certified Fitness Trainer		*Z* = -1.633 (.102)	*Z* = -1.342 (.180)
Manufacturer; Fitness Facility Owner/Manager(Industry)		*Z* = -2.588 (.010)	*Z* = -2.714 (.007)
Researcher		*Z* = -2.070 (.038)	*Z* = -2.456 (.014)
Consumer		*Z* = -1.857 (.063)	*Z* = -1.890 (.059)
C			
Fitness Facility Architect and Access Consultant(Broker)	$\chi^{2}= 3.667$, p =.453	*Z* = .000 (1.000)	*Z* = -1.000 (.317)
Certified Fitness Trainer		*Z* = -1.000 (.317)	*Z* = -.378 (.705)
Manufacturer; Fitness Facility Owner/Manager(Industry)		*Z* = -1.000 (.317)	*Z* = -1.414 (.157)
Researcher		*Z* = -1000 (.317)	*Z* = -2.060 (.039)
Consumer		*Z* = -1.857 (.063)	*Z* = -1.342 (.180)

Note: T_1 represents the treatment group exposed to the tailored and targeted dissemination of knowledge intervention; T_2 represents the treatment group exposed to the targeted dissemination of knowledge intervention; C represents the control group that received neither of the above interventions, but assumed to be exposed to passive diffusion.

§The Recreational Access Technology case study.

In both types, the effect was retained to follow-up 2 (*p*=.007 and *p*=.014). In contrast, no significant changes occurred in the C group in any of the stakeholder types, by the time of follow-up 1, while only researchers showed a significant change by the time of follow-up 2.

Of the five stakeholder types exposed to the two effective strategies, brokers showed no change in knowledge use levels either in the T_1 or in the T_2 group. Fitness industry and researchers showed significant change in knowledge use levels both in T_1 and T_2 groups. Prescribers/certified fitness trainers and consumers in the T_1 group reported changes but not those in the T_2 group. It can be further noted that the above differences among the five stakeholder types were consistently observed both for the initial four months and for the total eight months.

Case Two: Discussion and Conclusions

Effectiveness results for both strategies were similar to those obtained in Case One, and are summarized below.

Overall Effects

The results refer to effects on the total sample that represented all five stakeholder types. As in Case One, a consideration in drawing conclusions was that active intervention by the *target-only* strategy occurred in the first four month period, with no additional intervention afterward. Thus effects over the first four months carry a special weight as indicator of effectiveness in reference to the *target-only* strategy. The *tailor-and-target* strategy, in contrast, had two distinct intervention components, one during the first four-month period and the other during the second.

Between-group analyses of all stakeholder responses showed a significant difference among T1, T2, and C groups regarding their knowledge use levels, both by the end of the first four months and at the end of the eight month study period. However, there was no significant difference between T1 and T2 groups. Thus, both *tailor-and-target* and *target-only* strategies were effective compared to *passive diffusion* over the first four months, with effects retained over the total study period. With respect to the AIMFREE instrument in recreational access technology addressed by Case Two, we can therefore conclude the following. The tailored CKP, taken alone or in combination with tailored webcast and availability of technical assistance, was an effective method to communicate the value of the AIMFREE instrument to the collective sample of the five stakeholder types. Targeting stakeholders to directly deliver the research article that published the AIMFREE instrument was also an effective method. However, as there was no significant difference between the two strategies themselves, one cannot be said to be more effective than the other.

Within-group analyses showed that both T_1 and T_2 groups changed significantly with respect to knowledge use levels in the first four months, as well as over the eight-month study period, even though no new changes showed in the second four-month period. All these changes represent a true effect, having surpassed the significant changes made by the C group likely due to testing. We can conclude that the *tailor-and-target* and the *target-only* groups were effective in the first four months and retained the effect over eight months even though there was no new effect in the second four-month period. The tailored CKP, taken alone or in combination with tailored webcast and availability of technical assistance, was effective on the recreational access technology stakeholders, whereas just the webcast and available technical assistance cannot be said to be effective. Targeting stakeholders to directly deliver the research article that published the AIMFREE instrument was also an effective method with the total sample.

Additionally, both T_1 and T_2 groups showed significant frequency increases from Non-awareness to higher levels in the first four months as well as over the eight-month study period. Therefore, both *tailor-and-target* and the *target-only* strategies can be said to be effective at raising awareness in stakeholders in the first four months and also at retaining it over eight months. The CKPs effectively raised stakeholder awareness of the AIMFREE instrument, and the follow up webcast and technical assistance opportunity sustained the effect. Targeted delivery of the publication of the AIMFREE instrument was also effective and the effect was sustained over 8 months. However, the same conclusions could not be drawn regarding moving non users to the Use level. In this respect, both strategies were effective in the first four months, but neither strategy was effective in retaining that persuasive effect over the eight-month period. The CKPs as well as the directly delivered publication on the AIMFREE instrument to targeted stakeholders were both able to persuade stakeholders to use the new information.

Differential Effects

Analysis of effects from the *tailor-and-target* and the *target-only* strategies, by stakeholder type, revealed that these effects were different for the different stakeholder types. Brokers showed no change in knowledge use levels either in the T_1 or in the T_2 group. We can conclude that neither the *tailor-and-target* nor the tailor-only strategy was effective on brokers. There was change in knowledge use levels of fitness industry and researchers in both T_1 and T_2 groups. So, both strategies were effective on these stakeholders. Changes were observed in prescribers and consumers in the T_1 group but not in the T2 group. Therefore, only the *tailor-and-target* strategy was effective on these stakeholder types but not the tailor-only strategy. These changes were observed in the initial four months and also over the total eight months. We can thus conclude the following. 1) the CKPs, webcasts, and the offer of technical assistance about the use of AIMFREE instrument were effective with researchers, industry stakeholders, prescribers (certified fitness trainers), and consumers. This is an important conclusion as both industry and practitioners play a major role in technology transfer, whether by adapting knowledge for use or by seeking evidence as basis for practice. Also, consumers are the beneficiaries of the technology. 2) Targeted delivery of the article only with no tailoring was effective with researchers and industry stakeholders; which suggests their high level of interest in (or perceived value of) the AIMFREE instrument. As noted, they also benefited by tailoring. 3) Brokers were least affected by either strategy regarding change in levels of knowledge use, suggesting least context relevance as perceived by them. Brokers in this case study were advocates of independent living for persons with disability.

Case Three: Communicating Knowledge to Stakeholders of Wheeled Mobility Technology

This section details study procedures used for the intervention evaluation in the third case study on WhMob technology. It also describes the development of the intervention materials specific to the stakeholders of WhMob technology. The overall methodology described earlier provides the framework for both.

Case Three: Method

Developing Intervention Materials

Selecting the knowledge area and the publication. For this case study, a pool of recently published research articles related to wheeled mobility technology was compiled. The publication "Use of Power Tilt Systems in Everyday Life" by Sonenblum and colleagues was selected (Sonenblum, Sprigle & Maurer, 2009).

Identifying stakeholders in the selected knowledge area. Stakeholders were defined in the context of wheeled mobility, and national organizations were engaged to identify and recruit participants. The stakeholders included as participants in Case Three, the WhMob study, included: (a) manufacturers who made product development decisions about power wheelchair seating and positioning technologies; (b) suppliers who provided consumers with access to power wheelchairs; (c) prescribers and therapists who provided power wheelchair users with clinical guidance about seating and positioning; (d) researchers who investigated issues related to wheeled mobility technology; (e) nurses who were involved in the care of power wheelchair users; and (f) consumers who used power wheelchairs.

Materials. The contextualized knowledge package and webcast interventions that participants received as part of the *tailor-and-target* communication strategy within this area contained information about Sonenblum, Sprigle , and Maurer's (2009) research regarding the use of power tilt systems in everyday life. All stakeholder types were presented with the researchers' findings that consumers significantly under-utilize the tilt feature in their power wheelchairs. One reason for underutilization is due to misperception of the appropriate tilt angle that produces pressure relief (Sonenblum et al., 2009).

The CKP and webcast included information about potential solutions that manufacturers and suppliers can make available to consumers for efficient tilting. One such solution was a timed alert/reminder system in power tilt wheelchairs. It would notify users when to tilt. Another such solution was an override feature to delay notification for a short, predetermined time (Center on KT4TT, 2012, Series C: 2).

As part of the persuasive and motivational strategy included in the CKPs and webcasts, prescribers and therapists were urged to determine alternative approaches to relieve pressure, maximize pressure relieving tilt with evaluation and training specific to the user, address user comfort to increase participation, and provide follow-up training (Center on KT4TT, 2012, Series C: 3). Researchers were urged to consider how their expertise could be used to enhance the quality of life of power wheelchair users by advancing the state of knowledge about pressure relief and tissue healthcare, whether they promote evidence-based clinical practice, advance theory, or promote technological solutions (Center on KT4TT, 2012, Series C: 4). Nurses were prompted to talk to patients about their tilting habits, encourage patients to use the wheelchair's tilt function, share Sonenblum et al.'s (2009) research findings with patients to inform them about tilting, and recommend pressure mapping to show patients how much to tilt to achieve pressure relief Center on KT4TT, 2012, Series C: 1). Power wheelchair users were informed not only about the health benefits of pressure relieving tilts, but also about other uses for a power tilt system that include but were not limited to: watching television, balancing items on lap, resting or relaxing, eating, adjusting posture, using a table or desk, reaching, managing acid reflux, controlling spasms, managing dizziness, and getting into a vehicle (Center on KT4TT, 2012, Series C: 5).

Participants assigned to the *target-only* group received a copy of Sonenblum et al.'s (2009) published article along with a cover letter explaining her background and related interests.

Case Three: Study Procedures

Participant Recruitment

After obtaining approval from the institutional review board, individuals presumed to have an interest in wheeled mobility related research were sought through the following national organizations representing the five stakeholder types: 1) National Coalition for Assistive and

Rehab Technology (NCART), which represents manufacturers and suppliers, 2) American Physical Therapy Association (APTA), which represents prescribers and therapists, 3) Rehabilitation Engineering & Assistive Technology Society of North America (RESNA), which represents researchers, 4) Association of Rehabilitation Nurses/Rehabilitation Nursing Foundation (ARN/RNF), which represents knowledge brokers, and 5) Paralyzed Veterans of America (PVA), which represents consumers.

Case Three: Results

We describe below the sample that provided the data and the results of the analyses for the two research questions: (1) the effectiveness of the three communication strategies with the total sample and (2) their differential effectiveness with the different stakeholder types.

Sample Distribution and Characteristics.

A total of 236 participants, randomized into the T_1 (tailor-and target), T_2 (*target-only*), and C (passive diffusion) groups started the study and answered the baseline test. Of these, 224 completed follow-up 1 (at four months) and 210 completed follow-up 2 (at eight months).

Table A.13 shows the final sample distributed by study group and stakeholder type. The sample consisted of 31 brokers, 59 clinicians, 45 manufacturers, 21 researchers, and 54 consumers that completed the study. Of those 210 participants, 72 were in the T_1 group, 65 were in the T_2 group, and 73 were in the C group.

Demographic characteristics among the three study groups were not significantly different except for race/ethnicity (χ2= 15.99, *p*=.042). Regarding this characteristic, the difference between the minorities groups (4.2% of the sample) and the majority (95.8% of the sample) was larger than that observed in the two earlier case studies. Non-significant differences refer to the following characteristics: (a) age (*F*=2.11, *p*=.124), (b) years of experience (*F*=.053, *p*=.949), (c) gender (χ2= 1.927, *p*= .382), (d) education (χ2= 7.784, *p*=.650), and (e) work status (χ2= 7.523, *p*=.275). As in Case

Table A.13
Case Three§ Sample by Stakeholder Type and by Group (*N*=210)

		Study Group			
		T_1	T_2	C	Total
Stakeholder Type	Broker	11	7	13	31
	Prescriber/Clinician	20	19	20	59
	Industry/Manufacturer	17	13	15	45
	Researcher	7	6	8	21
	Consumer	17	20	17	54
	Total	72	65	73	210

Note: T_1 represents the treatment group exposed to the tailored and targeted dissemination of knowledge intervention; T_2 represents the treatment group exposed to the targeted dissemination of knowledge intervention; C represents the control group that received neither of the above interventions, but assumed to be exposed to passive diffusion.
§The Wheeled Mobility Technology case study.

One and Case Two there were more women (57.5%) than men (42.5%). The average age was 45.36. The sample was thus comparable to the Case One sample and older than the Case Two sample. Among the wheeled mobility technology stakeholder participants, the average amount of experience in the knowledge area was 15.79 years. Thus, this stakeholder sample was more experienced in the field than were the stakeholder samples in the other two case studies.

Effectiveness of knowledge communication strategies. Findings reported in Tables A.14-A.17 refer to Case Three. They address Research Question 1 and summarize analyses of effectiveness of the communication strategies: *tailor-and-target*, *target-only* and *passive diffusion* focused on wheeled mobility technology. As noted earlier, the analyses addressed both between-group differences in knowledge use levels at the three assessment points as well as within-group changes regarding knowledge use levels from assessment to assessment.

Between-group analyses. The distribution of the participants' self-reported knowledge use levels appears in Table A.14. The table shows results

Table A.14
Frequency Distributions Across Knowledge use Levels at Baseline, Follow-up 1 and Follow-up 2 in Case Three§(*N*=210)

		Level					
	N	Non-awareness	Awareness	Interest	Use	χ 2 (*p*=)	T_1 vs. T_2 χ 2 (*p*=)
Baseline							
T_1	72	58 (80.6%)	2 (2.8%)	3 (4.2%)	9 (12.5%)		
T_2	65	48 (73.8%)	2 (3.1%)	0 (0%)	15 (23.1%)	6.865 (.333)	
C	73	52 (71.2%)	2 (2.7%)	1 (1.4%)	18 (24.7%)		
Follow-up 1							
T_1	72	37 (51.4%)	9 (12.5%)	5 (6.9%)	21 (29.2%)		
T_2	65	26 (74.2%)	1 (4.3%)	9 (8.6%)	29 (12.9%)	20.605 (.002)	1935.50 (.060)
C	73	41 (56.2%)	2 (2.7%)	1 (1.4%)	4 (4.1%)		
Follow-up 2							
T_1	72	29 (40.3%)	8 (11.1%)	4 (5.6%)	31 (43.1%)		
T_2	65	31 (47.7%)	4 (6.2%)	5 (7.7%)	25 (38.5%)	4.550 (.603)	2189.00 (.479)
C	73	32 (43.8%)	4 (5.5%)	2 (2.7%)	35 (47.9%)		

Note: T_1 represents the treatment group exposed to the tailored and targeted dissemination of knowledge intervention; T_2 represents the treatment group exposed to the targeted dissemination of knowledge intervention; C represents the control group that received neither of the above interventions, but assumed to be exposed to passive diffusion.
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for each of the three time points: beginning (baseline), at four months (follow-up 1) and at eight months (follow-up 2). The left-most column lists the three study groups T_1, T_2, and C with their corresponding sample sizes listed in the next column. The four columns that follow this column display participant frequencies corresponding to the three groups that are distributed over the four knowledge use levels *Non-awareness*, *Awareness*, *Interest* and *Use* as measured by the LOKUS instrument. As the second last column shows, there was no significant association between the groups and their distribution into the four levels at baseline ($\chi 2 = 6.865$; $p = .333$). However, there was a significant difference among the three groups at four months ($\chi 2 = 20.605$; $p = .002$), and the post-hoc analyses revealed no significant difference between groups T1 and T2 ($\chi 2 = 1935.50$; $p = .060$). So, both T_1 and T_2 differed from the C group at four months. At follow-up 2, the three groups did not differ significantly ($\chi 2 = 4.550$; $p = .603$). Additionally, post-hoc analysis revealed no significant difference between the T1 and T2 groups either ($\chi 2 = 1.801$; $p < .615$).

Within-group analyses. Results from the preceding between-group analyses are corroborated by results from within-group analyses, which focused on changes occurring in knowledge use levels within each of the three groups across the three time points. Table A.15 below shows such an analysis for the T_1 group. The rows in Table A.15 present the baseline frequencies and percentages

Table A.15
Changes in Knowledge use Levels Between Baseline and Follow-up 1 for Group T_1 in Case Three[§] (*N*=210)

			Frequency and Percentage					
			Follow-up 1					
	Group	Levels	Non-awareness	Awareness	Interest	Use	Total	Z(*p*=)
Baseline	T_1	Non-awareness	35 (60.3%)	7 (12.1%)	4 (6.9%)	12 (20.7%)	58 (100%)	3.656 (<.001)
		Awareness	0 (0%)	0 (0%)	1 (50.0%)	1 (50.0%)	2 (100%)	
		Interest	1 (33.3%)	1 (33.3%)	0 (0%)	1 (33.3%)	3 (100%)	
		Use	1 (11.1%)	1 (11.1%)	0 (0%)	7 (77.8%)	9 (100%)	
		Total	37 (51.4%)	9 (12.5%)	5 (6.9%)	21 (29.2%)	72 (100%)	

Note: T_1 represents the treatment group exposed to the tailored and targeted dissemination of knowledge intervention; T_2 represents the treatment group exposed to the targeted dissemination of knowledge intervention; C represents the control group that received neither of the above interventions, but assumed to be exposed to passive diffusion.
[§]The Wheeled Mobility Technology case study.

spread across the four knowledge use levels, while the columns present the same information for follow-up 1. The numbers to the right of the boxed cells represent a frequency change between baseline and follow-up 1 from lower to upper levels. Numbers to the left of the boxed cells show frequency changes from upper to lower levels. Thus, 26 out of 72 participants reported moving up, while four participants reported moving down. Also, of the 58 who were non-aware at baseline, 39.7% moved to higher levels at follow-up 1. These changes in the T_1 group were significant ($Z= 3.656$, $p<.001$). Similar within-group analyses in the T_2 group showed the changes were significant ($Z= 3.83$; $p<.001$), as well as in the C (control) group ($Z= 2.493$, $p<.013$). Further examination showed that 16 (29.9%) of 52 participants in the C group moved to higher levels. In the T_1 and T_2 groups respectively, 39.7% and 49.5% of participants moved up from Non-Awareness. Thus, the change in these two groups was greater in magnitude than in the C group, therefore reflecting an effect that surpassed the testing effect.

Within-group analyses detected no significant changes between follow-up 1 to follow-up 2 for either T_2 group or the C group, but changes were significant for the T_1 group ($Z=2.156$, $p<.031$). This group maintained the effect gained in the first four months, but the other two groups did not.

Interestingly, changes between baseline and follow-up 2 were significant in all three groups: T_1 ($Z=4.741$, $p<.001$); T_2 ($Z=3.209$, $p<.001$); and C ($Z=3.842$, $p<.001$). Thus the T_1 group made steady progress in the first four months as well as in the second four months. It also showed overall changes in the eight-month period. As for the other two groups, the foregoing result suggests that the effect observed in the first four months was maintained at eight months, even though no new effect occurred in the second four months. In terms of magnitude of change, recall that a valid effect was found in the T_2 group in the first four months; the effect surpassed testing effect. But this was not so in the overall eight-month period. The T_2 group registered only a 26.1% reduction in Non-awareness, while it was higher (27.4%) in the C group. On the other hand, the T_1 group registered a 40.3% reduction in Non-awareness, surpassing the testing effect over the eight-month period.

The results indicate that both *tailor-and-target* and *target-only* strategies were effective over the first four months of the study compared to *passive diffusion* (control), which showed no change. However, neither was more effective than the other as per post-hoc analyses ($\chi 2 = 1935.50$; $p= .060$). Over the eight-month period, the *tailor-and-target* strategy was clearly effective compared to passive diffusion. But the same could not be inferred of the *target-only* strategy. This indicates that both the CKP component (first four months) and the webcast-plus-technical-assistance-offer component (second four months) of the *tailor-and-target* strategy were effective. The *target-only* strategy, with its delivery of the research article to targeted audiences, was also effective in the first four months; but the effect was not retained at eight months. It should be noted that no additional intervention was provided in the second four months, as was done for the *tailor-and-target* strategy. Limitations of self-reporting measures, such as participants' recall issues over an eight-month period may explain why changes did not surpass testing effect thus obscuring the true measure of effectiveness of the *target-only* strategy.

Considering that both *tailor-and-target* and *target-only* strategies were effective in the first four months, data corresponding to this period was further analyzed to see how these strategies raised awareness in stakeholders and/or got non-users to use the knowledge.

Table A.16
Frequency Changes in Non-awareness and Awareness-plus Levels Between Baseline and Follow-up 1 in Case Three§(*N*=210)

T_1 (*N* = 72)		Follow-up 1			
		Non-awareness	Awareness+	Total	Exact Sig. (2-sided *p*=)
	Non-awareness	35 (60.3%)	23 (39.7%)	58 (100%)	
Baseline	Awareness+	2 (14.3%)	12 (85.7%)	14 (100%)	.001
	Total	37 (51.4%)	35 (48.6%)	72 (100%)	

T_2 (*N* = 65)		Follow-up 1			
		Non-awareness	Awareness+	Total	Exact Sig. (2-sided *p*=)
	Non-awareness	24 (50%)	24 (50%)	48 (100%)	
Baseline	Awareness+	2 (11.8%)	15 (88.2%)	17 (100%)	.001
	Total	26 (40%)	39 (60%)	65 (100%)	

C (*N* = 73)		Follow-up 1			
		Non-awareness	Awareness+	Total	Exact Sig. (2-sided *p*=)
	Non-awareness	36 (69.2%)	16 (30.8%)	52 (100%)	
Baseline	Awareness+	5 (23.8%)	16 (76.2%)	21 (100%)	.027
	Total	41 (56.2%)	32 (43.8%)	73 (100%)	

Note: T_1 represents the treatment group exposed to the tailored and targeted dissemination of knowledge intervention; T_2 represents the treatment group exposed to the targeted dissemination of knowledge intervention; C represents the control group that received neither of the above interventions, but assumed to be exposed to passive diffusion.

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Raising Stakeholder Awareness. Focusing on the changes occurring in the levels of knowledge use between baseline and follow-up 1, Table A.16 offers a closer view of such changes in each group. In this table data are arranged and distributed into two broader levels: (1) Non-awareness and (2) Awareness-plus (which combines *Awareness*, *Interest* and *Use* levels). The table compares the pre and post frequencies in awareness versus Awareness-plus levels separately in relation to the three groups as described below. The top section (first five rows) refers to the T_1 group, where 35 participants were Non-aware both pre and post intervention, while 12 participants were at Awareness-plus level at pre and post. However, 23 participants who were Non-aware at baseline moved to Awareness-plus at follow-up 1; and two participants who were Aware-plus at baseline moved to Non-awareness at follow-up 1. Applying the McNemar test (right-most column) showed that the movement from Non-awareness to Awareness-plus level was significant (*p*=.001) for the T_1 group. The next two sections of this table repeat similar analyses, showing that the movement was also significant for T_2 (*p*=.001),

Table A.17
Frequency Changes in Non-use and Use Levels Between Baseline and Follow-up 1 in Case Three§ (*N*=210)

T_1 (*N* = 72)		Follow-up 1			
		Non-use	Use	Total	Exact Sig. (2-sided *p*=)
	Non-use	49 (77.8%)	14 (22.2%)	63 (100%)	
Baseline	Use	2 (22.2%)	7 (77.8%)	9 (100%)	< .004
	Total	51 (70.8%)	21 (29.2%)	72 (100%)	
T_2 (*N* = 65)		Follow-up 1			
		Non-use	Use	Total	Exact Sig. (2-sided *p*=)
	Non-use	34 (68%)	16 (32%)	50 (100%)	
Baseline	Use	2 (13.3%)	13 (86.7%)	15 (100%)	< .001
	Total	36 (55.4%)	29 (44.6%)	65 (100%)	
C (*N* = 73)		Follow-up 1			
		Non-use	Use	Total	Exact Sig. (2-sided *p*=)
	Non-use	39 (70.9%)	16 (29.1%)	55 (100%)	
Baseline	Use	5 (27.8%)	13 (72.2%)	18 (100%)	<.027
	Total	44 (60.3%)	29 (39.7%)	73 (100%)	

Note: T_1 represents the treatment group exposed to the tailored and targeted dissemination of knowledge intervention; T_2 represents the treatment group exposed to the targeted dissemination of knowledge intervention; C represents the control group that received neither of the above interventions, but assumed to be exposed to passive diffusion.
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and, not surprisingly, also for the C group (*p*=.027). In terms of magnitude of change, however, 30.8% in the C group moved up from Non-awareness to Awareness-plus levels at the end of the four months whereas 50% in the T_2 group did so. So, the changes in the T_2 group surpassed the testing effect. Thus, both the *tailor-and-target* and *target-only* strategies significantly raised participants' awareness in the first four months.

Within-group analyses for participant movement from follow-up 1 to follow-up 2 showed no significant results for any of the three groups. No further increase in awareness occurred in the second four-month period.

However, there was significant movement from baseline to follow-up 2 in all three groups: T_1 (*p*<.001), T_2 (*p*<.001, and C (*p*<.027) signifying that the groups retained the intervention effect until the end of the eight month intervention period. Considering the effect on the C group to be due to testing effect (as there was no intervention), the magnitude of changes were compared across the three groups. In the C group, 13.4% of participants moved from Non-awareness. A greater number of participants moved up from Non-awareness in the T_1 and T_2 groups, which were respectively 39.7% and 50%, thus surpassing the testing effect. Thus, both the *tailor-and-target* and *target-only* strategies significantly raised participant awareness over the eight-month study period, compared to *passive diffusion*.

Moving stakeholders from non-use to use level. Subsequent analyses used a line of reasoning similar to the foregoing and examined pre and post frequencies related to participant movement from the Non-use level (i.e. combining data on Non-awareness, Awareness and Interest) to the Use level as measured by the LOKUS instrument. These results are presented in Table A.17. This table shows data for T_1, T_2, and C groups in sub-sections. As seen in the right-most column of Table A.17, the McNemar test p values are significant for groups T_1 ($p<.004$) and T_2 ($p<.001$) as well as for group C ($p<.027$). In terms of magnitude of change, 29.1% moved from Non-Use levels to Use in the C group. If this can be considered a testing effect, then the T_1 group did not surpass this effect, moving only 22.2% to the Use level. However, 32% of T2 group participants moved from Non-Use levels to Use, surpassing this effect.

The changes between follow-up 1 and follow-up 2 (second four months of the study period) from Non-use to Use levels were not significant for either the C group or the T_2 group. On the other hand, they were significant for the T_1 group ($p<.041$). This indicates that the webcast-plus-offer-of-technical assistance component of the *tailor-and-target* strategy was effective, although as seen above, its CKP component was not effective. The *target-only* strategy produced no further effect during this period. Again, we note that there was no new delivery of this strategy during this period.

Between baseline and follow-up 2, all three groups showed significant movement from *Non-use* to Use level: 38.1% moved up in T_1 ($p<.001$; 26% moved up in T_2 ($p<.021$); and 34.5% moved up in the C group ($p<.001$). The magnitude of the movements relative to the C group indicates that the *tailor-and-target* strategy effectively moved participants from Non-use to the Use level surpassing changes due to testing effect. The *target-only* strategy did not. While it demonstrated effectiveness over the first four months, the effect was not retained at eight months.

Differential effects of knowledge communication strategies among stakeholder types. Research Question 2 of this case study concerns differential effects of the three communication strategies - *tailor-and-target*, *target-only* and passive diffusion among the five stakeholder types: brokers (nurses), clinicians/prescribers, manufacturers/suppliers, researchers, and consumers. Table A.18 addresses this question and reports the results from the analyses of stakeholder levels of knowledge use. The table presents both between-group (comparative) and within-group (absolute) differences among the stakeholder types, considering the T_1, T_2, and C groups individually. The table reports changes from baseline to follow-up 1 (first four-month period) and from baseline to follow-up 2 (overall eight-month period). As shown in the second column of Table A.18, baseline level differences (Kruskal-Wallis one-way ANOVA) among the five types were significant in the T_1 ($p = .049$) and T_2 ($p = .017$) groups. The different stakeholder samples in the C group started at similar knowledge use-levels.

The within-group analysis shows that nurses in the T_1 group (exposed to the *tailor-and-target* strategy) demonstrated significant change from baseline to follow-up 1 ($p=.007$) as did consumers ($p=.024$). The right-most column shows that they also changed significantly from baseline to follow-up 2 ($p=.039$ and $p= .014$).

Table A.18
Changes in Knowledge Use by Stakeholder Type and by Group: Case Three[§] (*N*=210)

	Between Group Difference at Baseline	Within Group Analyses	
T_1		Change from Baseline to Follow-up 1 *Z*(*p*=)	Change from Baseline to Follow-up 2 *Z*(*p*=)
Nurse	χ^2= 9.538, *p*= (.049)	*Z*=-2.714 (.007)	*Z*=-2.060 (.039)
Prescriber and Therapist		*Z*=-.136 (.892)	*Z*=-.2.274 (.023)
Manufacturer and Supplier		*Z*=-.1.794 (.073)	*Z*=-.2.058 (.040)
Researcher		*Z*=-.816 (.414)	*Z*=-1.903 (.057)
Consumer		*Z*=-2.264 (.024)	*Z*=-2.456 (.014)
T_2			
Nurse	χ^2= 12.079, *p*= (.017)	*Z*=-2.121 (.034)	*Z*=-1.414 (.157)
Prescriber and Therapist		*Z*=-2.478 (.013)	*Z*=-2.541 (.011)
Manufacturer and Supplier		*Z*=-1.169 (.242)	*Z*=-.272 (.785)
Researcher		*Z*=-1.000 (.317)	*Z*=-.000 (1.000)
Consumer		*Z*=-1.857 (.063)	*Z*=-2.070 (.038)
C			
Nurse	χ^2= 4.281, *p*= (.369)	*Z*=.000 (1.000)	*Z*=-1.732 (.083)
Prescriber and Therapist		*Z*=-1.131 (.258)	*Z*=-2.428(.015)
Manufacturer and Supplier		*Z*=-2.157 (.031)	*Z*=-.2.268 (.023)
Researcher		*Z*=-.849 (.396)	*Z*=-1.604 (.109)
Consumer		*Z*=-1.000 (.317)	*Z*=-1.000 (.317)

Note: T_1 represents the treatment group exposed to the tailored and targeted dissemination of knowledge intervention; T_2 represents the treatment group exposed to the targeted dissemination of knowledge intervention; C represents the control group that received neither of the above interventions, but assumed to be exposed to passive diffusion.

[§] The Wheeled Mobility Technology case study.

Both nurses and consumers benefitted from the CKP materials as well as from the webcast and related offer of technical assistance. Prescribers and therapists showed significant upward movement between knowledge use levels only at the end of the eight months (*p*= .023). The benefit appears to have been a cumulative effect from both components. Researchers were the least affected.

In the T_2 group exposed to the *target-only* strategy, nurses showed significant upward movement between knowledge use levels in the first four months (*p*= .034) and did not retain the effect at eight months. On the other hand, prescribers/therapists changed significantly in the first four months (*p*= .013) and also retained the effect at eight months (*p*=.011). Targeted delivery of the article alone appears to have been effective with them. The changes in knowledge use levels in consumers appear to have been cumulative over the eight-month period, showing significant change only at the end of the study period (*p*= .038).

Neither manufacturers nor researchers showed significant changes in knowledge use levels due to *tailor-and-target* strategy or due to the *target-only* strategy.

The above results are slightly different from the results of Case One and Case Two. Similar to the previous two cases, the above results demonstrated the effect on clinicians and consumers; but unlike either of the two cases, the effect was also shown on brokers (i.e., nurses who care for consumers). Also, unlike the previous cases, there was no effect on the manufacturers. Sonenblum et al. (2009), the knowledge producers in this case, discuss and mention all these stakeholders in their research article as the intended users of the findings. Thus the foregoing results, except those for the manufacturer or researcher, are congruent with the expectations of the knowledge producer. The unperceived relevance of the specific findings by industry or researcher might be explained by its applicability as seen by these stakeholders. To recall, the knowledge was about consumers' lack of compliance with tilting in their wheeled chairs in relation to preventing pressure sores. In terms of importance and the urgency of application this knowledge has ready appeal to consumers, the direct beneficiaries. It is also obvious to their caregivers (nurses) and to the clinicians who seek evidence-based protocols to evaluate and assist consumers with their seating; but not so obvious to manufacturers and researchers. In fact, a challenge in preparing CKPs for them in this case study was to suggest ways of application.

Finally two unexpected effects were noted in the C group: one by manufacturers at four months (*p*=.031) and at eight months (*p*=.023), and the other by the prescriber sample at eight months (*p*=.015). As discussed earlier, the effects could be attributed to repeat testing.

Case Three: Discussion and Conclusions

While results from the previous two cases showed similarities in the strategies' effectiveness with stakeholders of AAC and RecAccess technologies, results from Case Three were slightly different with stakeholders of WhMob technologies. As summarized below, this apparent inconsistency is explained both by the limitations posed by the LOKUS instrument and by the singularities of the new knowledge in communication to this stakeholder audience.

Overall Effects

These are effects of the strategies on the total sample representing all five stakeholder types. As with Cases One and Two, we considered that active intervention by the *target-only* strategy occurred in the first four month period, with no additional intervention afterward. The *tailor-and-target* strategy, in contrast, had two distinct intervention components, one in each four-month period. Therefore, effects over the first four months provided a primary source of effectiveness for the *target-only* strategy. An additional consideration related to a limitation posed by the LOKUS instrument, which possibly compromised response accuracy in two ways. First, self-reporting allowed for subjective judgment by participants regarding their own knowledge use level, and variation in responses according to how each defined knowledge use. Second, participants were asked to respond to questions that were repeated over time during the study period, which might have introduced a difficulty in recalling facts, therefore compromising accuracy. Thus, both observed effects of the strategies and any testing effect registered by the control group were examined in light of such response distortion.

Analyses of stakeholder responses on knowledge use levels included both between-group analyses, which compared the T_1, T_2, and C groups at the three assessments, and within-group analyses, which tracked changes within each group from assessment to assessment.

At four-months, the between-group analyses showed a significant difference among the three groups but no difference between T_1 and T_2, groups. Thus, both the *tailor-and-target* and the *target-only* strategies were effective over the first four-month period, compared to passive diffusion, although one was not better than the other. This result was corroborated by the within-group analyses for the first four months. Both T_1 and T_2 groups changed significantly compared to the control group, surpassing the testing effect registered by the control group. We can thus conclude that both the *tailor-and-target* and the *target-only* groups were effective in the first four-month period. Therefore, the CKP component of the *tailor-and-target* strategy was effective, as was the targeted delivery of the publication by the *target-only* strategy.

For the second four-month period, within-group analyses showed that the T_1 group changed significantly but not the T_2 or the C groups. This indicates that the webcast-plus-technical-assistance-offer of the *tailor-and-target* strategy was also effective. The *target-only* strategy did not obtain added effect in the second four-month period, which is not surprising as there was no additional intervention provided during that period. Unlike Cases One and Two, the between-group analyses at eight months showed no difference among the three groups. This may seem surprising, since within-group analyses, as mentioned below, showed that the T_1 group changed significantly relative to the C group. On closer look, however, one can see that the control group also had changed significantly, in a way that it obscured any difference among T_1, T_2 and C at eight months. Importantly, there was no difference between T_1 and T_2 at eight months, which is a result similar to the previous cases.

Within group analyses over the eight-month period (baseline to follow-up 2) corroborated the above results. They showed the T_1 group registered changes surpassing the testing effect, while the T_2 group registered a significant change but did not surpass the change in C. Thus, the *tailor-and-target* intervention was clearly effective compared to *passive diffusion*, while the same could not be inferred of the *target-only* intervention. This may appear inconsistent with the between analyses results over the eight-month period, which showed that the three groups did not differ in their knowledge use levels, independent of any growth that might have occurred in each group. Even though changes in T1 surpassed changes in both the T_2 and the C groups as mentioned above, the fact that all three changed significantly likely contributed to the apparent non-significant difference among the three at the end. Thus, we can conclude that both the CKP component and the webcast-plus-technical-assistance-offer component of the *tailor-and-target* strategy were effective. The targeted delivery strategy was also effective but the effect was not retained beyond the first four-month period

Regarding raising participant awareness, within-group analyses for the first four-month period showed significant changes for both T_1 and T_2 groups. Both the *tailor-and-target* and *target-only* strategies significantly raised participant awareness of the new knowledge produced by Sonenblum et al. (2009) in the first four months. No further increase in awareness occurred in the second four-month period in any of the three groups. But over the eight-month study period, both the T1 and T2 groups registered significant changes compared to C. We can conclude that both the *tailor-and-target* and *target-only* strategies were effective in raising participant awareness.

Interestingly, within group analyses of movement of non-users to the Use level showed that the T_1 group did not change significantly in the first four months, relative to C. Therefore, the *tailor-and-target* strategy was not effective in moving non-users to use the new knowledge in the first four months. However, the T1 group registered a valid change in the second four months, as well as over the total eight months. Therefore, the *tailor-and-target* strategy was effective in moving participants to use during the second four months as well as over the eight-month period. On the other hand, results in the T_2 group showed the *target-only* strategy was effective in moving non-users to use during the first four months, but it was not effective during the second four months. Also, the changes it produced over the eight-month period did not surpass the testing effect registered by the C group.

We can conclude that the CKP component of the *tailor-and-target* strategy effectively raised participant awareness, without moving them to use. The webcast, and accompanying offer of technical assistance, were able to move participants further to Use. The targeted delivery in the *target-only* strategy succeeded both in raising participants' awareness and moving them to the Use level initially (in the first four months). However, this effect was not observed in the second four months, which is not surprising given that participants were not exposed to any additional intervention component as with the *tailor-and-target* strategy. But the effect was not observed over the eight-month period either, as the changes in the T_2 group did not surpass the testing effect. In other words, the effectiveness achieved in the first four months was not retained beyond that period. As stated earlier, limitations imposed by self-reported measures of knowledge use may partly explain this result. Subjectively interpreting Use as any isolated application of the knowledge could have initially overestimated participants' true state of "use" that remained steady at that level thereafter. Second, recall issues over the period of eight months could have interfered with consistency in giving repeated responses across the three assessments as called for by the LOKUS instrument. Recall difficulties over eight months is quite plausible when one considers that there was no additional intervention component designed in the *target-only* strategy for the second four-month period, almost likening it to the control group.

Differential Effects

Additional between-group and within-group analyses investigated how effective the three strategies were with the five different stakeholder types: brokers (nurses), clinicians/prescribers, manufacturers/suppliers, researchers, and consumers. The results showed the following. Of the stakeholders exposed to the *tailor-and-target* strategy (T_1 group), nurses and consumers changed knowledge use levels significantly in the first four months as well as over the total eight-month period. The CKP materials were effective with these stakeholders. Also, following up with webcast and an offer of technical assistance was effective in retaining that effect. Prescribers and therapists showed significant change only by the time of eight-month assessment. The effectiveness of the *tailor-and-target* strategy on these stakeholders was cumulative accrued from both CKP and the follow-up webcast and offer of technical assistance. The strategy was not effective with researchers either in the first four months or over the eight months.

In the T_2 group, which was exposed to the *target-only* strategy, nurses and prescribers/therapists showed significant upward movement between knowledge use levels in the first four months. But nurses did not retain the effect at eight months, while prescribers/therapists did. Given that this intervention did not provide for follow-up reminder in the second four months, we can conclude that targeted delivery of the article alone was an effective strategy with prescribers as well as with nurses but not sufficient for the latter group for effect retention. The changes in consumers showed up only at the end of the study period leading to the conclusion that the *target-only* strategy was effective with these stakeholders, with the effect accumulating (that is, more and more individuals moving up) over the eight-month period.

Both manufacturers and researchers, whether exposed to the *tailor-and-target* strategy or the *target-only* strategy, showed no significant changes in knowledge use levels. The singularity of the new knowledge conveyed in Sonenblum et al.'s (2009) findings offers a plausible explanation of this result. The findings reported consumer compliance with appropriately tilting in their wheeled chairs as crucial for preventing pressure sores. The importance of this message to consumers and the opportunity for immediate use of this knowledge for their own benefit is straightforward and obvious. It is also readily recognized by their caregivers (nurses) and by clinicians who abide by protocols to evaluate and assist with consumer seating. But the immediate application opportunity is not so directly evident to manufacturers and researchers; as for example, provision of a reminder mechanism in the wheelchair to help consumers with tilting.