Technology and Disability 24 (2012) 181–185
DOI 10.3233/TAD-2012-0355
IOS Press

Guest Editorial

Assistive Technology-Technology Transfer

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Abstract. This special issue editorial discusses the inspiration for the Association for the Advancement of Assistive Technology in Europe's 2010 workshop – the concept of a social model for assistive technology-technology transfer, anecdotal shortcomings in assistive technology innovation and the desire to identify what the state of the art was and what future research is needed. The themes of the workshop were addressed by the presentations through case studies that use methods drawn from other fields, but the papers included in the special issue are instances where different approaches were taken, methodological issues in user requirements gathering and challenges in meeting regulatory requirements for CE marking. Ambiguity in the use of the terms 'assistive technology' and 'technology transfer' are observed. Embracing definitions are given for both. The inadequacy of many simpler models of technology transfer is discussed. Factors suggesting inadequacy are competitive innovation and, technology transfer implementation that employs parallel tasks that are modelled as sequential. An argument to innovate non-medical assistive technology in preference to medical ones to reach markets quickly is described. Consequential challenges are noted. Areas of assistive technology-technology transfer needing further research are highlighted.

Keywords: Assistive technology, technology transfer, models, definition

1. Introduction

The importance of technology transfer to whole societies in general is illuminated by the fact that governments often establish initiatives to promote it. This is typically seen as part of science and technology innovation so that a country or countries can remain competitive and continue to have a healthy income for their citizens. Such initiatives operate in what are seen as strategically important and/or large or valuable markets. In this aspect assistive technology is quite different in that some technologies aim at sizeable markets while others target small or even tiny populations. As the latter markets will in principle look uneconomic, this raises questions about the consequences of European Union commitments to an inclusive society, namely, that moral and/or social inclusiveness should dictate state encouraged innovation and technology transfer of assistive technology as well.

In 2010 the AAATE workshop [1] focused on technology transfer for assistive technology, this special issue has come from the papers presented at that workshop. The workshop aimed to address the theme of 'a social model for Assistive Technology-Technology Transfer'. The idea was that the social model is one that assumes that the development of assistive technology is something that has to be driven by the goal of achieving an inclusive society – and so there are moral, financial, business and scientific issues to understand and manage. Partly the aim was to explore if there was or should be a change due to the continuing anecdotal perception that assistive technology innovation can be slow and/or was sometimes inappropriate.

While the workshop call asked that contributions should focus on all, some or specific parts of the technology transfer process (rather than specific technologies), the papers presented [1] individually cut across at least a few and collectively across many of the identified themes i.e. technology development and issues, evidence of effectiveness or market, how information about assistive technology helps transfer, social and ethical implications, open innovation/development,

ISSN 1055-4181/12/$27.50

taking account of service delivery issues, commercialisation issues, the role of customer and public involvement and, approaches to technology transfer and innovation. Some themes were not addressed in any significant way – contrasting commercial and social models of assistive technology and technology transfer, and, financing; perhaps identifying needed research.

In most cases the studies reported in the papers did not aim to investigate the topics of the workshop themes. Most presented a case study involving the use of a single methodology and approach during some steps of technology transfer. Some of the methods or approaches are standard for domains other than assistive technology, while some (like the papers in this special edition with lead authors Keijer, Magnusson and McCullagh) were developed during the research. This highlights doubts. For instance are methodologies and the corresponding standard tools from other domains appropriate for all assistive technology? The implication being where there are indications of inappropriateness or known faults then further methodological research is suggested for the Assistive Technology domain. Lane in his paper in this special issue proposes that it is important to rebalance the 'evidence' and the 'needs' to take into account the needs of business and not just the end user. Another area of this debate is addressed in this special issues' paper with lead author Blackburn where the authors discuss appropriate use of methods for eliciting user requirements.

2. What is meant by 'Assistive Technology-Technology Transfer'

In writing this editorial it became evident that universal understanding of the terms 'assistive technology' and 'technology transfer' does not exist. This is because there are many professional domains that have a particular perspective or agenda and for which there can be technology, processes or context that are quite different in nature from that of others. In the case of the term assistive technology some debates have developed over the inclusion or not of telehealth or telecare technologies [2]. Most readers of this journal will believe that they reasonably understand what is meant by the combined term 'assistive technology-technology transfer', understanding that any technology transfer is an important part of innovation that ultimately should result in end users having desired assistive technology. However, even today a precise meaning of the combination of the two terms 'Assistive Technology' and 'Technology transfer' is not straightforward because for both it is possible to find many different but similar definitions. The variations usually account for requirements of the specific contexts, which in turn can reflect details of constituent steps and/or processes. The variations can occur for example: where the technologies are domain specific, e.g. climate change, pharmaceuticals; or, where the transfer occurs between different types of people/organisations, e.g. business to business, university to business, industrial country to developing country. The application domain can also make a difference; this was observable at the workshop and in many of the papers of this special issue by the assumption of, what is often called, a 'medical model'. And a notable impact – a difference – exists with assistive technology intended for education. The latter technologies have to be CE marked but are not required to meet the more exacting Medical Device Directive [3] that some assistive technology has to meet. A consequence of this difference is that in general it can significantly increase times to market and delay the benefit reaching individuals. Indeed impacts and challenges that the directive cause are discussed in the paper by McCarthy in this special issue.

In a multidisciplinary field like assistive technology it is familiar to take steps to avoid potential confusion and so it is important to at least be aware of the existence of numerous interpretations of 'technology transfer' and assumed corresponding characteristics. Nonetheless for the purposes of this special issue single definitions that are reasonably embracing will be used. The chosen definition for assistive technology is synonymous with this journal's focus - any product, or, technology based service, that enables people of all ages who have activity and/or cognitive/intellectual limitations in their daily lives, education, work or leisure. The two words of 'technology' and 'transfer' retain their basic and widest meanings that are readily understood. Combined as a single term 'technology transfer' describes a situation where there are those who supply the technology and those who receive it. However a special added meaning to the term which is almost universally employed, is an assumption that greater distribution (many receivers) is intended and that this will directly, or ultimately, result in commercial activity. So the definition chosen here is "the transfer of new technology from the originator(s) to the user(s) ultimately resulting in many users benefitting".

Technology transfer is often described through use of a schematic diagram. In some it is shown as a loop of many sub-processes each one feeding into the next,

in others as a smaller number of sub-processes that have some feedback loops. These are not just used to share understanding but often to also design and manage technology transfer systems or services – therefore having very real impact on what is done in practice. This further demonstrates the potential impact of the variability of understanding implied above. Modelling of technology transfer is discussed later.

It is worth noting that technology transfer is often taken as being a special case of knowledge transfer. In fact a technology transfer process will always include some knowledge transfer but it often involves the transfer of a physical item or system. In addition a new term has begun to emerge, that of 'knowledge exchange'. This is exactly the same as 'knowledge transfer' but the new name recognises that almost always there is a two-way transfer of knowledge, i.e. the originator (s) gaining in some knowledge too.

3. Technology Transfer as part of the idea-to-product (innovation) journey

Table 1 shows a simple representation of the steps of innovation of technology for a marketable 'solution'. While it is inspired by steps in innovating health technology and/or services it is equally applicable for other kinds of assistive technology. Two descriptions of the steps are shown because this demonstrates what could happen if business factors are not taken account of, cf the issues raised by Lane in this special issue.

Technology transfer might typically or traditionally be seen as occurring somewhere around the end of Evidence I and up to the start of the final product launch. Table 1, and other descriptions of technology transfer, portray technology transfer using a simple sequential flow diagram or schematic. Somewhat more sophisticated models use feedback loops between specific steps. In reality such depictions are simplistic or managerial conveniences.

Technology transfer is a professional and research field in its own right and with many models, the latter mostly from quite different perspectives to that focussed on in this special issue [4]. In practice technology transfer processes are chaotic not least because of external influences. This can be easily demonstrated by the fact that unanticipated changes in available basic technologies, tools and indeed in competition can all *a priori* instantly and unavoidably impact the activities in many of the steps. In general these impacts can be positive or disruptive and have from major to minor consequences. It is also important to note that some of these impacting factors are outside the scope of traditional understandings of technology transfer. Hence there is a fairly compelling argument that technology transfer models cannot be sensibly constructed if they don't consider the whole innovation process and indeed that any individual project is occurring in a competitive space. However for the discussion hereafter the term 'technology transfer' will still be employed in its traditional meaning.

The relative speed with which innovation and technology transfer steps/processes can occur should also impact any model and understanding. If any one of the above simple models of innovation are implemented so that it is significantly faster than external competing activities, it is much more likely that the model is usable (i.e. realistic) and that exploitation will occur. As already alluded to, in reality external competition exists across the world. If the teams or individuals involved in innovation have the right knowledge, enough facilities, and the capability to apply them, then finance can have a large impact on speed and success. However lateral thinking, right-place right-time and random or opportunistic factors can disrupt any otherwise non-chaotic modelling.

Another aspect around speed of technology transfer, is that some steps in any model can be completed or repeated quickly compared to other steps. This can create opportunity for parallel activity in the steps and internal project disruptive impacts from the faster steps to the slower ones. But such occurrences are within the control of the project management – to act on them or to hold them back for a future version of the product. In electronics and information and communication technologies the rapid pace of competitive innovation across the world means assistive technologies based on them can also be invented at a rapid rate. However meeting regulatory requirements and achieving wide adoption when in a health context usually cannot occur rapidly. The latter requiring substantial investment in evidence (e.g. steps Evidence II and III in Table 1). This is one reason why in this area of assistive technology (and indeed in other care technology related contexts, e.g. rehabilitation and self-management) there is a tendency to look for commercial opportunities that allow a non-medical application/use of the technology first. In effect, developing a non-health technology first allows a quick route to market and still allows the medical version to be developed – over a longer period and if return on the extra investment is evident.

Innovation of technological solutions can be so rapid that research to demonstrate effectiveness (or even ef-

Table 1
Sequential steps model of the innovation of technology

Step	Technology focused view	Business oriented view
Concept	Idea/need → reasoned 'paper' description and/or mock up	Idea/need → reasoned 'paper' description that includes apriori view of market potential and mock up
'Lab' prototype	partially functional prototype → fully functional prototype	partially functional prototype → fully functional prototype that has considered cost of production
Evidence I	proof of concept	proof of concept and evidence of market
Commercialisation I	commercial prototype	establish return on investment potential → commercial prototype
Evidence II	proof of efficacy	proof of efficacy, monitor competition
Commercialisation II	commercial version (CE marked)	commercial version (CE marked), marketing strategy and early marketing materials
Evidence III	proof of effectiveness	proof of effectiveness, review of market competition and opportunities
Commercialisation III	launch of proven technology	review and update of marketing strategy and marketing materials → launch of proven technology

ficacy) can be more difficult to propose because before seeking funding the cross-discipline team see a wide set of possible solutions and innovations and are reluctant to commit to any one solution. This risks adoption of unproven technologies that are available as non-health products. A current illustrative example of too much choice is in the use of mobile phone apps related to health care, for instance in diabetes mellitus type II a recent review identified 250 apps [5]. Of these only twenty two had been evaluated to any level of clinically noteworthy evidence – the review found the interventions were effective and still wide health service adoption has not occurred. Meanwhile there is some online forums that suggest that many of the apps are being used by many thousands (perhaps tens of thousands) of the public. So presuming that the apps are beneficial – this demonstrates the potential for rapid end-user benefit from rapid technology transfer. Furthermore this raises a potential issue for study, how should the trade-off between collecting evidence and achieving end user benefit in a reasonable time frame be managed?

Active innovation projects (like most endeavours) almost always have tailored and finite specific resources. This may or may not feature investment proportionate to the size of market or return on investment potential. The more resource wealthy an innovation projects is the more scope there is to employ thorough and highest quality standards to the research, development and commercialisation. When resources are restrictive, less rigorous methods are inevitable and as time costs, faster methods are also preferred. Because of time to market issues and final cost of their product, generally businesses are keen to push towards the second scenario. In addition funders can co-incidentally promote this approach by reducing the funding offered. Both the former and latter pressures can also lead to conducting steps from the transfer process in parallel, while properly managed this is not a problem practically, it does mean the simpler models of technology transfer are no longer representative. It is the authors' observation that quicker, less rigorous and lower cost approaches are quite prevalent in assistive technology – technology transfer processes, especially when the funding is small, the market is either known to be small or the return on investment is more uncertain. However this is not unique as it has also been observed outside of the assistive technology domain, especially where the business aims are at developing a non-health technology.

Looking at speed factors more generally, if in any of the steps of the technology transfer process there are systematic elements that are demanding in time or that force delays then the whole process is slower. If competing innovators are able to operate without such hindrances they are at a systematic advantage. It is arguable that in general, few projects exist that are so unique that they will not be impacted by competition, nor are there that many where the technology transfer can occur much more rapidly than competitors could achieve. It should be noted that intellectual property ownership can significantly impact this view of competition. Namely whoever owns key knowledge and can uniquely exploit it, has a distinct advantage that may go far enough to protect the project to a large, or some, degree from external influences.

In conclusion technology transfer occurs in a competitive space and does not occur in a vacuum nor is it pragmatically a simple sequence of steps. There are always ongoing external activities that can impact the progress of a specific technology transfer, e.g. changes in compatibility, competing products, personnel, economic climate, and/or company finances, avail-

able component technologies, understanding of underlying science, etc. The variability of speed of steps, commercial pressures and lack of funding can all conspire to make technology transfer a very complex and dynamic activity.

4. Summary

The 2010 AAATE workshop hosted in Sheffield was very well attended and provoked a lot of discussions. It highlighted that most projects and innovators tend to use approaches validated in other fields in their projects. Methodology, method and tools are often selected on the basis of convenience (including familiarity), affordability and finally suitability. Some of the included papers in the special issues demonstrate that sometimes projects do adopt novel approaches. The special issue and this editorial point out the possibility that new techniques are needed for a field where user populations vary dramatically numerically, across the need of each population and indeed the variability of needs between populations.

It is hoped that the discussion of the definition of terminology and analysis of models of technology transfer versus a pragmatic view of technology transfer is helpful and may provoke some discussion. They highlight the need for further work in this area, especially with a view to investigate any specific consideration because it is assistive technology that is being transferred. It is noted that there seems to be a need for a better route to adopting technology by services, especially in the face of technologies that avoid being labelled as medical devices.

This editorial has not broached many important topics that relate to technology transfer of assistive technology. Perhaps one of the most important is the translation of commitments to an inclusive society into resourcing innovation (especially for smaller populations of end users). The way much state funding and the natural commercial interest calls for innovation places a financial value on return on investment, often meaning that innovation for niche assistive technology becomes impossible or incredibly slow through 'free' routes (e.g. student projects). While open innovation offers some potential to make a positive contribution [6] there is still a need to adopt a social approach to return on investment. Indeed the most promising tool to help justify bids for funding seen by the author is that of Social Return On Investment [7] which is currently being adopted and researched worldwide.

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