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Adoption of e-Infrastructure: frontline experiences of researchers, and a model for researcher development

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Introduction

Drawing on a recent study, this paper discusses technology adoption among a group of 26 experienced researchers from eight higher and two further education institutions. It develops the contents of a workshop delivered by the author at the Vitae Researcher Development International Conference in 2014, and highlights the relevance of individual and institutional contexts in terms of technology use. This paper proposes a model for a strategic researcher development approach for institutions to enhance researchers' technology adoption. It also recommends further dialogue and research around effective use of e-Infrastructure for research activities.

The development of a sustainable and cutting edge e-Infrastructure eco-system is vital to support excellent and innovative research across a wide range of disciplines and industrial sectors [Morrell, 2014]. Research Councils UK (RCUK) defines e-Infrastructure as the combination and interworking of digitally-based technology (hardware and software); resources (data, services, digital libraries); communications (protocols, access rights and networks); and the people and organisational structures needed to support modern, internationally leading collaborative research, be it in the arts and humanities or the sciences [RCUK, 2010]. The Research Councils, the Funding Councils, the Technology Strategy Board and Department for Business, Innovation & Skills (BIS) play a key role in developing the strategy as well as delivering the funding to support e-Infrastructure in the UK [Morrell, 2014]. Adoption of e-Infrastructure into mainstream use by a majority of researchers with support from the research funding agencies is one of the strategic action areas of the UK Research Council [RCUK, 2010].

The European Commission encourages wider collaboration as part of its funding. "Horizon 2020 is the biggest EU Research and Innovation programme ever with nearly €80 billion" [European Commission, 2015b]. Higher Education Institutions will be collaborating as well as competing with other research organisations, non-governmental organisations, companies, etc. to get a slice of such funding. The European Commission plan includes investment in e-Infrastructures for research and ambitiously envisages that "by making every European researcher digital, e-Infrastructures increase creativity and efficiency of research and bridge the divide between developed and less developed communities and regions" [European Commission, 2015a]. This suggests that the use of technology will have an increased role to play in facilitating collaborative research. Research Institutions and Universities need to understand the implications of engaging with such e-Infrastructure, and address issues such as technology adoption for the institution as well as its individual researchers. They need to develop and prepare researchers' capacity to make the best use of the e-Infrastructure and related technological innovations.

Researcher development is a collaborative and complementing endeavour for institutions and individual researchers alike to maintain research excellence. Researcher development can be defined as "the process whereby people's capacity and willingness to carry out the research components of their work or studies may be considered to be enhanced, with a degree of permanence that exceeds transitoriness" [Evans, 2011]. This paper focuses on enhancing the capacity and willingness of researchers in terms of making the best use of technologies and e-Infrastructure.

The Vitae Researcher Development Framework (RDF) [Vitae, 2011] recognises the importance of technology use. It expects researchers to have an advanced level of skills in areas such as interactive communication technologies, multimedia, and web tools for networking, information/data sharing and promoting research presence. Resources and frameworks such as the Seven Pillars of Information Literacy lens on the Vitae Researcher Development Framework (contributions from Society of College, National and University Libraries, and the Research Information Network) focus on various stages of dealing with information [Bent & Stubbings, 2011] and help researchers to prepare for the technology era. The Vitae RDF [Vitae, 2011] acknowledges the challenges in adopting these innovations however, it calls researchers to learn and develop additional skills and capabilities in information technology and digital technology, as appropriate.

Emphases on e-Infrastructure and digital literacy raise a number of questions around technology usage: How does the technology adoption and diffusion take place in the context of research activities for both individual researchers and institutions? What are the experiences and issues faced? How can these be addressed? Are research institutions and their researchers ready to use the new e-Infrastructure effectively? Answers to these questions could be sought through exploring the current technology adoption and diffusion among experienced researchers.

Technology adoption is a “complex, inherently social, developmental process”; it can vary depending on the individual and their “cognitive, emotional, and contextual concerns” [Straub, 2009 p645]. Drawing on the notions of Everett Rogers’ Diffusion of innovations [Rogers, 2003], effective and sustainable take-up of technology can be seen broadly from two perspectives: the adoption of it by individuals; and its diffusion across the population. Adoption theory is a micro-perspective that “examines the individual and the choices an individual makes to accept or reject a particular innovation” whereas the Diffusion theory takes a macro-perspective and describes “how an innovation spreads through a population” across time [Straub, 2009 p626].

The UK e-Infrastructure Advisory Group sees the decline in research grade e-literacy among UK researchers as a concern and recognises that the one size fits all approach of training might not be amenable [e-Infrastructure Advisory Group, 2011]. Another possible approach would be to analyse researchers’ experiences of technology use and understand the various characteristics and issues of technology adoption, and use that to inform researcher development activities. This paper, therefore, draws the findings from a recent study (referred as ‘the study’ hereafter) that focused on educational researchers’ use of technology by understanding their experiences, conceptions and strategies [Appukuttan, 2014]. The study makes an assumption that technology use in science, technology, engineering, maths and medicine (STEMM) disciplines are more embedded and specialised compared to non-STEMM disciplines, and thus it focuses on technology use by researchers from non-STEMM disciplines. However, readers from all disciplines are encouraged to compare the findings with their own experiences and consider how far they reflect an international perspective especially in terms of interdisciplinary research. It will also enable readers to gain insight into the issues of technology use and recognise individual and institutional challenges around policy and practice.

The following sections will consider some of the experiences of researchers in terms of their technology use for research activities through three thematically-developed vignettes. It will then examine the issues using a set of common characteristics of various adoption and diffusion theories. A discussion of researchers’ technology use in the context of researcher development would then lead to proposing a researcher development model for technology adoption. It finishes with some closing thoughts and scope for further study.

Researchers’ experiences of technology use

The range of experiences of researchers’ technology use can be examined through various theories of technology adoption and diffusion. Such experiences can be sets of issues around individual researchers’ technology adoption or technology diffusion across the population [Fichman, 1992]. Diffusion across a population, such as researchers across an institution, is informed by individual’s adoption [Straub, 2009].

Thus, to examine the diffusion, or in other words how the investments in e-Infrastructure are going to get adopted widely, we need to look at the technology use of individual researchers. This is where we need to consider the current experiences and practices among researchers.

This paper draws on a study that was interested in educational researchers (referred as just researchers hereafter) and how they used technology for their research activities. For the study, technology was broadly defined as tools and resources that enabled and supported research activity. The sampling for the study was done from eight Higher, and two Further Education institutions in the UK. It included 16 female and 10 male researchers. The main data collection was done through semi-structured interviews on two separate occasions and included some short paper-based surveys as part of the interview.

Findings from the study (Figures 1 and 2) showed a consensus that technology does help, or at least it doesn’t hinder their research. 70% of the researchers also thought their choice, skills, and use of technology could influence their research in some way. In terms of its usage, the conceptions of technology were varied among researchers. They also had varied levels of access and use of technologies at different stages of research. Based on the ‘E-research across Phases’ [Dutton & Meyer, 2010], the participants were asked at which stages of research they were likely to use technology. The general answer was ‘all stages’, from setting an agenda to archiving all research resources, with the exception of some researchers mentioning that they may not use technology when they are thinking and making decisions

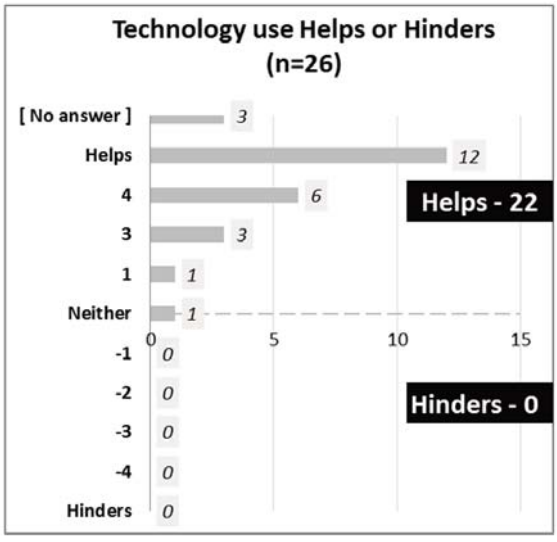

Figure 1 Technology use Helps or Hinders

(for example, defining the research problem and questions, or doing ethical reviews).

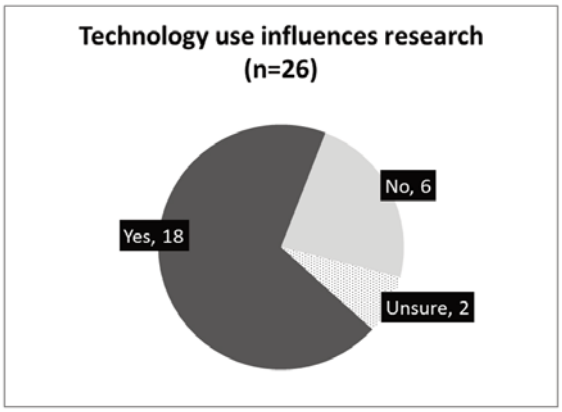

Figure 2 Technology use influences research

Some of the findings relevant to technology adoption and diffusion are presented below using vignettes to highlight the experiences and issues raised by the researchers. Use of vignettes is a valuable technique "that can elicit perceptions, opinions, beliefs and attitudes from responses or comments to stories depicting scenarios and situations" [Barter & Renold, 1999]. Miles and Huberman define vignettes as:

> "…a focused description of a series of events taken to be representative, typical, or emblematic in the case you are doing. It has a narrative, storylike structure that preserves chronological flow and that normally is limited to a brief time span, to one or a few key actors, to a bounded space, or to all three"
>
> [Miles & Huberman 1994, p81]

Vignettes offer a way to mine "pockets of especially representative, meaningful data… that can be pulled together in a focused way for interim understanding" [Miles & Huberman, 1994]. They are used mostly as a data generation technique [Barter & Renold, 1999; Miles & Huberman, 1994; Spalding & Phillips, 2007]. However, vignettes are used here as a way to present and discuss some of the findings and provide "sufficient context for (readers) to have an understanding about the situation being depicted" [Barter & Renold, 1999]. The vignettes were constructed based on experiences of participants, the author's own experiences of working with researchers, and relevant literature to ensure validity. From a broad range of issues around adoption and use of technologies, three scenarios are presented that highlight some of the experiences of researchers: 1) the use of technology from an individual's perspective; 2) access issues from the institutional perspective, and 3) conceptions from both the individual and institutional perspectives.

Individual's usage of technology for research activities

Vignette 1: Changes in technology and learning curve

It is Sunday 9.00 p.m. Linda decided to indulge herself with half a glass of wine. It takes about 7 minutes for the laptop to start and be ready for use. The laptop had come with a lot of software that she has no use for whatsoever; all they do is slow the machine down. Not to mention the millions of windows that keep popping up which she has to close down one by one before she can start her work. So she had plenty of time to enjoy a sip or two. She wanted to make a start on analysing the large amount of data collected for a research project and is under pressure to finish the analysis quite soon. She thought it would be useful to do it electronically as it will be easy to share and collaborate with two other researchers in the team. She loaded the qualitative data analysis software that was installed on her laptop and started reading the notes on the exercise file she had from a training session. However, the software looked nothing like the training she had 6 months ago. Linda felt very confused. She had a look at the wine glass and then the bottle; and wondered "it's not the wine, is it?" She looked at the help options within the software. After an hour she had reached nowhere. Disheartened, finally she gets her scissors and envelopes out. She starts reading and cutting the printed data and sorts them into groups before putting them in labelled envelopes as she has always done; she knows that it will work. She doesn't bother about the laptop that had gone dark because the battery was dead. She doubts whether she will ever bother with that software again.

Vignette 1 highlights some adoption issues of individuals. Analysis is one of the very intensive research tasks and often needs a clear space and mind. Some researchers, like many other professionals, do some of their core work at evenings and away from their office. This could also mean that the research tools and technologies have to be set up mostly by themselves. Computers are sometimes overloaded with unwanted software that slows the researcher down even before they start research. In addition, many respectable web software companies tactfully or covertly install all sorts of cluttering software making people's computers even slower. It is important to note that the researchers' patience and time is already spent even before they start any research activity. This often puts them off from using technology altogether and has a direct impact on its adoption. However, the study showed that some researchers take it as a norm and patiently wait for it to be ready. Linda here, for example, uses that time to enjoy her drink. Once she gets to the software it seems to be a different version to what she had training on. She is lucky that it opened her file; often vendors make it impossible for older versions of software to even open files saved in their new format.

Along with the technology usage issues, this vignette also points out to the increasing time pressure put on researchers by the funding bodies to complete research within shorter deadlines. In fact this could be an impetus to the adoption of technology routes because of its perceived efficiency gains.

However, the vignettes illustrates what could actually happen when it comes to engaging with technology, and why researchers might end up resorting to traditional ways of conducting research knowing it works, despite having less time than they used to have. Sometimes, researchers use technology as a replacement for traditional ways of doing things. Having access to a tool doesn't necessarily mean that researchers would want to use it. Some researchers see technology as a disruption to the demanding and intense cognitive research tasks. Simultaneously they value it as useful and efficient in more mechanical and laborious tasks such as content editing and formatting. Many researchers in the study used various tools and technologies that are highly useful for data management, communication and networking. However, many researchers agreed on the lack of value in comprehensive training before they have an actual need for its application because either they forget the training, or the technology becomes obsolete or changes considerably. Eventually, for some researchers, bad experiences can put them off from using these technologies. The vignette here shows that, in practice, the individual researcher's adoption of technology is much more complex and contextual than we might assume, and could slow down the technology diffusion across the population.

Institutional access to technology and information

Vignette 2: Research information and infrastructure

Sheila picked up her shiny new iPad and started walking back to her office after a meeting with the Head of Research Information. She had just moved to this university and as a new Professor she is expected to start bringing projects and funding straight-away. However, it has been three months and she still doesn't know what are the key research projects that have already been funded at the university; who are the experts; how much funding has been received so far; what project management support she has access to; or what is the technological infrastructure, software and technical assistance she has access to support her research activities. At the meeting, she highlighted the need to improve the access to information and resources for researchers. She boasted how her previous research-led University has a well-established CRIS (Current Research Information System) that gave her a clear picture in terms of access to information, resources, skills and technology that is relevant for the research project in hand. After the meeting she found that there are challenges to streamlining access to research systems such as buy-in from senior management in terms of huge financial investment and support for such systems. More importantly she recognised the need for engagement from all researchers in terms of providing the relevant information at least once, and updating it periodically. Sheila initially thought it will be straightforward to have access to all the relevant tools and resources she needed. However, she now sees that they are disparate, less supported and not well integrated, resulting in much avoidable duplication of effort. She is now wondering whether it is her responsibility to worry beyond her own immediate access to systems and tools.

Access to technologies and systems can vary considerably among institutions and this can be a factor in its adoption and diffusion. Sheila, in the vignette 2 above, experiences this when she moves from a research-led university with a well-established CRIS to one without such integrated systems.

However, the vignette mentions a "shiny new iPad" to indicate that availability of funding for popular generic tools is not uncommon. Research processes and resources at many institutions are managed and supported by different departments, people and systems. This results in a huge amount of time-consuming administrative and management effort to identify the right resources and tools and then use them effectively. Researchers in the study that this paper is based on talked about not having access to relevant information, tools, technologies, support and skills development, or even not knowing how to go about finding them.

Systems such as CRIS can provide researchers with "easy access to relevant information and associated software, processor power, storage systems and … [helps] … to collect more data to overcome incomplete or inconsistent information" [Jeffery, 2008]. The latter part of this assertion shows that it can help to improve visibility of information and resources leading to fixing any deficits. Setting up CRIS would also contribute to researchers' CVs and profiles (as considered in vignette 3) and saves duplication and administration time as well as contributing to diffusion among researchers due to its attractive efficiency gains.

However, buy-in and active involvement from stakeholders such as senior management team, researchers and research administrators are critical for such adoption and diffusion endeavours to take-off. Sometimes individuals or a group of researchers' autonomous enthusiastic efforts can overcome the many access barriers. However, the study showed that having to repeat the effort for each project can lead to frustration, as Sheila feels towards the end of this vignette.

Individuals may not have complete autonomy on the adoption and use of technologies within an institutional context [Fichman, 1992]. Researchers' use of technology depends a lot on what tools and technologies are available to them although it is often not a choice they can make. The institutional access to tools and technologies, and how the researchers are exposed to them (for example, through contextual development events, and enforced policy) contributes to the usage; if any of it comes across as useful, researchers might adopt it. The study showed that money is not seen as an issue for institutions and they often have the funding to make basic or common tools and technologies available for researchers, even to work from home. However, more advanced, specific, or custom use of technologies are advised to be included in the project funding bid itself as such technologies mostly only apply to that particular project. So access supported by the institutional funding and technology usage strategies contributes to researchers' exposure to technologies, and thus leads to its adoption and diffusion.

Vignette 3: Online profile and social media impact
Alex is an experienced researcher in Music and is well known among his vast social circle for his critical ear for a range of music genres. He has been asked by his institution to keep his University profile and the institutional digital repository up-to-date. Although he doesn't see the value of it, he makes a good effort when he gets time. Many colleagues have encouraged him to join Facebook and Twitter but he says "I am not a techie and I am too busy to know what people ate for breakfast". Recently, an international university contacted him via his University profile page and invited him to work together on an exciting new research project. This made him think about the value and power of online profiles in a professional context. They requested him to submit some evidences of impact of his research work for the joint research bid. Alex contacted his publishers to get some download rates, etc. and eventually submitted an evidence of 72 downloads of five of his relevant papers. Elsewhere on the internet some of his papers were being mentioned and re-tweeted by hundreds of social media users making them reach and be read by thousands of researchers. Many of them wanted to network and follow his research to inform their own research. This popularity was noted by the international university and they alerted Alex that his papers are much more popular than he thinks. Alex is now pondering whether to join social media.

Many researchers acknowledge that technology in general is a useful thing (Figure 1) yet they may not fully understand how to use it effectively in their own context. This largely depends on their conception of technology. In vignette 3 above, Alex is a passive user of technology and somewhat unsure of its benefits. The institution, however, sees technology mainly as a means to improve efficiency and communication. They ask researchers to keep their online profiles up-to-date to promote their research but are often less effective in convincing the individual researchers of the benefits in their own context. In this scenario, Alex happily complies with the request to keep his University profile updated and eventually gets a positive experience to realise some of its value. He is now even wondering whether to reconsider his social media usage for professional purposes.

The conceptions of technology uses can inform the researchers' technology adoption. The study drawn in this paper showed that some researchers may limit technology to basic usage while others recognise its affordances and use where appropriate. Research data showed that, increasingly, institutions now promote the adoption of digital technologies as a capacity and impact builder.

Alex, in the vignette here, normally limits technology use and sees it as an external phenomenon to his research activities. Although he is still not fully convinced, he now recognises that it could have some value in his research context such as dissemination and networking. A closer examination of this vignette shows that individual and institutional conceptions align with each other when the contextual needs are clarified. It could then enable a meaningful adoption of technology that leads to diffusion across all researchers over time.

All three vignettes above highlight that institutions and researchers want to explore how technology can be useful in saving time and improving efficiency without compromising the rigour and quality. Various types and stages of research activities are now heavily reliant on information and communication technology. However, there are numerous factors and challenges to address if we are to reap the perceived benefits of e-Infrastructure through technology adoption and diffusion. The next section examines some of the factors and challenges using three common characteristics of technology adoption and diffusion theories.

Researchers' technology adoption

In terms of technology use, the vignettes above conceptually consider the current experiences and practices among researchers from three different angles - actual usage, access to it, and conceptions of technology - from individual as well as institutional perspectives. This section will be examining the technology use among researchers using three common characteristics of technology adoption. It will then briefly consider the implications for researcher development.

Individuals' adoptions of technology can be explored from various perspectives such as Rogers five stages of adoption [Rogers, 2003], the Concerns-Based Adoption Model (CBAM) [Hall & Hord, 2006], and Moore's Technology Adoption Cycle [Moore, 1999], whilst institutional adoption can be studied using models such as Technology Acceptance Model or Technology Acceptance Model and the United Theory of Acceptance and Use of Technology [Viswanath Venkatesh, Michael G. Morris, Gordon B. Davis, 2003], etc. Although these theories have various scopes and different perspectives, Straub identifies that "most theories share three categories of characteristics that influence the adoption and/or diffusion of an innovation" [Straub, 2009 p628]. Within the scope of this paper, researchers' experiences of technology use are examined through these three categories of characteristics of adoption – individual, technology, and context.

Straub's first category of characteristic focuses on individuals and their differences –"state- or trait-based characteristics that predispose a person to seek out or shun change" [Straub, 2009 p628]. It is interesting to note the characteristics of the researchers in the vignettes. Vignette 1 presents Linda's experiences of working on her research at home. She generally follows traditional research practices but is very strategic about technology adoption and uses it with discernment. She is patient with technology and seeks training as she is not an autonomous learner.

However, technical challenges make her give up and resort to the traditional ways that she is comfortable with. In addition, she is now probably unlikely to use that particular technology. Vignette 2 shows Sheila's experiences, someone who is very successful, confident, enthusiastic and enterprising. She is interested in research management aspects and actively engages with the e-Infrastructure which she sees as an integral part of research activities. However, the challenges and delays due to institutional business process and complexity is edging her to being despondent. Vignette 3 describes the experience of an established researcher, Alex, who has a good research network. He sees technology as separate phenomenon to research but adheres to policies set by the institution. He is open to change and makes an effort to explore and adopt technologies.

Individual characteristics in these experiences have similarities and differences. Alex's positive experiences lead him to seek the adoption of new technologies while Linda's negative experiences make her shun it. Sheila, however, is still enthusiastic despite the challenges, although her future experiences in the new institution could influence her technology adoption. Such variety of experience, conceptions and characteristics of individual researchers is a factor in their technology adoption.

Straub's second category of characteristic focuses on the specifics of a particular innovation itself – "how easy an innovation is to use, how the use of an innovation is compatible with the lifestyle of an individual" [Straub, 2009 p628]. Looking from a lifestyle angle, researchers use technology that suits their research preferences. Some of the tools discussed in the vignettes are for local usage within individuals' space or computers (offline) while others were through internet (online). Vignette 1 focuses on offline characteristics and specifically on data management and analysis aspects. It also mentions scissors which once was an innovation but has been diffused over time and continues to be stable and reliable. Vignette 2 mentions more personalised tools such as iPads as well as complex centralised information systems such as CRIS. Vignette 3 highlights the impact of using online media which enables the international collaborative working. Thus, Straub's observation of technology's compatibility with lifestyle is valid in the researchers' context as well.

All three vignettes show that technology gets adopted when it matches researchers' needs and preferences. However, ease of use is also a key factor. Fichman classifies technologies based on the level of knowledge burden and user interdependencies to Type 1 and 2 where the Type 2 is distinguished as technologies with high knowledge barriers and significant user interdependencies compared to Type 1 [Fichman, 1992]. Scissors, social media, and iPad arguably fall into Type 1 with perceived ease of use which helps their adoption. The study referred to here confirmed that many research specific tools have fewer user interdependencies but have a high learning curve or knowledge burden issues similar to Type 2. This makes it challenging to master the skills and retain it till the point of application. Thus, compatibility with research styles/approaches and ease of use appears to be important in researchers' adoption of technology.

Straub's final category of common characteristic focusses on the contexts that "make up the environment and surroundings of an individual during the adoption process - frequently this is the work-based organization, but it also may be the mass media or individuals acting as facilitators of change" [Straub, 2009 p628]. The study drawn in this paper sampled from researchers of non-STEMM disciplines. However, 'context' here doesn't mean research areas or topics, but the settings at which researchers use technology and the experiences that trigger their use of technology.

All researchers sampled for the study worked at an educational institutional setting but some researched at work and others outside. In vignette 1, the context is characteristic of a researcher working in isolation. It involves the intense cognitive research data analysis and management task under the time pressure which makes Linda consider using the qualitative analysis software. Although Linda is working at home, it is merely an extension to her organisational context. In vignette 2, it is Sheila as an individual who is trying to bring change, as well as influencing the adoption of CRIS at her new university. New job and research management responsibilities are the context that encourages her to explore technological solutions. Thus, in a broader sense, her context can also include being the facilitator of change, as Straub suggests above. In vignette 3, although Alex is based at the university, it is the mass media (an online audience especially through social media) that has an effect on his possible adoption. His open attitude to trying technology as well as willingness to engage with institutional policies of keeping profiles and the repository up-to-date have contributed to an international exposure. Such exposures, together with the positive environment of encouraging colleagues, also influence his technology adoption. In all three vignettes, elements of the organisational environment are visible. Thus the range of contextual characteristics is an element that contributes to researchers' technology adoption.

The sections above discussed researchers' experiences of technology use through adoption 'characteristics' (individual, technology, and context) and the vignettes presented adoption 'issues' (usage, access, and conceptions). These two adoption factors are discussed with a third factor - adoption 'level' (individual, institutional, and joint). The next section discusses how a researcher development model can be considered based on these three adoption factors and aims to achieve researchers' technology adoption.

Researcher development model for technology adoption

The preceding discussion showed that individual, technological and contextual characteristics of technology adoption [Straub, 2009, p628] are valid factors in researchers' adoption of e-Infrastructure. The vignettes above illustrated the experiences of researchers and showed that researchers' conceptions of what technology is and can do for them; having the right exposure and access to relevant technologies, and then the actual challenges they face during the usage are some of the key issues.

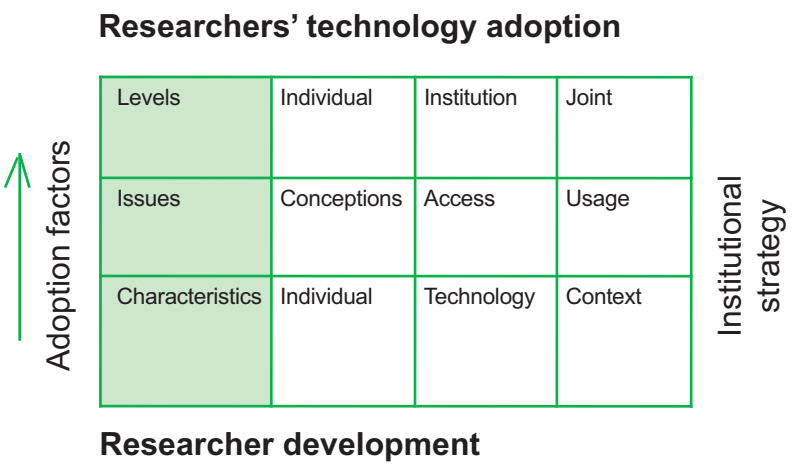

Figure 3 - A researcher development model for researchers' technology adoption

They are relevant from individual and institutional perspectives and work well when they both align with each other.

In terms of technology adoption, researcher development and support could act as a catalyst. The developmental support from initial exposure to on-going usage could address some of the challenges faced by researchers. The RCUK suggests that "e-Infrastructure must be planned to be usable from the onset, actively supported once developed and positively welcomed by researchers" [RCUK 2010, pp17–18]. This planned approach would enhance researchers' capacity, willingness, and best practice of e-Infrastructure use. However, encouragement through policies alone will be inadequate; it needs to consider various factors and that could inform strategic planning.

In vignette 1, Linda wanted some initial refresher type support and a faster computer. In vignette 2, Sheila wanted support in terms of access to information and infrastructure. Alex, in vignette 3, didn't need much technology support but needed contextual support in seeing how it can benefit his research. Based on the illustration of researchers' experiences through the vignettes, and the discussion of the adoption characteristics, this paper proposes a model for a strategic approach to researcher development on technology use. It presents a bottom-up model from researcher development through the adoption factors (characteristics, issues, and levels) to researchers' technology adoption. The institutional strategy would be guiding the decisions and processes.

The model presented in Figure 3 (above), proposes a strategic researcher development approach for institutions to enhance researchers' technology adoption. It focuses on three adoption factors and its sub-categories. Starting from the bottom, the first adoption factor 'characteristics' includes individual, technology and the context. It aims to address individual researchers' attributes and requirements; the characteristics of the technology in consideration; and the context in which it is being introduced and will be applied. The next adoption factor 'issues' include conceptions, access and usage. The issues strand will consider researchers' conceptions of technology, their access to it, and considers possible challenges and how they could be addressed in terms of technology usage.

Finally, the adoption factor 'levels' would be at individual, institutional, and joint levels. This route of researcher development activities to achieve researchers' technology adoption would be guided by the institutional researcher development strategy that addresses technology adoption with a view to enhance the use of e-Infrastructure. This model can be adapted and modified to add or extract various adoption factors and sub-categories to align with institutional researcher development strategies as appropriate.

Let's take an example to evaluate this model. The case here is the use of qualitative data analysis (QDA) software. If a researcher development programme is planning to encourage researchers to use qualitative data analysis software, it needs to be aligned with the institutional researcher development strategy of improving efficiency, rigour, and quality of research outputs. Along with this overarching strategy, the adoption factors proposed in the model can be considered. Starting with the characteristics of the individual, the programme would consider what kind of skills and attitudes the targeted researchers would have towards technology. Then it will examine the characteristics of technology: What kind of QDA software is being considered? How is it different to any other similar tools? What attributes are important to researchers? Next, it would examine the characteristics of context: Is the length of the study worth the effort? Is it a collaborative study? Does the scale and scope of study need consideration? Does the subject area have any traditional knowledge and precedence?

Moving on from characteristics, it could consider the layer above - adoption issues. It starts with conceptions: What do researchers think about qualitative data analysis software? What do they think its benefits are? Then, in terms of access: Do they all have the software where they need it, for example, at home? Do they have the licenses annually or perpetually? And then in terms of usage: How would they actually use it in practice? Do they need help? Is it time-consuming?

Finally, consider the top layer - adoption levels. Most of the factors in the current example may already be at an individual level. Hence, consider whether this aligns with institutional wide technology adoption: Whether different departments and disciplines across the university are using this tool? How can the institutions expectations align with individual researchers requirements?

And so on. This illustration worked through the proposed model to consider the various adoption factors. It demonstrates how a researcher developer could use it to consider relevant adoption factors along with their institutional strategy to plan and enhance researchers' adoption of a chosen element of e-Infrastructure.

Closing thoughts and scope for further study

Higher education institutions in UK are analysing the outcomes of the Research Excellence Framework (REF) 2014 to inform their preparations for the REF2020 which is going to be the next key milestone for many UK research-led universities and research leaders. The pressure is already on to improve efficiency and impact. Effective use of e-Infrastructure investments will be important for universities to benefit from funding such as Horizon 2020 and conduct collaborative international research projects. It is important to note the vision of European Commission to make every European researcher digital [European Commission, 2015a] as well as the e-Infrastructure investments made by Research Councils in Europe and UK to enable collaborative research and reach. For example, adoption of e-Infrastructure is one of the RCUK strategic areas of action [RCUK, 2010 p15].

Researcher development will be key to prepare researchers to make effective use of e-Infrastructure investments. Vitae Researcher Development Framework clearly identifies relevance of technology use and encourages researchers to explore digital tools and enhance their digital skills [Vitae, 2011]. In addition, there are digital literacy frameworks available with specific a 'research lens' [Bent & Stubbings, 2011]. From these efforts and focus it is evident that technology use or adoption among all researchers is becoming an increasingly relevant topic to research further and understand its implications and impacts.

Researchers' technology adoption and diffusion is an understudied area. Although there are many similarities with technology enhanced learning (TEL) skills development models, it may not be transferable to a researcher development context because of the esoteric nature of many research projects compared to learning, teaching and assessment activities.

This paper presented some of the technology adoption experiences and challenges faced by non-STEMM researchers in practice. It asserts that the development of researchers in terms of technology is ever more important due to the changing nature of demands on researchers and funding bodies alike. All researchers in the study had agreed that technology use is helpful for their research and the majority of them thought technology use could influence their research. However, a deeper examination reveals that individual researchers' adoption of technology is much more complex and contextual than it might appear at the outset, and that technology diffusion across the population of researchers can be considerably slow. To achieve an effective use of e-Infrastructure technology diffusion needs to happen across the researcher population, and the rate of individual adoption will decide how quickly it happens.

To address these challenges this paper proposes a flexible model and encourages consideration of its relevant elements to inform and complement institutional researcher development strategies to achieve the adoption of a certain technology or a set of them.

This paper raises further questions. Will the adoption of technology reach an effective diffusion 'in time' to make best use of future e-Infrastructure investments? Diffusion can happen over time but should researchers wait for it? What level of buy-in is required from researcher developers and senior managers? Are there unseen problems with the increasing push and expectations on e-Infrastructure? Is there a danger of its perceived efficiency gain becoming a generalised expectation and funding bodies, adding extra pressure on researchers to finish their project in increasingly shorter time regardless of whether it is appropriate to use e-Infrastructure on a project or not? Or is the adoption of e-Infrastructure still not an issue? The paper recommends further dialogue and research around the topic to address such questions and inform researcher development in preparing researchers for the effective use of e-Infrastructure.

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