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Investigating Training Technologies in the Australian Armed Forces

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Abstract

Observations of unexpected uses of technology triggered re-examination of current IS models of technology adoption, acceptance and use. The outcome is a framework for investigating an individual's uptake of new technologies in our early twenty-first century environment. The framework draws on theories of context, portfolios and dialectics. Application of the framework to the use of training technologies in the Australian armed forces illustrates its usefulness as well as some further issues that remain relatively neglected in IS theorising. The paper concludes with implications for IS research and practice.

Keywords

Technology uptake, context, technology portfolios, dialectics

INTRODUCTION

Our reflections in this paper were triggered by observations at an Australian armed forces training centre. When innovative technologies—in this case, high-fidelity simulators—are introduced to trainees, they are not used in isolation. Rather, the trainees employ a range of technologies in their training including well-known, older technologies and ad hoc, creative aids that complement the innovation. Our observations raise several interesting theoretical and practical issues that led us to re-examine current information systems (IS) models of technology adoption, acceptance and use.

Understanding how and why new systems and technologies are perceived, used, adapted and accepted or rejected by individual users has been a central concern of IS research over the last four decades (Jasperson et al. 2005; Venkatesh, Davis, and Morris 2007). The uptake of a new technology (such as a method, device, system or information technology) has impacts that range from return on investment, productivity, effectiveness of work and collaboration.

Various theories, models and frameworks have been applied to investigate individual uptake of technologies. These have been taken from other reference disciplines, built inductively from IS research studies or based on IS researchers' conjectures; the majority fall into the first category. Theories from other disciplines include the Theory of Reasoned Action (Fishbein and Ajzen 1975), Diffusion of Innovation (Rogers 1995), Structuration Theory (Giddens 1984) and Actor Network Theory (Latour 1987). Adaptive Structuration Theory (De Sanctis and Poole 1994) extended Structuration Theory for the IS domain through inductive theory building. Finally, conceptual models of technology uptake include Kwon and Zmud (1987).

Models are constructed, shaped and accepted against a background of available technologies, current user skills, management priorities and prevailing organisational fashions (Abrahamson 1991). They are a product of a particular historical, technological and social environment (Hirschheim and Klein 2012). Over time, there are changes in this environment—available technologies, use practices and social norms—that may render some models less effective for investigating individual users' uptake of new technologies. There may be gaps where these core concepts have limited value or traction in the contemporary environment.

We identify some of the gaps in current theorising about individual user interactions with new technologies and present a framework for understanding the processes of uptake of new technologies that reflects the background of the early twenty-first century technologies, use practices and social norms.

The paper is structured as follows. We start by outlining some of the changes in our environment and critiquing one of the dominant models of technology uptake. Next, our framework is presented and its three component

theoretical lenses (context, portfolios and dialectics) are explained. Utility of the framework is illustrated through the example of training technologies in the Australian Armed Forces where it is applied to examine the assemblage of resources collected by army personnel as part of the training process. Finally, the broader implications of the framework for IS theory and research are outlined.

BACKGROUND

Much of the research into technology adoption and acceptance dates from the 1980s and early 1990s when technologies, user practices and social norms were very different to today (Hirschheim and Klein 2012). A key difference is that the current availability of affordable, easy to use digital technologies has led to high levels of acceptance and even comfort in using them: digital technologies have become a part of our everyday experience (Yoo 2010). This means that 'to use or not to use' is no longer the question. IS research has turned to investigating what is use and how to use technologies productively (e.g. Burton-Jones and Straub 2006; Jasperson et al. 2005). Another, related difference is that people are using multiples technologies, either in sequence or in parallel, to accomplish their activities. However, the majority of prior research has studied the adoption, acceptance or use of a single technology.

These contemporary issues have implications for the effectiveness of existing theories, models and frameworks for investigating the individual's uptake of new technologies. This argument is illustrated using the Technology Acceptance Model (TAM) which is the dominant IS model for describing individual uptake of technology (Plouffe et al. 2001). TAM (Davis 1989) drew on aspects of a theory from psychology, the Theory of Reasoned Action (Fishbein and Ajzen 1975). TAM has subsequently been tested and refined through thousands of empirical studies (Benbasat and Barki 2007). Two constructs, perceived usefulness and perceived ease of use, are posited as key factors that shape a user's intention to use a new technology. Leaving aside the almost tautological nature of TAM (i.e. people intend to use a new technology if they expect that it will be useful), other criticisms of TAM include:

1. Two main constructs shape intentions to use regardless of the type of technology (Al-Natour and Benbasat 2009), user characteristics (Benbasat and Barki 2007), and nature of the use context such as experience with, and availability of, other technologies (Jasperson et al. 2005; Plouffe et al. 2001).
2. It provides great detail about one small aspect of individual user's uptake of new technologies to the neglect of other aspects such as:
    a. What constitutes 'usefulness' in users' eyes and the antecedents of usefulness. Benbasat and Barki (2007) argue that perceived usefulness and ease of use "have largely been treated as black boxes that few have tried to pry open."
    b. The outcome of the model is either 'intention to use' or 'use' (measured by length or frequency). Other possible outcomes such as adaptation, partial use (e.g. use of a limited set of functions) or rejection after a trial period (Carroll et al. 2003; Jasperson et al. 2005; Majchrzak et al. 2000; Orlikowski and Hofman 1997) are neglected.
3. IS commentators argue that TAM has limited value for IS uptake research in an environment that has changed significantly since it was first proposed. For example, Benbasat and Barki (2007:214) note that the context of IS has shifted from "a single-user system in an organizational context to multiple users communicating via technologies in inter-organizational and more global settings .." Since 2007, the use context has further shifted, to use of IS in personal and social contexts of apps, social media, and cloud resources that are embedded in our everyday environments (Beath et al. 2013; Yoo 2010) as well as use of multiple technologies (Carroll 2008).

Our particular interest is point 3 and leads to the question: '*What is the nature of an IS uptake model that is suited for our contemporary environment*?' This paper proposes a Technology Uptake Framework that addresses this question and overcomes some of the identified shortcomings of TAM. Specifically, it includes consideration of the context of uptake and existing resources (point 1) and outcomes of the introduction of a new technology (point 2b). It also illuminates some aspects of 'usefulness' and how a particular user cohort perceives—and works to achieve—usefulness of the resources to hand (point 2a).

We draw on three theoretical lenses to explain the processes of technology uptake: context, portfolio theory and dialectics; each lens is nested within its higher-order lens.

The importance of contextualising studies of technology adoption and uptake has long been recognised by researchers (Plouffe et al. 2001). Providing details about organisational actors, their actions and their means of acting can also help us to provide usable advice to industry (Ramiller and Pentland 2009:474). Typical contextual information included in studies of technology uptake are the characteristics of the user cohort, the

organisational context and the nature of the users' tasks. However, we argue that current research has often omitted an important contextual element: details of users' existing technology resources.

We address this omission by applying investment portfolio theory to users' collections of technologies. The concept of a 'technology portfolio' was developed to describe the collection of technologies regularly accessed by a user (Carroll 2008). The metaphor of a technology portfolio provides a vocabulary to discuss the influence of users' existing technology resources on their interactions with a new technology.

Investigation of the outcomes of introducing a new technology is supported through the use of dialectics (Van de Ven and Poole 1995). Dialectics describes the resolution of tension or contradiction between an existing entity (thesis) and a new entity (antithesis). There are three possible outcomes of introducing a new technology to a user's technology portfolio: the new will replace the part or all of the contents of the portfolio (ascendance of the antithesis), fail to replace the any of the resources in the portfolio (maintenance of the thesis), or be used to complement the resources in the portfolio (synthesis).

The Technology Uptake Framework is shown in Figure 1 and each lens is described in the following sub-sections.

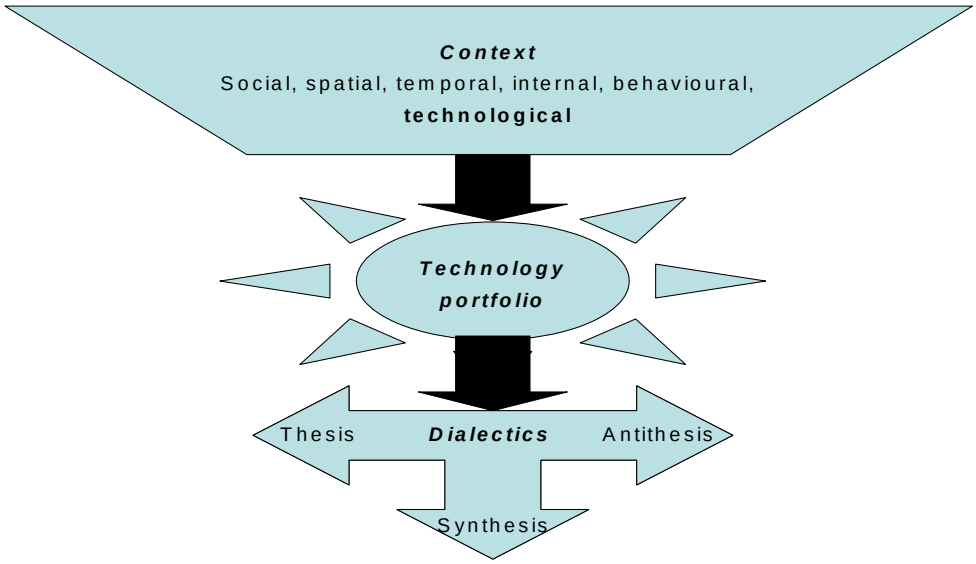

Figure 1 Technology Uptake Framework

Context

A central theme of the IS discipline has been to investigate "both IT artifacts and their human contexts simultaneously in its research" (Beath et al. 2013: iii). Yet the nature of these 'human contexts' remains relatively unspecified. Context is an ill-defined concept that has been applied in various ways in IS research. A common view sees context as the 'background' to some other person or activity: "*Context is what surrounds*" (Gellersen et al. 2002:341). Thus context is everything except the focus of attention, whether a human actor, an object (e.g. a technology) or activity (human speech). This is the 'container' view of context: context surrounds or frames an entity (object, activity) of interest. Goodwin and Duranti (1992:4) suggest that it is important to specify what is the focus (i.e. what is being contextualised) and what is the background.

An alternative view sees context as the 'whole situation' or the reality in which the behaviour occurs (however that is defined). Dey, Abowd and Salber (2001:106) apply this view to context-aware computing and define context as '*Any information that can be used to characterize the situation of entities … that are considered relevant to the interaction between a user and an application, including the user and the application themselves*'. This indicates that context is information about a situation that is relevant to interaction between a person and computer-based system. It differs from the 'container' view of context in that it includes the entity of interest. This alternative view of context is applied in this paper.

What dimensions of context constitute 'information about the situation' that is relevant to users' interactions with new technologies? A useful heuristic for identifying contextual influences (Carroll 2004) is who, what, where, when, why, how (Cougar 1995:35):

- Who is involved? The social dimension refers to the user and other people they relate to (including their characteristics, and the strength of the ties between the user and other members of the group).

- What technologies/resources are involved? The technological dimension of context is the technologies (non-digital and digital including devices, applications, systems and infrastructure) available to the user (Dix et al. 2000).
- Where is the user interacting? This incorporates spatial dimensions of context include the location (either virtual or physical) and its characteristics such as noise levels. It also includes characteristics of the places where interaction occurs such as the organisational, social and group culture, norms and etiquette.
- When is the user interacting? Temporal dimensions refer to time that may be absolute (9am), scheduled (future, past or current) or relative (before or after).
- Why? What are the activities or tasks that the user is tackling? What are the user's motives, needs and desires? These internal dimension incorporate a user's intentions, purposes, world view, knowledge, and goals. This includes emotional, philosophical and cognitive aspects and covers such influences as preferences for technologies, interactional channels and communication methods.
- How do users interact with the technology? Behavioural dimensions reflect what users do as they interact with their technologies. People's interactions are not purely responsive: they can also change or reshape technologies as part of the interaction.

The influences of many of these dimensions of context have been explored in research into the uptake of new technologies including user characteristics, organisational and group norms, intentions and preferences. One dimension that has less explored is the technological dimension. This paper focuses on the technological context of training technologies and we draw on portfolio theory to conceptualise this dimension of the users' context.

Technology Portfolio

Traditionally, IS research has focused on the selection, adoption and use of a single technology (e.g. Davis 1989; De Sanctis and Poole 1994; Goodhue and Thompson 1995). Some researchers have studied the introduction of a single technology and the factors that influence individuals' intentions to use it (Davis 1989). Other researchers have examined the selection of a single technology, usually from a small number (typically four) and the reasons for participants' selections (e.g. media selection research). Finally, many more have studied the use of a single technology (for example, De Sanctis and Poole 1994; Orlikowski and Hofman 1997**).** Until recently, there was a scarcity of research examining clusters or collections of technology. Rogers (1995) argues that examining innovations in a cluster separately leads to distortion and incomplete understanding of the processes of diffusion. This is supported by Shih and Venkatesh (2004) who found the presence of complementary technologies led to increased variety of use of the computer, as did ownership of the 'latest' technology.

Greater availability and lower costs of digital technologies have led to changed patterns of technology use. Today, users draw on multiple technologies, often contemporaneously, for various purposes. As a result, use of multiple technologies or media is receiving attention from researchers. For example, Watson-Manheim and Belanger (2007) studied use of multiple media in two organisational units. Dennis et al. (2008:576) found that, for many organisational tasks, "*communication performance will be enhanced when different media are used at different times; it is usually best to use several media either simultaneously … or in succession*." In addition, the impact of existing technologies on the selection and use of new technologies has been noted, particularly when resulting in unexpected outcomes (Carroll and Fidock 2011). However, there are few frameworks or conceptual vocabularies to describe, analyse and explain these newer patterns of technology use.

Investment portfolio theory has been extended to develop the concept of a 'technology portfolio' as a means of studying and describing this trend. A technology portfolio is *"the purposeful collection of technologies that is assembled by individuals to meet their needs"* (Carroll and Reich 2013).

A technology portfolio is constructed to meet the needs of a particular user. It contains a diverse mixture of resources, both electronic and non-electronic, where individual resources can be 'mixed and matched' to maximize the overall value gained from technologies (Carroll 2008). A technology portfolio is dynamic: the contents of the portfolio can be updated and applied in different ways as the user's needs change.

A technology portfolio lifecycle was induced from empirical studies of participants' technology selections and uses (Carroll and Reich 2013). It represents users researching and then trialling new technologies that results in integration into the portfolio, and consequently their regular use, or otherwise rejection. The choice to add a new technology to their portfolios was the outcome of careful and discriminating decision-making; it was clear that mandating use of a technology or strong peer pressure alone are not sufficient to ensure integration into a technology portfolio. Technologies continued to be used until they were retired from the portfolio. Various reasons for retiring a technology were observed: frustration or dissatisfaction (e.g. poor usability), acceptance of

an improved technology (e.g. replacement of home phones by mobile phones), or simply the age of a device. This last reason applied only to mobile phones: participants sought to replace their mobile phones after 12 to 18 months and a new phone replaced the existing one in users' portfolios. For all other technologies observed, the addition of a new device to a portfolio did not replace an existing device; rather, obsolete resources were often retired some months later. The diverse outcomes captured in the technology portfolio lifecycle have interesting implications for the uptake of new technologies. We seek to explain these through reference to dialectics.

Dialectics

Dialectics is one of the four foundational 'generative mechanisms' or motors of change identified by Van de Ven and Poole (1995). Dialectical theories explain change through reference to the tension that exists between opposing or contradictory forces, such as that between advocates of the status quo (the thesis) and those promoting change (the antithesis) (Van de Ven and Poole 1995). Such an approach can be seen as a counter balance to deterministic theories that assume that introduction of a technology will lead to particular, predictable outcomes (Robey and Boudreau 1999). Dialectics explains change outcomes in terms of maintenance (where the thesis dominating the antithesis), substitution (of the thesis by the antithesis) or synthesis (an emergent result that differs from both the thesis and the antithesis).

Most applications of dialectics in IS research have focused on identifying opposing forces and how they are played out rather than their management or resolution. But dialectics is useful not only for explaining the process of change (based on opposing forces) but also the outcomes (maintenance, substitution or synthesis). Also, a dialectical lens has generally been applied post-hoc to existing data. Thus, researchers have applied a dialectical lens to explain unexpected findings (Carlo, Lyytinen and Boland 2012; Robey and Boudreau 1999:168).

Applying a dialectical lens to our problem of technology adoption and uptake is useful for investigating the uptake process and explaining its outcomes. If a new training technology is viewed as an opposing or contradictory force to the current contents of a person's technology portfolio, then the three possible outcomes are:

- The user rejects the new technology and continues to apply the existing technology portfolio to undertake work. Dialectics explains maintenance of existing technologies and work practices as the thesis dominating the antithesis.
- The user replaces one or more of the existing technologies with the new technology. Dialectics explains replacement of existing technologies and work practices as substitution of the thesis by the antithesis.
- The user updates his technology portfolio by adding the new technology to it; new work (training practices) may be developed that incorporate both existing and the new technology. Also, some existing resources in the technology portfolio may be deleted from it over time. Dialectics explains these emergent changes to the technology portfolio as a synthesis that differs from both the thesis and the antithesis.

  This synthesis may have negative impacts on an individual's training. Dennis et al. (2008:595) warn of the extreme case where incorporation of too many technologies in a task may result in cognitive overload, leading to "reduced information processing and impaired communications performance."

ILLUSTRATIVE CASE

Research Design

The impetus for this paper came from reflections on the use of training technologies in the Australian armed forces. The site of the research was the Army Aviation Training Centre (AATC). The AATC trains helicopter pilots for Army and Navy as well as mechanics and maintenance workers. At the time of data collection, the AATC provided training on two helicopters, the Armed Reconnaissance Helicopter (ARH) and the Blackhawk. Alongside of the actual helicopters, simulators were the main training technology employed. The AATC had one simulator of each type. Each of the simulators costs tens of millions of dollars. These costs were seen as reasonable within the armed forces, especially in comparison to the costs around the loss of a helicopter (a single helicopter costs about the same as a simulator but has high operating costs). The simulators are described as 'high fidelity'; that is, they aim to provide an accurate representation of the aircraft cockpit. The ARH simulator, for example, has two pods, one for the pilot and one for the co-pilot; these are completely separate. They are both on separate motion bases. Each pod has a huge screen (around three metres high) that receives feeds from nine projectors. The simulator is housed in a building like a massive warehouse. Such high-fidelity, high-cost technologies are seen as the 'sexy' stuff of simulation.

One author visited the AATC to examine ways in which simulation is used in training and its effectiveness. Data collection involved observations, a short questionnaire and semi-structured interviews with 12 participants (staff and trainees) at the AATC. The questionnaire collected demographic information, participants' definitions of 'simulation', their experience with information technologies generally and simulators in particular (through construction of a time line) and the role of simulators as a part of overall training. An interview protocol was devised to guide the interview questions but additional questions were introduced to pursue issues and experiences that were raised in individual interviews.

One issue that emerged was the range of resources used to complement simulators; this was noted early in the research and explored in subsequent interviews. The interviews were audio-recorded with participants' permission. The researcher also made field notes of his observations and reflections. The tapes were transcribed. For this research, the transcripts were analysed to identify the nature and roles of resources used to complement simulators, their origins (e.g. whether corporately sanctioned) and their frequency of use.

Findings

Personnel attending the AATC tend to be motivated high-achievers. The trainee army personnel take responsibility for their learning as their career progression depends on passing tests at the end of training. They spend significant amounts of personal time on their training, and employ all possible resources, in order to pass and progress.

Pilot training lasts approximately four months. A substantial part of the AATC curriculum is standard classroom instruction: 'chalk and talk'. Trainee pilots start in 'hueys' (Bell Huey) to get some experience. These are basic training helicopters from the Vietnam War era. The hueys allow novice pilots to learn to fly in a simple and inexpensive helicopter before moving on to modern machines (termed the 'beasts' by pilots). It should be noted that there is not nearly as much training in actual helicopters as we expected. Helicopters are expensive, their running costs are high and errors by novice pilots may result in damage to or loss of a machine as well as human lives. Therefore simulators play a large role in training.

Simulators allow novice pilots to develop skills and practice responses to emergencies such as engine failure. There was limited access to the two high-fidelity simulators and so they were complemented by a range of different simulators. Low fidelity simulators provide functionality relating to some aspects of a cockpit while not attempting to replicate the whole cockpit with great accuracy. An example is the lower fidelity ARH simulators. These are static (no motion base), have a smaller screen and provide a basic cockpit layout. The AATC has three of these lower fidelity simulators: they cost far less (each in the order of hundreds of thousands of dollars) than the high-fidelity simulators.

Repeated practice, over and again, is required for the pilots to routinise basic flight procedures. One participant described it: "*It's practicing all your procedures, not just rote learning like you do with other aircraft, emergencies, moving your hands and getting the motion, to simulate where they would put their hands, getting the motion rather than just checklists.. Don't just say 'I'd move my hands', you'd actually be moving your hands*." The aim is to develop "*muscle memory*".

Personnel employed creative methods to gain the required routines of action. Other, 'unofficial' resources were also used. One participant demonstrated a range of training aids constructed by trainees to increase their familiarity with all of the cockpit dials and switches; these were used in evenings, otherwise "*they simply wouldn't pass the course*." One student had made a mock up of a basic helicopter. It had a frame and basic seat, and a mock-up of the screen, constructed from printouts pasted to a solid surface. Trainees could sit in the mock up and act out basic training procedures: the cabin was spatially roughly accurate. This is a student initiated simulator. Several participants referred to their use of Microsoft Flight Simulator, both prior to joining Defence and afterwards. Also novice pilots use broomsticks as a substitute/simulator for the cyclic stick as part of basic training; they call this "*chair flying*".

Training technologies are provided not just for novice pilots. Mechanics and maintenance personnel also need to learn the intricacies of the two types of helicopter. When the Blackhawk was acquired in the 1980s, the only training aid for maintenance personnel was documentation. These personnel then cobbled together simulators from spare parts for training purposes. A Blackhawk simulator has a very realistic cabin, sitting in a room and all lights on dashboard are working. A staff member described it as a: "*virtual cockpit (all of aircraft plus all sub-systems) for tradies to check, remove and insert parts, connect systems to fault-find etc in order to get their qualifications"*. This model of a Blackhawk cabin was used by pilots as well as maintenance personnel. The pilots liked it because they could sit in it and touch, flick switches and practice the mechanics of flying; the pilots are building routines of action. The ARH was acquired later, in the 2000s. It came with training aids that included a purpose-built, full-sized version of helicopter for maintenance training (e.g. trainees were able to walk on it, which isn't possible on the actual platform). Sub-systems, engines and so on were all included. A full mock

up of a cabin for maintenance personnel was also used by pilots for training in their own time. Further, despite availability of these aids, maintenance people still constructed artefacts for training.

Reflections

The expensive, high fidelity simulators were viewed as the mainstay of the AATC training capability. However, these simulators were only one aspect of the training resources used by army personnel. There were a number of 'taken for granted' artefacts in use at the AATC. Some of these were obsolete technologies (the hueys and lower fidelity ARH simulators) while many other were unofficial, low-tech aids created by people to enhance their training.

Two theoretical issues arise from these observations. First, the introduction of new, cutting-edge technologies for training does not take place in a vacuum. Trainees are familiar with a range of technologies and have constructed practices around their use. Understanding the outcomes from introducing new training technologies requires examination of both existing and the new technologies. Second, if officially sanctioned training technologies do not meet trainees' needs then they will locate or construct complementary resources to meet these needs. At the AATC both trainers and trainees had constructed training resources. Some of these resources will be used by an individual but others will be used and refined over time and eventually become part of the training program (e.g. the student-constructed cabin mock up). Even in this highly constrained and pressured environment, people enhanced their training by creating (and sharing) artefacts to meet their learning needs.

DISCUSSION

Application to the AATC case

Our interest in unexpected observations of the range of resources used to complement high fidelity simulators was reinforced by prior research into the contemporary technology uptake landscape: where people commonly use a wide range of technologies to support work, social, educational and personal needs. Examination of existing uptake models revealed a gap that we have attempted to address in the Technology Uptake Framework. In this section we show how the three theoretical lenses in the framework go some way to explain our findings:

- Context. Understanding of various dimensions of context (the high-pressure, competitive environment (social) with tight time lines to pass training (temporal), the high levels of motivation of the trainees (internal), and the creative sharing of 'cobbled together' resources (social) helps to explain our findings. These are all core aspects of IS research that studies the interactions of people and technology in context (Beath et al. 2013). What is novel about our framework is the emphasis on the technological dimension of context: the range of resources that is available to the trainees.

- Technology portfolio. A range of technologies were drawn on to support training. The primary technological resource is the expensive high-fidelity simulators. These were complemented by the hueys, the lower-fidelity ARH simulators, computer applications such as Microsoft Flight Simulator and obsolete simulators intended for maintenance training. The trainees re-shaped and re-purposed existing technologies (broomsticks, chairs, brown paper) for their training needs. The concept of a technology portfolio provides a vocabulary to discuss this collection of technologies and a way to analyse the way that available resources were evaluated and used by the trainees.

- Dialectics. The organisationally-sanctioned training resources were 'chalk and talk' classroom sessions, the hueys, the Blackhawk and ARH, and the high fidelity simulators. These resources did not replace familiar, ready-to-hand resources in the trainees' portfolios (i.e. substitution). The trainees did not reject the high-fidelity simulators for other resources (i.e maintenance). Instead, emergent outcomes were observed (synthesis); unusually, this was not simply a combination of new and existing technologies. Rather, in some cases, available materials were used to craft or construct new training resources that were used along with the simulators and existing technologies.

The Technology Uptake Framework addresses the first theoretical issue outlined in the section above, that the introduction of new technologies does not take place in a vacuum. However, it does not adequately address observations of users creating resources to augment new technologies, as was observed at the AATC. We note that users at the AATC had limited time (up to four months) to master the high-fidelity simulators and pass their exams. This time pressure may have intensified their willingness to create and re-shape resources to aid their learning. Work on technology adaptation, reinvention and appropriation (e.g. Orlikowski and Hofman 1997) highlights the creativity of people in modifying existing technologies to meet their situated needs. However, further theorising is needed to address the second theoretical issue. Perhaps the innovation literature can supply useful theories or models here.

Broader Implications

Investigating adoption, acceptance and use has been a central theme of IS research for almost 30 years (Hirschheim and Klein 2012). Why do we need yet another paper on the theme? As noted in the introduction to this paper, models are a product of their times. Times – technologies, management fashions, user practices – change and so our models need ongoing re-examination to assess their usefulness in understanding core IS phenomena. Prominent IS researchers are calling for innovative thinking, new ideas, broader scope of topics and especially for the development of indigenous (i.e. grounded in IS) theories for our research (Beath et al. 2013; Grover 2013). Re-examination of accepted models and development of new models is essential for a vibrant and relevant IS discipline.

This paper represents one attempt to come to grips with some aspects of contemporary technology practice. Our observations of training practices at the AATC triggered an examination of existing IS models of technology uptake and identified gaps related to use of multiple technologies and users' willingness to improvise with resources to hand to derive value from a new technology.

This paper has outlined three interlinked concepts that impact the uptake of new technologies and associated practices to enhance training.

First, we have argued that the *technological* context in which new technologies are introduced should be investigated. We believe that this is particularly important in the period immediately after the introduction of an innovation. This is because users faced with a new technology will draw on any available resource that helps them to make the innovation 'work' for them and maximise value that can be derived from the innovation.

Second, the technological portfolio provides concepts and a language for analysing the effects of existing technologies and practices that trainees bring to their interactions with a new technology. The dominant approach in previous IS research has been to focus on a single artefact or system (Carroll 2008). Our discipline lacks ways to describe the increasingly common practice of using multiple technologies (either sequentially or in combination) to undertake an activity. We believe that portfolio theory, already familiar to IS researchers in IS project management, can address this lack.

Third, the outcomes of users' encounters with the new technology are explained through reference to dialectics. To date, the many IS adoption and acceptance models focus on 'use' as the outcome, where use is conceptualised as length in time or frequency, thus omitting many other potential outcomes (such as types of use, range of functions used, faithfulness of use and adaptation of the technology and practices). In addition, we need a more nuanced approach when studying the uptake of a new technology in the context of a collection of existing resources. Dialectics accounts for use or non-use of the innovation as well as a range of emergent outcomes.

While the trigger for developing the Technology Uptake Framework was observations of the range of training technologies used at the AATC, we believe that the framework has broader application. This is because the issues raised by the AATC case are also found in the environment of early twenty-first century technologies and use practices.

The Technology Uptake Framework contributes to our understanding of how and why new systems and technologies are perceived, used, adapted and accepted or rejected by individual users. It draws attention to one particular influence on technology uptake: the role of existing resources and their impact on outcomes when introducing a new technology. It complements our prior research on technology appropriation that has investigated the dynamics of interactions between an individual user and a new technology over time (Carroll et al. 2002; Fidock and Carroll 2011). These provide fragments of understanding of a complex and changing phenomenon that is core to our discipline.

CONCLUSION

This paper has identified an issue of importance to both IS theory and practice, that of the influence of existing technologies and technology-related practices on users' uptake of a new technology. The strategy taken in IS research of analytically separating key technologies or innovations in order to understand them more deeply may lead to distortion and incomplete understanding of the processes of adoption (Rogers 1995). The trigger for this research arose during an investigation of the use of expensive high-fidelity simulators. Observation showed that multiple resources were used during training to complement these simulators. This demonstrates how investigations of use of a single technology need to be complemented by field studies of the whole phenomenon in order to gain a more complete understanding of technology uptake. We suggest uptake studies should include analysis of existing technologies, those technologies that are combined or accessed contemporaneously, and users' perceptions of synergies between these technologies.

We present the Technology Uptake Model that incorporates three theoretical lenses that a. illuminate the importance of existing technologies as a part of contextualising the issue, b. conceptualise the collections of

technologies as technology portfolios, so emphasising the role of multiple, complementary technologies, and c. explain some of the outcomes from the tensions between existing and new technologies. The model is applied to an illustrative case and addresses some, but not all, of the unexpected observations in that case.

Further investigation of the importance and roles of existing technologies provides many challenges for further research. This will enable improved design and application of technologies including technology selection, training and change management.

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