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Alignment of perceptions about the uses of ICT in Australian and New Zealand schools

Improving the Uptake of ICT in schools

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Contents

The problem

There is now a long tradition of research that documents a shortfall in adoption that are characteristic of the early stages of an innovation, especially educational innovations involving ICT. The main reasons usually given for this, however, – lack of awareness, access and basic technical skills – are no longer enough to explain the persistently low adoption rate of ICT among teachers. Content is widely accessible, teachers are, by and large, aware of the resources, and technical skill gaps have been addressed through widespread professional development in relation to use of ICT in the school sector. From the survey data available to date, including the recent data reported in Freebody, Reimann, & Tiu (2008), there is no reason to believe that teachers and/or other educational personnel have a predominantly negative attitude towards the value of ICT for learning in general. It is worth noting, however, that, although still on the positive side, teachers' judgements of the benefits of ICT are significantly lower than those of the other three groups of respondents in that study. This may be due to differences in aspiration, but it can also be due to experience, a choice that cannot be resolved by the survey data at hand.

The generally low adoption of ICT (especially in the middle secondary years) is by no means specific to Australia. It is beyond the scope of this discussion to analyse the research in detail, but the explanations range across low technological reliability, limited access, and limited bandwidth. The latter is, in many countries including Australia, regrettably still the case. Also named are alignment breaks, in particular a lack of alignment between curriculum, pedagogy, assessment of students' performance, and high-stakes testing. If anything, the situation is bound to change in Australia rapidly and dramatically over the next months due to the Australian Government's computing initiative for years 10–12. Subsequently, perhaps slower but even more widespread adoption will arise from an increasing focus on personalised learning.

Ways forward

In order to address the adoption gap, we suggest a three-pronged approach:

1 *Changing focus* from sector-wide variables to details of use practices
2 *Teachers as innovators* – changing the role that teachers play in the adoption of technology
3 *Design-based research* –changing research methodology from 'at arm's length' studies to 'close-up' studies of technology and practice.

Changing focus

To go beyond explanations that rely on the 'usual suspects', we suggest considering learning objects not only as curriculum resources or as generic information technologies, but as information technology artefacts – as concrete objects in the hands of leaders, administrators, teachers and students. Looking at learning objects as artefacts invites an analytic focus on the practices of use of various groups in an educational sector. We believe that progress in analysing many aspects of educational technology in schools requires studying organisational routines and individual practices in more detail – from 'close-up' rather than 'at arm's length' – and over longer periods of time. This change in perspective is motivated by the observation that, at least in Australia where the use of ICT in education in widespread and mainstream (though not necessarily intensive), explanations for a lack of adoption need to go deeper than merely logistics or attitudes. In particular, explanations need to account for how individual and organisational practices impede or embrace technological innovation. The number of studies that focus on the way teachers interact with and make sense of learning technologies in general, and learning objects and learning object repositories in particular, is surprisingly small compared to studies of other ICT areas. As a consequence, the field of educational technology lacks knowledge of those impediments to technology adoption that are related to work practices and sense making (Weick 1995).

We can regard learning objects, like other technological artefacts, as *negotiated, embedded and sedimented sets of rules for goal-oriented action* (Masino & Zamarian 2003, p 694). This definition, which focuses on the logical function of artefacts rather than on their symbolic or physical properties, is particularly appropriate for carefully

and purposefully designed artefacts such as learning objects. It combines a cognitive perspective (Norman 1991) with an organisational perspective (Orlikowski 2000). Seen as technology artefacts, learning objects are not (only) resources for learning; they mediate people's actions. A central question, therefore, is: What role do these artefacts play in the regulation of work activities? By 'work', we refer in particular to teachers' and students' work – goal-oriented activities in the service of teaching and learning.

By and large, research that has assumed a straightforward deterministic link between ICT artefacts and organisational change has not been successful in establishing consistent findings accounted for by parsimonious theories (Robey & Bourdreau 1999). Various approaches to organisational change have been developed as alternatives, for instance, models based on structuration theory (Orlikowski 2000), institutional theory (Gosain 2004) and actor–network theory (Latour 1996). These perspectives take it that artefacts become causally effective only when used, and that only the agent's intention in the use of the artefact can give it the quality of artefact-in-use. This does not deny the independence of the artefact from human intention and use, but implies that the effective use of an artefact is the outcome of an interaction between the agent and the artefact (Volkoff, Strong & Elmes 2007).

Given the concrete nature of ICT artefacts, we need to be clear about what artefact we are talking about in the context of this study. One relevant type of artefact is the learning object, others are the learning object repository, the portal and the learning management system. Learning object repositories, portals and, in particular, learning management systems can be seen as enterprise systems, whereas the individual learning object can be seen as being a small individual application. Future research needs to be more specific in distinguishing between these categories, because they differ in nature, with respect not only to how the user interacts with them, but also to how decisions on their adoption and deployment are made.

As Norman (1991) observed, 'cognitive artefacts' have two purposes: first, they support the use of scarce cognitive resources (memory in particular) and guide the representation of problems for effective solutions. As well, artefacts have social meaning, representing '… receptacles of common experience ... shared within the

group that conceives, builds and uses them' (Masino & Zamarian 2003, p 695). Since artefacts are purposefully designed, they express organisational values.

The cognitive and social function of ICT artefacts can certainly be found in portals and learning management systems, but they are also found in individual learning objects. An individual learning object can be designed and used for structuring actions, by affording and supporting certain ways of interacting with the encapsulated content. Like technological artefacts in general, learning objects and portals come with a 'tension': on the one hand, an artefact supports cognition and rationality; at the same time, it expresses control over an agent's activities. Artefacts designed for organisational use, in particular, in incorporating an element of heteronomous control, or regulation from the outside, suggest shared ways of going about things.

Masino & Zamarian (2003) put the concept of ICT artefacts into a decision-making framework that is well suited to identifying the various points of potential misalignments of organisational and individual decisions. Their model distinguishes between *design*, *adoption*, and *use* decisions. *Design decisions* concern all the technical, operational and physical features of the artefact, thus including decisions concerning not only functionality but also the way users can interact with the artefact. DeSanctis & Poole (1994) speak of the 'spirit' of an artefact, the way it presents itself to the users.

Adoption decisions deal with how an artefact is to be integrated into the organisational structure, into business and work processes. In the case of learning objects, adoption decisions will typically be made by the teacher or, in the case of self-guided learning, the student. In the case of learning object repositories, portals and learning management systems, adoption decisions are more complex because they concern larger units, such as schools, districts or jurisdictions. In such situations, the main adoption decisions are not made by the end-users, even though the end-users may be consulted.

Use decisions concern the way end-users interact with the artefact in actual work processes, for instance, how a teacher introduces a learning object in her classroom, how deeply a student engages with a learning object in her learning. Analysing use decisions is particularly relevant because users' decisions are not necessarily aligned with the expectations of designers and adopters; the artefact-in-use can be different

from the artefact-as-designed. This is advantageous from an organisational perspective, if the artefact-in-use is an efficient or even creative adaptation to the local situation. It is disastrous when the artefact-in-use is incompatible with the organisational rationale embedded in its design. For instance, the designers and adopters of interactive digital whiteboards probably had in mind purposes different from those for which we see this artefact often being used – for example, as an expensive projection surface for slide presentations.

The manner in which these decision-making processes are related is schematically depicted in Figure 44. Design decisions concern firstly the artefact's core (A1), that is, the elements not directly connected to the users' choices because they are kept outside of users' control. Secondly, they concern the artefact's interface (A2), consisting of those elements directly under the users' control. Users appropriate the artefact through use decisions (B), the most crucial link because it is here that the artefact-as-designed can become distorted, either because of misalignments in the interpretation of the meaning of the artefact, missing alignment with the nature of the users' work, or because the artefact is perceived as a threat to the users' autonomy.

> Use decisions can be seen as a way to gain control over the work process, directly or indirectly, by controlling the way the artefact is a actually used in work activities.
>
> (Masino & Zamarian 2003, p 700).

Users also negotiate with adopters over the manner in which the artefact is embedded organisationally, for instance, over its role in workflows (D). Adoption decisions influence the artefact-in-use by suggesting, or even imposing, certain use modalities and interpretations (C1), and by influencing the artefact's interface by affecting design decisions (C2).

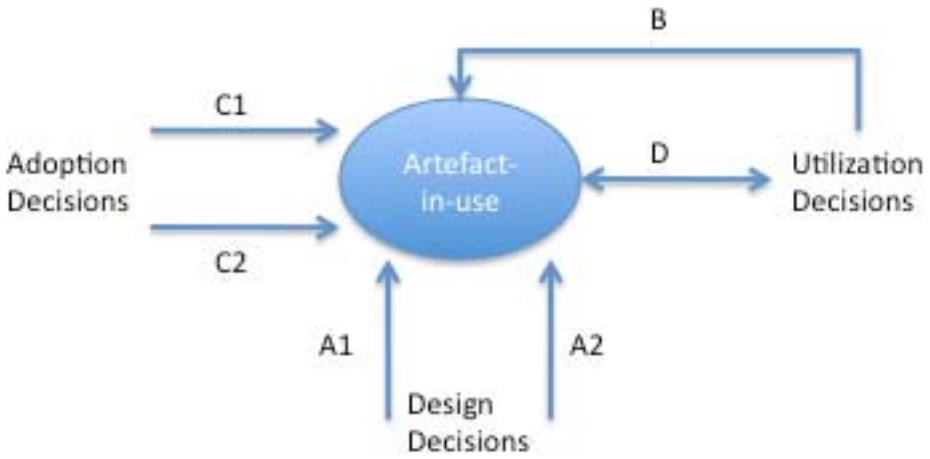

Figure 44: Decision framework for technology adoption (from Masino & Zamarian 2003)

This decision-making model, originally developed to help in understanding the processes involved when software is introduced into organisational work processes (Masino & Zamarian 2003), also provides a useful framework for the analysis of processes involved in the integration of learning objects and learning object repository/portal/learning management system technologies into schools and classrooms. The framework is readily applied to educational technologies such as repositories, portals and learning management systems, since all three share many similarities with enterprise software. The framework can also be applied, on a smaller scale, to the decision making of individual teachers regarding the use of learning objects in their teaching and learning. In this case, teachers act as adopters and as users at the same time, with more weight on the adopter role in situations where teachers select learning objects for students but do not themselves work through the learning objects.

It is worth noting that reforms and innovations can ‘go wrong’ not only because of misalignments and conflicts arising from them, but also because of a lack of specificity and a lack of development support (Cohen & Ball 1999). Specificity refers to the explicitness with which an intervention is articulated and mapped. A well-specified innovation goes beyond goal statements to suggesting specific representations of teachers’ enactments of the innovation (Blumenfeld et al 2000). In the context of decisions about artefact use, introducing teachers to an artefact-as-designed that lacks of specificity in terms of its intended use would allow many different, and potentially conflicting, interpretations of the artefact’s meaning and its intended use. ‘Development’ refers to the well-known need to support technical

innovation with curriculum and assessment materials as well as infrastructural support and opportunities for professional development.

Applied to an analysis of the adoption of learning objects, the practice-oriented analysis of learning objects as ICT artefacts-in-use suggests a focus on questions such as:

- What choices are being made with respect to the learning objects' user interface and the integration of learning objects into teaching and learning processes?
- To what extent is the learning object supposed to act as a structuring device (Poole & DeSanctis 2004), that is, as a device to gain higher organisational control by implementing heteronomous rules (Masino & Zamarian 2003) into teaching processes?
- How is the learning object interpreted by the users, and how does it affect their work? In particular, how 'disruptive' a technology is the learning object vis-à-vis established ways of working and learning?
- How do the users appropriate the learning object, and how is its use negotiated with the adopters?
- What are the divergences between the intended use of the learning object, and its use when appropriated by users?
- What are the differences between the organisational changes (for example, changes in work processes, culture, climate) intended to be triggered by the learning object, and the actual changes that emerge?

Questions such as these can be raised at the various levels of an education system: at the policy level (among policy makers, adopters and users); at the school level, in the interface between district/school management (as adopters) and teachers (as users); and at the classroom level, in the interface between teachers (as adopters) and students (as users).

Teachers as innovators

Learning and teaching have been changing rapidly. In trying to move away from standardised approaches, schools are increasingly aspiring to personalise learning and to adapt instruction to the needs of sub-groups and individual students (OECD 2006). Rather than focusing exclusively on teaching what is known, teachers are being urged

to guide learner-inspired processes in knowledge building (Bereiter 2002b; Fisher, Higgins & Loveless 2006; Hargreaves 2006). To succeed in supporting students in this open and intrinsically unpredictable process, teachers cannot rely only on existing domain and pedagogical knowledge, but instead need to be knowledgeable designers and investigators of their own instructional practices (Bereiter 2002b; Hakkarainen, Palonen, Paavola, & Lehtinen 2004; van den Dool & Kirschner 2003). Teachers need to be able to create and adapt their instructional practices, to use robust methods of systematic inquiry, to engage in knowledge-building dialogues with professional instructional designers and university researchers, and to contribute to advances in their specialist knowledge domains. In other words, teachers need to work as *innovators* who design and create new pedagogical practices, as *researchers* who inquire into and assess their innovations, and as *knowledge builders* who contribute to accumulating the knowledge of their professional community.

More generally, in order for innovative technologies and innovative pedagogies to become usable and sustainable in classrooms, schools themselves must become more like innovation systems (Fullan 2005) or innovation networks (Hargreaves 2003). This requires, in particular, that teachers be committed, encouraged and supported to engage in systematic disciplined innovations and systematic inquiry into their own practices. As Markauskaite and Reimann (2008) have argued, this requires shifting the focus from developing teachers' ICT skills and putting ICT in schools, towards enhancing teachers' capacities to innovate with ICT, to engage in inquiry into their own daily work practices, and to create school-level and larger-level innovation systems. From earlier reports of the use of ICT in schools, which include case studies of effective practice (for example, Freebody & Muspratt 2007a), it is clear that some teachers and some schools are already well on the way towards bringing about these processes.

The capacity for innovation in education may be increased by supporting more developmental work led by teachers and schools (Bentley & Gillinson 2007; Bereiter 2002a; Hannon 2007; OECD 2004). The need for innovation is driven not only by technological developments but also by the recent shift towards personalised education (OECD 2006). As Bentley and Gillinson (2007) stated, students and parents have expectations that educational services will be tailored to their needs; and, together with educators, they are willing to be involved in shaping these services. This

cultural and social shift makes new demands that can open new avenues for classroom innovation.

The central role in educational change and innovation is typically attributed to leading teachers who innovate in their everyday practices. Foray and Hargreaves (2003), however, identify two broad issues in the structure and dynamics of professional knowledge that impede the efficiency of innovations in classrooms. First, linkages and feedback between formal research and classroom practices are weak, with professional researchers rarely drawing upon the practical knowledge of innovative practitioners. Practitioners' capacity and willingness to conduct educational experiments are also limited. Secondly, most of a teacher's practical knowledge remains tacit. Lack of knowledge codification impedes the accumulation of know-how and, as a result, information spill over's and dissemination are weak. The last few decades have seen an substantial growth in volume and interest in practitioner inquiry in education (Cochran-Smith & Lytle 1999; Dana & Silva 2003). The outputs, however, vary greatly in quality and significance. Some typical critiques of teacher–researcher approaches describe insufficient conceptual and methodological rigour, low generalisability of practice-oriented and highly contextualised outputs, and a lack of clear connection of practitioners' research goals with larger social and political agenda (Cochran-Smith & Lytle 1999).

In the traditional scientific innovation model, better outputs are typically achieved through a twofold process: by investing more in fundamental research, and by improving the efficiency of the development processes through which formal research is transformed into products that reach the market and the workplace (Bentley & Gillinson 2007). This innovation chain, however, is not so straightforward in education. As Bentley and Gillinson (2007) point out:

> Developing applications, like teaching materials, that really take note of [this] fundamental insight, may depend heavily on user testing and development, rather than just on prototyping new educational products and bringing them to market. (pp 9–10).

While basic laboratory-based research may support educational innovation, ground-breaking fundamental discoveries have a less central role; they can affect educational practices only through practitioners' acceptance, sense-making and everyday work. As in many other service-oriented domains, most educational innovations are

incremental, emerging from everyday practices in response to specific issues, rather than derived from formal experimental research (Bentley & Gillinson 2007; Bereiter 2002a, 2002b). Therefore, designing educational innovations, testing them in actual learning settings, and conducting purposeful work on improvement of designs and incremental development, can all be more important than isolated scientific experiments.

We argue that, in order to make progress with the integration of ICT into classroom activities, teachers need to be more involved in the design of ICT artefacts, and need to be more involved in research on how students use these artefacts and what they learn from this use. We argue further that the paradigm of design-based research is a promising methodological approach to research into innovation in education, precisely because it yields knowledge that teachers can incorporate into their pedagogical decision making and practice (Markauskaite & Reimann 2008).

Design-based research

Design-based research represents an advance on the traditional choice between standard, clinic-style experimentation (which generally takes little account of the diversity and complexity of educational settings) and ethnographic or action-research descriptions (which take little account of a system's legitimate interest in finding grounds for productive generalisation and 'scalability'; see Bannan-Ritland 2003). Design-based research experiments have established themselves as productive approaches to the examination of the effects of interventions in classrooms by demonstrating both responsive management of variables and the provision of rigorous small-scale prototyping of intervention elements. Cobb, Confrey, di Sessa, Lehrer & Schauble (2003), for instance, point out that design-based research can explain why teaching and learning designs *work,* and can provide empirical bases for how they can be adapted to new circumstances.

'Design-based research' was proposed in the early 1990s by Brown (1992) and Collins (1992) as an extension of other educational research methods. Since then, it has been used in educational technology research in various forms, and in recent years it has been the subject of extensive methodological discussions and reflections in special issues of educational journals such as *Educational Researcher* (Kelly 2003),

The Journal of the Learning Sciences (Barab & Squire 2004) and *The Educational Psychologist* (Sandoval & Bell 2004).

Design-based research was developed to address several key issues central to research into learning, including the need to address theories of learning, to study learning in the real world, to go beyond narrow measures of learning, and to derive research findings from formative evaluations (Collins 1992). Wang and Hannafin (2005) defined design-based research as:

> a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually sensitive design principles and theories. (p 6)

They identify five characteristics of design-based research. It is:

- pragmatic, that is, design-oriented and intervention-oriented
- grounded in theory and research
- interactive, iterative and flexible
- integrative
- contextual.

As Markauskaite and Reimann (2008) argue, design-based research provides a framework for research into pedagogical and technical interventions in classrooms that affords rigour with respect to the methods employed, and that gives rise to *distributed* educational research (distributed among designers, teachers, and university researchers). It thus offers a pragmatic approach to the huge demands on time and expertise that are necessary conditions of high-quality research.

While design-based research has proved to be appropriate for small-scale (classroom) and mid-level scale (school) research, it has so far not been transferred to larger-scale work at a district or system level. Markauskaite and Reimann (2008), however, have suggested that such larger-scale projects might be accomplished through building on recent developments in e-research, such as the use of Grid computing methods in the social sciences. In this report, and in related work (Markauskaite & Reimann 2008), they suggest that, for studying uses of ICT in educational settings on a larger scale, ICT should become not only the *object* of study but also the *tool* for conducting it.

They conclude that educational technology cannot continue to be confined to developing platforms and tools for teaching, learning and administration. The vision of ICT integration in schools needs to be broadened to include cooperatively conducted inquiry processes. This becomes a reality with the emergence of e-research methods and technologies (O'Brien 2005). Developers of educational technologies might gain inspiration from sectors with a longer tradition of using e-research to support systematic inquiry, such as e-science, where technological environments support a complete digital chain of knowledge creation (De Roure & Frey 2007), and e-social science, where integrated research data are embraced to support evidence-informed decision making (Philip, Chorley, Farrington & Edwards 2007). Similar e-inquiry environments with built-in research and innovation tools can scaffold all stages of teacher-led innovation processes and help integrate individual innovations into larger knowledge-creation systems.

So focusing future research on critical aspects of teachers' and students' practices in the use of ICT, combined with an extension of teachers' roles in the evaluation process and a research approach that includes designers, adopters, teachers and students in intervention studies, can lead to insights into the complexities of innovation adoption and appropriation that go beyond the scope of studies that report only outcomes and reports of practice.

Summary recommendations

Learning objects, and ICT more generally, need to be seen as both curricular and technical interventions into classrooms. In that regard their use poses challenges to teachers and students that are cognitive, attitudinal, technical and practical. Studying their adoption, adaptation and sustained use therefore means building up detailed knowledge from a variety of case sites, targeting practices and outcomes in close-up design-based interventions in which everyday practices – initiations, modifications, challenges, responses and outcomes – are documented and disseminated. The development of such a corpus of research findings can then allow the collection of repertoires of successful pedagogical practices in which teachers have adopted, integrated and coordinated their uses of learning objects and ICT generally. In these ways, actual knowledge of practice can form the basis or a more nuanced view of the extent of system-wide alignment.

This is important because there is currently no well-developed sense of the extent to which misalignments of ICT policy and practice among educators constitute a strength or a weakness of a sector or system. This issue has considerable significance for our understanding of the uses ICT-based online materials, and on actions to be taken on the basis of that understanding. It is impossible to resolve this issue through conducting one definitive research study. Rather, resolution requires a patient and focused set of collaborative research efforts over extended periods of time, and the support of educational jurisdictions with enough confidence to invest in such efforts.

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