Chapter 17
Implementing Technology-Enhanced Learning

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Abstract In this chapter, we look at the implementation perspective from the starting point of the fundamental educational aims that unite the academic community. We argue that interactive and cooperative digital media have an inherent educational value as a new means of intellectual expression. Our primary concern is not the optimisation of knowledge transmission but the use of digital technologies to enhance intellectual expressiveness and creativity: helping the students in their appropriation of the world with a special emphasis on their intellectual development, it is essential for the education system to incorporate new digital media as tools for intellectual expression and production. We outline the main issues relevant to the implementation of technology-enhanced learning (TEL) – the link to overall educational aims, the relationship between innovation and practice, the importance of user engagement, the nature of TEL research, and the characteristics of the local context, and the nature of TEL as a catalyst for change. The chapter concludes with some of the key lessons learned in recent research and development projects that will help to develop more successful ways of ensuring that the technology achieves its potential to enhance learning.

Keywords Technology-enhanced learning (TEL) · Implementation · Higher education · User engagement · Pedagogy

17.1 Introduction

This chapter will discuss and summarise strategies and successful approaches to delivering innovative technology to different learning settings and fostering innovation through technology. Our perspective, however, is not focused on "efficiency" in terms of using technology to accelerate learning processes by faster delivery and distribution of learning materials. It is rather oriented towards the role of technology

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to enable new types of learning experiences and to enrich existing learning scenarios. To do this successfully, we have to understand not just teaching and learning, but also the context in which the implementation of technology-enhanced learning (TEL) has to take place.

One of the strongest arguments for bringing new digital technologies into schools and other educational institutions is that, by doing so, we would trigger pedagogical innovation. This argument can be explained in a system-theoretic perspective on education. One analysis has identified a basic "technology deficit" in pedagogy and education (Luhmann & Schorr, 1982).

Although Luhmann & Schorr argue for more "technological" approaches in education, they emphasise that the constraints inherent in the system have to be understood and considered in any attempt to foster serious change. Essentially, we cannot re-engineer or adapt the system from outside, it has to adapt itself. On the surface level, this is happening: computers and Internet connections are now widely distributed and available in many schools in Europe and even in supposedly less developed parts of the world. However, the consequences in terms of curriculum revision, in terms redefinition of the basic professional skills of teachers or in terms of classroom orchestration remain largely unsolved.

In this chapter we look at the implementation perspective from the starting point of the fundamental educational aims that unite the academic community. We argue that interactive and cooperative digital media have an inherent educational value as a new means of intellectual expression. Our primary concern is not the optimisation of knowledge transmission but the use of digital technologies to enhance intellectual expressiveness and creativity: helping the students in their appropriation of the world with a special emphasis on their intellectual development, it is essential for the education system to incorporate new digital media as tools for intellectual expression and production.

We outline the main issues relevant to the implementation of TEL – the link to overall educational aims, the relationship between innovation and practice, the importance of user engagement, the nature of TEL research, and the characteristics of the local context, and the nature of TEL as a catalyst for change.

17.2 The Relationship Between General Educational Aims and TEL Research

The European Union is united in the aspirations recorded in the Lisbon Agreement 2000, to make the EU the world's most competitive and dynamic knowledge-based economy by 2010. The focus must now be on training people for the knowledge economy, not just to acquire ICT skills, but also to be able to cope with the higher level skills of knowledge management and technical analysis required from the majority of professionals in an ICT-literate workplace.

The same point arises within individual partner states. For example, a major study of skills for the workforce set a similar agenda, and this is now influencing UK

education policy (Leitch, 2006). Within the Kaleidoscope Network of Excellence programme the studies of learning at work provide telling evidence of this by showing that the knowledge and skill level of most working people now has to be much higher than was traditionally needed, in order to take account of the complex information handling that has been driven by the spread of technology in the workplace (Chapter 5). However, technology is also the means by which these skills can be enhanced. The identification of the need for "techno-mathematical skills" makes it possible then to use this diagnosis to develop the technology-based interventions that make explicit the models underlying the kinds of technological representations being used in many workplaces, such as finance products and statistical processes (Hoyles, Noss, Kent, & Baker, 2006).

Education has a role in preparing people for work – traditionally for the industrial environment, but now for the knowledge economy, and that must affect both what and how students learn. European educational policy aims are ambitious, which means that education has to learn to adapt faster, in line with the rate of change in the worlds of work and leisure.

Technology-based environments can provide alternative ways of offering a more authentic learning context. One critique of current education argues that students are rarely involved in a context in which they need to develop or modify knowledge (Grabinger & Dunlap, 1995). This is poor preparation for a role in the knowledge economy. Part of the point of specialist disciplinary training is to prepare people to contribute to that discipline. Universities are comfortable with teaching specialist knowledge produced by experts, but practitioner knowledge and the skill to develop it, which is what the knowledge industry needs, are not a natural part of university curricula. Michael Gibbons and others suggest that universities should move into this area at the undergraduate level, and not just leave it to the postgraduate, or post-experience programmes within the private sector (Gibbons et al., 1994). Adequate preparation must therefore include the development of expertise in the skills of knowledge negotiation, taking the skills of inquiry, critique, evaluation and debate beyond the understanding of ideas to the development and representation of the new knowledge that comes from being a practitioner in a field. For example, the study of chemistry will be preparing at least some students for the role of being a professional chemist, that is, entering a community of practice (Wenger, 1999). It is therefore extremely important to understand what chemists actually do. The same point is valid for science in general, where learners need to experience authentic environments for the study of science, both to excite their interest and to enhance their understanding (Braund & Reiss, 2006), but the conventional field trip will always be occasional whereas a virtual field trip, simulated through technology, could achieve at least some of the same motivation and understanding. Thus TEL offers new ways to present and study domain content and domain-related skills and competencies.

This is why research in TEL can be of particular value. It necessarily focuses on the aims of education, but it also has to act as a catalyst for rethinking the instantiation of those aims in curriculum development. Because very little is known about the ways in which the professions actually develop knowledge, there may be an important role to be played by the field of science and technology studies (Kuhn, 1970;

Chapter 8; Latour & Woolgar, 1979). In addition, the socio-cultural approach to TEL offers a view of learning that is situated in human social practice; existing practice forms the foundation for the design of the future use of new technological tools (Bannon & Bødker, 1991).

The context of implementation for TEL research is an education system that is changing, but not changing fast enough. Learners are being prepared for a world in which technology is increasing the speed of innovation and change, but they are being prepared by an education system that is not oriented towards rapid change in the way it is managed and operated. TEL systems could help education adapt to a world that is rapidly changing in response to technology.

17.3 Disseminating TEL Research and Innovation

Although many positive developments in the use of TEL have been identified, the relationship between these and wider educational practice often remains aspirational. Even when taken up in policy, the effects on practice can be unpredictable and erratic (Conole, White, & Oliver, 2006).

Attempts to explain this situation often focus on the social contexts in which these innovations are developed and shared. Greater rationality in the process of fostering adoption may help, but does not solve the problems. For example, using policy to encourage change is often ineffective because many practitioners see these as disconnected from their own experiences, so that the contrast between the policy "hype" and the challenges that characterise their own use of TEL can increase rather than reduce their scepticism (Price et al., 2005). It has long been recognised that this is no simple case of technophobia (Cuban, 2001) – indeed, this can be seen as a sensible response by teachers to a situation that seems to threaten their sense of professional identity.

The situation can be quite different, however, where the process of implementation is treated as a research endeavour in its own right, rather than as a known, controllable and largely technical problem. Studies have shown that teachers persevere even with difficult developments where these support or enhance the professional values they hold, but are more likely to reject or adapt an innovation that fails to accord with these values, rather than abandon that in which they believe (Price et al., 2005). An analysis of the relative success of different approaches to changing academics' practices identified a series of factors that make change more likely (Sharpe & Oliver, 2007). They suggest that a scholarly approach to implementing innovation can be more successful with academics. TEL requires a more structured approach to designing learning, giving rise to much greater thoughtfulness about what learners need, and to further reflection on their beliefs about learning and teaching. Sadly, time and space for reflection of this kind is often marginalised by outcomes-oriented funding or accountability regimes.

Less common, but perhaps most successful, are initiatives that permit co-development. Where developers brought a part-finished artefact, for example a "half-baked microworld" (Kynigos, 2007) to an existing community, and then

worked with those community members to tailor it to address their own interests and preoccupations, a sense of ownership and engagement resulted that made adoption of the innovation a much more plausible outcome. This approach has clear resonances with processes of action research, and with models of design research that involve iterative and participative practices (Barab & Squire, 2004). Importantly, the artefacts produced are not just given to intended users, but are jointly negotiated. Wenger proposed that when any group is given an artefact produced by others, they have to engage in a process of making sense of how this relates to what they already do as they start trying to use it (Wenger, 1999). If the purpose of the artefact is obscure to them, then what it may come to mean for the group is that they are marginal, unimportant in determining the agenda for their work. If this is the case, then the resistance of many teachers to innovations that they were not involved in developing becomes much less surprising.

This certainly happens with TEL developments. Falconer's analysis of the LADiE project (Falconer, 2007) reveals how, even when teachers, researchers and developers are committed to working together, communication can break down and difficulties arise. Here, each community failed to understand the representations that the others used to specify design features and requests for information failed to be met simply because the recipients could not understand what was needed of them. Eventually, "mediating representations" had to be developed to support design discussions. Similarly, when the British Educational Communication Technology Agency sought to develop a model of e-learning to guide its work with teaching practitioners, teachers only wanted to make use of it once they had the opportunity to adapt the model so that it reflected their assumptions and values rather than those of a central agency (de Freitas, Oliver, Mee, & Mayes, 2007). Simplistic models of research "dissemination" are unlikely to lead to widespread change. Unsurprisingly, the transmissive pedagogy so broadly criticised by TEL researchers in relation to student learning is not particularly effective when educating our peers either.

This has implications for the way in which researchers and developers work with teachers. Directive approaches, such as a mandated series of workshops, do less to help teachers make sense of these innovations than dialogic approaches (Price et al., 2005). Such negotiation is certainly possible to achieve through conventional approaches such as workshops or training programmes, if these are conducted responsively, but were most clearly exemplified by "shepherding" – a consultative approach to supporting innovation in which a centrally based specialist works with disciplinary academics so support their curriculum work (Oliver et al., 2005). In the UK, such individuals might be referred to as Learning Technologists, but terminology around this role is currently inconsistent – and the idea of shepherding is evocative and informative. Such support is resource intensive, but this scaffolded development of teachers' expertise embodies some important principles of effective adoption.

Thus, dissemination, in the simple sense of "transmission" of innovation, does not work. Resources and approaches from other contexts can be offered to the teacher for consideration, but are adopted or adapted in the service of addressing immediate, meaningful concerns. The intensive nature of this kind of work means

that it is unlikely to be the sole approach adopted for disseminating innovation, but its documented success suggests that it could play an important role as part of a repertoire of dissemination approaches.

17.4 The Importance of User Engagement in TEL Research

If we cannot simply "transmit" research results through conventional dissemination processes, how are we to effect the adoption of TEL? In this section we build on the previous section and argue for the importance of user engagement in TEL as a design science that is attempting to affect human behaviour, where "users" are students and teachers, as well as policy-makers and stakeholders. Involvement of the key stakeholders in the design and creation of learning technologies is crucial to the success of TEL research because it concerns the changing behaviour of the users of that research.

This is an unfamiliar way of working in education, which has traditionally been a relatively private exchange between a teacher and their learners. In the context of a modern educational environment, a wide range of stakeholders believe they have a role to play, and the teacher has to play their part in a team, an institution and beyond the institution, a community. The teacher no longer acts alone, but must expect to build on others' knowledge, and share their own knowledge of teaching and learning.

TEL research can be directed at supporting this new form of professionalism. One recent study proposes ways of supporting communication and knowledge sharing between key stakeholders – educators, researchers, practitioners, designers and software developers (Chapter 13). By developing a set of design patterns, they provide the basis for deep collaboration between the various stakeholders when designing and deploying educational resources.

This kind of approach is essential if we are to succeed in the form of user engagement where research begins with practice and builds its aims and methodologies from that (Ludvigsen & Rasmussen, 2005; Rasmussen & Ludvigsen, 2009). The general approach to research is to use the methodology of "design research", which typically involves users right from the beginning of the project, as "practitioner informants" or "action researchers", testing, trialling and critiquing the digital tools and resources being developed within the research. This is a key condition for the success of implementation. As on study showed, teachers need to be involved in the design phase and have the main responsibility for execution in the learning environment. This is critical to the success of the project, so one does not create an implementation problem (Wasson & Ludvigsen, 2003).

The European SEED project took exactly this participatory approach and included teachers in the design of interactive and cooperative tools for the classroom (Lingnau, Harrer, Kuhn, & Hoppe, 2007). SEED did not strive for curricular reform but operated on the basis of the given curriculum with a focus on "maintaining, possibly enriching each teacher's grown teaching style and preferences" (Hoppe, 2009), that is, the "active appropriation" of these new media in the everyday classroom.

This was achieved though a balance between the teacher's articulation of their ideas for transforming their practice with new media and the researcher's illumination of the possibilities of the new media. The collaborative modelling platform Cool Modes (Pinkwart, Hoppe, Bollen, & Fuhlrott, 2002) provided general shared workspace enabling extensions to be suggested and defined by teachers. These extensions have been successfully used in several practical trials in real school settings with positive effects on the teacher's role as non-directive learning coach, and on students' intrinsic motivation and capabilities in autonomous collaborative problem solving (Lingnau et al., 2007).

The design-based research approach used in TEL has highlighted the importance of the interaction between educational aims and TEL research outputs, with the latter acting as a spur to challenge curriculum development. Rich, ethnographic descriptions of professional and working practice contexts will be required if learning objectives are to be rethought and re-written. Although such investigations might be thought to fall more naturally into the fields of educational or sociological research, their relevance here is as a foundation for the TEL work that follows. Furthermore, Barab and colleagues argue that design-based researchers

> can instantiate a critical stance in different aspects of their design work and at different levels of its implementation, including transforming the curriculum, the student, the teacher, and the socio-cultural contexts in which their designs are being realized (Barab, Dodge, Thomas, Jackson, & Tuzun, 2007, p. 265).

Thus, TEL researchers need to work closely with those researchers who can help to illuminate the practice contexts of users and practitioners, if adoption and successful implementation is to be feasible.

We can exemplify this argument by detailing some of the skills required for professional practice, such as in medicine). However, medical education seeks to change practice, not just improve it; the patient safety agenda, for example, means that policy must also be considered, since it serves to critique current practice, not just sustain it. How a TEL project is positioned in relation to this will determine whether it sustains or develops the existing educational system.

The symbiotic relationship between research and practice, for TEL research, therefore means that implementation will only be successful when this relationship is reflected in the way research is conducted. User engagement, from the earliest opportunity, is important for the relevance of the innovation to users, and for the authenticity of the learning at its core.

17.5 The Characteristics of TEL Research that Adversely Affect Adoption

17.5.1 The Different Goals of Researchers and Practitioners

As we discussed in the earlier section, there is a difficult relationship between the innovative developments in TEL research and their implementation in practice. This

breach between researchers and practitioners clearly affects adoption (see as an example Chapter 6). Natural language processing technologies are often unreliable and expensive to develop; it would not be a sensible use of educational resources to try to adopt such a system, as it might lead to erroneous feedback to learners. Consequently, it tends to be established technologies, which are less interesting as a focus for research, that tend to be most useful to practice. In the case of language learning, the teacher would want tools that assist morphosyntactic analysis for text enrichment or learning production analysis (Chapter 6), neither of which would excite TEL researchers. However, although the accuracy of tools such as natural language processing may not be foolproof as direct feedback to learners, nonetheless they can be important tools for giving the teacher an easy way of checking learners' outputs.

Funding for TEL research does not typically begin by analysing the most critical problems in education that could be solved using technology. Funding is generated either for research on new technologies as speculative solutions or for researching educational problems. For the two to come together research funding has to identify the enhancement of learning through technology as a unified research field, and not rely simply on the happy coincidence that disparate research funding traditions might some day find each other. From the work done within the Scientific Quality Committee in Kaleidoscope, which used an international committee of experts to identify research funding sources for TEL, both national and international, it was clear that there were very few such calls that bring together education and technology as an interdisciplinary field. When research funding sources recognise the importance of TEL research that is targeted on user requirements and policy aims (see for example, www.tlrp.org/e-learning) the field is able to progress as it should, with users and practitioners closely involved.

17.5.2 A Disruptive Technology

TEL research provides both opportunities and threats to the teacher. The opportunities lie in the new forms of learning and teaching opened up to them. The threats lie in the disruptive nature of digital technology. This is probably the most important factor that tends to inhibit adoption of TEL. It is not a simple addition to a classroom or educational process. The opportunities it offers for more flexible, adaptive and learner-centred ways of learning require a fundamental rethink of teaching and learning. Without this, the technology can simply be an inconvenience or can even reduce learning effectiveness if it is used inappropriately.

It is well recognised that teachers' practices tend to change slowly, particular if the values they hold seem to be threatened by the innovation. One recent study offers the example of the teacher role as being to "orchestrate" learning through the use of a collaborative tool, and this is disruptive of the classroom and so affects adoption (Chapter 10). Where things do change they are often brought into the service of existing approaches rather than being allowed to overturn them (Cuban, 2001). It is less risky to use technology simply to improve current practice. This may be a

sensible response – the concerns in medical education around patient safety have an echo in concerns about the well-being of students (Luengo et al., 2008). There are ethical implications for carrying out research in education where, by definition, the outcome of the process is unknown. Teachers may wish to avoid taking such risks themselves, until something they find persuasive convinces them that it is a risk worth taking. The problem with this is that low risk usually means sub-optimal outcomes. Technology is not being exploited for what it can do best and is not serving the reform the educational system needs.

New technology is also disruptive because of the new skills it requires of teachers, as for all professionals. The e-literacy skills demanded by the spread of new technology are being acquired by teachers, as they are by students, to meet their personal requirements. The majority of teachers in European countries are by now probably familiar with the skills required for word-processing, e-mail, web-searching and Internet transactions, by virtue of their leisure and domestic transactions. This reduces the hurdle for using new technology in teaching and shows how quickly new technology can be adopted when it fits the requirements for personal value, utility and usability. The design issue for TEL, therefore, is to reduce the disruption entailed by new technology by creating tools and services that fit teachers' and learners' requirements as well as commercial and leisure technology does. Meanwhile, the optimal implementation model being adopted by most institutions is gradualist and incremental, bringing in e-mail, websites for information about courses, VLEs for the dissemination of lecture slides and for discussion forums, interactive whiteboards for presentation – all the technologies that enhance existing teaching methods and are therefore neither risky, nor disruptive, and therefore not transformational.

17.5.3 The Role of Assessment

Assessment is one of the teachers' responsibilities that creates most stress; and rightly, because the design and deployment of assessment activities profoundly affect students' lives. TEL can be highly beneficial, if used well, but, for good or ill, it unquestionably changes assessment.

By changing the nature of the learning process, and what can be learned, TEL outputs inevitably challenge conventional forms of assessment and lead to requirements for different kinds of assessment (Schoonenboom & Levene, 2007). A similar example comes from inquiry-based learning (IBL), which enables learners to create their own representations of knowledge as models, animations and diagrams (Chapter 2). As learners become creative participants in a knowledge-building process they are acquiring skills and knowledge in a different way, matching the demands of the world of work, but it means they need to be assessed in a different way. It is not sufficient to assess what they know, as this does not represent their skills. In the transmission model of teaching the skills developed by learners were revision skills of recall and re-representation of the knowledge

taught. The unseen exam was an appropriate assessment method, and success clearly measured those skills. The same unseen exam for students who use IBL will measure what they know, but cannot represent the different possible ways of *coming to know*. It would be possible to recall and re-represent a very clear account of a concept that looks little different from that of a student who has built their own account of it. An employer who wants someone to be able to précis a report will be content with the former assessment; an employer who wants someone to research a local issue will need the applicant with the latter skills and therefore needs an assessment method that is capable of identifying them.

The workplace in a knowledge economy needs people who can think for themselves; TEL provides the means to rehearse learners in these skills. The education system cannot escape the responsibility of embracing those two facts in a programme of assessment reform. It is difficult, and risky, however, to change so much – what is learned, how it is learned and how it is assessed. TEL does not demand this change, it is an enabler. It is the effect of knowledge technologies on the world of work and leisure that makes the demand, and our job in education is to respond to that. It is not a task that can be shouldered by the individual teacher. In the final section we consider how it might be addressed.

17.6 Characteristics of the Local Implementation Context that Affect Adoption

17.6.1 Senior Management Support

The successful implementation of learning technology requires a fundamental rethink of the organisation of teaching and learning within an institution because it affects not just the transactions between teachers and learners, but the distribution of resources and support for teaching as well. These changes are so fundamental that full implementation cannot be carried out within one part of the system – it has to be systemic. This puts the onus on senior managers in an institution to lead and promote the change process.

One recent study of enterprise-wide e-learning in a telecom company found that the support the training administrator received from their senior manager was crucial to a unit's successful adoption of e-learning (Netteland, Wasson, & Mørch, 2007).

The bottom-up change that teachers could effect themselves is likely to be slow in education systems that more commonly operate top-down:

> Education systems change slowly because they tend to be hierarchical command-control systems, rather than devolved-power adaptive systems. Teachers and lecturers are given neither the power nor the means to improve the nature and quality of the teaching-learning process through technology (Laurillard, 2008a: 324).

This has long been argued as an aspect of our quality assurance systems that needs to change if education is to adapt to its environment within a reasonable timescale (Elton, 1999).

The hierarchical organisation of education is therefore also one of the reasons that institutions have been slow to implement technology-enhanced learning:

> The education system is run by leaders who are not comfortable with either the detail or the implications of the technology potential, and those who are, are not powerful enough within the system. There has been radical change in some institutions, demonstrating the importance of leadership. Institution leaders need the direction to be set at national level, and they need more support for the changes they must direct within their own institutions (Laurillard, 2008a: 324).

For this reason, the UK national strategy for e-learning in education made support for leadership as one of the main priorities (Department for Education and Skills, 2005).

17.6.2 Multiple Contexts

The introduction of new technologies into the management of educational institutions has already had a disruptive effect on the way they operate: the boundaries break down between home and work, and across departments and staff, as a result of the open networking now made possible. Networking and access to mobile devices necessarily creates multiple contexts for working (see Chapter 14). The same is true for students. Teachers designing online learning experiences must recognise that the Internet is not easily bounded, and their students are expert navigators within that world. They cannot ignore it, but they can make a virtue of it. Students are enthusiastic users of online networking, and with careful design of an educational equivalent, they can be nurtured into using their skills effectively for learning. Similarly, the easy mobility afforded by mobile devices makes it easier to access different learning contexts.

For teachers, this means orchestrating learning across multiple contexts. The learning system can reach beyond the classroom into more authentic contexts for learning, and for applying theoretical concepts. An online collaborative learning system can collect and manage data from several groups of students and compile the results in a meaningful way for the teacher (Chapter 1), enabling them to adjust and differentiate the kind of scaffolding they offer to individuals and groups. For teachers to maintain some degree of control over these multiple contexts in which their students are working, it will be important for them to have appropriate monitoring tools, as in the context of learners using "trails" in exploration of a real-world environment (Chapter 12).

Similarly, it has been shown that the design of collaborative learning systems (both the technological and the pedagogical aspects) needs to address the extent to which the instructors and tutors can get feedback on the student's collaboration process during the deployment of the learning activity (Wasson, Guribye, &

Mørch, 2000). For example, Wake (2002) found that the facilitators (instructors and tutors) felt that their ability to follow the students' progress in the learning activity was difficult and thus their ability to give feedback was limited. In the DoCTA project, pedagogical agents were added to a collaborative learning tool that provided the teacher with information on the students' collaboration and suggested ways in which teacher might want to respond (Chen & Wasson, 2003, 2004). Intelligent agents of this kind will be essential features of support tools for teachers, as the multiple online courses they are tutoring each foster a multiplicity of learner contexts of engagement. The complexity of these parallel social worlds of teacher–learner encounters can only become more elaborate in future, so digital management tools will be essential.

The value of multiple contexts made possible through networking is also demonstrated in research projects that build links between educational institutions. It is difficult for any one educational institution to provide the kind of flexibility in curriculum and teaching methods that personalisation requires, so collaboration across institutions is an important way of achieving this. Each contributes to the other and benefits by more than they contribute, if the collaboration is managed sensitively. The DoCTA study shows that a learning environment that is shared across distributed learning spaces, such as two schools, requires careful adjustment and greater flexibility of timetables in the two schools (Wasson & Ludvigsen, 2003). Inevitably, this involves institutional managers in the collaboration, which underlines the importance of their involvement in the change process. It cannot be done by teachers alone.

There is also growing interest in the way that particular pedagogic approaches can operate in multiple contexts. For example, storytelling is a powerful approach for education, both for its motivational value and for the structure it provides (Chapter 4). It enables the learner to organise concepts and relations, and thereby internalise them more easily. Some TEL resources, as may be expected, are particularly well suited to a small number of disciplinary contexts. Technology-enhanced language learning approaches will be of obvious benefit for language-related subjects, and also to any TEL learning activity where learners need to learn how to use language carefully, which is relevant to any discipline (Chapter 6). However, all disciplines develop their own languages and technical terms, and so resources such as intelligent glossaries – because they relate to the *process* of doing work in a discipline, not just the subjects under study – may be of value across disciplinary contexts.

17.6.3 Summary

The common recommendation to enable implementation is to combine "top-down" and "bottom-up" approaches. This mantra is hard to disagree with, but really says very little. Of course managers need to promote and support change and teachers need to work to incorporate this into their practices. What is often ignored, however, are the innumerable structural changes that accompany this and the ongoing

discussions needed in order to make these changes. These discussions will be much easier when the alterations required make sense to those involved and accord with their own beliefs and values.

17.7 TEL as a Catalyst for Changes in Pedagogy

17.7.1 The Teacher as Facilitator

Because digital technologies embody such a wide range of media and services they can be used to provide an elaborated virtual learning environment that works alongside the physical and social educational environments to support the full range of relationships within the learning process. One such example is "situated multi-environment learning tools", an open learning system that supports visualisation, communication and re-elaboration, creative exploration of problem-solving, representation and justification of knowledge, and the social relations between teachers and learners (Chapter 5).

If the teacher is able to decide the level of control they exert on their learners' use of such an environment, it becomes a highly flexible tool for their learning design, enabling them to adjust the learning process to the needs of individual and groups of learners. The teacher is therefore a kind of "conductor" of the learning process – or "orchestrator" (Chapter 1) or "narrator" (Chapter 4).

This kind of innovation makes the setting into which TEL is introduced very significant, as it will inhibit adoption unless it is adapted to the capabilities of the new system. The learning objectives, the content, and the roles of teachers, all need to be examined with respect to how they need to change (Chapter 5). The teacher is sometimes offered what sounds like an unexciting role of "facilitator" in this new world. But if this term means anything, it is not simply someone who marshals resources and organises students into learner-focused self-help groups. Taking into account the kinds of arguments made throughout this book, the teacher becomes "a facilitator of the learning process", which means they take responsibility for what and how a student learns, and set up the learning environment within which it becomes possible for every learner to achieve their learning potential. In their study of collaborative knowledge-building in middle school, Wasson and Ludvigsen (2003) saw evidence that the teacher is extremely important in *supporting, stimulating* and *motivating* the students *to integrate previous knowledge* with their new knowledge.

Not all TEL research, nor its implementation in practice, attends very much to the needs of the teacher. There is a danger that the increasingly common idea of the teacher as facilitator could effectively de-skill teachers if it were misinterpreted as a low-level skill. In fact teachers should be seen as centre stage – enabling learners to learn by marshalling a much greater variety of learning experiences and opportunities. This is a highly skilled role that makes teachers more like reflective practitioners in the practice of their profession – perhaps we should even regard teaching as a form of "design science"?

17.7.2 The Teacher as a Designer of Learning

With this kind of development TEL research helps to professionalise the teacher, giving them the opportunity to create the ideal learning environment for all their students, and greatly extending their practice beyond the capability of conventional methods. This is significant shift in the role of the teacher, and teachers will need supportive systems to help them build the skills and orientation to this new way of working (Chapter 3). Fortunately, while TEL research is building support for learner collaboration, the same tools and environments can be used to support teachers in the discovery and development of their new capabilities as "designers of learning" and "educational innovators".

Systems that offer collaborative learning environments could be used to support collaborative learning among teachers, in their discovery of how best to use TEL (Laurillard, 2007). Online communities developing around authoring environments such as LAMS (Learning Activity Management System[1]), and learning object repositories such as MERLOT (Multimedia Education Resources for Learning and Teaching OnLine[2]) are the early stages of the kind of collaboration that could enable teachers to work together as "reflective practitioners", progressing their field, as researchers do (Laurillard, 2008b; Schön, 1987).

We know from TEL research on computer supported collaboration scripts that external scripts scaffold learner participation in collaborative learning activities and engage them in high-level collaboration processes. We can apply that same result to the teacher "as learner". One recent study argues that external scripts can be seen as part of the learning environment (Chapter 10). By scaffolding the collaborative learning process, there is evidence that learners are able to work on tasks and engage in activities that they normally would not, and that their expectations change. They give an example where the expectation of having to present their results to peers leads to better elaboration of the learning material and to more knowledge construction. In the same way, we could imagine that a collaborative learning design tool for teachers, scaffolding their decision-making about learning design, could help them think more constructively and more innovatively, as they work together on learning design. How external scripts are integrated into wider social environments such as classrooms is one of the challenging issues related to the instructional design of computer supported collaboration scripts. They also point to a need to learn more about how to facilitate the teacher's authoring of such scripts. One way would surely be to provide a collaborative tool that fosters a teaching community in developing this knowledge for themselves (Laurillard, 2008a).

If teachers do eventually become TEL designers, it will be important for them to be able to share their designs and to build on models generated by others. Such models must include representations of knowledge, diagnosis and didactic decision-making, which can help the teacher develop a well-designed educational interven-

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[1] created at Macquarie University – http://www.lamsinternational.com/

[2] based in North America – http://www.merlot.org/

tion. There is a continuing interest in the idea of shareable learning designs, going beyond what is envisaged in the IMS LD specification (IMS-LD, 2003), and the projects continuing in this area will continue to challenge that specification.

17.7.3 New Relationships with Knowledge

The knowledge economy, fuelled by knowledge technologies, is changing what we know, and how we come to know it. At several points in our discussion, notably in relation to curriculum pedagogy, and assessment, we have seen how our relationship with knowledge and its representation is changing due to new technology. Bottino and colleagues summarise the main factors that make TEL in the workplace successful as follows: authenticity, visibility and complexity (Chapter 5). However, the authors argue that this conclusion would be valid across other educational sectors as well. The interesting outcome from this work is the reciprocal relationship between knowledge and pedagogy – each opens up new possibilities for the other. This is certainly a principle that will travel across educational sectors. New kinds of knowledge, such as the modelling of an organisational system, require new kinds of pedagogy, which focus on the construction and sharing of models. New kinds of high-level cognitive skill, such as the distillation of critical information from many diverse information sources, require new kinds of pedagogy, which rehearse students in searching, identifying, evaluating and selecting, with appropriate feedback on those processes. Conversely, the use of new technology in the workplace means that learners can experience authenticity through digital tools because they are the same tools as those used in the workplace. This is not a "virtual" work experience; it is the real experience of the digital world of the worker.

17.8 Concluding Points: Strategic Approaches to the Implementation of TEL Research

The discussion set out in the sections of this chapter demonstrates a need for a holistic, systemic approach to TEL adoption and implementation, whether at national, institutional or departmental level. TEL implementation has to be carried out with an awareness of national strategies for educational reform and an EU-wide approach to educational collaboration. Technology makes its best contribution when it is implemented in the service of high-level strategic ambitions, less so when we use it "because it's there". Educational policy has been clearly defined within the EU and its nation states, and given the scale of its ambition, it needs the assistance of technology, used well. We have tried to set out some of the requirements for implementation to succeed.

We conclude that the route from research to innovation, then to practice, through to mainstream implementation requires the following:

- An understanding of the authentic professional contexts that will influence the curriculum, pedagogy and assessment practices that need technology enhancement.
- Congruence between innovation and teacher values.
- Teachers having time to reflect on their beliefs about learning and teaching because TEL requires a more structured and analytical approach to pedagogy.
- Teachers and practitioners need a sense of ownership through their involvement in co-development of the TEL products and environments.
- TEL research must be conducted to reflect the interdependence between researchers and users.
- Education leaders need more support for the radical change of institutional teaching and learning models needed, if technology is to be exploited effectively.
- Teachers need to be more closely engaged in the design of teaching that uses technology, collaborating with peers and exchanging ideas and practices.

Education systems in all the EU countries are still in the relatively early stages of mainstream implementation of digital technologies for enhancing learning. We have assembled some of the key lessons learned in recent research and development projects. Through building and sharing this knowledge, we will develop gradually more successful ways of ensuring the technology achieves its potential to enhance learning.

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