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Technology-enhanced Learning and Teaching in Higher Education: What is 'enhanced' and how do we know? A Critical Literature Review.

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Abstract

The term Technology-enhanced learning (TEL) is used to describe the application of information and communication technologies to teaching and learning. Explicit statements about what the term is understood to mean are rare and it is not evident that a shared understanding has been developed in higher education of what constitutes an *enhancement* of the student learning experience. This article presents a critical review and assessment of how TEL is interpreted in recent literature. It examines the purpose of technology interventions, the approaches adopted to demonstrate the role of technology in enhancing the learning experience, differing ways in which *enhancement* is conceived and the use of various forms evidence to substantiate claims about TEL. Thematic analysis enabled categories to be developed and relationships explored between the aims of TEL interventions, the evidence presented, and the ways in which *enhancement* is conceived.

Introduction

In education it is often taken for granted that technologies can 'enhance learning' and the term 'Technology Enhanced Learning' (TEL) is increasingly being used in the UK, Europe and other parts of the world. Referring to the application of information and communication technologies to teaching and learning, TEL subsumes the older term 'e-learning', which was used with a confusing variety of meanings (Guri-Rosenblit & Gros 2011). However, it is rare to find explicit statements about what TEL actually means. Most frequently, TEL is considered synonymous with equipment and infrastructure. For example, the UK Universities and Colleges Information Systems Association provides only a technical definition of TEL as "*Any online facility or system that directly supports learning and teaching*" (Walker, Voce and Ahmed 2012, 2). No clarity is imparted by the UK's Technology Enhanced Learning Research Programme (TELRP) (http://www.tel.ac.uk/), which received funding of £12 million for the period 2007–12 and involved education in both schools and universities. In a recent document presenting some brief findings (TELRP undated, 2) the Director of the research programme provides little elucidation in his introductory statement:

> *Does technology enhance learning? It's not unreasonable to ask this question, but*
>
> *unfortunately it's the wrong question. A better question is: how can we design*
>
> *technology that enhances learning, and how can we measure that enhancement?*

This raises questions about *how* technology enhances learning and *what value* is being added to learners' experiences. Unlike other terms, TEL implies a value judgement: 'enhanced' suggests that something is improved or superior in some way. Oxford Dictionaries Online (2011) defines *enhancement* as "an increase or improvement in quality,

value, or extent": but exactly *what* will be enhanced when technology is used for teaching and learning, *how* will enhancement be achieved, and *how* can an enhancement be determined? Is the enhancement concerned with

- increasing technology use?
- improving the circumstances/environment in which educational activities are undertaken?
- improving teaching practices?
- improving (quantitatively and/or qualitatively) student learning outcomes?

Since the 1990s there has been considerable growth in the adoption of technology within higher education. Using technology can be costly, not only in terms of the financial investment made by institutions for infrastructure, equipment and technical support staff, but also in relation to the personal investment made by staff and students in using the technology for teaching and learning. In western universities institutional 'learning environments' are almost ubiquitous and their use by teachers and students can no longer be considered a novelty or the domain of enthusiasts alone. Despite the widespread growth in practice, concerns continue to be expressed about the extent to which effective use is being made of technology to improve the learning experience of students (Cuban 2001; Guri-Rosenblit 2009; Kirkwood and Price 2005; Zemsky and Massy 2004).

The sharing of 'good practice' and 'lessons learned' among members of the higher education community can help academic teachers to concentrate on effective uses of technology and to avoid the unnecessary duplication of effort and expense. Although most TEL projects are relatively small-scale and context-specific, the cumulative lessons learned

from a number of similar interventions can provide a useful indication of benefits that might

be achieved.

The Higher Education Funding Council for England (HEFCE) in their revised e-learning

strategy (2009) define TEL as 'Enhancing learning and teaching through the use of

technology'. While this is unclear in its characterisation of enhancement, the document

does identify three levels of potential benefits that TEL might bring (HEFCE 2009, 2):

- *Efficiency* – existing processes carried out in a more cost-effective, time-effective,

  sustainable or scalable manner.

- *Enhancement* – improving existing processes and the outcomes.

- *Transformation* – radical, positive change in existing processes or introducing new

  processes.

Senior managers and decision-makers are likely to be interested in *efficiency* benefits that

contribute to the reduction or containment of costs, increasing student numbers,

competitive advantage, or meeting student expectations. Those more directly involved in

teaching and supporting students are likely to be interested in potential *transformational*

benefits. However, what is more commonly found in practice is that technology is used to

replicate or supplement traditional activities (Blin & Munro 2008; Eynon 2008; Roberts

2003). After investigating the adoption of technology for education in California, Cuban

(2001, 134) observed that

> *the overwhelming majority of teachers employed the technology to sustain existing*
>
> *patterns of teaching rather than to innovate … [and that] … only a tiny percentage of*
>
> *high school and university teachers used the new technologies to accelerate student-*
>
> *centred and project-based teaching practices.*

Reviewing existing research on technology for teaching and learning in higher education

Several different focal points can be used when attempting to review or synthesise research studies in the field, depending upon the purpose they are intended to serve. Some reviews focus on assessing the uptake of technology in the higher education sector (e.g. Walker, *et al.* 2012). There are reviews undertaken to synthesise findings relating to a particular technology (e.g. Naismith, *et al*. 2004; Kay & LeSage 2009; Sim & Hew 2010) or discipline area (e.g. Arbaugh *et al*. 2009; Papastergiou 2009). Others reviews attempt to provide a meta-analysis of findings from experimental or quasi-experimental studies of the effects or impacts of TEL projects across the sector (e.g. Means *et al.* 2010; Tamim *et al.* 2011). Because meta-analyses often impose very strict inclusion/exclusion criteria (only including large-scale controlled quantitative experimental or quasi-experimental studies), some reviews have attempted to synthesise findings from research and evaluation studies on a less restrictive basis (e.g. Conole & Alevizou 2010; Du Boulay *et al*. 2008; Price and Kirkwood 2011). Yet other reviews are undertaken to explore the motives and aims of teachers (e.g. Jump 2010) or the conceptions of educational practices exhibited by practitioners/researchers (e.g. Hrastinski 2008).

One review of the use of technology for learning and teaching in higher education (Price and Kirkwood 2011) observed that there were issues in relation to the concept of enhancement and the associated evidence: both required further scrutiny. The term 'enhanced' was widely used in the literature, but frequently in an unconsidered and unreflected way so that its meaning was opaque and/or 'taken for granted'. Similarly, conceptions of 'teaching' and 'learning' (and the relationship between them) were often unquestioned. The investigation reported here builds upon that review in order to examine how enhancements of TEL might

be conceived and how evidence of enhancement claims are presented and articulated. This review is not concerned with the *findings* that researchers derived from their studies of TEL interventions: instead we attempt to learn more about *the variety of things they were searching for* and the means they used for *showing what they had found*. It aims to provide increased clarity to debates and discussions about TEL by exploring variations in the meanings ascribed to TEL by teachers and researchers and differences in their beliefs and associated practices.

Method

Literature search

The review covers literature for the period from 2005 to 2010. It comprises articles related to technologies used for teaching and learning in higher education. This was to reflect current thinking and evidence supporting positions and claims relating to TEL and included accounts of technology-supported interventions in higher education that

- were intended for specific teaching and/or learning purposes;

- were associated with one or more particular course/module or group of students, and;

- included some form of evaluative evidence of the impact of the intervention described.

To ensure a wide international coverage of journal articles and conference papers relating to higher (rather than school-based) education, the 'Web of Science' and the 'Academic Search Complete' databases were selected. Articles were identified using the search terms/keywords: 'technology', 'university *or* higher education', 'teaching *or* learning' and

'evidence *or* empirical'. Several hundred abstracts were scrutinised, but surprisingly few interventions met all three of the criteria listed above. After duplicates were removed, 70 unique references were identified from the 'Web of Science' database and 11 unique references from the online 'Academic Search Complete'. Our concern about the low yield of appropriate documents led us to review manually a number of relevant journals for pertinent articles (See Note 1 at end for details).

Initial screening

The abstracts of the identified articles were scrutinised to ensure that they fulfilled the criteria above: some were excluded because they were wholly or primarily about

- technology interventions in schools

- students' attitudes to and use of technologies in general

- plans for technology interventions that were yet to be introduced with students

- the generalised or idealised potential or affordances of technologies in education

- approaches to professional development for teachers' adoption of technologies

- institutional policies relating to the adoption of technologies.

(For consistency, we have used the term *intervention* throughout this article to refer to any instance where technology has been used to support learning and teaching in higher education.)

Articles primarily concerned with using technology for assessment and/or feedback purposes were also excluded, as a separate parallel review was being conducted in that area (Whitelock *et al* 2011).

After applying the inclusion/exclusion criteria, a total of 50 unique articles and papers were selected for review. Three of these were literature reviews and were excluded, leaving 47 articles. These comprised interventions that varied in their nature, discipline, country and approach. Detailed references for these documents appear in the Appendix.

Full-text review

Almost all of these articles reported on interventions that had been initiated and conducted by one or more academic teacher with responsibility for the modules or courses involved. Some articles related to studies undertaken by academic developers, examining similar interventions on several modules or courses. There were a variety of drivers for the interventions we reviewed. Many appeared to be technology-led: to scrutinise the impact or potential of particular technologies in teaching and learning. In fewer cases, authors/researchers were responding to an identified educational issue or aspiration (e.g. larger class size, remote learners, promoting reflection).

The following questions guided our analysis of the full texts and enabled us to gain a better understanding of how researchers and teachers in higher education conceptualise enhancement in relation to teaching and learning with technology:

- What types of technology intervention might be connected with teaching and/or learning enhancements?

- How is enhancement conceptualised in relation to teaching and learning processes and experiences?

- What evidence is considered necessary or appropriate to demonstrate the achievement of enhancement(s)?

Thematic Analysis (Braun & Clarke 2006) was used for analysing the content of the articles. Each article was read several times in order to become familiar with views about enhancements and the evidence presented to support these claims. Each author read the articles independently and noted salient points relating to (1) the driver for the intervention/study, (2) the enhancement sought, (3) the research/evaluation approach and methods, and (4) the type(s) of evidence acquired. The process was repeated to ensure that each of the above three questions had been fully explored. Through discussion, agreement was reached on the themes that emerged from the process of analysis.

In the articles we reviewed, authors had sometimes articulated the enhancements expected during the planning or design of an intervention. For example, "whether wikis could facilitate collaborative learning and positively affect student attitudes to group work in the context of an assessed group project" (Elgort *et al* 2008, 196). Several studies had adopted an explicitly exploratory approach (e.g. Bailey & Card 2009; Downing *et al* 2007; Hramiak *et al* 2009), so that enhancements only became apparent during the research. In our analysis of the articles we identified several themes by categorising emerging topics with brief descriptions. These form the basis of reporting structure in the following section.

Findings

Differing types of interventions

Each article was scrutinised to ascertain the goal/rationale of the intervention, although this was not always stated explicitly. These were characterised as having a primary focus on one of the following:

1. replicating existing teaching practices

2. supplementing existing teaching

3. transforming teaching and/or learning processes and outcomes.

Although the interventions reported were disparate, it was possible to assign interventions to one of two sub-categories within each of the three main categories. These are listed in Table 1. Each article appears only once.

Table 1 about here

Intervention type 1. Replicating existing teaching practices

In almost one-fifth of the interventions, technology had been used to replicate existing teaching. The main sub-category (1a) comprised interventions in which an element of conventional teaching was replicated and delivered to students using some form of technology. The other sub-category of replication (1b) involved a comparison being made of different technologies for delivering the same material or resources to learners.

Intervention type 2. Supplementing existing teaching practices

Half of the interventions were in this category. Studies in sub-category 2a involved resources or tools being made available that increased flexibility for learners. For example, recorded lectures or other course components were made available online to increase flexibility with regard to when and/or where students undertook their learning activities (e.g. Copley 2007). While such interventions typically examined students' responses to the additional flexibility provided, in many there was no exploration of any quantitative or qualitative changes in student learning. The studies in sub-category 2b explored the benefits

associated with the adoption of elements, often optional, which were available *in addition* to regular course components.

Intervention type 3. Transforming the learning experience

In less than one-third of interventions, technology had been associated with structural changes in the teaching and learning processes. Often they were linked with attempts to achieve *qualitative* changes in the outcomes achieved by students. Interventions in sub-category 3a involved redesigning activities or parts of modules to provide active learning opportunities for students. For example, resources were prepared for students to undertake enquiry-based learning activities and to develop reflective skills (Cooner 2010); a video game was used to improve mechanical engineering students' engagement with numerical methods (Coller & Scott 2009); an existing module was transformed into "problem-based blended learning on the basis of a social constructivist approach" (Dalsgaard & Godsk 2007). Collaboration, knowledge-building and meaningful learning were expected from interventions that involved the generation of TEL resources by students (e.g. Hakkarainen *et al.* 2007; Lee *et al.* 2008).

Studies in sub-category 3b investigated how TEL activities could most effectively promote qualitatively richer learning among students.

Differing ways in which enhancement is conceived

While several studies adopted an overtly exploratory approach, others were vague about the nature of any anticipated enhancement, either to *learning* or *the learning experience*. While not all documents used the term 'technology enhanced learning', all described some form of benefit or improvement, either explicitly or implicitly. Thematic analysis enabled us

to discern what the designers of each intervention were seeking by way of *enhancement* to learning and/or teaching. As many documents referred to more than one form of enhancement, we listed all that could be identified. Our analysis enabled us to characterise the desired enhancements (*not* the interventions) in terms of their emphasis on:

1. operational improvement (e.g. providing greater flexibility for students; making resources more accessible)

2. quantitative change in learning (e.g. increased engagement or time-on-task; students achieving improved test scores or assessment grades)

3. qualitative change in learning (e.g. promoting reflection on learning and practice; deeper engagement; richer understanding)

Several sub-categories were identified within each of these. The studies are listed under each category and sub-category in Table 2 (each intervention could involve more than one form of enhancement).

Table 2 about here

A comparison of Tables 1 and 2 indicates some correspondence between the type of intervention and the way(s) in which enhancement was conceived. Most of the interventions that involved 'replicating' or 'supplementing' existing teaching considered enhancement to relate to *operational improvement* or *quantitative change in learning*. In contrast, the interventions aimed at 'transforming' the learning experience tended to conceive of enhancement in terms of *qualitative changes*.

Intervention types 1 & 2. Replicating or supplementing existing teaching practices: anticipated enhancements

Improvements in test or assessment scores were among the most frequently sought forms of enhancement. This suggests that learning is viewed largely as *quantitative change* and that 'enhanced learning' is interpreted as an improvement in the acquisition and/or retention of knowledge. For example:

> *It was our hope that students … would show greater retention of course material and enhanced course satisfaction* (Cramer *et al.* 2007, 106-7).

Several studies used a pre-test/post-test experimental method to establish whether students using the TEL intervention had achieved higher scores than students who had not. Other studies compared scores for the end-of-semester assessment to determine whether TEL learners had achieved higher grades than non-TEL learners (either parallel groups in the same presentation or cohorts in different presentations). In the Discussion (below) we examine some of the problems associated with this approach.

Many interventions sought to achieve *favourable perceptions or attitudes* among students and academics in relation to the technology application. Typically these studies employed self-completion surveys, the results of which require careful interpretation in respect of demonstrating the achievement of an enhancement. This too is considered further in the Discussion section.

Intervention type 3. Transforming the learning experience: anticipated enhancements

The interventions in this category were more likely to characterise enhancement in terms *of qualitative changes in learning*. In other words, the studies tended not to be concerned about how much students learned, but with the development of deep learning or

intellectual skills (see, for example, Dahlgren 2005; Marton & Säljö 2005; Perry 1970; Säljö 1979). One such study stated that:

> *… computer mediated interaction provided a highly structured context which successfully engaged students and supported their achievement of key skills and assessment goals, notably problem solving, team work and tackling unfamiliar problems.* (Thorpe 2008, 69).

Typically these studies involved altering the design of teaching and learning activities in order to promote higher quality outcomes. In most cases a range of data collection methods was used to provide evidence.

Differing forms of evidence collected to demonstrate enhancement

A range of approaches was adopted in the 47 studies reviewed including variation in data collection methods, both quantitative and qualitative, and in the types of evidence used to demonstrate enhancement. Table 3 shows data collection methods and types of evidence identified from statements within the documents (each study could be listed under several sub-categories).

Table 3 about here

Tables 2 and 3 enable us to relate data collection methods to how enhancement was conceived. Overall, thirteen studies (28%) used only quantitative methods: all were concerned with enhancement as *operational improvement* and/or *quantitative change in learning* (although three studies also sought *qualitative* changes). Eight studies (17%)

employed only qualitative methods: all were seeking evidence of *qualitative change in learning*.

These differing forms of evidence are discussed below in relation to the three categories of intervention presented in Table 1.

Intervention type 1. Replicating teaching

Of the nine studies in this intervention category, six (67%) involved quantitative methods only. Performance measures (assignment or test scores) were typically used to compare TEL and non-TEL student groups. Questionnaires and/or attitude scales were often used to determine students' perceptions of and reactions to the teaching modifications introduced. Data were also collected from system usage records, teaching staff surveys, open-ended comments from students and staff interviews.

Intervention type 2. Supplementing teaching

Five (22%) of the twenty-three studies within this category employed only quantitative methods. Three studies used data from just one source. In contrast, six studies collected data using four or more methods. While some studies used assessment or test scores for comparative purposes, the most frequent source of data was the self-report student survey (in 16 of 23 studies). Qualitative data were often acquired from interviews, the analysis of online interactions, or from individuals' online postings.

Intervention type 3. Transforming the learning experience

Several data collection methods were used in the majority of the fifteen interventions categorised as 'transforming', with exclusively qualitative methods being used in four studies (27%). Only one study used pre- and post-test scores. Similar to the previous

category, the most common data source was the self-report student survey. Also, much use was made of individual interviews (students and/or teachers) or focus groups. Several studies involved the quantitative and/or qualitative analysis of online interactions.

Discussion

Our review of the literature has exposed a number of issues that warrant closer scrutiny. In this section we critically discuss six areas that relate to

- conceptual variations (in sub-section a);

- methods adopted for interventions and their evaluation (b and c);

- types of evidence used (d);

- difficulties in attributing causality (e); and

- the extent to which findings can be generalised (f).

a. Differing ways in which 'enhancement' and 'evidence' are conceived

Our review revealed different ways in which *enhancement* had been conceptualised and different forms of evidence that were sought to substantiate claims about TEL. This may reflect differing traditions and disciplinary practices in this emerging field, drawing as it does upon education, psychology and computer science. Nonetheless three interesting themes emerged overall from this review:

1. The goals of the interventions/studies reviewed

2. How enhancement was conceived

3. How evidence of enhancement was conceived

Table 1 illustrated that interventions were intended either to replicate existing teaching practices, to supplement existing teaching, or to transform the learning experience. While

these terms appeared infrequently in the statement of goals for a TEL intervention, it was evident which of the categories was most appropriate from the description of each project. The objective of the first two goals appears to be 'doing things better', while the third goal appears to be focussed on 'doing better things' (Reilly 2005). These distinctions are important as they underpin implicit views about TEL and delineate the kind of enhancement anticipated and evidence sought and presented.

Table 2 illustrates how enhancements were conceived. Although we set out to look for 'conceptions of enhancement' in this literature review, we felt that the data were not rich enough to draw out conceptions in a manner associated with phenomenographic studies. However, the categories in Table 2 provide useful insights into how enhancement was envisaged. These were often implicit conceptions, and authors seldom acknowledged these characteristics. For example, a study might not have stated explicitly that quantitative change in learning was a goal of the TEL intervention, but test scores had been used as a performance measure to demonstrate the impact of the TEL intervention.

Table 3 provides an indication of how evidence was conceived. This is the only categorisation that was wholly derived from explicit statements in all the documents reviewed. These distinctions illustrate how the evidence provided confirmation that the enhancement conceived (Table 2) had been achieved and contributed to the goals of the study (shown in Table 1).

We outline here some of the issues that concerned us about the evidence of enhancements.

b. Comparative studies: Seeking variations between TEL and non-TEL student groups

Evaluating differences between groups of students is the basis of the *comparative study* experimental method. In a true comparative study all independent variables would be held

constant, with only the dependent variable – the medium of delivery – differing. Many replication studies have shown 'no significant difference' (see Reeves 2005). However, causality is difficult to attribute if independent variables are not held constant; the comparative study method is only appropriate where teaching is being replicated (Joy & Garcia 2000). When an intervention provides additional/supplementary resources or tools for only some learners, any enhancement observed might simply be attributable to additional inputs or time spent on the task, rather than to the mediation of technology *per se*.

Even if teaching was successfully replicated using technology, it still leaves unanswered questions about what has been enhanced. The experimental comparative approach is associated with behaviourist/cognitivist views of learning and usually assumes that *enhancement* involves a quantitative improvement (higher scores equals more learning). This approach reveals nothing about whether students have developed a qualitatively richer or deeper understanding (Dahlgren 2005; Perry 1970; Marton & Säljö 2005).

c. Evaluation methods: Interpreting self-report survey data

Kirkpatrick's (1994) four-stage evaluation model proposes that the effectiveness of education/training is best evaluated at four progressively challenging levels – *Reaction*, *Learning*, *Behaviour* and *Results*. It stresses that evaluations need to attend to all four stages, focusing not only on changes in what individuals know and do, but also on the subsequent impacts attributed to the knowledge and behaviour developed. Holton (1996) argues that the *reactions* are less important than the other three levels because they reveal little about the outcomes attained. In other words, *reactions* data alone have limited value in demonstrating 'enhancement'.

Where students' views of TEL interventions were explored, the approach tended to rely upon self-reporting by students. Respondents may vary in their interpretation of the questions. For example, what exactly can be derived from findings such as these:

> *when asked whether they believed the Virtual Lecture Hall would enhance their learning, 73% either agreed or strongly agreed* (Cramer *et al.* 2007, 111);
>
> *these results provide good evidence to suggest that students think that podcasts enhance their learning process* (Evans 2008, 496).

Statements such as these leave unanswered questions about whether all students shared the same interpretation of 'enhancement of learning' and whether these matched the views of their teachers.

d. Appropriateness of measures used

Where course assessment or tests were used to determine learning 'gains' or 'improvements', it is necessary to consider the extent to which they were appropriately matched for the enhancement being sought. When a test is designed for a particular intervention study, it must be suitable and sensitive to the anticipated learning enhancement (for example, multiple-choice or short answer questions are unlikely to reveal qualitative changes in learners' understanding). When actual course assessments are used, those conducting the study need to be aware that the form of assessment influences *what* students attend to in learning activities and *how* they approach the task (Marton & Säljö 2005; Scouller 1998). So, if a TEL intervention is intended to promote student discussion and/or collaboration on group tasks (drawing upon a social constructivist view of learning), pre-existing assessment requirements that focus solely upon the work of each individual (reflecting a behaviourist or cognitivist view) will have considerable impact upon students'

behaviour (Cubric 2007; Neumann & Hood 2009). Downing *et al*. (2007, 211) reported that students

> *felt a sense of friendship or community with their fellow [online] students but that this*
>
> *was tempered by the need to get a good individual grade in their final assignment.*

Students' expectations can also have a substantial impact. For example, Elgort *et al.* (2008, 208) found that

> *the use of wikis was not enough to counteract some students' preference for working*
>
> *alone rather than as part of a team.*

If qualitative changes in student learning are expected, then the associated activities and assessment strategy must give them the opportunity to develop and practice appropriately. For example, Coller *et al.* (2009) scrutinised concept maps that their students generated to indicate their understanding of numerical methods. In other studies the qualitative analysis of individual or group interviews about both the process and product of group knowledge-creation provided illustrations of what and how students had learned (e.g. Cooner 2009; Lee *et al.* 2008).

> *Compared with previous years, the presentations [made by students] demonstrated*
>
> *evidence of better reflective analysis and a deeper theoretical understanding of the*
>
> *issues that impact on diverse communities. Although there was no significant difference*
>
> *in assignment marks, it can be argued that they may not be an appropriate measure for*
>
> *the full impact of learning undertaken by this design* (Cooner 2009, 285).

While an anticipated enhancement might be 'greater participation in online discussions', the ways in which *participation* is conceived and evidence collected can vary enormously from *quantitative* measures (e.g. the number of messages posted) to *qualitative* ones (e.g. richer

discussion or knowledge building). Six differing conceptions of 'online learner participation' were identified in a review of research articles (Hrastinski 2008, 1761) ranging from simple to more complex criteria:

> *It was found that research is dominated by low-level conceptions of online participation, which relies on frequency counts as measures of participation. However, some researchers aim to study more complex dimensions of participation, such as whether participants feel they are taking part and are engaged in dialogues, reflected by using a combination of perceived and actual measures of participation.*

What students gain from participating in group activities depends more on how they engage actively with peers than simply upon their online presence. While *quantitative* measures of student participation might be easy to capture, they contribute little to understanding how participation in collaborative processes can promote *qualitative* developments in learning. Measures that are sensitive to the complexities of human interaction are more appropriate for gathering evidence of enhancement.

e. Transforming the learning experience

Studies categorised as focusing on transforming the learning experience usually involved substantial and structural curriculum changes in the redesign and production of TEL resources (Cooner 2010; Coller & Scott 2009; Dalsgaard & Godsk 2007). Extensive changes were also necessary when interventions involved the generation of TEL resources by students (e.g. Hakkarainen *et al.* 2007; Lee *et al.* 2008). In all these cases technology had contributed to the redesigned teaching and learning activities. However, to what extent was any enhancement achieved the product of changes in the syllabus and learning design

rather than the application of technology as such? The attribution of causality is difficult

when several variables are altered, as Coller & Scott (2009, 911) found in their study:

> *What is unclear is the degree to which the game itself is responsible for deeper learning.*
>
> *To incorporate the video game, we had to completely re-develop the course.*

Typically, interventions that sought transformative outcomes drew upon a range of data

sources and richer forms of evidence were collected. This not only enabled the triangulation

of evidence, but also acknowledged that many interrelated factors influence student

learning. It is not only difficult to bring about improvements in student learning within 'real'

contexts, it is even more problematic to demonstrate what has been achieved and how it

has occurred (Price & Richardson 2004).

f. Generalising findings to other contexts

Attempts to generalise the findings of TEL studies from one context to another is often

impeded by the manner in which such accounts are reported. Teaching and learning

interventions too often focus on a fairly specific application of a technology (e.g. podcasts,

wikis, etc.), although there are often multiple ways in which a particular technology can be

used for different educational purposes. The use of a particular technology in one context

may differ from use in another. Published reports often provide insufficient detail about the

context in order to make generalisations possible. The educational design of what has

actually been studied is often considerably more complex than what is reported. Thorpe

(2008, 57) argues that:

> *... research might have increased value if it provided more information about the design*
>
> *of the teaching and learning interactions associated with its findings. This would enable*
>
> *the findings reported to be interpreted in relation to the way in which the technology*

was implemented, and the context of the implementation, rather than to the technology as an abstract concept such as 'computer mediated communication'.

There appears to be an under-utilisation of theoretical models to examine TEL and to generalise about enhancements. Academics and managers need a clear articulation of what is meant by *technology enhanced learning* in higher education to develop a better understanding of achievements. This is vital if research is to inform future practices in teaching and learning with technology to maximum effect.

Reflections on the review

As mentioned earlier, we were concerned about the scarcity of published documents identified in our database searches that reported studies of actual university teaching/learning situations and also drew upon and/or generated evidence appropriate to the intervention. Perhaps the difficulties inherent in carrying out and reporting such studies are greater than those involved in other related research activities. Related research includes surveying student and staff access to and use of technologies for education, establishing attitudes and preferences to technology use, experimenting with technology tools in situations that are not directly course related, and speculating about the potential of particular technologies for educational purposes.

There were a variety of contexts and drivers associated with the interventions we scrutinised, although most involved academic teachers associated with the modules or courses involved. When reviewing the documents identified in the searches, we discovered that many interventions were technology-led (e.g. 'how can we use podcasts/wikis…?'), rather than being derived from an identified educational need or aspiration. While in some

cases this technology-led approach was undoubtedly a response to larger or more diverse classes and encouragement to make greater use of institutional 'learning environments', there seemed to be many cases of deterministic expectations that introducing technology would, *of itself*, bring about changes in teaching/learning practices. This might contribute to the lack of an explicit educational rationale for many interventions.

Conclusion and further research

The term TEL is too often used in an unconsidered manner. While technology has increasing influence throughout higher education, there is still much to be learned about its effective educational contribution. This review has highlighted variations in both the purpose of TEL interventions and the ways that *enhancement* has been conceived. Underpinning this is a conflation of two distinct aims:

- changes in the *means* through which university teaching happens; and
- changes in *how* university teachers teach and learners learn.

Many of the studies reviewed concentrated on the *means*: replicating and supplementing existing teaching. Fewer considered the second aim - *how*. The ways in which academics conceptualise teaching and learning with technology have significant and interrelated impacts upon their students' experience of learning (Kirkwood and Price 2012). The potential of technology to transform teaching and learning practices does not appear to have achieved substantial uptake, as the majority of studies focused on reproducing or reinforcing existing practices.

Transforming learning is a complex activity that frequently necessitates reconsideration by teachers of what constitutes 'teaching' and 'learning'. It requires sophisticated reasoning about the goals of any intervention, the design of the evaluation and the interpretation of the results within the particular educational context. Further research needs to examine the relationship between these factors and their bearing on the potential of technology to transform the student learning experience.

There is increasing recognition of the limitations of much research that has been undertaken to understand the relationship between technology and learning (Cox and Marshall 2007; Oliver, 2011; Oliver *et al*, 2007). Research is often characterised by a lack of critical enquiry (Selwyn, 2011) and a limited range of research methods and approaches. We hope that this critical review of the TEL literature will contribute to debates in the field and to informing subsequent research activity by teachers and academic developers. We recommend that when conducting studies of TEL interventions in authentic teaching/learning contexts, researchers should examine the assumptions that underpin any research method or approach considered and the associated limitations. They should also state those limitations explicitly in any report for publication and indicate the extent to which they consider that their findings can realistically be generalised to other teaching/learning situations and contexts.

Note 1. The journals additionally reviewed were: Active Learning in Higher Education; ALT-J (the journal of the Association for Learning Technology); Australasian Journal of Educational Technology; British Journal of Educational Technology; Computers and Education; Higher Education; Internet and Higher Education; Journal of Computer Assisted Learning; Learning, Media and Technology; Open Learning; Studies in Higher Education; Teaching in Higher Education.

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Table 1. A categorisation of the reviewed interventions involving technology for teaching and learning

Nature of intervention or study	Article(s) involving this form of intervention
1. ***Replicating existing teaching practices*** [9 studies]	
a. Replicating an element of conventional teaching for delivery to students using some form of technology	Connolly *et al* (2007); Delialioglu & Yildirim (2008); de Grez *et al* (2009); Hui *et al* (2007); Lorimer & Hilliard (2008); Neumann & Hood (2009); Stephenson *et al* (2008); Woo *et al* (2008)
b. Comparing differing technologies for delivering the same material or resources to campus-based or distance learners	Griffin *et al* (2009)
2 ***Supplementing existing teaching practices*** [23 studies]	
a. Making available versions of existing course materials/resources/tools that students can access and use whenever they want	Copley (2007); Cramer *et al* (2007); Dalgarno *et al* (2009); Evans (2008); Fernandez *et al* (2009); Lonn & Teasley (2009); Swan & O'Donnell (2009); Taylor & Clark (2010); Tynan & Colbran (2006)
b. Adopting or developing additional learning resources or tools for students to use	Cubric (2007); Demetriadis *et al* (2008); Elgort *et al* (2008); Hramiak *et al* (2009); Kerawalla *et al* (2008); de Leng *et al* (2009); McLoughlin & Mynard (2009); Murphy & Ciszewska-Carr (2007); Ng'ambi & Brown (2009); Sorensen *et al* (2007); Wheeler & Wheeler (2009); Wyatt *et al* (2010); Xie *et al* (2008); Zorko (2009)
3 ***Transforming the learning experience (structural changes)*** [15 studies]	
a. Redesigning learning activities or substantial parts of modules to provide active learning opportunities for students	Coller & Scott (2009); Cooner (2010); Dalsgaard & Godsk (2007); Hakkarainen *et al* (2007); Hemmi *et al* (2009); Herman & Kirkup (2008); Lee *et al* (2008); Tormey & Henchy (2008)
b. Investigating how TEL activities could most effectively promote qualitatively richer learning among students	Bailey & Card (2009); Chen *et al* (2009); Downing *et al* (2007); Kanuka *et al* (2007); Kirkwood (2006); Melrose & Bergeron (2007); Thorpe (2008)

Table 2. A categorisation of how enhancement *was conceived in the accounts of technology interventions reviewed*

Conception of 'enhancement'	Article(s) exhibiting this conception
1. *Operational improvement* **[6 studies]**	
a. Increased flexibility [5 studies]	Copley (2007); Ng'ambi & Brown (2009); Taylor & Clark (2010); Tynan & Colbran (2006); Woo *et al* (2008)
b. Improved retention [1 study]	Connolly *et al* (2007)
2. *Quantitative change in learning* **[32 studies]**	
a. Improved engagement or time spent on learning task [10 studies]	Coller & Scott (2009); Cubric (2007); Dalsgaard & Godsk (2007); Downing *et al* (2007); Kirkwood (2006); Neumann & Hood (2009); Ng'ambi & Brown (2009); Sorensen *et al* (2007); Tormey & Henchy (2008); Tynan & Colbran (2006)
b. More favourable perceptions or attitudes (e.g. higher ranking of satisfaction or importance) [24 studies]	Coller & Scott (2009); Connolly *et al* (2007); Cooner (2010); Copley (2007); Cramer *et al* (2007); Dalgarno *et al* (2009); de Grez *et al* (2009); de Leng *et al* (2009); Delialioglu & Yildirim (2008); Elgort *et al* (2008); Evans (2008); Fernandez *et al* (2009); Griffin *et al* (2009); Hakkarainen *et al* (2007); Hui *et al* (2007); Lonn & Teasley (2009); Sorensen *et al* (2007); Stephenson *et al* (2008); Swan & O'Donnell (2009); Taylor & Clark (2010); Tormey & Henchy (2008); Tynan & Colbran (2006); Woo *et al* (2008); Wyatt *et al* (2010)
c. Improvement in test or assessment scores [14 studies]	Connolly *et al* (2007); Cramer *et al* (2007); Cubric (2007); Dalgarno *et al* (2009); Dalsgaard & Godsk (2007); de Grez *et al* (2009); Delialioglu & Yildirim (2008); Demetriadis *et al* (2008); Griffin *et al* (2009); Hui *et al* (2007); Lorimer & Hilliard (2008); Neumann & Hood (2009); Stephenson *et al* (2008); Swan & O'Donnell (2009)
3. *Qualitative change in learning* **[28 studies]**	
a. Deeper learning or understanding / higher order thinking processes and skills [16 studies]	Coller & Scott (2009); Connolly *et al* (2007); Cooner (2010); de Leng *et al* (2009); Demetriadis *et al* (2008); Hakkarainen *et al* (2007); Hemmi *et al* (2009); Kirkwood (2006); Lee *et al* (2008); McLoughlin & Mynard (2009); Stephenson *et al* (2008); Thorpe (2008); Tormey & Henchy (2008); Wheeler & Wheeler (2009); Wyatt *et al* (2010); Xie *et al* (2008)
b. More reflection / critical awareness by students [6 studies]	Connolly *et al* (2007); Cooner (2010); Herman & Kirkup (2008); Hramiak *et al* (2009); Kerawalla *et al* (2008); Xie *et al* (2008)
c. Improved student interactions in online discussion and/or collaborative activity [13 studies]	Bailey & Card (2009); Chen *et al* (2009); Downing *et al* (2007); Elgort *et al* (2008); Hemmi *et al* (2009); Kanuka *et al* (2007); de Leng *et al* (2009); Melrose & Bergeron (2007); Murphy & Ciszewska-Carr (2007); Neumann & Hood (2009); Thorpe (2008); Wheeler & Wheeler (2009); Zorko (2009)
d. Sharing of experiences (related to professional practices) [2 studies]	Chen *et al* (2009); Kerawalla *et al* (2008)

N.B. When multiple forms of enhancement were identified for a study, that study appears in more than one category above.

Table 3. The form of data collection and types of evidence collected in the reviewed interventions

Form of data / evidence	Article(s) using that form of data/evidence
Quantitative data [39 studies]	
System usage data	Copley (2007); Cramer *et al* (2007); Dalsgaard & Godsk (2007); Lorimer & Hilliard (2008); Ng'ambi & Brown (2009)
Completion/retention rates	Connolly *et al* (2007); Thorpe (2008)
Course or module assessment grades	Connolly *et al* (2007); Cramer *et al* (2007); Cubric (2007); Swan & O'Donnell (2009); Xie *et al* (2008); Zorko (2009)
Separately administered test(s)	Dalgarno *et al* (2009); Dalsgaard & Godsk (2007); de Grez *et al* (2009); Delialioglu & Yildirim (2008); Demetriadis *et al* (2008); Griffin *et al* (2009); Hui *et al* (2007) Lorimer & Hilliard (2008); Neumann & Hood (2009); Stephenson *et al* (2008)
Attitude scale	Cramer *et al* (2007); Delialioglu & Yildirim (2008); Demetriadis *et al* (2008); Griffin *et al* (2009); Neumann & Hood (2009)
Self-report survey – students (including established inventories, instruments, etc.)	Coller & Scott (2009); Connolly *et al* (2007); Cooner (2010); Copley (2007); Cubric (2007); Dalgarno *et al* (2009); Dalsgaard & Godsk (2007); Delialioglu & Yildirim (2008); Demetriadis *et al* (2008); Elgort *et al* (2008); Evans (2008); Fernandez *et al* (2009); Hakkarainen *et al* (2007); Herman & Kirkup (2008); Hui *et al* (2007); Kirkwood (2006); Lonn & Teasley (2009); Neumann & Hood (2009); Sorensen *et al* (2007); Stephenson *et al* (2008); Swan & O'Donnell (2009); Taylor & Clark (2010); Thorpe (2008); Tormey & Henchy (2008); Tynan & Colbran (2006); Wheeler & Wheeler (2009); Woo *et al* (2008); Wyatt *et al* (2010); Xie *et al* (2008); Zorko (2009)
Self-report survey – teaching staff (including established inventories, etc.)	Lonn & Teasley (2009); Woo *et al* (2008)
Scrutiny of student-generated artefacts	Coller & Scott (2009)
Analysis of online interactions (*quantity*)	Chen *et al* (2009); de Leng *et al* (2009); Downing *et al* (2007); Kanuka *et al* (2007)
Qualitative data [34 studies]	
Interview – individual student	Chen *et al* (2009); Dalgarno *et al* (2009); de Leng *et al* (2009); Downing *et al* (2007); Fernandez *et al* (2009); Hemmi *et al* (2009); Herman & Kirkup (2008); Kerawalla *et al* (2008); Melrose & Bergeron (2007); Swan & O'Donnell (2009); Thorpe (2008); Zorko (2009)
Interview – student group (focus group)	Cooner (2010); Hramiak *et al* (2009); Lee *et al* (2008); Melrose & Bergeron (2007); Sorensen *et al* (2007); Taylor & Clark (2010); Tormey & Henchy (2008); Wyatt *et al* (2010)

Interview – teaching staff	Bailey & Card (2009); Chen *et al* (2009); Connolly *et al* (2007); de Leng *et al* (2009); Elgort *et al* (2008); Fernandez *et al* (2009); Hemmi *et al* (2009); Murphy & Ciszewska-Carr (2007); Taylor & Clark (2010); Thorpe (2008); Woo *et al* (2008)
Individual diary	Hakkarainen *et al* (2007)
Open-ended comments in student self-report survey	Hakkarainen *et al* (2007); Herman & Kirkup (2008); Lonn & Teasley (2009); Neumann & Hood (2009); Sorensen *et al* (2007); Swan & O'Donnell (2009)
E-mailed comments	Fernandez *et al* (2009); Herman & Kirkup (2008); Thorpe (2008)
Reflective activity	Cubric (2007); Elgort *et al* (2008); Hemmi *et al* (2009)
Online forum/discussion	Fernandez *et al* (2009); Hemmi *et al* (2009); Herman & Kirkup (2008)
Analysis of online postings and/or interactions (*quality*)	Chen *et al* (2009); de Leng *et al* (2009); Downing *et al* (2007); Elgort *et al* (2008) Hemmi *et al* (2009); Kanuka *et al* (2007); McLoughlin & Mynard (2009); Xie *et al* (2008); Zorko (2009)
Analysis of individuals' online messages	Hramiak *et al* (2009); Kerawalla *et al* (2008); Ng'ambi & Brown (2009); Wheeler & Wheeler (2009)
Scrutiny of student-generated artefacts	Coller & Scott (2009)
Observation of practice	Hemmi *et al* (2009); Sorensen *et al* (2007); Swan & O'Donnell (2009); Tormey & Henchy (2008)
Case study of practice	Sorensen *et al* (2007)

N.B. When multiple forms of data collection were used in a study, that study can appear in more than one category above.