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Article

A holistic model for evaluating the impact of individual technology-enhanced learning resources

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Key words: technology-enhanced learning, evaluation, learning resources, cost analysis

Abstract

Background

The use of technology within education has now crossed the Rubicon; student expectations, the increasing availability of both hardware and software and the push to fully blended learning environments mean that educational institutions cannot afford to turn their backs on technology-enhanced learning (TEL). The ability to meaningfully evaluate the impact of TEL resources nevertheless remains problematic.

Aims

This paper aims to establish a robust means of evaluating individual resources and meaningfully measure their impact upon learning within the context of the programme in which they are used.

Methods

Based upon the experience of developing and evaluating a range of mobile and desktop based TEL resources, this article outlines a new four-stage evaluation process, taking into account learner satisfaction, learner gain and the impact of a resource on both the individual and the institution in which it has been adapted.

Results

A new multi-level model of TEL resource evaluation is proposed, which includes a preliminary evaluation of need, learner satisfaction and gain, learner impact and institutional impact. Each of these levels are discussed in detail, and in relation to existing TEL evaluation frameworks.

Conclusions

This paper details a holistic, meaningful evaluation model for individual TEL resources within the specific context in which they are used. It is proposed that this model is adopted to ensure that TEL resources are evaluated in a more meaningful and robust manner than is currently undertaken.

Introduction

Technology-enhanced learning (TEL) utilises the increasing availability of smart phones, tablets and laptops to support flexible and mobile learning. These devices enable learners to access learning resources, such as eBooks, applications, videos and podcasts (Lupton 2015), in a location, and at a time, that suits their own specific learning needs (Ally 2009). Recently the education sector has embraced this technological development, with higher education institutes and commercial developers creating TEL resources to support a wide range of educational disciplines (Bullock 2014). However, with increasing acceptance and use of such resources (Bickerdike et al. 2014; Joynes & Fuller 2015) and finite time available for learners to engage in preparation for summative assessments, it is essential that such resources are efficient, and support learner gain (that is, an increase in usable and retained knowledge). It is inconceivable that any educational establishment, at any level from school to higher education institution, would consider withdrawing technology from their curriculum (Fuller & Joynes, 2015a; Lumsden et al. 2015). Simultaneously, educators must now consider “how can technology be designed and developed to enhance student education and provide learner gain?”

At Leeds, the MBChB (Bachelor of Medicine and Surgery programme) has a long standing TEL programme whereby significant parts of the curriculum, including on-campus teaching and clinical placement based learning, are supported through a range of technological resources. This approach to curriculum delivery enables students to use key learning resources at a time and place that best suits them and their learning (Joynes & Fuller 2015b). A specific example of this approach is across the anatomy curriculum where traditional didactic lectures are delivered alongside cadaveric

dissection classes, with associated small group discussion sessions. For each of these sessions there are numerous 'blended learning' resources embedded into the teaching, including paper-based workbooks, digitally captured lecture content, online formative questions, eBooks and applications to support students in reaching the desired learning objectives (Pickering 2015a). Whilst the overall uptake of these TEL resources has been extensive, it remains difficult for those interested in developing and improving the efficacy of technological resources for learning to evidence the impact of an individual resource to the individual learner or institution. Furthermore, it has been acknowledged that existing frameworks and instruments fall short of providing a sufficiently robust mechanism to evaluate TEL resources (Cook & Ellaway 2015). From our own experiences, it appears that there is an absence of connectivity between theoretical frameworks for evaluation and the realities of developing pragmatic tools to explore the impact of TEL resources on student learning. This paper therefore aims to provide a practice-informed evaluation model that enables educators to understand the overarching impact of a single intervention TEL resource within the context in which it is used. The model proposed here has the potential to be used across a range of disciplines, but has been developed based upon our experiences of evaluating TEL resources within medical education. It is intended to move evaluation of TEL resources beyond superficial discussions of whether resources are well-perceived by the user cohort. The rationale for developing this model is in part due to the rapid expansion of technology and the introduction of TEL resources within medical curricula, combined with the concomitant lack of adequate evaluation of such resources. This model intends to serve as a filter for the implementation of TEL resources into curricula to ensure that they are fit for purpose, with the results

intended to provide meaningful data on the role of such resources within the context in which they are delivered.

An exploration of existing resource evaluation models

A broad range of evaluation frameworks are already well-documented within educational literature, however their focus tends to be at the level of programme or course evaluation rather than on the impact of a single resource intervention embedded within a wider course (Frye & Hemmer 2012). Perhaps the most influential and widely cited of these are Kirkpatrick's (1994; 2010) models, which describe evaluating four levels of learner outcomes in order to understand the impact of training programmes. Detailed review and critique of these models (Holton 1996; Yardley & Dornan 2012) suggest that they are reductionist in approach, thereby limiting their utility within a resource-heavy, complex, multi-faceted learning environment. Whilst we would agree that evaluation of a resource in isolation is of limited use within a medical education context, our view is that the levels outlined by Kirkpatrick (2010) are a useful starting point in developing a more nuanced approach to evaluating TEL resources. However, despite the fact that this is an updated approach to training evaluation, we believe the model is not wholly transferable to medical education curricula. For example, where Kirkpatrick (2010) proposes that 'confidence' in a newly acquired knowledge is important, within medicine we would want evidence that this knowledge is both 'learned' and maintained beyond a students' perceived confidence.

Unfortunately, evaluations of TEL resources remain largely aimed at exploring the levels of student engagement and satisfaction (Koehler, 2012; Wallace et al. 2012) or

type of device (Chen & Denoyelles 2013). Recently a comprehensive TEL evaluation framework has been proposed by Cook and Ellaway (2015) who seek to improve 'meaningful comparison' of TEL courses across institutions, learners and courses. This framework provides an approach incorporating seven broad areas of evaluation activity that the authors suggest are 'relatively unique to TEL' (Cook & Ellaway 2015). While we would agree that this framework provides an excellent underpinning for TEL course or programme level evaluations, in our opinion it is not flexible enough to generate information on the efficacy of a single intervention TEL resource.

The model proposed in this paper seeks to establish a precise step-by-step protocol for evaluating an *individual TEL resource*: measuring its effectiveness not only as part of a wider module but also as a stand-alone learning tool. This proposed dual focus for evaluation arises from our own experiences of using technology to enhance student education and wanting to understand the specific impact these learning approaches have on the individual student. The strengths of TEL resources to support student education are well documented (Beetham & Sharpe 2013), but that does not mean every resource developed is of sufficient or equivalent quality. The need for this level of evaluation is thus essential as students put considerable faith in the teacher who recommends learning resources to supplement their studies, consequently, these resources need to be both academically and technologically sound.

Two fundamental questions shaped the proposed evaluation model and are significant due to the changes in educational delivery that are currently underway within the education sector. They were: What impact do individual TEL resources have on learning? What learner gain is achieved in comparison to existing resources? This

evaluation model intends to provide a mechanism in which the efficacy of TEL resources is measured within the context of supporting learners in reaching the desired learning objectives, not just how effective the technology aspect of the resource was. It is our assertion that only when this is more widely understood will the pedagogy behind TEL be better understood. Moreover, with these factors taken into consideration it is important that a full return on investment (ROI) analysis is conducted to ensure that the time spent, the resources used and the overall outcomes achieved are of sufficient benefit to support the further development of TEL resources. The proposed model contains four levels which, as will be explained, work as a protocol in which a single TEL resource can be evaluated from its inception to the overall institutional benefit. However, it is also feasible that each level may be treated in isolation if required. The proposed model is therefore based upon the premise that if significant research has already been conducted by the institution on a particular aspect of technology, then sufficient evidence may already be available, rendering one or more of the proposed levels unnecessary.

Proposed model

The evaluation model is outlined in Figure 1.

INSERT FIG 1 HERE

Level 0: Preliminary evaluation of need

Derived from: *Module evaluation, student feedback, assessment scores, staff-identified need*

Addressing: Perceived teaching shortfall or module development requirement

Before the development of any TEL resource an evaluation of need is essential. This information can be retrieved via a number of methods including module evaluations, module grades and staff awareness of poor topic engagement. If technology is the preferred solution, consultation with relevant faculty members (business managers and technologists) to ascertain the feasibility of developing resources (i.e. staff time, associated technology and infrastructure costs) is then required (Laurillard 2007). The goal of this initial level is to make sure technology is being introduced into the module's curriculum to serve a pedagogical purpose and *not for its own sake* (Fuller & Joynes 2015a).

Development

The development phase, although key to the production of TEL resources, is not considered to be an integral part of this evaluation model. Nevertheless, it is anticipated that in order to create a user-friendly resource, a collaboration between students, academics and learning technologists would be required. Based upon our experience of creating TEL resources, it is essential that all relevant stakeholders are involved in the development, in order that it is academically appropriate, relevant and seen as 'legitimate'. At this stage it is necessary to know the types of device students will be using to access the resource (Chen & Denoyelles 2013). This decision may be determined by institutional policy, or learner choice.

Although many institutions may have the infrastructure and expertise to design and develop their own resources which can be specific to the curriculum in which the resource is going to be deployed, consideration should also be given to similar

resources which could be procured from external providers. If a suitable resource can be found from an external provider the content of that resource should be appropriate to ensure the students are being exposed to material that is relevant to their course.

Level 1

This level aims to evaluate two core areas of an individual TEL resource: (a) the degree of user satisfaction and (b) the degree of learner gain achieved. These simultaneous evaluation stages rely on piloting the resource to a group of learners from a broad range of academic achievement in advance of the resource being deployed to an entire cohort.

Level 1a: Learner satisfaction

Derived from: *Likert-scale based questionnaires, focus groups*

Measuring: *Level of satisfaction with resource*

User satisfaction with resources is a basic but necessary stage of the evaluation process. In order for users to engage with the resource to a meaningful level it will need to be sufficiently user friendly and closely aligned to the academic content of the topic. A resource that receives low levels of satisfaction will deter users from engaging with what could be an essential learning tool.

This level of evaluation is superficial and is essentially detailing if the students liked the resource aesthetically and also, importantly, that they found it effective in delivering the relevant aspects of the curriculum. From this data you should be able to comment: “they liked it and engaged with it” but nothing more. However, where levels of satisfaction are identified as being low, it would be advantageous to ascertain why this

is. Unless a decision is made to move away from TEL, the feedback should be used to modify the resource, moving the process back to the development stage. If levels of satisfaction are high, then it is recommended that the results of evaluation of learner gain (level 1b) are also explored.

Level 1b: Learner gain

Derived from: *Pre-test and post-test measures*

Measuring: *Degree of equity in learner gain between developed TEL and existing learning resources*

With the increasing deployment of TEL resources it is essential to ensure they are of actual benefit to the individual and provide at least an equitable level of *learner gain* compared to existing learning resources. The purpose of this level of evaluation is, as far as possible, to measure any potential increase in knowledge and is most appropriately assessed in an artificial situation by asking for volunteers.

An established approach to measuring learner gain from TEL resources already exists in the form of pre-and post-testing (Issa et al. 2011). Not only does this allow a direct measure of learner gain to be ascertained, it provides information on the duration of time for which knowledge has been retained. Moreover, there are multiple approaches which can be employed to compare the efficacy of the TEL resource within this pre- and post-test approach. For example, a randomised control study could be implemented which splits a cohort of volunteers into two groups. One of which would receive the TEL resource while the other received existing resources, such as a paper-based workbook. Each group would be given identical conditions with which to access their resource after completing a pre-test set of questions (Pickering, 2015b). Having

run the exposure a post-test set of questions would be delivered to measure and compare the learner gain between the two contrasting resources. It is anticipated however, that at this stage, and irrespective of resource type, an increase in learner gain would have been achieved. It is essential, therefore, to perform a subsequent series of post-tests to ascertain the degree of knowledge retention between the two resource types over time (Hake 1998; Issa et al. 2011).

Having access to this level of data will be useful in judging whether the TEL resource is an effective tool to support learning. Moreover, at this stage it would be important to scrutinise the results against learner demographics: gender, age or prior academic achievement for example. Additionally, analysing the results across different question types (i.e., factual vs conceptual; easy vs hard) will allow a more detailed understanding of the impact such a resource has on learner gain.

To ensure the test is valid the participants should have no prior knowledge of the specific topic area, which would lead to sampling bias, but should be sufficiently aware of the general discipline that they are not considered a lay person. From our own experience we appreciate that recruiting sufficient volunteers to achieve a meaningful assessment is challenging; nevertheless, this is an important step that needs to be implemented in order to establish if the resource “works”.

Upon successful completion of levels 1a and 1b there should be adequate evidence of pedagogical advancement to confidently deploy the resource.

Level 2: Learner impact

Derived from: *Likert-scale questionnaire, focus group, usage metrics, assessment data*

Measuring: *Influence of TEL resource on course outcomes for individual learners*

Having rigorously evaluated the satisfaction and efficacy of the TEL resource it is necessary to understand its ability to influence individual learner outcomes within a specific teaching setting (i.e. a course, module or programme). However, as highlighted by critiques of existing evaluation models (Holton 1996; Yardley & Dornan 2012) it is acknowledged that being able to realistically quantify the impact of one single resource within a multi-faceted setting is both reductionist and extremely difficult. It would, of course, be unrealistic to assume that a student would be able to progress through their course with only one package of information influencing their learning. All of these will form part of the individual student's learning portfolio to varying degrees, depending on what suits their own learning preferences.

Nevertheless, it should still be possible to measure the impact of an individual learning resource provided the context of its provision is acknowledged. The method to achieve this is made possible through access to learner analytics, *combined with* individual structured questionnaires, focus groups and assessment data. To that end, evaluation of 'level 2' in this model is complex and requires careful planning and execution.

To achieve this level of evaluation a detailed questionnaire is required which accurately measures both the range of learning resources accessed and the amount of time an individual student engages with each resource. At this stage it is essential that individual students are identifiable and that demographics and specific learning analytics are available. This would include information on level of usage such as number of downloads (where applicable), and when and how often during the course a resource was accessed. Further parameters such as cohort demographics, academic background and performance quartiles from previous assessments would need to be

correlated against the assessment outcomes. Due to the sensitivity of this data, this stage necessarily requires student permissions for their individual data to be accessed and used in this way (Sclater 2015). This allows the individual responses from the questionnaire to be linked to the student's own assessment performance, in order to compare resources in a holistic manner. Having an understanding of the influence a specific TEL resource can have on learning outcomes for specific subgroups of students will allow for a more personalised learning approach through increased learner choice or the direct targeting of resources. This in-depth form of evaluation is paramount to 'level 2' and aims to provide a very clear and holistic overview of the impact the TEL resource has had on the learning outcomes of an individual.

By this stage of evaluation, the efficacy of the TEL resource in relation to learner satisfaction, gain and impact should be well-established. For some educators, this may meet the needs of evaluating a specific TEL resource. However, for others, there may be an institutional requirement to inform debates on the implementation of TEL resources at both a local and wider higher education level.

The final proposed level can therefore be considered as an optional extension of the evaluation model to establish if there is a ROI for introducing a TEL resource within a host institution.

Level 3: Institutional impact

Derived from: *Return on investment analysis to include multiple measures of impact*

Measuring: *Impact of developing TEL resource(s) on a range of stakeholders*

Level 3 is an opportunity to reflect on the financial, temporal and personal *cost* of developing the resource alongside the benefit to a range of stakeholders. It is widely

appreciated that higher, and especially medical, education is inherently expensive (Frenk *et al.* 2015). It is therefore important to establish the ROI of any resource implemented into a curriculum. The importance of establishing the cost to institutions of developing TEL resources has long-been acknowledged. For instance, Laurillard (2007) proposes a prospective model of costing for TEL interventions that involves predicting the staff and per-student cost of a TEL resource. However, due to this model allocating resource costs prior to their development this tool is unable to take into consideration the full effect on learner gain and impact, as these outcomes would be unknown at this stage.

A comprehensive summary of cost analyses applicable to all elements of medical education has been described by Walsh *et al.* (2013). Previously, attempts at cost-analyses have been applied to a range of medical education areas (Walsh *et al.* 2013), but at present, no specific ROI model for individual TEL resources is available. Cook and Ellaway (2015) do identify the key components that would be required such as the costs of financing hardware and software, staff time and all supporting infrastructure. Walsh *et al.* (2013) identify four approaches to exploring the true cost of delivering education (cost-utility, cost-effectiveness, cost-benefit and cost-feasibility) all of which can be applied to the evaluation of a single TEL resource. More specifically, each of the four identified approaches can be closely aligned with one or more of the evaluation levels proposed in this paper (Figure 1). The cost-utility measure takes the comparisons of satisfaction established in Level 1a and assigns a cost per student to providing each resource (Walsh *et al.* 2013). Clearly this approach has its shortcomings, as it is based upon subjective application of value to satisfaction outcomes. We would therefore not propose that the entire cost-analyses of a TEL

resource be based solely on this approach, but it may provide useful contextual information.

Cost-effectiveness necessarily involves comparison of the outcomes of utilising alternative approaches or resources. This may take the form of comparing the TEL resource with an alternative learning resource, as described at Level 1b. To develop this stage of evaluation further (and thus into a 'level 3' evaluation) this would include comparisons of the associated costs of each resource by assigning a monetary value to each of the interventions.

Cost-benefit analysis is more complex and involves exploration of the impact of introducing a resource on the associated stakeholders. Aligned with an exploration of learner impact (Level 2) it may therefore be possible to assign monetary value to not just the development and hardware costs of a TEL resource, but also take into account the received benefits. For example, if it is established at Level 2 that a TEL resource has had a positive impact on the pass rates for a module, and thus subsequently a lowering of attrition rates for a course (Pickering 2015b) a monetary value may be assigned to the retention of students on a course. Conversely if having established at Level 2 that there is no significant positive benefit from course outcomes, then it may be considered that the cost of developing such a resource does not provide sufficient value for an institution to fund the creation of similar resources. An overarching view on all the cost elements discussed here would constitute the cost-feasibility of implementing the specific TEL resource.

Conclusions

The evaluation model proposed in this paper aims to address the current lack of robust evidence for the widespread implementation of TEL resources, and the disconnect between the adoption of technology in curricula and its meaningful evaluation. Using the model described in this paper, it may be established that a TEL resource is well liked and improves both the individual learner and course outcomes in terms of pass-rates. However, more detailed analysis such as that described at Level 3 may indicate that the financial costs of developing such resources still appear to outweigh the financial benefits. At this point it becomes the responsibility of senior faculty to decide whether they will continue to support the development of TEL resources with the aim that they find more cost-effective ways to do so, or withdraw from the development of such resources altogether.

This model has provided a framework for educators to comprehensively evaluate the impact of a single TEL resource in their course. The authors propose that this model differs from existing TEL evaluation models by offering a holistic and multi-faceted approach that is nevertheless adaptable to suit individual institution needs. It is hoped that by utilising this model an increased understanding of the educational impact of TEL resources can be established. In order to explore the practical application of the model, the authors are working on a case study of how this model has been used to inform TEL-resource design within their own institutions, which endeavours to provide further evidence of the need for such holistic evaluations.

Practice Points

- Developing TEL resources for campus-based teaching is an increasing priority to meet the developing approach to medical education in the twenty first century.
- TEL resources that form part of a course's blended learning strategy need to be both accepted and therefore adopted by the target audience, and effective in supporting learner gain. Evaluation of these resources therefore needs to establish that any new resource can meet these needs.
- To introduce such resources into a course, which already has a range of teacher-led and student-led resources, requires justification both financially and temporally. The evaluation model proposed here outlines a series of levels to help educators gather evidence for such justification.

Notes on Contributors

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Illustrations

Figure 1
Holistic TEL evaluation model



