The Need for Evidence Innovation in Educational Technology Evaluation

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Abstract

More complex and chaotic methods are being adopted in the development of technology to enhance learning and teaching in higher education today in order to achieve innovation in teaching practice. However, because this type of development does not conform to a linear process-driven order, it is notoriously difficult to evaluate its success as a holistic educational initiative. It is proposed that there are five factors that impact on effective educational technology evaluation, which contributes to insubstantial evidence of positive outcomes, these being: premature timing; inappropriate software evaluation techniques and models; lack of shared understanding of the terminology or the semantics of education technology; the growing complexity of agile and open development; and the corporatisation of higher education.

This paper suggests that it is no longer helpful for policy makers to evaluate whether educational technology project outcomes were successful or unsuccessful but instead they should use agile evaluation strategies to understand the impact of the product, process and outcomes in a changing context. It is no longer useful to ask the question, 'did the software work?' The key is for software

developers and policy-makers to ask ‘what type of software works, in which conditions and for whom?’ To understand this, the software development community needs to look at adopting evaluation strategies from the social science community. For example, realist evaluation supplies context driven and evidence-based techniques, exploring outcomes that tend towards the social rather than technical. It centres on exploring the ‘mechanisms’, ‘contexts’ and ‘outcomes’ associated with an intervention and is a form of theory-driven evaluation that is the theory and reasoning of its stakeholders that is rooted in practitioner wisdom.

1.0 Background

The Centre for Engineering and Design Education (CEDE) at Loughborough University has been working with educators for over 15 years in developing, enhancing and innovating teaching and learning practice. The Centre comprises a team of specialists in pedagogic research, education and learning technology development. It has not only proved to be a highly effective support mechanism for discipline specific academics but has also developed and maintained national and international networks and collaborations [1]. Much of the Centre’s external recognition has come from the development of educational technology, much of which is open source and in use at higher education institutions (HEI) around the world. Two examples of these are WebPA™ [2] a peer-moderated marking system and Kit-Catalogue™ [3], a cataloguing system for research and teaching equipment.

The Centre has evolved and refined its approach to working within inter-disciplinary, often inter-institutional, educational teams in the design and development of educational technology. The Centre has reached a certain level of maturity in its practices including:

- agile co-development and service design approaches to software development;
- strong project management and ongoing support to users for the effective embedding of software in teaching and learning practices;
- fostering supportive and active open source communities;
- the continued development of the technical skills set of our in-house educational developers which has flourished in recent years.

However, despite this apparent progress, the outlook for the Centre’s capability in delivering in-house software development is becoming more challenging for a number of reasons.

The year 2011 marked a rapid and critical demise in funding within Higher Education in England. This has impacted on not only CEDE but much of the in-

house educational development community in the UK. The lack of funding is starting to bite but in contrast, the UK's Department for Business, Innovation and Skills has published the 'International Education: Global Growth and Prosperity' report outlining the UK's role in contributing to worldwide innovation in education, including leading the world in educational technology development. David Willetts MP, lays down the gauntlet, "we need to be at the forefront of the edtech revolution" [4].

With tighter budgets and smaller teams, it is imperative for institutions that invest in in-house educational technology development to understand exactly what works, for whom and why. Moreover, it is critical for in-house educational developers to provide evidence that their new and emerging co-design and development methods are indeed a catalyst for innovation in teaching and learning. It is, therefore, timely to review the ways in which the outputs and outcomes of in-house educational technology development projects are being evaluated. There is a huge opportunity for the in-house educational software development community to leverage the right evaluation approach, to help provide decision makers and funders with evidence which supports, not only a case for in-house development, but that in-fact, fostering co-creation between academics and software developers is the only way to achieve real innovation in teaching and learning.

For the purposes of this paper the term 'edtech' is used (as David Willetts has done) to describe software and software systems that are used in higher education to support teaching and learning.

2.0 Contributing Factors that lead to Narrow Evaluation

CEDE has carried out many types of evaluation to try and understand the success particularly of homegrown edtech interventions. Traditionally, because the purpose of the technology has been to enhance teaching, the measure of success has been centred on the end-user as the learner. Therefore, much of the evaluation has been pedagogic. Did the student do better as a result of the software? Despite positive pedagogic results [5], a small proportion of CEDE's seemingly successful homegrown edtech has not stood the test of time.

There are a plethora of frameworks, toolkits and models that exist to evaluate particular elements of generic software development and implementation, such as:

- usability and heuristics;
- maturity and diffusion models;
- benchmarking and auditing frameworks.

However, are any of these really useful for the institution as well as the educators to understand if technology has been leveraged to improve teaching and learning

across the board? So, what is the best approach to evaluate the impact of an edtech intervention in higher education environment, particularly homegrown ones? Are there different evaluation tools that suit different types of interventions – or can a common approach be used? Once an intervention is evaluated, what outcomes will help decision makers in HE highlight best practice in the development and implementation of edtech in the future?

It is proposed that there are five factors that impact on effective edtech evaluation, which contribute to insubstantial evidence of a positive outcome, these being:

1. premature timing;
2. inappropriate existing software evaluation techniques and models;
3. political context and the corporatisation of higher education;
4. growing complexity of agile development and participatory design;
5. unclear terminology and the semantics of edtech.

2.1 Premature Timing

Summative evaluations carried out immediately after an edtech development will never fully give an understanding of the potential influence and impact.

Many funders and university managers have tried to answer the question, 'What makes homegrown edtech development successful?' In particular, the Joint Information Systems Committee (JISC), a major funder of educational technology development in England over a number of years, has provided their grant winners with guidance on how to evaluate their project effectively and advocate the 'six steps' approach. In their handbook, 'Six steps to effective evaluation – A handbook for programme and project managers' [6], they highlight the need to consider the timing and type of evaluation that projects should undertake, either process or product, outcome or impact. It is, of course, much easier for project staff to try and evaluate the success of the outputs or processes they have adopted during their project than it is to evaluate their impact; impact being the changes that have resulted, as a consequence of their project, in the behaviours, knowledge and skills of the users or the institution. Of course, it is difficult to evaluate the impact, as the timing of grant funding is mutually exclusive to understanding impact over time. It is ultimately the funders who want to try and understand the impact of the project and the fundamental changes that it might have had in the institution or sector in the long-term, whether social, economic or environmental.

In more recent years, it is also becoming increasingly difficult to quantify the success of a particular software initiative (process and/or product), as more often they are being constantly developed over time as an evolving application with growing functionality and extending their reach with APIs (Application Program Interfaces) into enterprise architectures across the organisation. In fact, edtech development can be compared to a growing organic eco-system – a mixture of agile software improvement and pedagogic action research to form a cycle of continuous improvement to the technology and the teaching. Once software or a

system is developed and used for the first time, evaluators can ask questions like, ‘Is it useful?’, ‘Is it usable?’ or ‘Is it used?’ at any point in time but the answers do not give you a picture of why it might continue to be useful, usable and used in the future. What works for who and why?

The Centres for Excellence in Teaching and Learning (CETL) programme represented HEFCE's largest ever single funding initiative in teaching and learning. HEFCE provided funding for 74 CETLs, totalling £315 million over a five-year period (2005 – 2010) [7]. The initiative had two main aims: to reward excellent teaching practice, and to invest further in that practice so that a CETL’s funding delivered substantial benefits to students, teachers and institutions. CEDE (engCETL during this period) was the recipient of one of the CETL grants from 2005 to 2010.

A thorough summative and formative evaluation of the CETL initiative was undertaken immediately at the end of the programme. After all, it had huge potential, being a major financial investment by the UK government coupled with a relatively long period of time to try and develop and sustain educational initiatives, all with the backdrop of a booming technology industry and rapid advances in web technologies, opening of data, social software innovations and mobile devices.

However, with regards to edtech, the final evaluation report [8] states that, “Only a handful of CETLs have provided evidence of the direct impact that technology-enhanced learning has had on its students, but in all cases, the belief has been that it has had a tangibly beneficial impact on learners. […]. Two CETLs (InQbate and CIPEL) pointed to how five years was simply not long enough to fully roll out technology in a way that would be most effective for learners.” When talking about evaluating innovation, “Several CETLs feel that innovation in teaching and learning is being sustained, although this is not always straightforward to evidence.”

It is understandable why the CETLs had an issue with providing evidence of innovation immediately after the programme had ended, especially as the evaluation was summative, in other words, equating innovation with uptake. Diffusion theories give an insight into the factors that affect the spread of innovations within an organisation and Perry introduces the idea that ‘time’ is a hugely important factor in the rate of diffusion [9]. Rogers defines five distinct adopter categories, in his diffusion of innovation theory [10], as being: innovators (2.5%), early adopters (13.5%), early majority (34%), late majority (34%) and laggards (16%). This bell curve of adoption rates implies that time is indeed linked to the uptake of innovations and perhaps that when the CETLs were evaluated, the results of the funding could only evidence a cohort of early adopters as users.

The Hype Cycle [11] is a graphical tool developed and used by IT research and advisory firm Gartner for representing the maturity, adoption and social application

of specific technologies over a period of time. Although not representing a cycle but a path to adoption, it can be used to illustrate how the innovators are usually the technology trigger for homegrown edtech development. The early adopters refine the application until a peak of inflated expectations is gained. However, what then follows, as an early majority start to utilise the technology, is that the institution needs to play a role in refining and supporting the initiative, scaling it upwards and outwards. Perhaps, as the institution is less agile in responding to a new technology than an individual can be, the early majority reach a trough of disillusionment at exactly the same time as the evaluators try to find evidence of impact.

2.2 Inappropriate existing software evaluation techniques and models

2.2.1 Maturity Models

Existing maturity models do not help us to fully understand the organisational factors that affect the potential for success of in-house edtech development.

It can be assumed then that two, linked factors in the successful adoption of new edtech, are time and the relative capability of the organisation to be able to scale up their homegrown innovations technically and also then embed the associated teaching and learning practices effectively. Therefore, if evaluation happens shortly after a project has ended, and usage is still in the early adopter stage, the evaluation needs to be able to make a prediction of the potential of that organisation to nurture, support and develop the software so that it can reach late majority adoption, right into the hype cycle's on-going plateau of productivity. The two linked organisational attributes are firstly, the *organisation's maturity* in its technical and process management capabilities with regards to software and, secondly, the *users' acceptance* of the technology itself.

The Capability Maturity Model (CMM) [12] has been used for many years to evaluate the maturity of an organisation with regards to their software development practices. However, as the application of capability maturity models has expanded into more flexible organisational environments, the levels concept has become less viable. Marshall and Mitchell, in developing and implementing their e-Learning Maturity Model (eMM) adopted an evolving view and replaced level with dimension [13]. They articulate five dimensions of eMM (learning, development, support, evaluation and organisation) each dimension having a subset of processes to benchmark your institution against. However, there are issues if the eMM is used to understand fully an institutions ability to react to and scale up homegrown edtech. Within the 'development' dimension for example, there is no process that quantifies the e-learning staff's ongoing skills development process with regard to learning and developing with new technologies. There is also no maturity in their associated development processes, such as the use of agile methodologies, code versioning and testing procedures.

The eMM's major issue though, is that it uses the term 'e-learning' to define, within a limited scope, specific course based technology which is predominantly technology provided by a teacher with the learner as end-user. This does not take into account much of the edtech that is currently being developed to aid with administration and management of teaching and learning, for example, or technology that is being developed to bring together the data held within institutional systems to support learning and teaching analytics, such as applications that provide insights into student engagement linked to retention and progression. Domain specific CMMs for higher education are starting to be theorised, such as the Student Engagement Success and Retention Maturity Model (SESR-MM) which "will indicate the capability of HEIs to manage and improve SESR programs and strategies and, because it identifies strengths and weaknesses, it has the synergistic benefits of maximising effort and deployment of resources to institutional priorities." [14] If one was developing edtech in this functional domain, this would be a good evaluation framework to use, however, an institution's development of technology to support SESR is notable by its absence in their model.

2.2.3 Acceptance Models

Existing acceptance models do not help us to understand fully staff and students' beliefs, attitudes and intentions with regards to adopting new edtech

It is not only the organisation's capability that affects the successful adoption of new edtech innovations; a user's beliefs, attitudes and intentions are also important factors. Technology acceptance models are a method of trying to understand the user's psychological predispositions and, therefore, the likelihood that an edtech innovation will take hold amongst the staff and student body. The unified theory of acceptance and use of technology (UTAUT) [15] consolidated eight previous models of technology acceptance, including the diffusion of innovations theory. Since the UTAUT was published, many authors have gone on to extend the theory as web technologies have advanced; in particular, one model looked at social networks and technology acceptance [16].

However, the model and its subsequent extensions have received criticism for being too complicated [17]. Bagozzi states that "UTAUT is a well-meaning and thoughtful presentation," but that it presents a model with "41 independent variables predicting intentions and at least 8 independent variables for predicting behavior," and that it contributed to the study of technology adoption "reaching a stage of chaos."

Technology acceptance models are continuing to be extended in the domain of edtech. For example, with regards to factors that affect the use of learning technology by HE staff [18], the authors suggest that the UTAUT be extended to include factors that recognise facilitating or inhibiting conditions for staff. However, this study assumes that university staff are a homogenous whole. In fact, as McLeod and MacDonell [19] point out from an extensive review the literature,

"users may be made up of groups of individuals from different functional, geographical, vertical and horizontal areas in an organisation with potentially different characteristics, interests in a system and capabilities to influence the course and outcome of a system's development."

2.3 Political Context and the Corporatisation of Higher Education

Higher Education is in such a rapid state of change that it makes contextual evaluations problematic with political drivers calling for quantifiable evidence of cost savings and efficiency

In 2011 an extensive review, covering over a decade of the systems development literature, was carried out and reported in 'Factors that Affect Software Systems Development Project Outcomes: A Survey of Research' [19]. The authors put forward a 'classificatory framework' to help categorise factors into: people and actions; development processes; project content; all set within an institutional context which then helps determine the project outcomes. This study is thorough and reveals that "labelling a project outcome as a success or failure can be both difficult and problematic' and that 'project outcomes vary along a continuum, may be interpreted differently from different perspectives [..] and constructed through processes of sense-making and negotiation with or within an organisation". The complex culture of the organisation and its own shifting priorities is therefore a significant factor in any evaluation.

The Higher Education Institution is becoming a more complex organisation with immense funding pressures, competing demands on academics time, the emergence of the dynamic of student as customer along with the rising expectations and digital literacy of the next generation of learners [20]. The recent funding crisis in HE has put pressure on the institution to review the efficiency and effectiveness of its activities in all areas. Prof Ian Diamond, Chair of the Universities UK Efficiency and Modernisation Task Group, says that the report on efficiency and effectiveness in higher education "comes at a crucial time for higher education. [..] across the UK we will all be facing increased pressure to demonstrate efficiency and effectiveness, and above all that we are providing value for money." [21]

The Leadership Foundation has produced management development resources for senior university managers, on how to respond to this rapid pace of change, including 'Lean Management – doing more with less'. Lean Six Sigma (LSS), is a powerful business process improvement methodology utilising a project pipeline model, and is being used in HE to underpin new operational and lean management processes. It is heralding a culture shift in HE. "In the HEI, the organisational culture is all about changing the way we take care of our customers (i.e. students, parents, local companies, faculties, alumni, etc.) and providing them with a world-class experience" [22]. With efficiency and effectiveness as drivers for change, the

requirement for quantifiable evidence of savings is a priority in any evaluation that is undertaken.

Benchmarking against other HEIs, including national league tables and the National Student Survey results, are also used as quantitative measures of success and push evaluation activities deeper into requirements for robust empirical evidence. The semantics of 'process', if used across all areas of university business, brings the danger of reducing teaching and learning to an over-simplified description of actions, which can be streamlined and made more efficient.

The Leadership Foundation's 'Getting to Grips with Information and Communications Technology' a resource for Governors of ICT in UK HEIs, supports the need for more evidence of impact. "Given so many unknowns, realistically what can governors do to help their HEI address such an uncertain future?" Suggesting that decision making needs to be strengthened to "be able to assess the value and impact of the ICT delivery, the business benefits and [assess the] impact of ICT-based projects after they have been completed" [23]. However, with regards to evidence of ICT projects relating to technology enhanced teaching and learning, Kirkwood and Price report that, "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" [24]. From the forty-seven studies reviewed on technology enhanced learning, "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." Could this be linked to the ICT governors' directive of using technology for efficiency gains, i.e. saving staff time, and streamlining processes, rather than allowing for an individual academic's freedom to innovate teaching and learning in a trial and error approach? Or perhaps it is because bottom-up innovation, created in an on-going agile way is incredibly difficult to evidence.

2.4 Complexity - Agile development & Participatory Design

Homegrown edtech development is a complex and chaotic cycle of process and product improvement.

Over the past 15 years, edtech has evolved from discrete desktop software tools, to complex enterprise architectures of interconnected web applications, APIs and web services, incorporating sophisticated multimedia and utilising big and open data. The scale of the development challenge is huge and the client base super-extended. No longer creating edtech for the sole academic, the developments are problem driven and try to resolve complex issues that are not only faced by the students and staff but for the organisation, the extended discipline community or the HE sector as a whole. The edtech solutions need to be developed rapidly, deployed on a diverse range of platforms and devices, be continuously updated, solving multiple users' needs and with a remit to innovate and be ahead of the curve in teaching and learning practice. The student voice could not be louder, "Institutions need to

initiate more agile processes of curriculum design and delivery and technology can provide the efficiencies and flexibility they need." [25].

The agile approach to edtech development has, therefore, been essential, especially when used in conjunction with an inter-disciplinary project team of technology specialists with the academics themselves contributing to the process. Development projects have, therefore, evolved from a linear waterfall model to an iterative cycle of developments in teaching and learning practice, intertwined with edtech re-development. This is an approach that involves all of the stakeholders of a project working together in an agile cycle of prototyping, piloting and refining. This co-design approach, sometimes referred to as participatory design, has emerged as the method of choice for CEDE.

Participatory design has proved to be successful because it maximises the team's hybrid experiences, or third space. "Recent work in cultural theory claims that this "in-between" region, or "third space," is a fertile environment in which participants can combine diverse knowledges with new insights and plans for action, to inform the needs of their organizations, institutions, products, and services." [26]. An example of a homegrown success story, resulting from a co-design and development project within HE, is the 'Course Signals' student success system. Course Signals was developed at Purdue University and partnered with SunGard Higher education in October 2010, becoming a global success story [27].

Traditional software evaluation can be problematic for example when product failure is beneficial, for instance, if lessons learned are taken on-board during early feedback loops. This is the case for the release early and release often (RERO) software philosophy (the mantra of the open source development model), which is contrary to the feature based release strategy. Advocates argue that RERO allows software development to progress faster but can seem a chaotic process to others [28]. Chaos theory of course is a scientific theory describing erratic behaviour in certain nonlinear dynamic systems but chaos is also the science of surprises, of the nonlinear and unpredictable. Co-design and open innovation embraces chaos, which can lead to innovation in many sectors [29], which potentially includes the edtech sector and also teaching practice in higher education itself.

2.5 Terminology - The Semantics of Edtech

The use of inconsistent terminology within the sector is a barrier to effective evaluation.

Different authors have referred to edtech in the literature in a variety of ways: learning technology, edtech, technology enhanced learning (TEL), e-Learning, ICT in teaching and learning and so on. However, how can we be sure we are talking about and evaluating the same thing? What is this discrete 'thing' we are actually evaluating? This paper has already highlighted the problem of referring to all edtech as e-learning with regards to the eMM. Technology is developing and morphing more quickly than our language can keep up with, which is a barrier to

providing evidence of impact. McLeod and MacDonell agree, “Future research would benefit from a greater degree of consensus or agreement among the software systems research community over the use of common and explicitly defined terminology, together with instruments and scales used to measure specific factors and project outcomes” [19].

3.0 Recommendations

The key is for developers and policymakers to understand what edtech works in which conditions, for whom and why. To help answer this, the development community could look towards the evaluation science community for inspiration. Realist evaluation [30] centres around exploring the ‘mechanisms’, ‘contexts’ and ‘outcomes’ associated with an intervention and embraces the complexity of the ‘contexts’ themselves. Pawson argues that this type of systematic review, or realist synthesis, is absolutely vital to evidence-based policy by learning from past failures and successes, whether the initiatives are within the same policy domain or not. The principles of realist evaluation are:

1. The concept of the generative mechanism is a theory of how the intervention affects the system to which it is introduced [31].
2. People’s collective decision making constitutes an additional underlying mechanism that generates all social outcomes [32].
3. The things that are studied (policies, programmes, interventions) are inserted into systems that are already fluid and changing. All an intervention can do is change the course of change. Therefore, programmes may well change the conditions that made them work in the first place and so can be expected to have a limited shelf life [32].
4. Realist evaluation is a form of theory-driven evaluation, which is the theory and reasoning of its stakeholders, which is rooted in practitioner wisdom. The realist evaluator’s task is to identify and explain the precise circumstances under which each theory holds.
5. Realist evaluation is built upon accumulative social science enquiry. That is finding the common thread in seemingly diverse behaviours, know as ‘reference group’ theory i.e. people base their own actions on the standards of ‘significant others’. Realist evaluators must consider the similarities between seemingly diverse programmes – what do they have in common? [33]
6. Realist evaluation comes from the Popperian philosophy of science, arguing that scientific laws are not established in experiment and observation, as it is in fact a continuous or ‘evolutionary’ process. [34]
7. The process of systematic review - of all evidence in all forms - will not lead to objectivity, what counts are the hypotheses that drive us to the data and the inferences that are drawn. Realist evaluation tries to study more closely the quality of the reasoning in research reports rather than look only at the quality of the data. [35]

4.0 Conclusion

In 2012, in response to the Wilson review [36], JISC has become a registered charity and no longer receives funding directly from HEFCE. From 2014/15 it will rely on a pricing model relying on sector subscriptions, and therefore be directly accountable to the Institutions who pay in. JISC claims it saves the sector £260million a year [37], and the principal finding from the review was that, "There is a common view that it has played a pivotal role in the UK as an enabler of innovation and early and widespread adoption of ICT." However, the other principal finding was that "There have been questions about the impact of some of JISC's activity". Even though the recommendations include, "With reduced public funding, the burden of investment will shift further to institutions. How might JISC and other bodies help them to make sensible choices and achieve value for money? How might institutions learn from each other more effectively, for example through sector representative bodies?" It is interesting to note that in the 34-page review document, the words 'evaluate' and 'evaluation' do not appear at all.

The suggestion, in this paper, is that the homegrown edtech development community is in crisis when it comes to being able to provide evidence of the impact of homegrown edtech in both the way that it can innovate teaching and learning and the potential benefit to the host institution. This is juxtaposed with demands from senior university managers, funders and policy makers for greater evidence of impact of edtech initiatives and the benefits that in-house edtech development can bring to enhancing teaching and learning and providing a competitive edge. There are two major consequences to this. One being the dwindling supply of government funding for edtech development in HE coupled with the reluctance of HEIs to fund their own in-house edtech visions. This will ultimately impact on edtech innovation, with a move towards less risky 'me too' homogeneous edtech products.

Steve Jobs, in an interview about the release of the Macintosh, 24th January 1984 stated "We're gambling on our vision, and we would rather do that than make 'me too' products. Let some other companies do that. For us, it's always the next dream." [38].

A new approach to evaluation based on the principles of realistic evaluation taken from the world of social science is identified as a possible way forward. Educational technologists need to explore and embrace this method of evaluation if they are to justify further funding in the future. A renaissance in institutional-level evidence based investment, could catalyse the co-development of innovate and visionary edtech tools that emanate from higher education.

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