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Design principles for fostering pedagogical provenance through research in technology supported learning

Abstract

This paper contributes new critical and theoretical approaches that build the capacity to link research and practice in the field of educational technology. Building on a recent meta-narrative review of the problematic concepts of impact and measurability of educational technologies, we explore the case for methodological design principles that could have the effect of increasing the pedagogical provenance of research into technology supported learning. We extend our previous review by exploring how the design principles we have delineated can contribute to evidence, that increases pedagogical provenance. We also extend this work through critical reflection on how meta-narrative approaches to reviews have the potential to contribute to increased pedagogical provenance in ways that systematic reviews often fall short.

Keywords

Educational technology, pedagogical provenance, meta-narrative, design principles, praxis, methodological innovation

1. Introduction

The aim of this paper is to highlight design principles that have the capacity to increase the pedagogical provenance of research into technology supported learning. Provenance, according to the Oxford Dictionary online (Lexico, 2019), is defined in relation to the authentication of both the source and history of an artefact including its ownership. We define pedagogical provenance as the authentication of the contextual source and history of pedagogical phenomena, yielding increased opportunities for meaningful application and use within praxis. The authentication of the range of primary and secondary factors that could be at play when technologies are appropriated in education, is seen as critical to generating a body of research that is rich in pedagogical provenance, that is; primary factors such as teachers' knowledge, understanding and capabilities in utilising digital tools effectively within teaching and learning but also secondary factors such as their philosophical attitudes and values when appropriating digital technologies or, their pedagogical values and beliefs more broadly. As Cuban has illustrated, teachers tend to adopt new technologies in ways that 'sustain rather than transform' the philosophical principles guiding their pedagogical actions (Cuban, 2001, p.53). Similarly, from the learner perspective, primary factors such as learners' knowledge, understanding and current capabilities both within subject domains and in relation to digital technologies is significant but so are secondary factors such as learners' past experiences and dispositions towards digital technologies which are formed both within and beyond the classroom context. It is beyond the scope of this paper to explore, in depth, theories of teaching and learning with digital technologies. However, we take the position that the appropriation of digital technologies often brings additional sources of complexity and thus the greater the provenance available about a pedagogical phenomenon, the greater the potential for meaning and understanding to be constructed by all stakeholders.

Much research into this complexity has focused on the interplay between the affordances of digital technologies, subject content knowledge and teachers' pedagogical knowledge (Mishra & Koehler, 2006), building on the seminal work of Lee Shulman (1986). Others have focused on the ways in which digital technologies are also embedded within broader socio-cultural signifying practices as teachers' and students' appropriation of mobile technologies and social media networks may converge with, and impact upon their use of digital technologies across formal and informal contexts (Bachmair, Turvey, Cook & Pachler, 2018; Pachler et al. 2010; Livingstone, 2012). By broader socio-cultural signifying practices, we mean the ways in which people's ubiquitous use of digital technologies and media for a range

of purposes, leads to the convergence of significant aspects about their developing professional, personal and social identities. Such convergence widens the debate about the role of digital technologies in formal schooling as attested by the debate surrounding the political, commercial and pedagogical interests in the increasing harvesting and use of people's data both within the formal context of education and beyond (Mayer-Schonberger & Cukier, 2013; Perotta & Williamson, 2018). Arguably, it is naïve to ignore the extent to which the appropriation of digital technologies in education may or may not serve wider commercial and political interests, which has led researchers of educational technologies to explore the sociological complexities and connections between digital technologies, individualistic pedagogies and their wider political and commercial implications (Selwyn, 2014; Perotta & Williamson, 2018). Consequently, our definition of pedagogical provenance attempts to authenticate the micro-level pedagogical factors at play whilst also acknowledging the influence and importance of such wider socio-cultural considerations in relation to teaching and learning with digital technologies. It is argued that pedagogical provenance cannot be built in isolation to the complex range of primary and secondary factors at play and that foregrounding pedagogical provenance, in the design or analysis of research could provide much needed insights into the complex interplay between the various socio-cultural, technological, cognitive and pedagogical factors that need to be taken into account when teachers appropriate digital technologies into their professional practice and students' learning.

Centering pedagogical provenance as an analytical perspective in the design and critical evaluation of research, we argue, has the capacity to sustain and inform practitioners' pedagogical judgements and professional development as they engage with the hermeneutics of integrating digital technologies into teaching and learning. We seek to illustrate how, too often, research into technology supported learning lacks the pedagogical provenance to render it usable or meaningful at a transformational level. Given the disruption and cost associated with their use, the desire to demonstrate the value added of digital technologies is often a significant driver. However, the difficulties in isolating digital technologies as independent variables, mean that capturing their impact is inherently problematic. The permeability of socio-cultural and educational boundaries together with the perpetual development of digital technologies adds further methodological challenges. By the permeability of boundaries we mean the ways in which school, home, social media, formal,

informal, leisure, and educational media amongst others are interrelated. As stated in our meta-narrative review (Pachler & Turvey, 2018, p.2), what is required, we argue, is methodological design principles that acknowledge "the fact that evidence of the pedagogical application of digital technologies" emerges from, and is "brought to bear in, complex and dynamic contexts" mediated by the complexities of human agency. We define human agency as the complex and diverse cultural beliefs, values and purposes that people bring to bear on their use of digital technologies. Whilst resonating with the concept of ownership in the dictionary definition of provenance, explored at the outset of this paper, human agency is central to pedagogical provenance as it recognises that in appropriating digital technologies into their pedagogical practice, teachers bring their own motivations and intentions into the pedagogical process, which research needs to bear witness to, and attempt to make visible. The methodological design principles we posit are not comprehensive but they do challenge some of the paradigmatic comfort zones that, we argue, have become sedimented in approaches to researching educational technologies and evidence-based approaches to education more generally. In the first half of the paper, we explain and summarise our approach to the meta-narrative review we carried out previously, and delineate our design principles. In the second half we explore how these design principles may be used as an analytical and critical lens through their application to a methodologically diverse range of selected research.

2. New critical and theoretical approaches to review methodologies

Meta-narrative reviews are a relatively new development in critical and theoretical approaches emerging from the field of health and medical research. Wong, Greenhalgh, Westhorp, Buckingham and Pawson (2013) note that meta-narrative reviews lend themselves to contexts where the subject of research has been historically conceptualised diversely. Wong et al (2013, p.1) define this approach to review as one which "seeks to illuminate a heterogeneous topic area by highlighting the contrasting and complementary ways in which researchers have studied the same or a similar topic". Similarly, they go on to explain that "meta-narrative review looks historically at how particular research traditions have unfolded over time and shaped the kind of questions being asked and the methods used to answer them" (Wong et al, 2013, p.2). In terms of heterogeneity, the field of educational technology is a case in point, where there are multiple stakeholders involved, and a diverse range of methodologies adopted. In a more recent paper Greenhalgh, Thorne, and Malterud (2018, p.2) claim that "sometimes, the term 'systematic review' allows a data aggregation to claim a

more privileged position within the knowledge hierarchy than it actually deserves". They base their argument on the fact that the characteristics of quantitative systematic reviews – narrow focus, tightly applied inclusion and exclusion criteria, pre-defined privileging of particular methods, mathematical averaging – can lead to an emphasis on "technical rather than interpretive synthesis" (Greenhalgh et al., 2018, p.2). Greenhalgh et al., (2018) argue that the persistent narrowing of focus, results in 'research waste' as such reviews tend to recommend the need for more of the same type of research (i.e. Randomised Control Trials [RTCs]). This channeling of research resources into increasingly narrow foci may well have limited relevance in terms of practice and policy. Whilst narrative reviews, like systematic reviews, can be conducted well or poorly, and be prone to researcher bias, the blind pursuit of the elimination of bias through the elevation of the technical over the interpretive can lead to the neglect of "in-depth, critically reflective processes of engagement with ideas" (Greenhalgh et al., 2018, p.3). Greenhalgh et al. (2018) are not alone in highlighting the various methodological silos that appear to be holding back various fields of research of which we contend educational technology is a specific case. Deaton and Cartwright note, (2018) with reference to RCTs, that these are only usable "as part of a cumulative program, combining with other methods" (p. 2). Similarly, Parkhurst (2017) coins the term 'issue bias' to highlight this phenomenon in evidence-based policy making, when he argues "social values can be obscured or marginalised through the promotion of certain forms or bodies of evidence" (p. 8). We also concur with this view and argue as Weinstein and Colebrook (2017) contend, that the various paradigms and methods to emerge from the social sciences throughout the modern era have reached the point where they cannot progress separately in any productive form.

The corpus of literature included in our initial meta-narrative review (Pachler & Turvey, 2018) is illustrated in Appendix A and a summary of the sources can be seen in Table 1. The period of review and selection was from September 2016 to December, 2016. We used our own institutional library search engines (e.g. OneSearch) which offers a wide search across journal content of all disciplines. We also searched education databases such as Education Resources Information Centre (ERIC), Web of Science and Google Scholar. Key search terms such as "ICT" "Digital Technologies" were used together with terms such as "impact" "measure" and "outcomes". These search terms were also used to find appropriate articles within relevant highly esteemed international peer-reviewed journals (e.g. *Computers and Education*, *British Journal of Educational Technologies*). Articles were stored and shared via

an online repository which allowed for critical discussion of the appropriateness of selected papers drawing on our shared professional judgement and experience in interpreting literature within the field. We were also opportunistic drawing on our existing experience and knowledge of the field to propose various papers and reports without the need for a search.

Table 1: Summary of source and quantity of literature included

Source	**Quantity**
Peer reviewed journal articles	17
Government commissioned reports	5
Think Tank/Charitable sector reports	3
Total	25

As Hobson, Ashby, Malderez and Tomlinson (2009) elaborate, systematic reviews are defined and characterised by tightly designed inclusion and exclusion criteria, set out at the beginning of a review and based on an explicitly focused research question or objective. Akin to a systematic review, we had a clear objective for our review; namely, to review a range of methodological approaches used to provide evidence of the impact of technology supported learning. However, we did not set out with a clear protocol as the scope of our review and its use of a meta-narrative methodology emphasised the need to prioritise the reviewers' professional judgement over 'a method of decision-making which prioritises the adherence to procedures' for including or excluding sources (Hobson & Sharp, 2005, p.29). Procedures for improving the rigor of our approach to analysing and reviewing the papers, were developed out of our professional dialogue. Our first priority was to establish whether the articles returned by our searches and suggested by both researchers, focused enough on the impact of digital technologies on learning, to address our objective. Our approach to this was to search within each article using the keywords "impact" "outcomes" and "measure" to understand how these terms were being use by the article authors, and also carrying out a full reading (Appendix A).

In line with a meta-narrative review methodology, we wanted to provide a diachronic perspective on the literature; that is, looking back over 50 years of research into the impact of

technology supported learning, but also obtaining a perspective on contemporary literature across a range of research paradigms. It is inevitable that a significant limitation of such a broad methodological and historical scope could not offer a comprehensive review of the field, given the resource we had available. However, we increased the rigor of our approach to addressing our aims by using our full reading of the articles to ensure the corpus of literature included a range of methodological paradigms aligned to our objective, and investigating the chronological range of the literature referred to in the papers reviewed. This enabled us to determine if the papers reviewed, gave a historical, contemporary or both historical and contemporary perspective (Appendix A). For example, for a historical perspective we identified meta-analyses from a positivist paradigm that synthesised the results of studies probing the past fifty years of research, investigating the impact of digital technologies on attainment (see for example, Higgins, Xiao, & Katsipataki, 2012). However, we also drew on seminal mixed methods approaches such as the Impact2 report (Harrison, Comber, Fisher, Haw, Lewin, Lunzer, McFarlane, Mavers, Scrimshaw, Somekh, & Watling, 2002) to gain insights and probe the historical literature from a different methodological perspective. Similarly, our search within journals, together with our procedures for evaluating the character (e.g. methodologically/chronologically) and quality of the evidence enabled us to identify appropriate contemporary research from across interpretivist and positivist paradigms, as well as research attempting to bridge methodological paradigms.

It is acknowledged that the approach adopted to the selection of the literature can be prone to researcher bias and we do not claim to have carried out a comprehensive review, but we believe such an approach is not invalid given our attempt to be as transparent as possible about the process. Also, despite the limitations of our approaches to searching and selecting literature, this approach was fit for purpose in relation to our objective which was to review a range of methodological approaches used to provide evidence of the impact of technology supported learning. The meta-narrative method of literature review, with its priorising of a) rigorous use of researcher dialogue and expertise, b) diverse methodological perspectives, and c) contemporary and historical analysis or evidence, provided a body of research with sufficient quality from which to evaluate the potential for further methodological innovation in the development of design principles for researching the impact of educational technology that are sustainable and may contribute to the pedagogical provenance in the field. Furthermore, taking a meta-narrative approach to the review enabled us to summarise different perspectives in an over-arching narrative to better understand the methodological

diversity of the field of educational technologies, including ***how*** current methodological approaches can often lead to the emergence of gaps or deficits in the kinds of detail needed by all stakeholders to provide increased pedagogical provenance (Pachler & Turvey, 2018). Next, we summarise our interpretation from our review, of how research approaches into educational technologies are often prone to the production of gaps and deficits, in order to establish the context further, and outline our design principles.

3. Findings and design principles summarised

Whilst our meta-narrative review was not able to offer a comprehensive review of the gaps and deficits in the field of educational technology research, we argue that its design and implementation did illustrate a propensity towards the production and reproduction of gaps and deficits across a range of research paradigms, which have particular significance in terms of pedagogical provenance. It is important to enter the caveat here that we are not claiming it is possible to eliminate the production or reproduction of gaps and deficits through research, and we do not exempt our own research from this. Indeed, in response to the helpful feedback from the peer reviewers in the preparation of this article, we turn our design principles on our own paper to consider the gaps and deficits we may have also produced here, in our concluding discussion. Furthermore, not all education research or research into technology supported learning has a pedagogical focus. Rather, our argument is that where there may be a methodological propensity towards the production or reproduction of gaps and deficits, and where these have particular implications for the pedagogical provenance of research evidence, foregrounding the design principles we delineate could help to mitigate this phenomenon.

The propensity towards the production and reproduction of gaps and deficits that impact upon the pedagogical provenance of evidence, concurs with the findings from Pérez-Sanagustín, Nussbaum, Hillinger, Alario-Hoyos, Heller, Twining, & Tsai (2017, p.12) comprehensive review of the field in this journal, in that they also identify some significant gaps and deficits which do, indeed, have significant implications for pedagogy. These include:

- a preponderance of quantitative research;
- a lack of focus on teachers' pedagogical actions;
- few studies involving participants in their design.

These characteristics identified by Pérez-Sanagustín et al (2017) are vital to the development of pedagogical provenance, because the documenting of teachers' pedagogical actions and the involvement of participants within the research process, can enable the authentication of participants' experiences and perceptions, or the teacher's rationale for their pedagogical actions. It is not surprising that conventional approaches to meta-reviews that tend to share the purpose of combining the results (e.g. effect sizes) of comparable studies and improve the power of small or inconclusive studies, are also prevalent in the literature. Pérez-Sanagustín et al. (2017) argue that such meta-analyses can offer insights from a wide range of settings and are effective for "re-conceptualising knowledge in mature areas" (p. 2). However, the 'perpetual obsolescence' of technologies challenges such notions of maturity and the lack of focus on teachers' pedagogical actions concurs with our own position that developing pedagogical provenance is dependent upon there being sufficient contextual detail to authenticate pedagogical interventions incorporating digital technologies. As others note, conventional meta-reviews cannot improve the limitations of original studies such as a lack of quality, depth or detail of original reporting (Ioannidis & Lau, 1999).

We found other calls for increased pedagogical provenance emerging from a propensity to produce and reproduce gaps and deficits within the current field of educational technology research. For example, Crook, Harrison, Farrington-Flint, Tomás, & Underwood (2010, pp.7-8) determine two dominant approaches to impact research; firstly, "contained interventions" or studies that focus on specific practices of technology supported learning, which tend to be unsystematic; or secondly, larger "system-wide" analyses educational technology impact. Crook et al's findings (2010) concur with our own that such prevalent methodological approaches offer limited translational potential in terms of classroom praxis and that "given the complexity of sites of teaching and learning" there is a need "for a broadening of the definition of impact and related research that yields a better understanding of learning practices and outcomes" (Pachler & Turvey, 2018, p.9).

This issue of a propensity to produce gaps and deficits that impact on the pedagogical provenance of the field of educational technology research, led us to the formulation of the four design principles that we outline below. The exploration and formulation of design principles to create the contingencies for desirable outcomes in education and education research is becoming an increasing feature of educational policy and research (Ellis,

Frederick, Gibbons, Heilbronn, Maguire, Messer, & Turvey, 2017). The principles we posit here are not exhaustive but their validity, we argue, emerges from applying an inclusive lens to the methodological lessons from significant selected past and contemporary research in technology supported learning. An important finding from our review was the need for a forward-looking framing of sustainability in educational technology research. As Bachmair and Pachler note (2015), pedagogically and methodologically, educational technology has yet to realise the "ability to maintain innovation over time" (p. 1). Sustainable innovation is dependent upon pedagogical provenance but, we argue, this can only emerge from approaches to researching educational uses of digital technologies that foreground greater insights into how digital technologies are appropriated by students and teachers. Thus, the design principles we reproduce here and develop further in the second half of this paper are intended to explore how the issue of pedagogical provenance in research into educational technologies might be addressed. In our previous meta-narrative review we express these principles thus:

"1. Methodological and pedagogical interoperability should be prioritised,
2. The quantitative should be qualified, as far as possible.
3. Post hoc analysis accompanied by concurrent description and analysis.
4. Impact defined broadly and theorised rigorously." (Pachler & Turvey, 2018, p.11)

3.1 Design principle 1: Methodological and pedagogical interoperability should be prioritised

By interoperability, we mean, how methodological or pedagogical designs can utilise one another via "the exchange of data, methods or pedagogical processes" (Pachler & Turvey, 2018, p.11). Such interoperability, we argue, can lead to increased pedagogical provenance as it is more likely to lead to the cumulative potential of ideas and evidence (Deaton & Cartwright, 2018). However, interoperability can only be based upon clear, shared and consistent understanding of terms and processes adopted. Practitioners and researchers reviewing or designing research, need to consider whether there is the potential for interoperability based upon clear, shared and consistent understanding between definitions of key concepts or processes adopted. For example, two research studies, both focusing on the impact of peer teaching, but based upon different definitions of peer teaching, might be assumed to have weaker pedagogical provenance, than if the definition and implementation was common across the studies. Meta-analyses already exploit interoperability by

aggregating and synthesising quantitative data from numerous studies, following protocols for checking that there is a clear and shared understanding of the phenomenon being researched. Meta-narrative and exclusively qualitative reviews focus on interpretive synthesis. However, the aim of methodological and pedagogical interoperability is to identify at the design stage how any interventions could contribute to greater synthesis of different research paradigms. Interoperability as a research design principle, we argue, is vital to the sustainability of innovation in practice with digital technologies. This echoes others, who have identified a need for contrasting research paradigms to be brought together through methodological innovation in this field (Jenkinson, 2009; Cox, 2013; Latchem, 2014; Kirschner & Kester, 2016). Crook and Garratt (2011) suggest that many of the foundations of interpretivism have roots in positivism. As we argue in our initial meta-narrative review, issues of "methodological design are not confined by paradigm so why should the data or analysis that is generated be confined and how do we render such data and analysis open to reuse" (Pachler & Turvey, 2018, p.11)? Kirschner and Kester (2016) argue similarly that we need to move beyond methodological "dogmas that split the world into quantitative, empirical positivists versus qualitative anecdotal ethnographers" (p. 538).

Our meta-narrative review identified a general lack of granular detail in much research into educational technologies; that is, granularity that is vital to constructing shared understanding and thus greater interoperability between research studies and paradigmas. It highlighted that improved granularity when researching the impact of educational technologies can lead to greater insights into the nature of the context as well as the nature of the intervention. Thus, while considerations of methodological and pedagogical interoperability are important, we also argue that one approach to achieving greater granularity and contextual detail is to ensure that any quantitative research is also adequately qualified.

3.2 Design principle 2: The quantitative should be qualified, as far as possible

The reliance on quantitative meta-analyses (Parkhurst, 2016; Deaton & Cartwright, 2018) by those making decisions about national education policy, echoes the econometric measures that dominate the quantitative measures used to draw international comparisons of education systems (UNESCO 2014; OECD 2015). But do they measure anything of cumulative value to policy makers or those at the forefront of praxis? As we found, the synthesis of RCTs through meta-analyses can also lead to "a tendency to view their results and findings at face value and a failure, tendentiously, to adequately qualify the quantitative effect sizes they produce"

(Pachler & Turvey, 2018, p.12). In terms of any cumulative contribution to pedagogical provenance this is particularly problematic. Such approaches often raise more questions than they answer regarding the actual nature of the interventions they focus on, due to insufficient contextual detail which requires substantial qualitative data. Questions relating to *how* learning with the technology has or has not taken place are particularly problematic in the absence of sufficient qualitative detail. Similarly, questions relating to the part played by formal and informal contexts are particularly problematic when the quantitative is not sufficiently qualified. Grappling with questions of context, granularity and pedagogical design as well as the way in which meta-analyses of educational technology interventions often lack sufficient qualitative detail led us to the principle that "post hoc analysis should be accompanied by methods that also facilitate concurrent description and analysis" (Pachler & Turvey, 2018, p.13).

3.3 Design principle 3: Post hoc analysis should be accompanied by concurrent description and analysis

As Alexander (2015) highlights, the various constituent complexities and practices that characterise educational processes are ubiquitous and distributed, which points to the need to both capture and analyse data near "to the source of an educational technology-based intervention" (Pachler & Turvey, 2018, p.13). Experimental and quasi-experimental studies can be prone to this issue in their prioritising of pre-test and post-test data. Post-test data is analysed and interpreted after the intervention as a potential proxy for an effect of an intervention that took place in the past, rendering it retrospective. As has been well documented through educational research into assessment practises (Black, Harrison, Lee, Marshall, & Wiliam, 2003), interventions are often not implemented in the way they are designed, and implementation fidelity, or the extent to which an intervention is implemented partially or fully, can be prone to significant variation. Indeed, because of this fact, medicine and health disciplines have a whole field of research dedicated to implementation studies. In our review Jenkinson (2009) drew particular attention to this issue suggesting that the distributed, ubiquitous and agentive nature of context-centred variables requires the design of methods that, "tightly integrate concurrent and retrospective" data-capture and analysis (p. 277). The implication is that concurrent data or data gathered throughout the process of an intervention can increase pedagogical provenance, because it affords greater insights into the actual, as opposed to the intended, pedagogical strategies adopted by practitioners, which, in turn, can lead to the re-use and repurposing of strategies as well as further methodological

innovation. As Pérez-Sanagustín et al., (2016) argue, research that lacks detail about teachers' actions and intentions "are unlikely to be of much value" (p.12). Examples of limited and uninformative methodological approaches could be argued to be a feature of some research examining the contested field of mobile technology use in education. Such studies are often reduced to testing the hypothesis that 'banning' or 'allowing' the use of mobile technology can impact on attainment outcomes (Beland and Murphy, 2015) and are of rather limited value, serving to merely propagate particular stances towards digital technologies in schools. They are also often under-theorised or conceived very narrowly, which brings us to our fourth design principle.

3.4 Design principle 4: Impact should be defined broadly and theorised rigorously

As discussed previously in Section 3, Crook et al (2010 p.4) provide significant evidence that defining impact only in terms of "system-level outcomes" such as attainment "pays insufficient attention to the contexts of learning" and teaching with digital technologies. Furthermore, if impact is to be "broadly defined" (Crook et al 2010), it is imperative that it is also theorised rigorously. Indeed in a more recent study, Hew, Lan, Tang, Jia, & Lo (2019) found that out of 503 empirical studies, few demonstrated explicit theoretical engagement. Cox & Marshall back in 2007 lamented that, despite decades of research, we do not know what we should know about technology supported learning. We argue that methodologies that adopt participatory approaches such as narrative (Pachler, Cook & Bradley, 2009; Pachler & Daly, 2009; Turvey, 2012) have much to offer as they acknowledge that the teachers and learners appropriating digital technologies are the most significant variables, as has been widely acknowledged in the research of educational technologies and which we found pervaded much of the research considered in our review (Harrison et al., 2002; Cox, Webb, Abbott, Blakeley, Beauchamp, & Rhodes, 2004; Somekh, 2007; Crook et al 2010). Similarly, methodologies that take their inspiration from design processes (Conole, 2013; Mor, 2015; Persico & Pozzi, 2015) also offer, we argue, the potential for a broader and more rigorously theorised conceptualisation of impact because of their focus on bottom-up approaches which require greater attention to be paid to the contexts of teaching and learning (Crook et al, 2010), potentially adding to the pedagogical provenance of research. Rigorous theorising is critical if the use of digital technologies to support learning is to be conceived, as some suggest, "as a design science" (Laurillard, 2012. p. 226) in which effective pedagogical implementation is a cumulative and iterative process. As Bachmair and Pachler (2015, p.5) note, "we cannot succeed without objectified tools and operational

implementation procedures" but such tools and procedures cannot emerge from narrowly defined and under-theorised research because praxis itself is contingent upon the adequate theorising of pedagogical interventions, before, during and after the event, if professional dialogue is to serve hermeneutical purposes. Thus, impact broadly defined but rigorously theorised, we argue, can contribute significantly by feeding into the cumulation of professional knowledge required to increase pedagogical provenance as broader conceptualising of impact leads to more attention being given to context and the range of factors at play.

4. Exemplification of design principles through four genres of research

Having documented the genealogy of our design principles, we turn our attention to exploring how they may be used as an analytical and critical lens through their application to selected peer-reviewed research and papers. These papers have been selected to reflect a range of different methodological genres, although it is acknowledged that they are not a representative sample of the methodological genre. The papers have also been selected because they generally appear to prioritise pedagogical concerns regarding the appropriation of digital technologies to support learning and they are all contemporary, by which we mean, they were published within the last 10 years. We used our researcher dialogue, professional experience and judgement, as the basis for final decisions about whether the selected papers offered enough methodological diversity and were pedagogically focused. We would also like to emphasise that this was not an exercise in merely highlighting flaws in others' valuable work. All research methodologies are flawed in having various strengths and weaknesses. Rather, our aim in trying to exemplify the design principles through these papers, was to identify where a propensity towards the production and reproduction of gaps and deficits might emerge and how these design principles might mitigate against this in order to develop pedagogical provenance. Because this was our first attempt to use these principles in evaluating a range of research methodologies it represents an exploratory investigation. The exploratory nature made it difficult to establish whether each principle was equally important. However, the wide range of methodological variation across the selected papers appeared to render some design principles less relevant than others. Thus some design principles may be omitted in the discussion that follows and our design principles are treated more holistically than individually for the sake of conciseness.

4.1 ***Mixed-methods, design-based research*** *(Jesson, McNaughton, Rosedale, Zhu, & Cockle, 2018)*

Jesson et al's article (2018, p.14) reports on a "design-based research partnership between researchers and a group of urban schools serving culturally diverse students from low income communities". Closely focused on teachers' pedagogical innovations in the use of digital technologies to teach writing, the researchers identified a number of case study teachers whose effectiveness in the teaching of writing within digitally supported environments was recognised, to try to establish the connections between what they did in their classrooms and students' progress in writing.

From the perspective of pedagogical provenance, it can be argued that Jesson et al.'s (2018) study demonstrates particular veracity due in large part to its methodological design and its aims. It sets out to explore 'new understandings about effective pedagogy' in context but in a way that does not merely focus on the technology or technological affordances. The authors identify from the outset their prioritising of pedagogy; their emphasis is on 'novel approaches' that are innovative but that they also claim to be 'educationally sound'. What is noticeable about the design of this mixed-methods study is its iterative nature and also its apparent closeness to the site and participants in the study. Jesson et al. draw heavily on participatory approaches. These factors – participatory, iterative nature, focus on pedagogy – align closely with our second and third design principles, in that there are significant attempts to qualify the quantitative as well as attempts to develop concurrent description and analysis of pedagogical practices. Their concern is in developing what they refer to as 'explanatory power' through their methodological design. In their analysis, they draw on both qualitative and quantitative data but what appears most significant here is that this data is within a dynamic relationship, with the qualitative, qualifying the quantitative and vice versa. For example, they state that they "used the variability in achieving progress rates in student writing outcomes as a basis for checking the features of more effective pedagogy" (p.16). They are careful to clarify that this was a process of hypothesising, as opposed to one of proving cause and effect but that due to the qualitative and quantitative data being in a dynamic relationship, this enabled hypothesised associations between pedagogical practices and gains in student achievement to be explored.

Jesson et al. posit 6 hypotheses for the additional progress in writing that appeared to be made by learners from their purposeful sample of case study teachers. This hypothesising of possible associations between pedagogical practices and writing progress, highlights our fourth design principle that impact has increased pedagogical provenance when it is both defined broadly but theorised rigorously. In the discussion of the six hypotheses that Jesson et al. develop, the complex socio-cultural ecology of factors at play in this pedagogical intervention is evident in a way that certainly lends itself to ongoing pedagogical development. Centering pedagogical provenance as an important approach to educational research values and recognises the cumulative potential of research, particularly where methods are able to contribute to conceptual and theoretical development of the field.

Whilst Jesson et al.'s paper certainly adds to pedagogical provenance through the description of the characteristics of the apparently more effective case study teachers' practices and learning environments, there is a lack of qualitative data offered at a more granular level. Explicit examples of how the various pedagogical characteristics captured in observations of these teachers were derived from the qualitative observations are not presented. For example, in their hypothetical explanations of the more effective case study teachers, they state "possibly, the case study teachers can be characterised as allowing greater creative use precisely because they were competent teachers" (p.28). The hypothetical characterising and interpreting of the teachers' pedagogical activities and the contingencies for learning that they created through their use of tools and learning environments, is not illustrated in relation to the qualitative data captured.

4.2 ***Conceptual/theoretical paper*** *(Kearney, Schuck, Burden, & Aubusson, 2012)*

Kearney et al.,'s paper sets out to contribute to pedagogical provenance of mobile learning, through developing a socio-cultural framework built on two previous mobile learning projects in the context of teacher education. However, due to the word limitations of this paper the authors divert the reader to a past paper for a fuller description of these projects. It is a common limitation of the genre and form of academic reporting that even in the digital era of multimodality and hypertextuality, the structures available for the dissemination of academic research are largely anachronistic and have been as yet unable to exploit the agility that internet technologies could yield. From this perspective Kearney et al.,'s paper is a typical example of how, in terms of our design principles 3 and 4, sound intentions to try to

exemplify the synthesis of theory and practice through concurrent description and analysis of empirical evidence is often limited by the form and medium, an irony given the focus of this paper on mobile learning. This also highlights a limitation of design principles 2, 3 and 4, because implicit within these is the need for a greater range and detail in the data as well greater conceptual and theoretical elaboration in order to develop implications for pedagogy and practice. In other words, the more the quantitative is qualified (design principle 2) and the more data collected concurrently during an intervention (design principle 3), the greater the volume of data and the more complex the task of theorising it (design principle 4). Similarly, the pedagogical provenance that emanates from empirical research often has to be repurposed and communicated for different audiences, as seen in the range of resources developed from and linked with this research as part of the Mobile Learning Network for Teacher Education (See e.g. MTTEP http://www.mobilelearningtoolkit.com/network.html). The ongoing work from this project repurposing it for different audiences are a reminder that potential beneficiaries of research may not have the resource to engage fully with the details of research. Furthermore the full impact of research may emerge over time rather than in the snapshot captured in a research paper which again is a limitation of our design principles most explicit in relation to conceptual papers.

In terms of conceptual elaboration and design principle 4, Kearney et al.'s paper is well theorised as the authors plot the evolution of their framework of mobile learning through various iterations. However, rigorous "document[ation of] the complex social cultural ecology" (Pachler & Turvey, 2018, p.11), into which mobile technologies were integrated, is absent in their description of the various iterations other than by way of passing reference to suggestions from the project's critical friend or feedback from presentations of the framework. The absence of any empirical data presented concurrently to exemplify their 'framework for examining m-learning scenarios' (p.7) impacts on the pedagogical provenance of this paper. This is not in any way to question the authenticity or intent of this work, which clearly contributes significantly to knowledge in this field. But in terms of its pedagogical provenance or its potential to afford meaningful application in and use within praxis, this is a high-level abstraction that has very few signposts to its contextual and practice-based origins, from which it has been theorised.

4.3 ***Policy orientated work*** *(Luckin, Bligh, Manches, Ainsworth, Crook, & Noss, 2012; Noss, Cox, Laurillard, Luckin, Plowman, Scanlon, & Sharples, 2012)*

In a report commissioned by Nesta, a United Kingdom foundation focused on innovation (https://www.nesta.org.uk/about-us/), Luckin et al., set out to address an innovation deficit they perceive to exist at the intersection of technology and education characterised by learners experiencing an underutilisation of technology in learning compared with its use in their everyday life (p. 6). They identify 210 cases of innovation from over 1,000 publications and 300 sources of teacher-led examples and, drawing on the "wisdom of the informed crowd" (p. 11) by which we understand that they consulted a wide range of stakeholders with stated expertise relating to educational technology innovations. Using the so-called Adaptive Comparative Judgement method, they rank the top 150 cases. The report claims to set out "where proof, promise and potential lie for technology in education" (p. 8). Rather than using a technology-orientated typology, they present their 'evidence' in relation to 'effective learning themes' for example, inter alia: learning from experts; with others; through making; through exploring; through inquiry; through practicing. With regards design principle 4, whilst the indicators of this work's theoretical underpinning are present and appear to be broadly defined, the epistemological and ontological origins of these categories and their evidence base is not discussed. The report also employs the so-called Ecology of Resources framework (Luckin, 2010) with only a brief overview given of its fitness for purpose as an analytical frame in Chapter 4; the framework does not seem to have been applied explicitly to any of the examples.

In line with numerous other studies in the field, Luckin et al., stress the fact that no technology has an impact on learning in and of itself; rather, impact depends on how technology is used (p. 9), or as we conceptualise, its pedagogical provenance, which evokes design principle 3. Concurrent description and analysis of innovations (design principle 3) is partially addressed through examples which are described selectively and in the form of vignettes, but reference to the evidence base remains at best indirect. Indeed, concurrency between the post hoc analysis of vignettes and how the empirical and concurrent evidence supports any pedagogical implications from these, is thinly evidenced. The notion of evidence is not problematised and, presumably, ranges from ideas and opinions, through to empirically founded information or facts. For each category the number of research- and teacher-led innovation types is given; for example, the category 'learning with others' is

supported by 23 research examples and 18 practice examples. Based on that body of 'evidence', which is not more clearly defined and enumerated, the following 'highlights' are abstracted in this category; four social dimensions of learning are differentiated: collaborative, networked, participative and performative (p. 20) but again without any explanation how the typology was derived and what concurrent evidential bases underpin them. From the perspective of pedagogical provenance, the report offers little by way of detailed guidance for application in practice and potential conditions for success as the post hoc analyses lack sufficient and concurrent detail and description (design principle 3). The most highly rated innovation of all 150 or so is classified as 'learning through inquiry' and seeks to connect learning with real-life, industry demands. In the brief analysis offered it is noted that, "rather than fundamentally change the learning process, this project introduces industry-based challenges to a broader range of learners" (p. 34). This, arguably, raises some questions around the validity of the method adopted, particularly in the light of the earlier assertion about the importance of how technology is used.

In the fifth and final chapter, the report sets out what the authors "believe" to be "the most compelling opportunities to improve learning through technology" (p. 59): improve assessment; learn by making; upgrade practicing; turn the world into a learning place; and make learning more social. Whilst the attentive reader will, no doubt, be able to follow the logic of these conclusions, there are no real explicit links to the underpinning evidence base despite each category being justified by a paragraph of explanation. Given that the section which introduces these recommendations is entitled 'learning from the evidence', a different framing might have been expected, foregrounding both post hoc analysis with rich and concurrent description of pedagogical practice (design principle 3).

In order not to be misunderstood, the report in question is not a traditional research report and, therefore, it quite legitimately adheres to specific writing conventions and it appeals to more of a practitioner and lay audience. However, there do remain questions around the utility of the findings in terms of the design of the study which, whilst described in Appendix 2, is not really discussed critically and analytically in terms of strengths and limitations, the relationship between evidence, how it is theorised and the conclusions drawn from it as well as the amount of detail and contextualisation available to the reader in order to try and render it useful for practice.

System Upgrade (Noss, et al., 2012) summarises, at a level of high abstraction, the evidence generated by the Technology Enhanced Learning research programme over four years. It

addresses 12 key themes of relevance to a general audience interested in learning and seeks to show how education needs technology that is specifically designed for its purposes so cannot rely on "leftovers … designed for other purposes" (p. 3). The report sets out the following themes: connect, share, analyse, assess, apply, personalise, engage, streamline, include, know, compute and construct. Whilst again this work appears to define impact broadly, the lack of explanation of how they have been derived, what particular evidence underpins them or, indeed, why they are presented in this order, mitigates the theoretical rigour evident within the report (design principle 4). For current purposes let us focus on the first theme, connect, which explores the interplay between formal and non-formal learning with a recommendation to exploit the power of personal devices to enhance learning. The benefits the report enumerates include linking learning in school with learning at home, creating links with distributed expertise, collecting data in the real world, capturing learning unobtrusively and rendering social interactions outside the classroom meaningful. No references to actual studies are presented apart from a list of 35 further readings in support of all 12 themes. For each theme a short example is presented, in this case a project on the use of iPod Touches to enable student to take charge of their own learning. The vignette references the school's principal at the time of the project who asserts that "this innovative use of technology is at the heart of the huge improvement in the academy's results – up from 55 per cent to 99.5 per cent A*-C grade GCSEs in two years" (p. 10). According to the principal, the technology functions as a motivational tool that empowers learners to explore their personal creativity and learning potential. Uses of the technology include asking for help and advice and monitoring of progress in lessons. Others are undertaking online research, accessing resources and engaging parents in their children's education. Due to space constraints, no additional information is featured and the two YouTube videos referenced in footnotes are no longer available. Post hoc analysis appears to have been carried out, but in the absence of concurrent description being presented (design principle 3), rather than inform practice, and thereby foster pedagogical provenance, the report seeks to engage a general readership by developing a broad understanding of the potential of technology in education. Whilst written by eminent researchers in the field, the report operates at a distance from actual research activity that makes it very difficult to envision impactful knowledge use by the readership in practice.

In a so-called 'provocation' paper, Nutley, Powell, and Davies (2013) explore the question: 'What counts as good evidence?' They foreground research evidence as the processes

surrounding its generation are systematic and include documentation of method, peer review and external scrutiny (p.6). Importantly for current purposes, Nutley et al.'s report raises questions about the provenance of supporting evidence surrounding practice recommendations by many bodies including government agencies, independent public bodies and professional associations – including those by Luckin et al. and Noss et al. – and the ability of readers to evaluate the credence of "different forms of evidence" (p. 9). They rightly refer to the complexities inherent in the transfer of practice examples from one context to another. The two reports featured in this section are no exception. One way of improving the pedagogical provenance of research findings in the field of educational technology, therefore, might be to adopt a more standardised approach to labelling of 'recommended' practices such as that offered by Perkins (2010) quoted in Nutley et al. (p. 9):

- Good practice – 'we've done it, we like it, and it feels like we make an impact';
- Promising approaches – some positive findings but the evaluations are not consistent or rigorous enough to be sure;
- Research–based – the programme or practice is based on sound theory informed by a growing body of empirical research;
- Evidence–based – the programme or practice has been rigorously evaluated and has consistently been shown to work.

4.4 ***Meta-reviews*** *(Hattie, 2009; Higgins et al., 2012; Haßler, Major, & Hennessy, 2015)*

Systematic reviews (see e.g. the EPPI-Centre; http://eppi.ioe.ac.uk) and meta-analysis have been *en vogue* in educational research (see e.g. Hattie, 2009) and research into the efficacy of educational technology in particular. It is driven by an attempt to identify 'what works' through an analysis of impact based on scientific data. In a critical appraisal of Hattie's work, Bergeron and Rivard (2017) posit the need to ask questions:

> "When confronted with any set of data, we must always know what is the main question to which we are seeking an answer. Relatedly, we must know which variables were measured and the way in which they were measured. What is the target population? How was the sample collected? With comparison groups, and especially when measuring an intervention, we must ask how individuals were allocated to different groups?" (p. 240)

Hattie, Bergeron and Rivard claim, computes averages without taking sufficiently into account that every effect size is a 'relative' measure (p. 241). In their final analysis, Bergeron and Rivard, rightly in our view, bemoan the reduction of everything to 'one single number',

in this case effect size, "because it is insufficient to represent reality" (p. 245). These issues are compounded by a significant difficulty in understanding inclusion and exclusion criteria as well as tracing the methods and sources drawn on in studies used by meta-analysis.

Higgins et al. appear to try to avoid the criticism around a reductionist approach by couching their findings in rather tentative terms. For example, they acknowledge that difficulty "to identify clear and specific implications for educational practice in schools" (p. 3) and conclude that

> The range of impact identified in these studies suggests that it is not whether technology is used (or not) which makes the difference, but how well the technology is used to support teaching and learning." (p. 3).

Regarding pedagogical provenance, their meta-analysis has very little to offer to practitioners interested in the *how* beyond the following types of statements: "collaborative use of technology (in pairs or small groups) is usually more effective" (p. 4). Rather than focusing predominantly on studies seeking to show effect sizes, a methodology very much favoured by the Education Endowment Foundation (EEF), our recommendation would be to also focus on qualitative studies that help us understand better how education technology use is influenced by teachers' knowledge about their subject, their knowledge of how learners understand it and how the affordances of digital technologies relate to such knowledge as well as on studies that explore how teachers' pedagogical beliefs and values shape the way technology-mediated learning opportunities are conceptualised and operationalised. The importance of these questions have been known about at least since the landmark literature review by Cox et al. (2004) but there appear to have been relatively little concerted effort to build on it through empirical research. Meta-analyses seem to have added little to our understanding of these dynamics.

These limitations, appear to apply when systematic reviews focus explicitly on practice-related questions, as in the case of Haßler et al. who examine the use of tablets by primary and secondary school children and conclude that "detailed explanations as to how, or why, using tablets within certain activities can improve learning remain elusive" (p. 139). What is of particular interest in the current context is also the authors' observation that there appears to exist little research that focuses on learning activities that draw on affordances that are specific to tablets, that there exist issues around the trustworthiness of some studies in terms

of rigour as well as that generalisability is hampered by the specificity of topics under investigation and the variety of research approaches being used. Their study, as that of Cox et al. and Higgins et al., concludes that the "power of using technology in some lessons relies on the premise that technology is integrated into the existing pedagogy" (p. 151). Alas, from a perspective of pedagogical provenance those researchers, themselves expert in conducting systematic reviews and meta-analyses, suggest much of the research reviewed and analysed offers little guidance on how pedagogical integration of digital technology is more effectively achieved.

5. Concluding discussion

Having critiqued a range of methodological approaches to the research of technology supported learning, we turn this critique on our own paper to consider briefly what we have learnt about the relationship between our design principles and pedagogical provenance, including how our design principles relate to this paper, and their limitations.

Our use of meta-narrative review has offered an opportunity for an inclusive approach to the review of research methodologies in this field and so addresses design principle 1 promoting interoperability. That is, the concept of pedagogical provenance is, we believe, one that bridges research paradigms and lends itself to interoperability in that research from any paradigm that may directly or indirectly engage in generating meaningful evidence for use in praxis, could benefit from engaging with the concept of pedagogical provenance throughout the process of methodological design and implementation. However, we recognise this is also a significant challenge. Striving for interoperability and the capacity to bridge research paradigms methodologically or conceptually as we have tried throughout this paper requires *researchers* to also operate between paradigms and beyond their methodological comfort zones, which can lead to various vulnerabilities. This is a significant challenge of this principle.

In trying to explore the pedagogical provenance of quantitative studies we have tried to highlight both opportunities, and the need to qualify the quantitative. Our initial review did highlight a propensity to the production and reproduction of gaps and deficits that impact upon pedagogical provenance. However, a gap or deficit that we may have unwittingly left here could arguably be the extent to which some methodological approaches to technology supported learning also do not adequately quantify the qualitative; that is, a propensity

towards avoiding the issue of how technology supported learning impacts on measurable outcomes such as attainment. In our attempt to explore pedagogical provenance and delineate relevant design principles we have attempted to broadly define the impact of educational technologies whilst rigorously evaluating our conceptual approach in line with our design principle 4 and acknowledging the limitations. However, further empirical and theoretical work is clearly needed beyond this review, to explore the relationship between pedagogical provenance and methodological design. Our third principle of post hoc accompanied by concurrent analysis appears to have less relevance within the methodological context of this paper. Our use of a meta-narrative approach, to review both historical and contemporary literature, reflects tenuously the principle of drawing on concurrent and post hoc data or evidence, which is a limitation of this principle within the context of conceptual research and literature reviews. However, as noted in section 4.2, another limitation of this principle and others is the fact that the traditional pathways for the dissemination of research often do not lend themselves to the inclusion of adequate quantities of data, requiring researchers to make compromises. Similarly the use of these design principles as an analytical lens also needs to acknowledge, as we noted again in section 4.2, that any research paper represents a moment in time and that the impact of such research may be ongoing. Explicit throughout our four design principles is the need to increase the richness and range of data as well as elaborate more explicitly the theoretical and conceptual basis of research into technology supported learning. Realising this in practice would also require further innovations in the genre and platforms for the dissemination of research.

Notwithstanding these limitations as well as the gaps and deficits left by our own work here, this paper has built on our initial meta-narrative review by developing and exploring the relationship between our design principles and the important concept of pedagogical provenance. Furthermore, the methodological design principles delineated and exemplified come, we think, at a significant moment in the development of critical and theoretical approaches to the research of educational technologies and education more broadly. What makes this moment significant is the capacity to automate the generation of increasing quantities of data directly and indirectly related to teaching and learning, or what Mayer-Schonberger and Cukier (2013) term 'datafication'. Our original contribution here, which we were unable to explore fully in our initial meta-narrative review, is to begin to exemplify some ways in which we might develop and sustain a critical and meaningful approach to data

and evidence in terms of identifying important methodological design principles that lend themselves to increased pedagogical provenance. In an age of intensified, automated data generation, we believe this will be vital if research evidence is going to add cumulatively to our pedagogical and professional knowledge and understanding of how digital technologies can play a meaningful and effective role in teaching and learning. What appears to be a propensity towards the production and reproduction of gaps and deficits within the methodological design of research into technology supported learning, will not be addressed simply through the ubiquitous and automated increase of data for its own sake. Without careful attention to methodological design that foregrounds the importance of pedagogical provenance, we contend, there is a risk of merely increasing the propensity towards the production and reproduction of gaps and deficits whilst also decreasing the propensity for pedagogically meaningful and useful evidence, with potentially significant repercussions for teacher agency and professionalism.

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Appendix A: Corpus of literature used for initial meta-narrative review

Reference	**Focus on impact** (keyword count in article ie references to impact, learning outcomes, measure/s)	**Methodological genre and historical range** (Methodological characteristics and chronological span of literature included in reviews or referred to)	**Source** (Peer reviewed Journal [PRJ], policy report etc)
Webb, M. & Cox, M. (2004) A Review of Pedagogy Related to Information and Communications Technology. *Technology, Pedagogy and Education*, 13(3), 235-286.	>30	Literature review (quantitative and qualitative research) Article > 10 years old Historical perspective as literature reviewed spans 1978 - 2004	PRJ
Higgins, S., Xiao, Z. and Katsipataki, M. (2012) The impact of digital technology on learning: summary for the Education Endowment Foundation. Full report.	>170	Systematic review including quantitative meta-analysis Article < 10 years old Historical as literature reviewed spans 1985 – 2012 but also some contemporary	Education Charity Education Endowment Fund
Pérez-Sanagustín, M., Nussbaum, M., Hillinger, I., Alario-Hoyos, C., Heller, R., Twining, P. and Tsai C.-C. (2017) Research on ICT in K-12 schools – a review of experimental and survey-based studies in Computers & Education 2011- 2015. In *Computers & Education 104*, A1-A15	>25	A systematic review Article < 10 years old Contemporary Literature spans 2002 - 2017	PRJ
Mor, Y. Ferguson, R. and Wasson, B. (2015) Editorial: Learning design, teacher inquiry into student learning and learning analytics: A call	>10	Editorial focussing on design-based methodologies incorporating learning analytics	PRJ

for action. In *British Journal of Educational Technology* 46 (2), 221-229		Article < 10 years old Contemporary Literature spans 1990 – 2015 but focus mainly contemporary	
Nguyen, L. , Barton, S. M. and Nguyen, L. T. (2015), iPads in higher education—Hype and hope. *British Journal of Educational Technologies*, 46: 190-203.	>10	Systematic review Article < 10 years old Literature spans 1996 – 2015 but mostly contemporary	PRJ
Karamti, C. (2016) Measuring the Impact of ICTs on Academic Performance: Evidence From Higher Education in Tunisia, *Journal of Research on Technology in Education*, 48(4), 322-337,	>60	Multi-level analysis ie quantitative survey and factor analysis to establish characteristics of use associated with performance outcomes Article < 10 years old Literature spans 2004 – 2016 but mostly contemporary	PRJ
Livingstone, S. (2012) Critical reflections on the benefits of ICT in education. In *Oxford Review of Education 38(1),* 9-24	>35	A conceptual/critical review Article < 10 years old Literature spans 1984 – 2012 giving both historical and contemporary perspective	PRJ
Latchem, C. (2014) Opening up the educational technology research agenda. In *British Journal of Educational Technology 45(1),* 3-11	>20	Special Issue editorial focusing on research methodologies for technology supported learning Article < 10 years old	PRJ

		Literature spans 1963 – 2014 giving both historical and contemporary perspective	
Jenkinson, J. (2009) Measuring the effectiveness of educational technology: what are we attempting to measure? In *Electronic Journal of e-learning 7(3),* 273-280	>30	A Review of experimental studies Article < 10 years old Literature spans 1983 – 2009 giving both historical and contemporary perspective	PRJ
Cox, M. and Marshall, G. (2007) Effects of ICT: do we know what we should know? In *Education and Information Technologies 12(2),* 59-70	>70	A critical review investigating a range methodologies and their affordances and limitations Article < 10 years old Literature spans 1962 – 2007 giving both historical and contemporary perspective	PRJ
Cox, M. (2013) 'Formal to informal learning with IT: research challenges and issues for e-learning'. In *Journal of Computer Assisted Learning,* 29(1), 85-105	>85	Critical review of various methodological paradigms for researching impact of ICT Article < 10 years old Literature spans 1965 – 2013 giving both historical and contemporary perspective	PRJ
Chauhan, S. (2017) 'A meta-analysis of the impact of technology on learning effectiveness of elementary students'. In *Computers and Education* 105, 14-30	>40	Quantitative meta-analysis exploring a selection of moderating variables (eg subject, duration of intervention)	PRJ

		Article < 10 years old Contemporary Literature spans 2002 – 2017 Mostly a contemporary perspective	
Cox, M., Webb, M., Abbott, C., Blakeley, B., Beauchamp, T. and Rhodes, V. (2004) ICT and pedagogy: a review of the research literature. Coventry: Becta	>65	A critical review of literature from various paradigms Article > 10 years old Literature spans 1977 – 2004 giving a mainly historical perspective	Government commissioned report BECTa/DfES
Harrison, C., Comber, C., Fisher, T., Haw, K., Lewin, C., Lunzer, E., McFarlane, A., Mavers, D., Scrimshaw, P., Somekh, B. and Watling, R. (2002) ImpacCT2: The Impact of Information and Communication Technologies on Pupil Learning and Attainment. London: DfES and Becta.	>150	Large scale mixed methods study Article > 10 years old Historical	Government commissioned report DfES/Becta
Somekh, B., Lewin, C., Mavers, D., Fisher, T., Harrison, C., Haw, K., Lunzer, E., McFarlane, A., Scrimshaw, P. (2002) ImpaCT2: Pupils' and Teachers' Perceptions in the Home, School and Community. Coventry: Becta.	>80	Large scale mixed methods study including concept mapping Article > 10 years old Historical perspective	Government commissioned report DfES/Becta
Haßler, B., Major, L. and Hennessy, S. (2015). Tablet use in schools: A critical review of the evidence for learning outcomes. In *Journal of Computer-Assisted Learning* 32 (2), 139-156	>50	Systematic review including quantitative meta-analysis Article < 10 years old Contemporary as studies included spans 2010 - 2016	PRJ

Luckin, R., Bligh, B., Manches, A., Ainsworth, S., Crook, C. and Noss, R. (2012) Decoding learning: the proof, promise and potential of digital education. London: Nesta.	>30	Critical review using what authors' describe as 'adaptive comparative review' of innovations (Luckin et al, p.66) Article < 10 years old The innovations included, span the previous three years to the publication ie 2009-2012. Although the literature referred to dates back to over 30 years, the innovations focused on are contemporary	Commissioned review by policy think tank Nesta
Ravizza, S., Uitvlugt, K. and Fenn, M. (2016) Logged In and Zoned Out: How Laptop Internet Use Relates to Classroom Learning. In *Psychological Science*,	>20	Quasi experimental methods incorporating learning analytics and survey responses Article < 10 years old Although references date back this is a contemporary study	PRJ
Crook, C., Harrison, C., Farrington-Flint, L., Tomás, C. and Underwood, J. (2010) The impact of technology: value-added classroom practice. Final report. Coventry: Becta	>150	Collection of qualitative case studies based on teacher lesson logs and interviews Article < 10 years old Contemporary	Government commissioned report Becta
Beland, L. and Murphy, R. (2015) Communication: Technology, Distraction & Student Performance. LSE: Centre for Economic Performance, Discussion Paper No 1350	>90	Discussion paper based on a quantitative quasi experimental Article < 10 years old Contemporary	LSE Centre for Economic Performance.

Bai, Y., Mo, D., Zhang, L., Boswell, M., & Rozelle, S. (2016). The impact of integrated ICT with teaching: Evidence from a randomized controlled trial in rural schools in China. *Computers & Education*, 96, 1–14.	>45	Randomized control trial Article < 10 years old Contemporary	PRJ
ICF Consulting. (2015). Literature review on the impact of technology on learning and teaching. Edinburgh: The Scottish Government	>145	Systematic review with a quantitative meta analysis Gives a contemporary perspective as reviews included span 2008 – 2014 and other literature referred to only goes back to 2005	Government commissioned Study Scotland
Kirkwood, A., & Price, L. (2014). Technology-enhanced learning and teaching in higher education: What is 'enhanced' and how do we know? A critical literature review. *Learning, Media and Technology*, 39(1), 6–36.	>30	Systematic literature review Article < 10 years old Contemporary because authors identify it covers period 2005 - 2010	PRJ
Tamim, R., Bernard, R., Borokhovski, E., Abrami, P., & Schmid, R. (2011). What forty years of research says about the impact of technology on learning: A second-order meta-analysis and validation study. *Review of Educational Research*, 81(1), 4–28.	>30	Systematic review and second order meta analysis Article < 10 years old Literature included in analysis spans 1988 – 2007 giving mainly a historical perspective	PRJ
Ross, S., Morrison, G., & Lowther, D. (2010). Educational technology research past and present: Balancing rigor and relevance to impact school learning. *Contemporary Educational Technology*, 1(1), 17–35.	>15	Critical review of various research designs and methodological paradigms for researching impact of ICT Article < 10 years old	PRJ

	Literature included in analysis spans 1983 – 2006 giving a mainly historical and some contemporary perspective

Timescales of literature review
Literature was selected and reviewed between September 2016 and December 2016

Peer Reviewed Journal Articles = **17**
Government commissioned reports = **5**
Think Tanks/Charitable sector reports = **3**

Total = 25 articles