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Bridging Practice and Theory: The Emerging Potential of Design-based Research (DBR) for Digital Innovation in Education

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Design-based research (DBR) and cognate, practitioner-oriented methodologies have gained increased prominence in the last twenty-five years, and in particular have become established approaches for exploring how we might best optimise the potential impact of digital technologies in education. This is highlighted by the research that shows how DBR has become a mainstay, ubiquitous feature of graduate programmes in the Learning Sciences internationally (Sommerhoff et al, 2018). The Learning Sciences is a field of academic enquiry concerned with advancing our understanding of how we can innovate systematically to improve educational experiences and systems; and invariably where we are trying to exploit the novel, interactive affordances and capabilities offered by new digital technology. The increased use of design as a systematic research methodology around the world highlights its continued, and growing relevance and importance. The increasing popularity of educational design research methodologies, including DBR, owes to their potential to be both practically focused but theoretically robust. DBR, as a participatory and principled research methodology, can potentially support educational designers, innovators, policymakers and technologists to bridge practice and theory. Starting with an outline of the provenance and history of DBR methodology, this paper describes educational design research methodologies, illustrating how DBR can be employed to enhance the development of digital technologies in education.

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Introduction

Design has emerged in recent years as a methodology for conceptualising and developing educational innovations and technologies. It is fundamentally solution-oriented, i.e. focused on envisioning and enacting solutions to identified educational challenges or problems. Design typically centres on answering two interrelated questions: can we change something for the better in education, and what's the best way to do it? This can emerge as a consequence of having to implement a new policy imperative, or where we are trying to solve a pressing problem of practice. Design also often entails illustrating whether technology offers real potential to improve learning, or not; and indeed, design can involve answering all of the above. In the current context and global pandemic, design assumes renewed urgency in the context of how we need to change education to respond to COVID-19. The emergency pivot to blended and online learning and teaching as a result of school and campus closures has underscored the importance of systematic approaches to change that are well informed and practically effective. Design aims to provide a systematic approach to supporting both through providing a solution-oriented methodology for the synthesis of practice and theory. As we will presently outline, successful design typically has a number of levels of impact and resultant outcomes, including: (1) *proximal* - the local, positive changes and effects for learners in the specific context under study; and (2) *distal* - models and frameworks that are transferrable to improve learning in other, cognate settings (McKenney & Reeves, 2018).

It is now over 25 years since Ann Brown and colleagues in the educational technology field first started to conceptualise and write about the possibilities and importance of what was originally termed *design experiments* in education. The use of 'design experiments' helped to convey the inherent complexity involved in trying to improve learners' educational experiences, situated as they are in complex and challenging, contemporary classroom environments and beyond. Furthermore, this goal is often made more difficult through the introduction of new technologies. There

can be considerable hyperbole around new technologies in education. How can we be sure they can have a positive impact on learning, teaching and assessment? Furthermore, where we can establish and exemplify the promise of a given, new technology, how can we try to create the conditions that are likely to result in it having optimal impact?

Educational design methods and approaches, including DBR, have emerged to help us consider technology and innovation from a critical standpoint, guided by theory, thus experimenting in an informed way with new technologies' capabilities and possibilities. Consequently, since the early 1990s, (which also historically marked the beginning of the more widespread use of the Internet in education and schools), design methods have gained increased prominence in educational research (McKenney & Reeves, 2018). They have come 'front and centre' in educational research, especially when we want to think judiciously about how we can make progress in initiating, iterating and *infrastructuring* (Penuel, 2015) sustainable change and innovation in educational settings and systems.

This paper focuses on the definition, history and development of educational design and design-based research (DBR), as high-potential participatory methodologies for conceptualising and creating educational innovations and technologies that have impact. I will highlight some of the signature features of design methods in education, and how these can be enacted in practice. The paper will explore the utility of DBR in supporting research design and methodological implementation in the context of innovations that aim for high-potential applications of digital technologies in education.

The emergence of design in education: What's in a name?

It is perhaps important at this point to position and clarify some key definitional issues, which can arise in discussions about design

approaches in contemporary education and learning technology research. It also enables us to explore key concepts of design-based research, and its place alongside cognate, practitioner-oriented educational research methodologies. The original usage of the term design-based research (DBR) comes from Prof Chris Hoadley, New York University, who first coined DBR to refer to methods of systematising and supporting educational change and innovation through design, which would include where innovative technology was being used to mediate and enhance learning, teaching and assessment.

Following from Hoadley and the Design-Based Research Collective (2003), the special issue of the *Journal of the Learning Sciences* in 2004 (Barab & Squire, 2004) did much to position DBR as a methodology in education, and in educational technology research more specifically. It outlined how design-based research was concerned both with building theory (the development of frameworks, exemplar models, guidelines and principles) while impacting on practice through supporting innovations that work in context. Reusability and replicability were important foci. As well as improving the immediate educational context, design-based research should generate resources and templates that others could adopt and adapt to achieve comparable positive effects in their respective educational environments and settings.

In 2018, in the *British Educational Research Journal*, McKenney and Reeves further highlighted the established and growing prominence of design and design-inspired approaches and methodologies in enhancing learning, teaching and assessment. Research has shown the continuing popularity of design-based research (DBR) specifically in educational technology research education and cognate graduate programmes around the world (Sommerhoff *et al*., 2018). Reflecting the creativity that is at the heart of design, and the diverse perspectives that obtain in terms of what constitutes design, there are a number of popular definitions in use now as nomenclature to describe the emergence of design as a research methodology in education. These include Educational Design Research (EDR), Design-Based Implementation Research

(DBIR), as well as DBR. While distinct in their respective focus, they all connote a suite of related philosophies, approaches and methods, which take as their focus key educational issues such as learning technology; teacher professional development; curriculum reform; school leadership; school building design; and educational change and innovation.

In Educational Design Research, the role of the teacher and their continuing professional development (CPD) are especially prominent. In DBIR, the implementation or process of design is foregrounded. In essence, in really good educational design, the process *is* the product; therefore, in DBIR, implementation is of foremost importance. It is also important to note that although the original use of the terms design experiments could tend to involve exploring the impact and potential of technology in classrooms and other educational settings, design research does not necessarily have to focus on technology. Indeed, one of the main international communities in the field of educational design, the International Society for Design and Development in Education (ISDDE) (the author chaired the 14th Annual ISDDE Conference in NUI Galway, 28th-31st May 2018:),[1] exemplifies the intrinsic complexity and diversity of design in education today. Major foci of ISDDE include the design of teacher education and innovative curricula, as well as digital education. For example, a most interesting, current innovation by one of the major institutes involved in ISDDE, Cambridge Mathematics, University of Cambridge, has been their development of an innovative approach to mathematics teaching, *Espresso*.[2] This is intended to enhance maths teachers' professional practice in classrooms by providing them with engaging and highly usable, 'byte-size' research-informed resources, which address key contemporary issues in mathematics classrooms:

> Each month we bring you an Espresso – a small but intense draught of filtered research on mathematics education, expressly designed with teachers in mind. Each Espresso considers one particular issue

[1] https://www.isdde.org/conferences/conference-galway-2018/
[2] https://www.cambridgemaths.org/espresso/

> in mathematics education, and how the latest good-quality research can provide helpful guidance or further reading. Perfect with a biscuit; sip gently and combine with a drop of professional judgement for a benevolent stimulant effect. (Cambridge Mathematics, 2020)

While the Cambridge Mathematics Espressos are published online and consequently rely on the powerful open educational potential of the Internet, learning technology is not in the foreground; teachers' professionalism and the pedagogical demands of modern mathematics classrooms are the priority. It is also very important that resources like Espressos are designed with very high levels of aesthetic quality and usability – it is imperative that teachers find these learning designs attractive, engaging and easy-to-use.

Design-based Research: Reframing the Unit of Analysis

Considering we are still in the recent history since Ann Brown, Alan Collins and contemporaries introduced the concept of design experiments, as an appropriate methodology for - as Brown (1992) termed it – the blooming, buzzing confusion of [the] inner-city classrooms in which she was working and researching at that time, the field of educational design is still taking shape. It is therefore interesting to see the diversity of nomenclature for educational design methods, e.g. DBIR, DBR. Indeed, in terms of conceptualising, and reconceptualising, what our unit of analysis should be in design methodologies, a major recent direction has been to look beyond technology, and how we can scale up and out, to realise greater impact with the ecosystems and innovations we propose to design to enhance education. In his 2015 keynote to the ISDDE, Penuel introduced the concept of *infrastructuring*. As Penuel (2019) notes, infrastructuring behoves educational designers to care about, and consider the multiple partnerships, dimensions and levels that necessarily impact upon the success, or otherwise, of educational change and innovation; whether this entails the deployment of learning technologies, or not:

> Rather, infrastructuring efforts demand that we also re-design educational infrastructures that influence implementation to be more equitable (Penuel, 2015). When we "design across levels" in this way, we are engaged in a special kind of design research my colleagues and I call Design-Based Implementation Research (DBIR; Fishman, Penuel, Allen, Cheng, & Sabelli, 2013), so named because we are concerned with developing knowledge, tools, and practices related to equitable implementation of innovations and the capacity of partnerships to improve outcomes through inclusive research and development processes.

Infrastructuring leads us to consider the complexity of variables that can have an impact upon the success of digital education, and how we can try to deal with this challenge, including through our attempts to bridge practice and theory in design. The expansive unit of analysis of educational design is exemplified by the 2017 special issue of the *European Journal of Education*, which focused on multiple stakeholders (e.g. teachers, architects) and diverse perspectives in relation to school building design (Könings & McKenney, 2017). This special issue provided a fascinating insight on innovative school building design, based on the curation of a range of insights on what constitutes inclusive partnership in "design across levels" for the planning and construction of new learning spaces and schools. These included historical views on classrooms and their design, and innovative architectural technology.

Design in Education as Practitioner Research Methodology

A further key question that often arises concerning DBR is its relationship to other powerful practitioner-oriented research methodologies, particularly action research. The question is a salient one. The author would see both methodologies coming from the same family of approaches: the philosophy and goals are generally the same – to effect real change and improvement in learning outcomes, and to do so equitably and inclusively for all learners. One major point of departure, perhaps, between the two

approaches is whether they focus, or not, on ontological innovation, or theory-building. McKenney and colleagues have done much highly valuable research to position and clarify the outcomes of educational design research approaches, which encompasses DBR. In the McKenney and Reeves integrative model of educational design research (2018), the typical contribution of design approaches in education is twofold: proximal and distal. Like AR, DBR focuses on achieving practical improvements in the naturalistic context of learning (proximal contribution), e.g. be it a classroom, museum, or CoderDojo.

Design-based methods, however, are also concerned with creating new conceptualisations of learning; and specifically creating principled models of design (distal contribution) that other educators, and educational designers and technologists can adopt and use within their own specific educational contexts, contingent as these are on local exigencies, constraints and requirements. Thompson Long and the author (2015) add a middle or *medial* level of impact, alongside the proximal and distal, which can encompass the highly valuable, repurposable design outputs that can emerge in digital education research, e.g. assessment rubrics, software specifications, even timetables, etc.

Given the contextual variance of learning environments, in design-based research we typically never refer to the distal models as finished, exhaustive or complete - they are tentative or *prototype design models* (Barab & Squire, 2004), which need to be adapted for the specific requirements of a given educational setting. Ciolfi & Bannon (2003) employ the term *sensitivities* to reflect more accurately the flexible/revisable nature of these kinds of guidelines or principles: they are informative and instructive (what one should/should not do in a given design setting), yet they need to be attuned to, and adapted for different contexts, depending on the peculiar and local requirements thereof.

In AR, it can be sufficient that the methodology achieves positive changes and impacts for the teacher and learners in context; there does not necessarily have to be a focus on theorising. By contrast,

design methods normatively must seek to offer new theoretical perspectives on learning and digital education. However, in design methodologies this seeking practical improvements within specific, local contexts while at the same time generating new ontologies of learning, generates a paradox. This is the tension that design-based research must contend with, and this paper presently will address - how educational design research, including DBR, aims to create a bridge between practice and theory in education. Firstly, how can this be done? (Indeed, can it be done at all?) And if so, what methods do we have to help us in this significant challenge?

Intervene, Innovate and Iterate: The Three Is of DBR

A key aspect of theory building in DBR – as well as having a practical impact – is engaging in ontological development work as an accretive process that builds upon and corroborates itself over time. The author refers to the three Is of DBR: interventional, innovative and iterative. Like AR, DBR must necessarily involve intervening to change and enhance a learning experience or context. Secondly, it typically involves doing something novel or innovative – something at the frontier of learning and teaching, or digital education. Thirdly, and relatedly, DBR must be iterative – there are usually a set of connected cycles, which each internally involve conceptualisation, design, implementation and evaluation. DBR is accretive in that each cycle aims to consolidate, augment and extend the previous cycle(s). The author would generally advise there be at least three contiguous meso-cycles of design: a first pilot study; a second cycle (which can involve scaling up or mainstreaming the design); and a final, capstone iteration, which should serve to corroborate the improvements made in the design process as a whole, while identifying areas for future research and development.

Principled and Participatory: The Two Ps of DBR

Furthermore, this accretive process over time helps to test out and verify the emergent theory of learning that comes from the evaluative and reflective cycles of DBR. Crucially, reflection and

theorisation must be at the heart of DBR. Within each cycle, design decisions are made in reference to the established and published literature. In addition, each design cycle must involve the key stakeholders. We can call these the two Ps of DBR: the process must be informed by theory throughout (i.e. it must be principled) and engage with the key actors and factors (i.e. it must be participatory).

In terms of being principled, all design changes and recommendations emerging in the iterative cycles of design should be predicated on, and justified with relevant concepts, principles and theories of learning and digital education, and concomitant reading and research by the designer(s). The two Ps help to ensure DBR is pushed by practice, while pulled by theory. DBR maintains a core focus on enhancing practice and supporting practitioner-based research in naturalistic contexts of learning, but the dual, core goal of DBR is to be principled and contribute to theory-building, enhancing practice alongside developing our ontological understanding of how we can best conceptualise the design of educational innovations and technologies for education. Design approaches in education can enable us to be informed by practice while instructed by theory, especially helpful when conceptualising, designing, deploying and evaluating digital technologies in situ, across diverse learning settings, formal and informal. We want to be able to develop innovations and technologies in education that are practically useful and impactful, but as importantly we need to be sure they are theoretically sound and cogent. The adage applies from start to finish in DBR: 'theory without practice is sterile; while practice without theory is blind.'

A key part of the process throughout is the original design conceptualisation or prototype design model. As well as giving direction to the design-based research ab initio, it also crucially should provide a critical framework for evaluating the design as it changes and moves forward through each cycle. This furthermore helps to ensure the minimising of gaps between practice and theory, between process and product. But where do we start in this kind of conceptualisation work? In order to scope out the prototype design model, the author recommends developing a nascent thematised framework, which emerges from a synthesis of four main activities by the designer(s), in consultation - where necessary - with the key

stakeholders. This will help to ensure the initial design is robust and provides a good chance of success as the design process moves forward through the (at least) three related, interventional cycles.

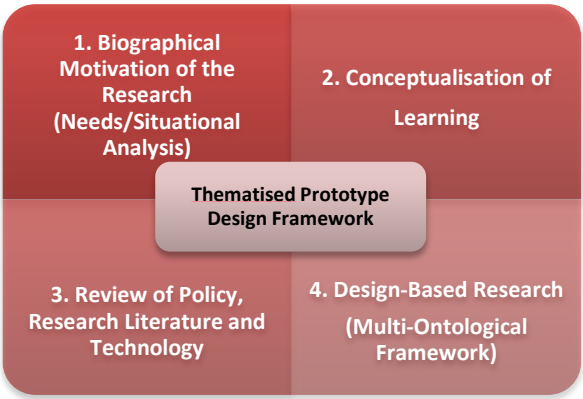

Figure 1. Scoping out the initial prototype design model in DBR

A further useful design activity to engage in early on in the process, and indeed throughout the lifecycle of the design is to create an acronym for the project. The acronym should identify the key sensitivities or criteria for the design. In the experience of the author, (as a principal investigator in design research projects and supervisor of doctoral work in the field), this can range from anywhere between 4 and 8 main features.

The acronym becomes a helpful design tool to mediate and deal with the complexity of any innovative educational design, particularly with technology, while maintaining the designer's crucial focus on the key goals and features of the innovation. For example, the ENaCT model was developed to describe design-based research, which focused on using innovative ensemble teaching methods, integrated with mobile devices and technologies, to enhance English literature education in Irish classrooms (Flanagan & Hall, 2017). ENaCT identifies the four key dimensions of the innovative digital education design: ensemble, narrative, collaboration and technology.

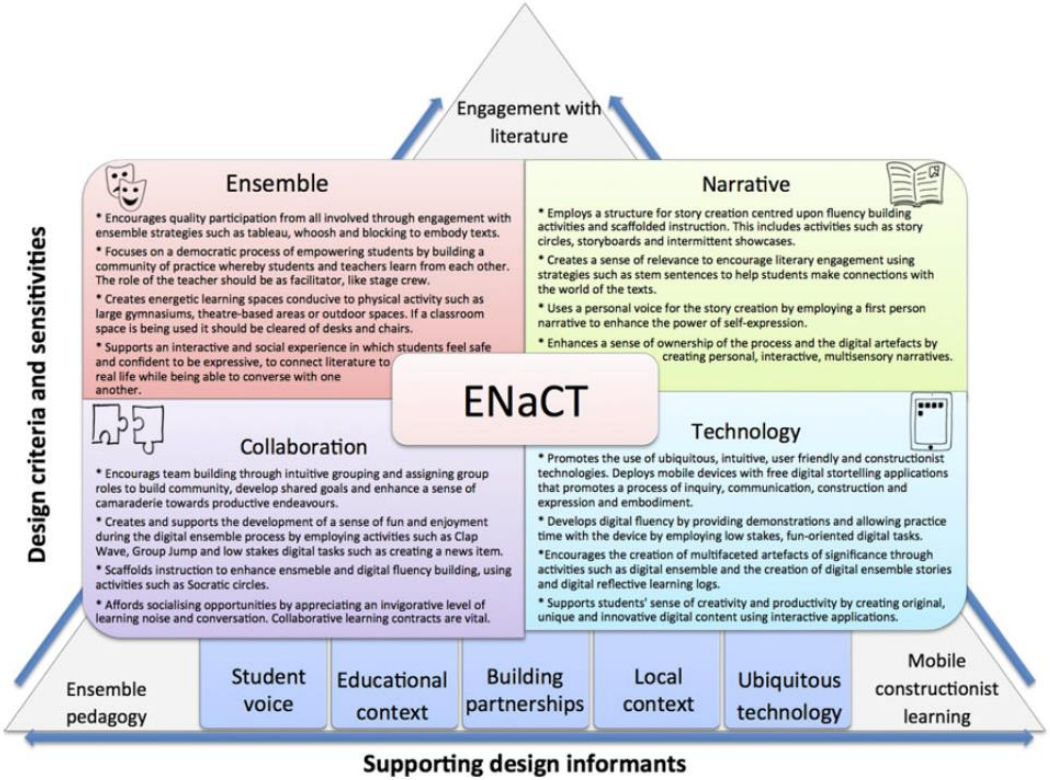

Figure 2. ENaCT design model for mobile learning in English pedagogy

The design model that emerged, and which was refined through the ENaCT design process is illustrated below, identifying the key sensitivities that need to be addressed when considering the deployment of mobile devices in English classrooms. The ENaCT model is typical of the distal outcomes of DBR and educational design research, illustrating the design criteria and informants of a novel ontology of English education, mediated by innovative pedagogy and mobile technology.

Complex Challenges Require Comprehensive Conceptualisations

Phillips (Reeves, 2015, p.616) described as folowsthe complexity of educational design and the myriad different actors and factors that can prevail upon the success of educational outcomes:

> Learning is a phenomenon that involves real people who live in real, complex social contexts from which they cannot be abstracted in any meaningful way. Difficult as it is for researchers to deal with/learners are contextualized. They do have a gender, a sexual orientation, a socioeconomic status, an ethnicity, a home culture; they have interests—and things that bore them; they have or have not consumed breakfast; and they live in neighbourhoods with or without frequent gun violence or earthquakes, they are attracted by (or clash with) the personality of their teacher, and so on.

But how do we even attempt to deal with such complexity? As mentioned, Penuel (2015; 2019) is highlighting the importance of the many actors and factors that can impact upon learning and digital education. Infrastructuring illustrates how there are multiple dimensions and levels when we undertake to design for educational change and innovation. A key advantage potentially of DBR and educational design methods is you can draw on multiple concepts and theories – as relevant and justified – to help to develop more comprehensive and inclusive conceptualisations of learning in context. As well as the many different actors/factors that influence the design of innovation, educational technology and resultant outcomes, education and learning are complex and emergent processes. Therefore, a single theorisation may not always provide

the broad kinds of insights needed. In DBR, we can draw on multiple concepts and ontologies of learning and create bespoke, novel and multi-dimensional frameworks of learning. This potentially supports us to address the complex design challenges we face – especially at the multi-level scale of infrastructuring.

Conclusion

In 1916, in his famous educational tract, *The Murder Machine*, Pearse (2016) seemed to prefigure the importance of bespoke learning design when he wrote: "Education has not to do with the manufacture of things, but with fostering the growth of things. And the conditions we should strive to bring about in our education system are not the conditions favourable to the rapid and cheap manufacture of readymades, but the conditions favourable to the growth of living organisms." But how do we systematise our experiences as design-based researchers? We need methods and approaches that enable us to deal with the complexities of the naturalistic learning context, and the emergent nature of educational experience. We also need to be able to exploit the novel affordances of technology while optimising the conditions for creativity – and indeed *learning though design.*

DBR and other cognate educational design research methods potentially provide us with useful frameworks to achieve these key educational goals. DBR can facilitate recursive intervention cycles where practice and theory enhance each other.

Multi-ontological frameworks help us to address the multiple dependent variables that affect learning in context – the comprehensiveness of theory aligning with the complexity of practice. Through DBR and related methods, we can also remain open and responsive to the emergent, experimental nature of things in classrooms and other educational settings: there is adaptability and flexibility of methods. A major challenge often faced by educational design researchers is that funded research often follows a predictive approach, meaning that design, implementation and evaluation are expected to happen in a sequential, rather than a cyclical fashion.

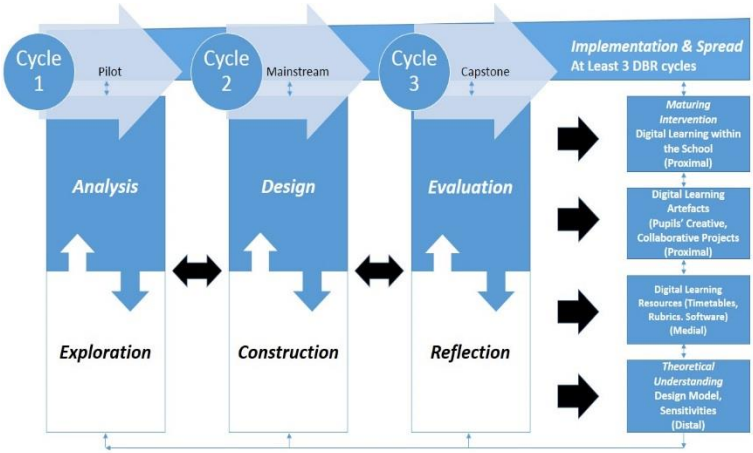

Figure 3. DBR Model based on McKenney & Reeves' (2018) integrative model

DBR and cognate design methods are predicated on iterative methods, wherein design, implementation and evaluation happen in cycles. Rigorous DBR processes culminate in exemplar processes (interventions) and products (models); and frameworks for design, analysis and evaluation. Its ternary contribution of proximal, medial and distal impacts can both improve learning in context while affording novel ontologies of learning. Thus DBR and related approaches can potentially help to advance and support educational research as a whole, including practice in the use of digital technologies for education.

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