DBRIEF: A research paradigm for ICT adoption

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The concern that educational research is often divorced from the problems and issues of everyday teaching practice, is strongly influenced by the chosen paradigm in which the research is framed. Modelled on design-based research methods, this paper presents the development of a theoretical research framework that accommodates complex interventions, such as the adoption of ICT into mainstream classroom practice, which can be informed and improved through empirical study. It is hoped that in developing the Design-Based Research in Innovative Education Framework (DBRIEF), the desirable outcome of providing a practical and adaptable instrument with the potential to find applicability, currency, and promote the sharing of knowledge in the wider educational research community, is achieved.

Design-based research, educational research framework, paradigm, innovation, ICT adoption

INTRODUCTION

The concerns of educational leaders and researchers that educational research is often divorced from the problems and issues of everyday teaching practice, resulting in "unusable knowledge" (Lagemann, 2002, p.1), is strongly influenced by the chosen paradigm in which the research is framed (Bauder et al., 1997). The United Kingdom's leading agency for ICT research in education raised this issue:

> A common framework should be developed for evaluating ICT in schools which incorporates a core set of measures, which can serve the needs of schools themselves as well as policy-makers and researchers. (Becta, 2003, p.2)

In order to produce professional knowledge that can be applied in practice, Haertel and Means (2004) called for (a) research that addresses the questions that educational leaders and teachers care about, (b) integration of local understanding driven by researcher-policymaker partnerships with disciplinary knowledge, and (c) the use of research findings to inform and transform practice. In response to the concern to produce usable findings, this article argues for research that is born out of the collaborative partnership between researchers and policymakers focused around inquiry that is of interest to educational leaders and teachers with the intention of informing practice. Moreover, this article argues that such research needs to be framed in an appropriate paradigm that furthers the understanding of how and why an innovation works within and across settings over time (Bauder et al., 1997; Brown and Campione, 1996; Terashima et al., 2003). Accordingly, this paper presents the development of a theory-driven research design that accommodates complex interventions that can be informed and improved through empirical study. The recent emergence of an important research method, called 'design-based research' (Design-Based Research Collective, 2003), provides a sound basis from which a more explicit framework is developed.

DESIGN-BASED RESEARCH

The premise of design-based research, to promote, sustain, and understand innovation in the world, particularly in an educational context, has maintained a close synergy with the development and adoption of ICT in educational practice. Design-experimentation has become,

over the past decade, an increasingly accepted mode of scholarly inquiry appropriate for the theoretical and empirical study of change in everyday educational settings brought about by complex educational interventions (Bell, 2004; Cobb et al., 2003). In particular, Bell (2004) states:

> Scholars came to engage in design-based research in order to better understand how to orchestrate innovative learning experiences among children in their everyday educational contexts as well as to simultaneously develop new theoretical insights about the nature of learning. (Bell, 2004, p.244)

Design-based research brings together research on educational practice and its effects by employing the scientific processes of discovery, exploration, confirmation and dissemination (Kelly, 2003). This interconnection of research and practice complements the fundamentally interventionist nature of education and provides practical and theoretical progress in the field by conducting empirical research in naturalistic settings. Cobb et al. (2003) suggest:

> Design experiments ideally result in greater understanding of a *learning ecology*—a complex, interacting system involving multiple elements of different types and levels—by designing its elements and by anticipating how these elements function together to support learning. Design experiments therefore constitute a means of addressing the complexity that is a hallmark of educational settings. (Cobb et al., 2003, p.9)

The importance that context and local interpretation plays in the successful adoption of ICT becomes salient when examining cases in which teachers develop different strategies to achieve similar learning outcomes. Just as there are many guiding principles when it comes to effective teaching and learning, there is no single right approach when it comes to embedding ICT into the curriculum successfully. The differences brought about by school, teacher, and student characteristics result in many models of successful implementation that yield positive outcomes. Accordingly, by not externally imposing a set of instructional methods of embedding ICT into teaching practice, research is underpinned by this philosophy and indicative of good design.

In order to explain the context and conditions associated with change in educational practice, design-based research should exhibit the following five characteristics (DBRC, 2003).

(1) The design of learning environments and learning experiences are intertwined with theories of learning.

(2) Development and research take place through a continuous cycle of design, enactment, evaluation and redesign.

(3) Research on design leads to sharable knowledge and practice that can be communicated to practitioners and other designers.

(4) Research must account for how and why designs work in authentic settings.

(5) Accounts of research must describe and connect processes of enactment with outcomes of interest.

However, because of these characteristics, there are a number of challenges faced by design-based research, centred around the issue of credibility and arising from unscientific research approaches in educational research (NRC, 2002), and the detachment of research from practice (Lagemann, 2002). Providing further clarification, Robinson (1998) argues that educational research is detached from practice when it does not account for the influence of contexts, the emergent and complex nature of outcomes, and the lack of understanding about which factors are relevant for prediction. In order to promote credibility and generalisability, the effective use of ICT in learning requires that the effects of ICT need to be studied across a number of contexts over time (DBRC, 2003). Furthermore, the research design needs to view educational innovation holistically. The design process is enacted as a product of the context in which the innovation is

adopted and emergent as one of the outcomes. By doing so, the disparity between well-designed research and that of unscientific detached research that is unable to claim credibly success or failure of an innovation in context is lessened.

Typically, design-based research relies on techniques used in other research paradigms in order to maintain objectivity, reliability, and validity. Triangulation of multiple sources of data to connect intended and unintended outcomes to the innovative practice is commonly employed. When data are collected using standardised instruments repeated on a number of occasions, validity can be tested. Since it is not logistically possible to pursue all possible factors equally that may contribute to the outcomes, particularly in complex longitudinal studies (for example, Dix, 2006) that span multiple settings over a number of years, the reliability of findings depends on the triangulation of data and repeated use of standardised instruments (DBRC, 2003).

A further logistical problem in design-based research results from the need to maintain a productive collaborative partnership between researcher and participants over a long period of time (Cobb et al., 2003). In maintaining these relationships, by the negotiation of a shared enterprise, regular opportunities for debriefing and further planning are necessary (Dix, 2006). Moreover, because a single line of research investigates multiple cycles of design, enactment and research, the study often spans years and potentially challenges teachers' and researchers' closely held beliefs. Successful examples of design-based research (for example, Dix, 2006; Linn and Hsi, 2000) minimise the potential tension between researcher and teacher to sustain a cooperative partnership. This tension is best summarised by the Design-Based Research Collective:

> The challenge for design-based research is in flexibly developing research trajectories that meet our dual goals of refining locally valuable innovations and developing more globally usable knowledge for the field. (Design-Based Research Collective, 2003, p.7)

Furthermore, the success of design-based research should be measured by its ability to inform and improve educational practice. Its choice as a paradigm for educational research, lies in its potential to explore novel learning and teaching environments that support and promote the adoption of ICT in real settings, and to increase human capacity for innovation through the exchange of ideas and expertise across academic and educational communities.

TOWARDS A RESEARCH FRAMEWORK FOR ICT ADOPTION

In developing a research framework that positions design research as a socially constructed, contextualised process resulting in educationally effective outcomes that can inform teaching practice, a review of existing theoretical models on the teaching and learning process and emerging frameworks used in design-based research was conducted. However, during the review process, it was evident that the terms 'framework' and 'model' were generally not defined and were often used interchangeably, resulting in a need for clarification.

Frameworks and Models

Dictionaries generally define a framework as a set of assumptions, concepts, values, and practices that constitutes a way of viewing reality. Smyth (2004) reflected on the purpose of a framework as a:

> … research tool intended to assist a researcher to develop awareness and understanding of the situation under scrutiny and to communicate this. As with all investigation in the social world, the framework itself forms part of the agenda for negotiation to be scrutinised and tested, reviewed and reformed as a result of investigation. (Smyth, 2004, p.168)

For the purposes of this paper, a framework provides a fundamental structure and a practical instrument that enables a researcher to think through ways of doing things. Frameworks are

commonly presented as structured tables with clearly defined interrelated concepts. However, frameworks are also portrayed in diagrammatic form and are often referred to as models.

Keeves (1997, p.386) defines a model as a hypothetical structure, that "is used in the investigation of interrelations between the elements". In investigating such interrelations, a set of hypotheses, "developed from intuition, from earlier studies, and from theoretical considerations" are proposed, tested and confirmed or rejected (Keeves, 1997, p.386).

A distinction can then be drawn between a framework, as a general structure that provides an overarching set of concepts and processes, and a model, as a specific structure of interrelated factors hypothesised to be tested. Indeed, a framework may include or reflect a model, or guide the development of a model or number of models. Such a distinction is necessary, particularly with the emergence of design-based research, where interrelated processes are represented alongside concepts and factors.

A Review of Educational Research Frameworks and Models

All models are wrong, but some are useful. (George Box, 1976)

Of the many models reviewed for this paper (for example, Jones and Paolucci, 1998), those of Carroll (1963), Biggs (1989), and Huitt (1993), in addition to the frameworks of Orrill (2001), Keeves (2003), Bannan-Ritland (2003), and Sandoval's (2004), are considered pertinent to the development of the framework presented in this paper.

Carroll introduced a model of school learning in 1963 that still has currency in educational research, some four decades later. The original model, presented in Figure 1, is formal and quasi-mathematical in design (Reeves, 1997). Carroll's (1963) model explains variance in school achievement through three time-related variables, namely aptitude, opportunity to learn and perseverance, and two classes of variables that focus on a student's ability to understand instruction and the quality of instructional events.
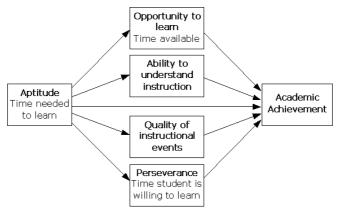

Figure 1.   Carroll's (1963) model of school learning to explain school achievement

Biggs (1989) proposed the 3-P model, which posits presage, process, and product as the main features of a learning system. Figure 2 presents the 3-P model and the paths of influence. The overarching assumption is that learning outcomes are a result of the interactions of teaching and learning contexts with student approaches to learning. Presage, what comes before the learning situation, involves student learning characteristics and teacher characteristics, which are embedded in the context of the learning environment, set by teacher and school. Both student and teaching presage factors interact to produce an approach to learning that produces characteristic outcomes. In the process phase, what happens in the learning situation, particular approaches to learning result in either deep or surface learning (Entwistle and Ramsden, 1983). Accordingly, processes used in learning are not simply a fixed attribute of the learner, but a function of both learner characteristics and teaching factors. The product phase of the 3-P model, the outcome of

learning, suggests that study approaches influence qualitative differences in learning outcomes. Deep approaches to learning produce high quality learning outcomes, while surface approaches result in lower quality outcomes.
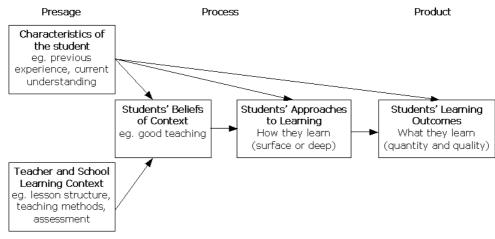

Figure 2. Biggs' (1989) 3-P model of the learning process consisting of presage, process, and product features

A useful review of models (including Carroll, 1963; Proctor, 1984; Cruickshank, 1985; Gage and Berliner, 1992) on the teaching and learning process, culminated in the development of Huitt's (1993) transactional model of the teaching and learning process, shown in Figure 3 as reported in McIlrath and Huitt (1995). The transactional model was developed to categorise factors that influenced variance in student learning and academic achievement in the context of classroom and school. According to the model, the factors were classified under four categories: context, input, classroom processes and output. Context included all those factors outside the classroom that might influence teaching and learning. Input was defined as those qualities or characteristics of teachers and students that they brought with them to the classroom experience. Classroom processes examined what was going on in the classroom and involved teacher and student behaviours as well as other variables such as classroom climate and interpersonal relationships. The last category, output, measured student learning separate from the classroom learning process (Huitt, 1993).
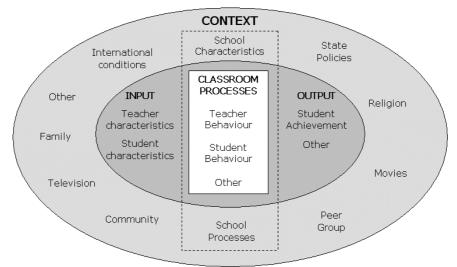

Figure 3. The transactional model of the teaching and learning process (McIlrath and Huitt, 1995)

Orrill's (2001) professional development framework centred around a context-based three-way interaction between the processes of enactment, reflection and goal setting. The objective of the

framework was to support middle-school teachers to become more learner centred when implementing computer-based instruction in their classrooms, and was grounded in the belief that "change is individual and needs to be supported in context and over time" (Orrill, 2001, p.15). The five key aspects of the framework, presented in Figure 4, included reflection, proximal goals, collegial support groups, one-to-one feedback, and support materials for the teacher.
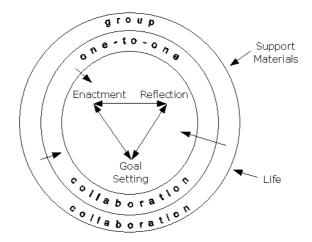

Figure 4.   The professional development framework (Orrill, 2001)

Applying the ideas presented by Cobb et al. (2003) and the Design-Based Research Collective (2003) to extend the work of Turner's (1991) analysis of Giddens' (1984) theory of structuration, Keeves (2003) developed a design-based research framework, presented in Figure 5. The framework consisted of inter-linked but discrete concepts that proceeded through five phases of design. Reading the diagram from right to left, the phases moved through an exploratory mode of operation with structural freedom, to a confirmatory mode with imposed structure reflecting good design.
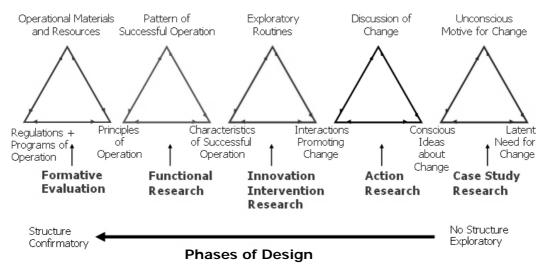

Figure 5.   Design-based research phases of design (Keeves, 2003)

During the case study phase, in Keeves' (2003) framework, the researcher examined the unapparent needs for change and helped to make conscious the underlying reasons and motivations for the desired change by identifying and specifying the nature and the purpose of the innovation. The action research phase collected evidence that would further assist in identifying the appropriate processes of change by promoting discourse about planning and designing the change. During the intervention research phase, the researcher and practitioners explored the different possible modes of change and sought to identify and introduce successful types of

change. At this stage, the intervention was designed and detailed, and the nature of implementation was planned. The functional research phase examined the operation of change and related the context and conditions of enactment to the outcomes achieved. In the final stage, the formative evaluation phase, iterative cycles of innovation and intervention allowed the researcher to examine how and why the changes introduced succeeded or failed to deliver the desired outcomes. Informed decisions guided modification of the subsequent cycle in ways that leads to better design.

Bannan-Ritland (2003) proposed the integrative learning design framework. This model emphasised the stage of sensitivity of (a) research questions, (b) data and methods, and (c) the need for researchers to conduct analyses at earlier stages in the research that could then be profitably used to inform later stages. The framework drew from product design (Ulrich and Eppinger, 2000), usage-centered design (Constantine and Lockwood, 1999), instructional research (Dick and Carey, 1990), and diffusion of innovation (Rogers, 1995), in addition to established educational research methods (Isaac and Michael, 1990; Keeves, 1988). The integrative learning design framework consisted of four broad phases: (a) informed exploration, (b) enactment, (c) evaluation – local impact, and (d) evaluation – broader impact. The first phase provided the foundations of the research by undertaking the fundamental processes of problem identification, literature review and development of research questions, supplemented by the identification of contextual factors through needs analysis and stakeholder perceptions. These activities were informed by the views of the researcher, school leaders and teachers, but also by school and classroom observation. Based on these findings, appropriate methods of intervention would emerge. The enactment phase was an iterative process, where the intervention was conducted, reviewed and refined, and might involve multiple cycles of design. At the evaluation phase, the local impact was assessed through data collection and analysis using an iterative process of formative and summative evaluation, and might well necessitate revisiting the enactment phase. The final phase, that of evaluation on a broader scale, extended the dissemination stage of educational research, which typically saw publication of findings as an end-point, by promoting ongoing research practices and interventions.

In Sandoval's (2004) framework of design-based research, presented in Figure 6, learning theory was developed through an iterative process of refining conjectures embodied in educational designs. Theoretical principles or conjectures were embodied in tools and materials, and structures of tasks and participants. These predictors of intermediate outcomes, which were embedded in the learning context, informed and modified the theory and the nature of the intervention in a micro-cyclical process. The refined intervention then led to the prediction of outcomes, which might, for example, examine the effects on learning motivation. These outcomes, in turn, re-inform the original conjectures and the intervention in a macro-cyclical process.

In undertaking a review of educational research frameworks and models, similarities and differences emerge. The similarities exist because the frameworks and models have been born out of the same field of research, that of the educational sciences. The differences exist because each framework or model considers a particular aspect or is designed to serve a specific purpose. They can be considered as part of a greater whole, or rather, the pieces of jigsaw puzzle, where the different pieces interlock at similar edges. It follows then that any new aspect of educational research potentially requires the development of a new framework or model, another piece of the puzzle. Driving the development of new educational research frameworks is usually the insufficient ability of previous frameworks or models to anticipate and embody the parameters of new studies.
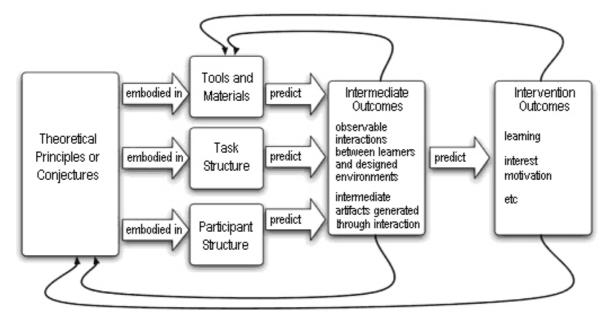
Figure 6.   Design-based research embodied conjectures of learning (Sandoval, 2004)

Rather than just develop another piece of the puzzle however, the question begs, are there enough pieces to anticipate the greater picture and develop a framework with general application? This author contends that there are enough pieces, and through the synthesis of previous frameworks and models, presents the resulting 'picture' of educational research, aptly named, *DBRIEF*.

DBRIEF: DESIGN-BASED RESEARCH IN INNOVATIVE EDUCATION FRAMEWORK

In order to provide a theoretical foundation to guide the development of a study, in addition to encapsulating the major features of the research design, a general framework is generally required. Influenced by previously developed educational research models and frameworks, detailed in the previous section, the resulting framework builds upon the emerging field of design-based research but remains firmly grounded in existing theory about the factors that influence teaching and learning in an innovative environment. This section presents the new framework and details its features.

The Design-Based Research in Innovative Education Framework (DBRIEF) is presented in Figure 7, and combines influential elements from previous research in the field of education (Carroll, 1963; Biggs, 1989; Huitt, 1993; Orrill, 2001; Keeves, 2003; Bannan-Ritland, 2003; Sandoval, 2004). For example, the stages of presage, process, and product are attributable to Biggs (1989), while the concept of moving from unstructured exploratory analysis through to structured confirmatory analysis originates from Keeves (2003). In fact each feature, discussed in detail further below, can, in one form or another, be attributed to a previous model or framework, but it is their presentation in this paper as an integrated whole, that offers new worth.

More importantly, DBRIEF attempts to provide a visual representation of a research paradigm that embodies what is currently considered good research design. Gage and Berliner (1992) argue that diagrammatic models make the process of understanding a domain of knowledge easier because it is a visual expression of the content. They found that students who studied models recalled as much as 57 per cent more conceptual information than students who received instruction without the benefit of seeing and discussing models. In accordance with Gage and Berliner's (1992) findings, the presentation of DBRIEF in diagrammatic form is chosen in order to, as the acronym implies, share knowledge.
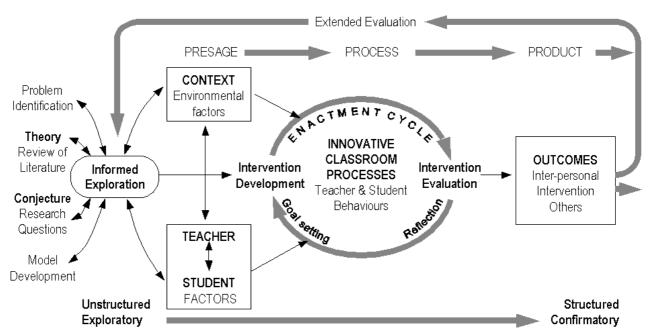
Figure 7.   The Design-Based Research in Innovative Education Framework (DBRIEF)

DBRIEF proceeds through five main phases: (a) informed exploration, (b) presage, (c) process, (d) product, and (e) extended evaluation. The elegance and power of DBRIEF is realised when an entire study can be mapped upon its main features.

Informed Exploration. Most educational research studies follow a standard format. Figuratively speaking, they begin in an unstructured exploratory mode by identifying the problem, usually presented in the first chapter, followed in the next by a review of related literature. In the following chapter, conjecture, informed by contextual factors derived from school and classroom observation, and stakeholder perceptions, leads to the development of research questions and model hypothesis (Bannan-Ritland, 2003; Keeves, 2003; Sandoval, 2004). All of this activity, conducted as an intuitive and iterative process and represented in Figure 7 by curved two-way arrows, is conceptualised under the banner of 'informed exploration'.

Presage. Reflecting Carroll's (1963), Bigg's (1989), and Huitt's (1993) models of the learning environment, the interrelationship between the presage factors of context, teacher and student are presented in a causal model defined by straight arrows or paths of influence. From these basic components, combined with process and product factors, detailed models are hypothesised for subsequent testing, and by doing so, more structure is imposed. Chapters containing rich descriptions of context and participants are presented along with discussion about data collection methods and instruments used.

Process. At the heart of DBRIEF is the 'enactment cycle', where innovative programs of classroom intervention, such as the adoption of ICT in learning, are developed and evaluated in an iterative process of micro-cycles. Contextual factors along with teacher and student behaviours are measured to provide intermediate outcomes that support reflection and further development of proximal goals, and refinement of the intervention (Orrill, 2001). The complexity of studying such activity is best represented by Keeves' (2003) framework (see Figure 5) of educational change through the use of multiple research strategies. Such a framework is too complex to embed in DBRIEF but does provide an example of one of many suitable methodological approaches. Related chapters would contain observation, descriptions of interventions and intermediate outcomes generated through interaction, and data collection.

Product. During the product phase of research, quantitative longitudinal data are rigorously analysed and hypothesised models, informed by qualitative data, are tested. By this stage, analysis takes a highly structured form and is confirmatory in nature. Other outcomes, such as intervention

programs and implications, are prepared for dissemination and evaluation to the broader educational research community. But rather than viewing the publication of findings as the end-point of the research, a final macro-cycle phase is necessary and fundamental to the design-based research method.

Extended Evaluation. Similar to those models of Bannan-Ritland (2003) and Sandoval (2004), this final stage is designed to promote ongoing research and development of further theory and interventions. Accordingly, the outcomes, findings and implications feed back into and re-inform the original theory and conjectures with the underlying premise that change is sustainable and that innovation in classroom practice should be ever evolving. With this outlook, long-term relationships between practitioners and researchers better ensure that educational research does inform teaching practice.

SUMMARY

The Design-Based Research in Innovative Education Framework (DBRIEF), developed and presented in this paper, derives from the early works of Carroll (1963) and Biggs (1989), and more recently from the works of Huitt (1993), Orrill (2001), Keeves (2003), and members of the Design Based Research Collective (2003). It is hoped that in developing DBRIEF, the desirable outcome of providing a practical and adaptable instrument with the potential to find applicability, currency, and promote the sharing of knowledge in the wider educational research community, is achieved.

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