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2005

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Publication Details

This conference paper was originally published as Peterson, R and Herrington, J, The state of the art of design-based research, Proceedings of the World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education, Vancouver, Canada, 24 October, 2005.

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The State of the Art of Design-Based Research

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Abstract: Ann Brown (1992) and Allan Collins (1992) introduced the term *design experiment* in 1992 as an innovative approach to educational research. Today, commonly termed *design-based research* (DBR), the approach itself is still very much being designed. There is a general consensus that DBR standards need to be set by addressing such questions as: What kinds of knowledge should DBR be expected generate? What theoretical requirements should be imposed on DBR? and What types of research can be considered DBR? Given the drive for empirical educational research and escalating interest in DBR, it is hoped that continued expert commentary will lead to a clear definition of DBR. This paper will examine the state of the art of design-based research, more than a decade on, and review current developments in the evolving standards of the approach.

Introduction

In his Invited Peter Dean Lecture, delivered at the 1995 National Convention of the Association for Educational Communications and Technology (AECT), Thomas C. Reeves asked educators to consider the state of research in educational technology. He provided an analysis of the type of research that predominated in the field and concluded, "This analysis is evidence of a research malaise of epidemic proportions" (Reeves, 1995, p. 8). In 1999, in his keynote address to EdMedia, Reeves called once more for a renewed approach to research in education, stating, "I contend that a wiser course would be to support more development research (aimed at making interactive learning work better) … and less empirical research (aimed at determining how interactive learning works)" (Reeves, 1999, p. 19).

Reeves and many other researchers find that development research, also known as design experiments, design research, or design-based research, has the potential to revitalize the research approaches extant in educational technology, approaches dominated by media comparison studies (cf., Clark, 1994) and "pseudoscience" (Reeves, 1993). Ann Brown (1992) and Allan Collins (1992) introduced the term *design experiment* in 1992 as an innovative approach to educational research. The foundations of the approach, however, were set many years earlier.

The Beginnings of Design Experimentation in Education

A distinction between natural sciences and sciences of the artificial is made by Herbert Simon's (1969 as cited in Collins, Joseph, & Bielaczyc, 2004). Natural sciences are defined as being concerned with how things work and are exemplified by the fields of physics, biology, and anthropology. Artificial sciences are defined as having a goal of producing and improving designed artifacts. The fields of artificial intelligence, aeronautics, architecture, computer science, medicine, and engineering exemplify sciences of the artificial. Collins et al. (2004) makes clear that design experiments are linked to the sciences of the artificial.

While Simon used the distinction between natural and artificial sciences to focus discussion on the field of engineering, Collins (1992) applied the issues raised by Simon to the field of education. He states, "Just as in aeronautics, where researchers look at how different designs affect lift, drag, and other dependent variables, he [Collins] argued that we need to develop a design science of education, where we investigate how different learning-environment designs affect dependent variables in teaching and learning" (Collins et al., 2004, p. 17). An idea central to Collins's vision of design-based research is that future designs benefit from the theoretical principles derived from prior research (Collins et al., 2004; Hsi, 1998). He terms this approach *progressive refinement* (Collins,

1999), whereby a design is put into the world to see how it works and is then revised based on this experience. This act is repeated "until all of the bugs are worked out" (Collins et al., 2004, p. 18).

Traditionally, educational research has taken a laboratory approach. Design experiments, in contrast, are proposed to take place in the "real world." Though laboratory-based experiments may be useful in the development of the initial version of a learning artifact, Ann Brown (1992) recommends that testing and refinement be carried out in real-world settings. Brown's canonical 1992 work was highlighted with details about a design experiment that she carried out regarding metacognition, reciprocal teaching, and establishing communities of learners. The experiment aimed at optimizing the design of a reciprocal teaching intervention that required students to work together and take responsibility in creating their own curriculum.

One important feature of Brown's experiment is that she makes clear her intention to maintain a firm empirical base. She states, "Even though the research setting has changed dramatically, my goal remains the same: to work toward a theoretical model of learning and instruction rooted in a firm empirical base. I regard classroom work as just as basic as my laboratory endeavors, although the situated nature of the research lends itself most readily to practical application. In the classroom and in the laboratory, I attempt to engineer interventions that not only work by recognizable standards but are also based on theoretical descriptions that delineate why they work, and thus render them reliable and repeatable" (Brown, 1992, p. 142). A second important feature of her experiment is the use of many different data collection strategies including audio transcriptions, student portfolio reviews, reviews of email among teachers, ethnographic observations, and video. One problem noted is that it was not possible to analyze all of the data collected. This problem is due, in part, to the number of variables and lack of researcher control in real-world experimentation.

Modern Dilemmas with Design Experiments

Today, the problem of dealing with messy real-world experimental environments has yet to be resolved (Collins et al., 2004; Dede, 2004; Gorarda, Roberts, & Taylor, 2004). Collins et al. (2004) reiterates Brown's (1992) finding that the amount of data collected during many design experiments is often too great to be fully analyzed. Though there are many variables that cannot be controlled in design experiments, Collins et al. (2004), maintains that researchers must "try to optimize as much of the design as possible and to observe carefully how the different elements are working out" (p. 19). Such observations, says Collins et al. (2004), require both quantitative and qualitative methods.

This requirement is met with uncertainty in the educational research community. At present, the divide between researchers who advocate strictly quantitative or qualitative methodologies continues, and the use of "mixed methods is far from common" (Hausman, 2000 as cited in Gorarda et al., 2004). Further, the latest guidance on conducting design experiments does not offer a formal procedure for combining data collected through mixed methods (Collins et al., 2004; Gorarda et al., 2004).

What is more, in direct contrast to Brown's (1992) hope that design experiments would produce reliable and repeatable results, researchers, including Brown and Campione (1996 as cited in Collins et al., 2004), have found that "the effectiveness of a design in one setting is no guarantee of its effectiveness in other settings" (p. 18). Collins et al. (2004) also reports that the enacted design is often quite different than what was intended by the designers. He cites Brown and Campione (1996) who term this finding *lethal mutations*, where the design goals are undermined by the enacted design.

Collins et al. (2004) puts forth an additional problem facing design experimentation that he terms *narrow measures*. This problem has to do with the evaluation methods used. Often, a single criterion is evaluated to indicate the success of an intervention, such as learning of content or skills. The problem here is that this criterion is not the only measure of importance to a student's application of training in later life. Such criteria as the motivation to learn and working well with others are often ignored in design evaluations.

A final issue to note is that, in practice, researchers have had a tendency to focus on design without proper regard to the theoretical framework (diSessa & Cobb, 2004). Hence, findings from experiments do not add to the evolution or refinement of theory and are difficult to generalize to future studies (Dede, 2004). Dede labels this type of research as "freewheeling" and guided by a "whatever works" approach (p. 107). He contends that such research projects "start with a predetermined 'solution' and seek educational problems to which it can be applied, a strategy that frequently leads to under-conceptualized research" (p. 107).

Design-Based Research

Now, more than 10 years after the launch of the design experiment approach in education, researchers are beginning to come to an agreement on the proper terminology. According to Sandoval and Bell (2004), "We [the Design-Based Research Collective] have settled on the term design-based research [DBR] over the other commonly used phrases 'design experimentation,' which connotes a specific form of controlled experimentation that does not capture the breadth of the approach, or 'design research,' which is too easily confused with research design and other efforts in design fields that lack in situ research components" (p. 199). The choice of a name for the DBR approach is important in that it leads to a proper definition. Sandoval and Bell (2004), both active members of the Design-Based Research Collective, argue that the research side of the term refers to the work of developmental psychologists, cognitive scientists, learning scientists, anthropologists, and sociologists. The design side of the term refers to the work of computer scientists, curriculum theorists, instructional designers, and teacher educators.

Terms that seem to easily be confused with DBR include *learner-centered design*, *developmental research*, and *development research*. The term learner-centered design stems from *user-centered design* (Soloway, Guzdial, & Hay, 1994). Both of these terms focus on the design and use of human-computer interfaces. Hence, these terms can be regarded as potential subsets of a DBR project with the goal of creating tangible computer-based artifacts. It is important to note that the result of some DBR projects may be less concrete, describing aspects of "activity structures, institutions, scaffolds, and curricula" (Design-Based Research Collective, 2003, p. 6).

The term developmental research is more elusive. To some extent, this term has been linked with research that takes place after the actual design and development process has been completed. van den Akker (1999) uses the term *reconstructive study* to define this type of research. Richey, Klein, & Nelson (2004) define it as *type II developmental research*. Type II developmental research is argued to provide results that are generalizable because they create or enhance theoretical research models (Richey et al., 2004). The developmental research term has also been linked to research that relates closely to the present definition of DBR, which is summarized in the bullet points below. The main difference being that results are not framed in terms of generalizable design principles. Rather, results are assumed to be context-specific. Richey, Klein, & Nelson (2004) define this form of research as *type I developmental research*.

The term development research is the most likely challenger to the term to DBR. Such researchers as van den Akker (1999) and Reeves (2000) have chosen to use it though its definition is interchangeable with that of DBR. In fact, Reeves (2000) nicely sums up what researchers seem to agree on regarding the function of DBR. He lists the critical characteristics of the approach as:

- addressing complex problems in real contexts in collaboration with practitioners;
- integrating known and hypothetical design principles with technological affordances to render plausible solutions to these complex problems; and
- conducting rigorous and reflective inquiry to test and refine innovative learning environments as well as to define new design principles. (Reeves, 2000, p. 26)

Publications by Brown (1992), Collins (1992), van den Akker (1999), the Design-Based Research Collective (2003), and Collins et al. (2004) describe DBR in a manner concurrent with this summation.

The Developing Field of Design-Based Research

The DBR approach is itself very much in the process of development. In this section, several important points about the nature of DBR are discussed including its key characteristics, the introduction and refinement of theoretical concepts, the theoretical breadth of the approach, its scientific underpinnings, and the drive for socially responsible research.

Some interesting new theoretical models have been suggested to help describe the characteristics of DBR as well as a variety of existing learning theories. The interactive learning design (ILD) framework proposed by Bannan-Ritland (2003) attempts to flush out each step of DBR under the main headings of "(a) Informed Exploration, (b) Enactment, (c) Evaluation: Local Impact, and (d) Evaluation: Broader Impact" (p. 21), see Figure 1. Reeves (2000) proposes a general diagram of DBR stages using similar but more descriptive headings. The headings read as follows: (a) "Analysis of practical problems by researchers and practitioners," (b) "Development of solutions

with a theoretical framework," (c) "Evaluation and testing of solutions in practice," and (d) "Documentation and reflection to produce 'design principles'" (Reeves, 2000, p. 25), see Figure 2.

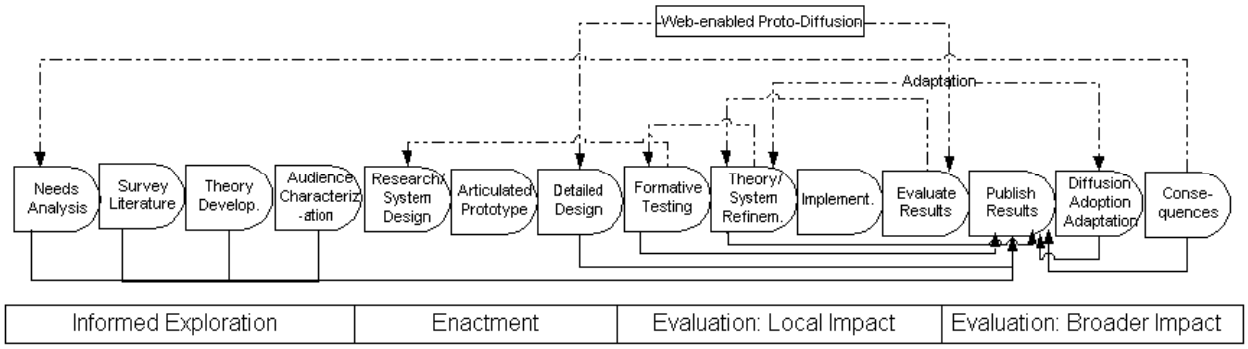

Figure 1: Integrative Learning Design Diagram (Bannan-Ritland, 2003, p.22)

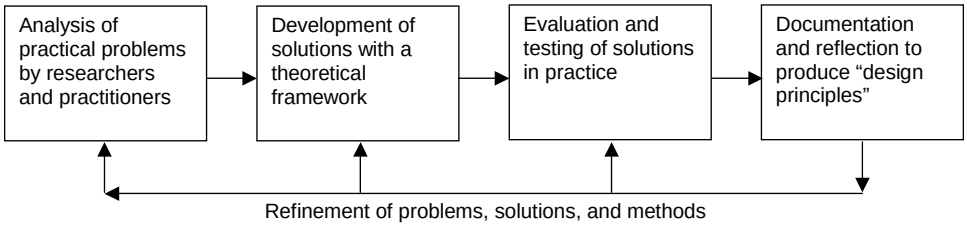

Figure 2: Design-Based Research Diagram (Reeves, 2000, p. 25)

An example of learning theory that has been enhanced through the findings of DBR experimentation is found in the theoretical area of learning transfer. A new theoretical model, termed *actor-oriented transfer*, was put forth by Lobato (2003) to describe the transfer of learning in real-world classroom environments versus laboratory settings. In real-world classroom settings, Lobato argues that researchers must look at learning transfer from the subject's point of view, finding that expert judgments based on observations are often unwarranted.

DiSessa and Cobb (2004) argue that such theoretical findings are one of the key contributions that can come from DBR. The term that they use to describe these types of findings is *ontological innovation* (p. 77). Their argument for the term is based on the generalization that there are many unforeseen issues the come up during DBR experiments due to the intensity and range of observations. This, in turn, leads to ontologically innovative findings that can instruct the introduction and refinement of explanatory theoretical concepts.

Bell (2004) argues that such findings should be welcome in the research community because it is the theoretical work that will ultimately lead to definition of the methodological and epistemological features of DBR. This definition, however, must be broad, argues Bell (2004), encompassing the use of mixed methods and many theoretical approaches possible in educational research. He says, "At a time when many efforts that are reviewing the status of educational research seem to be operating under the working assumption that our theoretical and methodological complexity should be reduced, I argue that rigor and utility can be actively pursued through *pluralism*—a coordination of different theoretical views on learning and education. … Given the inherent complexity associated with learning … we might be best served by exploring how far theoretical and methodological pluralism will carry us in better understanding, promoting, and sustaining innovation in education" (Bell, 2004, p. 251).

In addition to education and research theory, a focal point in the development of the DBR approach has been its link to the term *science*. A growing number of learning scientists are beginning to argue that DBR is a plausible approach to address recent pressure for educational research to be scientific (Sandoval, 2004). According to Hoadley (2004), "Design-based research is, at its heart, an attempt to combine the intentional design of learning environments with the empirical exploration of our understanding of those environments and how they interact with individuals" (p. 205). Nevertheless, some argue that researchers have yet to prove that DBR can produce results that compare to the systematic validity thought to be achievable with scientific experimentation (Shavelson, Phillips, Towne, & Feuer, 2003).

Similar to the debate regarding scientific merit, an important argument for the value of DBR is one of social responsibility. According to Reeves (2000), to be socially responsible, education research must be relevant to practitioners. Further, it must adhere to scientific standards including peer review, verification, replicability, and human safety. Moreover, there must be a focus on complex problems. To explain this point, Reeves, Herrington, & Oliver (2005) cite a recent study conducted by an assistant professor at a prestigious university that compared the effectiveness of one 50-minute lecture delivered in a classroom and on CD-ROM. As expected due to prior instructional technology research, no significant difference was found. Reeves et al. argue that such small-scale, isolated studies cannot provide the robust design principles needed to guide subsequent research.

To conclude, it seems that the founders and champions of DBR tend to pose more questions than answers at this time. There is a general consensus that DBR standards need to be set. Accordingly, further commentary regarding the following questions is expected: What types of research can be considered DBR? What kinds of knowledge can DBR be expected generate? How can DBR account for the generation of extensive, often excessive, amounts of data? What theoretical requirements should be imposed on DBR? What standards should judge the quality of DBR? and To what extent can DBR be classified as scientific?

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