A Journey Through a Design-Based Research Project

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Abstract: This paper discusses how Design-Based Research was utilised to inform the methodological design of a completed project conducted at the University of Wollongong in New South Wales, Australia. The project focused on the systematic development of an Electronic Performance Support System (EPSS) to assist K-12 teachers as they incorporated learning objects into a pedagogically effective learning design – a WebQuest.

The paper specifically details the background of the project, the history of Design-Based research, why a Design-Based Research approach was adopted and how the approach was implemented. The paper also includes a discussion about the practical problems, issues and advantages the researchers encountered as they worked through the Design-Based Research process. Finally the paper concludes with a comparison between Reeves' 2000 Design-Based Research model and his more recent 2006 model.

Introduction

In recent years there has been a dramatic increase in the amount of research, policies and programs concerned with the design, development, and installation of computer-based technologies for use within educational settings. The main focus of these publications is often on improving teaching and learning outcomes. As a consequence governments and private organisations around the world are spending considerable amounts of money connecting their educational institutions to the Internet. A subsequent trend to this growth has been in the expansion of educational software, with one significant area of focus being the development of learning objects. Learning objects, put simply, are any digital resources that can be used to support learning (Wiley, 2000). Basic examples of learning objects might include educational videos, pictures, or web sites; while more advanced examples may include in-depth interactive applications. Whilst learning objects have been around in one form or another for decades, it has only been in the last 10 years that there has been a worldwide focus to develop learning objects specifically for schools and to make them available to teachers via on-line databases or repositories (Friesen, Roberts, & Fisher, 2002; Laurillard & McAndrew, 2003; Suthers, 2001). Despite this worldwide focus, and the vast amounts of money governments and organisations are spending on the necessary infrastructure, there is a growing body of evidence indicating that the uptake of learning objects by K-12 teachers is still in its infancy (Hand et al., 2004; Johnson, 2003; McCormick, Scrimshaw, Li, & Clifford, 2004).

To ensure that this investment in learning object development is effective, it is imperative to find ways that successfully make use of this technology and to provide the necessary professional development to train teachers in these methods (Bratina, Hayes, & Blumsack, 2002; Porter, Garet, Desimone, Yoon, & Birman, 2000). One suggestion that has been put forward as a potential approach to support teachers as they attempt to utilize learning objects is by using generic frameworks which are based on effective pedagogical strategies (Laurillard & McAndrew, 2003; Wiley, 2003). Various frameworks that have been explored in the educational technology research arena include the IMS Learning Design (IMS Global Learning Consortium, 2003), Patterns (Goodyear et

al., 2004), the Learning Design Visual Sequence (The Learning Design Project, 2003) and the Learning Activity Management System (The LAMS Foundation, 2006). Regardless of the terminology or orientation, the commonality of these frameworks, or learning designs, is the focus on providing guidance on sequencing learning experiences through definition of learning activities, resources, and supports. A notable gap in the educational literature associated with these learning designs relates to the disproportional amount of research conducted in tertiary settings. There is however one type of pedagogical framework that has been used and tested in K-12 settings. This type of learning design is known as a WebQuest.

A WebQuest is "an inquiry-oriented activity in which some or all of the information that learners interact with comes from resources on the internet"(Dodge, 1995 , p. 1). A WebQuest will typically present students with a challenging task, which can either be simple and short-term (making an invitation to a class presentation), or more complex and long-term (planning a 4 week holiday overseas in a targeted culture). Students complete these tasks by working through a standardized WebQuest framework. The WebQuest framework is clearly structured into specific attributes: an introduction (sets the scene for the activity); tasks (describes what is to be accomplished); a process (the steps needs to complete the task); an evaluation (how students will be assessed); and a concluding (closure) section.
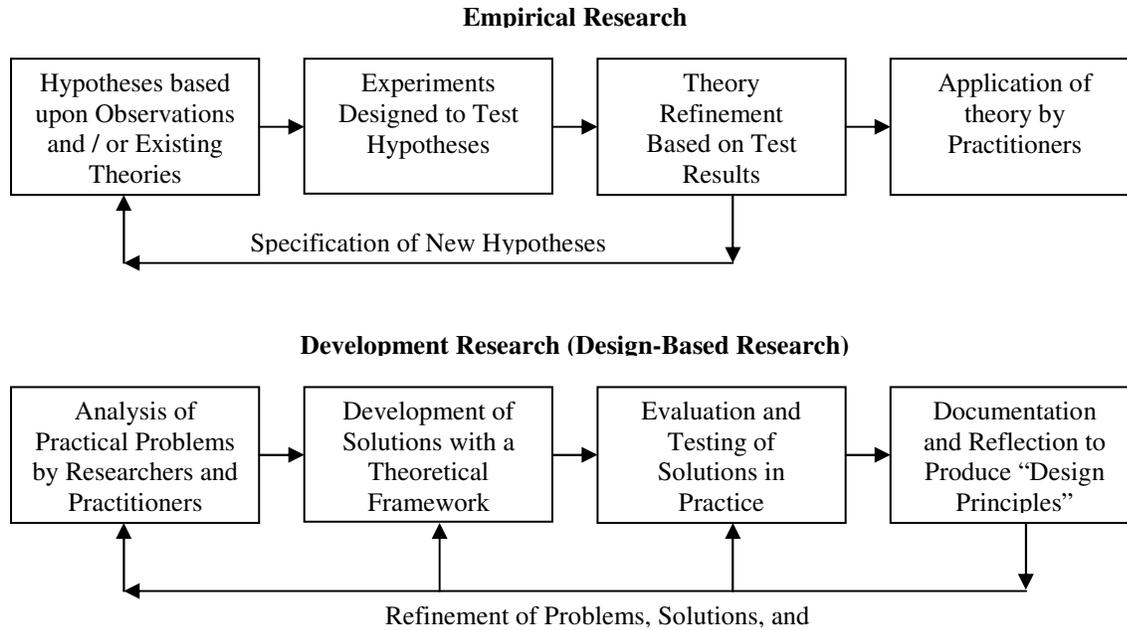
This study set out to explore the notion that an Electronic Performance Support System (EPSS) could be designed and developed to assist K-12 teachers as they worked through the process of incorporating learning objects into a WebQuest. Accordingly, it was necessary to situate this study within an appropriate research paradigm.

Design-Based Research

Design-Based Research, a term synonymous with development research (Reeves, 2000), focuses on solving broad based, complex, real world problems that are critical to education, while at the same time maintaining a commitment to theory construction and explanation (Reeves, Herrington, & Oliver, 2004). This approach also aims at making both practical and scientific contributions in the chosen field (van den Akker, 1999) which Shavelson and Towne (2002) believe is of importance to the educational field. Given this and the continuous design, development and evaluative nature of the research project, it was decided to ground the methodology for this project in the theoretical framework of Design-Based Research.

The concept of Design-Based Research is frequently traced back to the work of Ann Brown (1992) and Allan Collins (1992). They both conducted design experiments and looked at how they were developed as a way to carry out formative research to test and refine educational designs based on principles derived from prior research. Cobb, Confrey, diSessa, Lehrer, & Schauble (2003) have pointed out that, since Brown and Collins work, Design-Based Research has been used in a wide range of educational settings. These settings have ranged from one-on-one situations where the research is conducted on individuals or small groups of students, through to experiments which involve entire school communities.

While this type of methodological approach is not necessarily that different from those in other research approaches, van den Akker (1999) did point out some of the disparities between the philosophical frameworks and goals of Design-Based Research and that of more traditional approaches. Such disparities include the interaction between practitioners and researchers and the way knowledge is gained. In Design-Based Research there is continual interaction between practitioners and researchers throughout the entire research process. Van den Akker believes that this is needed to gradually clarify both the problem at stake and the characteristics of its potential solution. Also in Design-Based Research knowledge is gained in the form of design principles. These design principles however are not the sole outcome of the development research process. A fundamental tenet of this type of research is "the dedication to providing direct benefits to all stakeholders within the context of the research" (Reeves, 2000, p. 10). Reeves (2000) also provided further support for the use of Design-Based Research in applied contexts given its iterative, continual approach, rather than the linear approach of traditional empirical research. Reeves summed up these differences in his original development research illustration, shown below in Figure 1.

Empirical Research

| Hypotheses based upon Observations and / or Existing Theories | → | Experiments Designed to Test Hypotheses | → | Theory Refinement Based on Test Results | → | Application of theory by Practitioners |

Specification of New Hypotheses

Development Research (Design-Based Research)

| Analysis of Practical Problems by Researchers and Practitioners | → | Development of Solutions with a Theoretical Framework | → | Evaluation and Testing of Solutions in Practice | → | Documentation and Reflection to Produce "Design Principles" |

Refinement of Problems, Solutions, and

Figure 1: Differences between empirical research and development research (a term synonymous with DBR) as explained by Reeve's (2000)

Figure 1 clearly illustrates that there are four different and distinct stages in both empirical and Reeves' original Design-Based Research model. The key assumption of empirical research is that practitioners will apply the theory. Reeves and Hedberg (2003) speculate that this assumption is misplaced, especially in education research where persistent, significant problems are present. They claim that this problem is addressed by the continuing cyclic nature at all levels that Design-Based Research offers. It is this cyclic nature that allows for practitioners to be more directly engaged in the conduct of the research. It is also this cyclic nature that allows for the continual collaboration between practitioners, researchers and technologists.

Applying Design-Based Research
The four distinct Design-Based Research phases shown in Reeves' illustration provided the basis for the research approach used in this study as they encapsulated the planning, designing, developing, testing and refining nature of the project. In order to accommodate these four phases and the cyclic nature of original Design-Based Research model, this study was conducted in six stages. A diagrammatic outline of these 6 stages and how they relate to Reeves development research model can be seen in Figure 2.
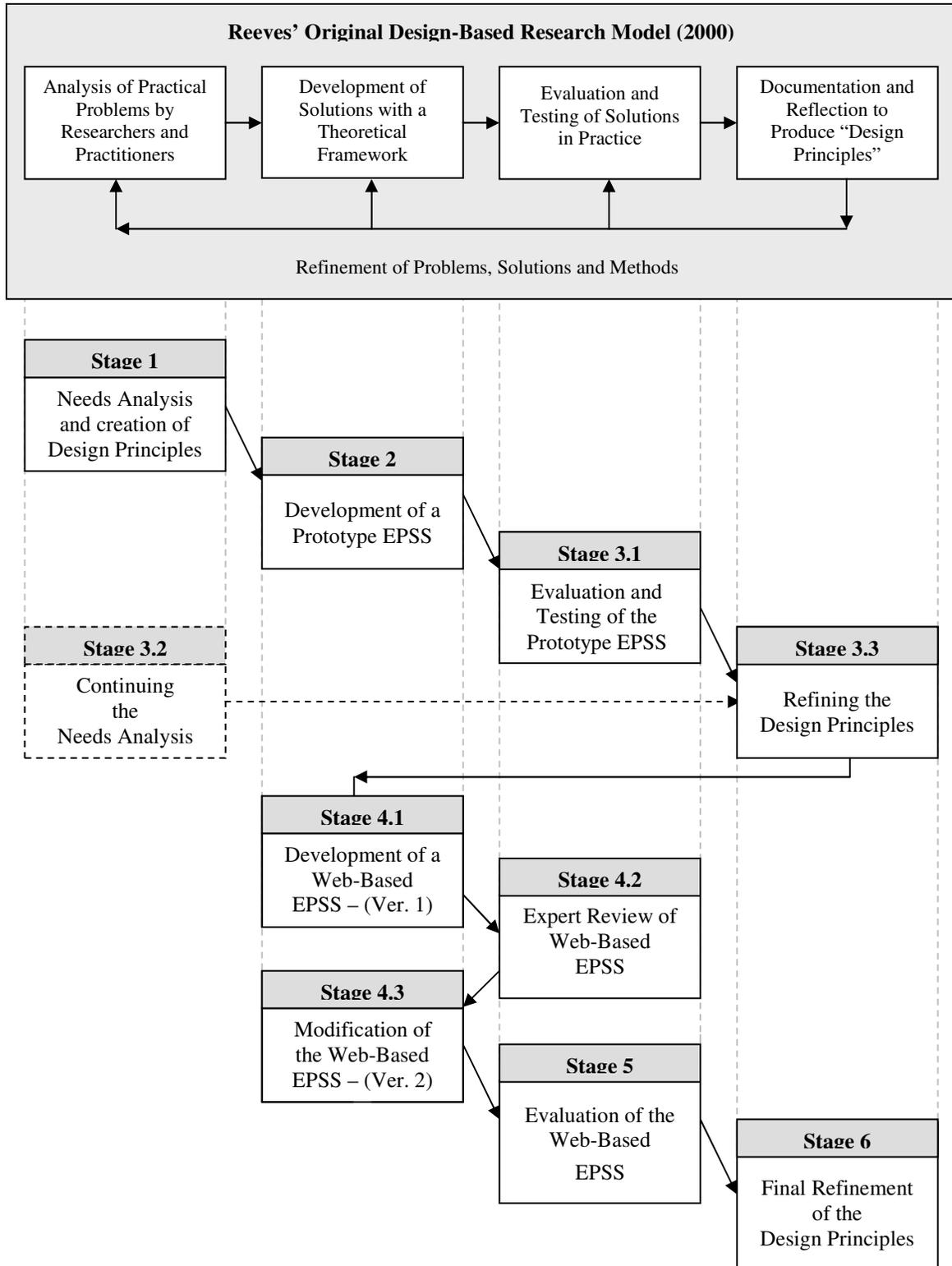
Figure 2 An outline of how Reeves' (2000) original Design-Based Research model provided a base for the methodology used in this project

A detailed breakdown of the six stages shown in Figure 2 is given below:

Stage 1 involved an initial needs analysis to identify what issues practitioners (i.e., K-12 teachers) faced when they attempted to combine learning objects with a learning design. Data for the needs analysis was gathered during and subsequent to a series of four 2-hour workshop sessions in which participants created WebQuests (i.e., learning designs) which incorporated learning objects. The data collected came from: a general information questionnaire about the background of the participants; field notes taken by two observers in the workshop sessions; resource sheets completed by the participants indicating where and why they selected the learning objects used; post workshop interviews with the participants; and, evaluations of the participants' completed WebQuests. This data was then used to create a series of design principles to guide Stage 2. These design principles were in the form of heuristic statements or single sentence 'rules of thumb'.

Stage 2 of the project involved the development of a prototype Electronic Performance Support System designed to support practitioners as they attempted to combine learning objects with learning designs. The underlying structure of the prototype was based on the design principles created in Stage 1, as well as guidelines for developing electronic support systems revealed by a review of literature on the topic. The prototype took the form of a paper-based flowchart, WebQuest templates and a supporting web site.

The third stage of the research involved evaluating and testing the prototype EPSS as well as continuing the needs analysis and refining the design principles. Data for this stage was gathered during and after a subsequent series of four 2-hour Workshop sessions in which participants created learning designs in the form of WebQuests which incorporated learning objects. To ensure reliability the workshop and data collection and analysis techniques were the same as the Stage 1. The analysed data of the project thus far was then used to inform the refinement of the design principles.

Stage 4 of the research process entailed the design and development of a web-based EPSS. The structure and content of the system was based on the design principles developed in this project. This stage also involved an expert evaluation, and subsequent modification of the web-based prototype.

The penultimate stage of the research involved evaluating and testing the web-based EPSS with practitioners within another a similar workshop setting. The workshop was conducted in a similar fashion to the workshops in Stages 1 and 3, and as in these stages data was collected via questionnaires, field notes, resource sheets, interviews and evaluations of the participants completed WebQuests.

The sixth and final stage involved the refinement and continued development of the series of design principles based on the analysed data from Stage 5.

Discussion

The application of these six stages within a real world problem gave the opportunity to critique Reeves' (2000) Design-Based Research model. This opportunity showed a number of advantages of the research framework, as well as practical problems and issues. These strengths and possible areas for improvement are discussed below in relation to the four phases of Reeves' model.

Analysis of Practical Problems by Researchers and Practitioners
This phase of the Design-Based Research model was implemented twice during the study, initially at the start of the study, and then it was revisited during Stage 3. This phase identified the starting point of the project, however a major issue associated with this phase related to the decision of what data to collect and how to collect it. The answers to these questions will vary depending on the research project and the specific type of data. In this study data was collected via questionnaires, observations, resource sheets, evaluations of the participants completed WebQuests, and post workshop interviews. This method of data collection provided more than enough information to give detailed descriptions of the practical problems faced by the practitioners as they attempted to combine learning objects with learning designs.

Development of Solutions with a Theoretical Framework

The second phase in Reeves' Design-Based Research model involved developing a solution (i.e., an EPSS) to solve problems identified in the first phase. This phase proved extremely difficult to implement as there were no guidelines to develop a solution. In order to overcome this problem an additional step in this phase was required. This new step involved developing design principles based on the results from the needs analysis conducted in first phase *and* existing design principles reported in current literature. These newly generated design principles, in the form of heuristic statements, were vital in this study as they provided both a theoretical and practical basis for the systematic development of the EPSS. They also enabled all aspects of the EPSS to be justified.

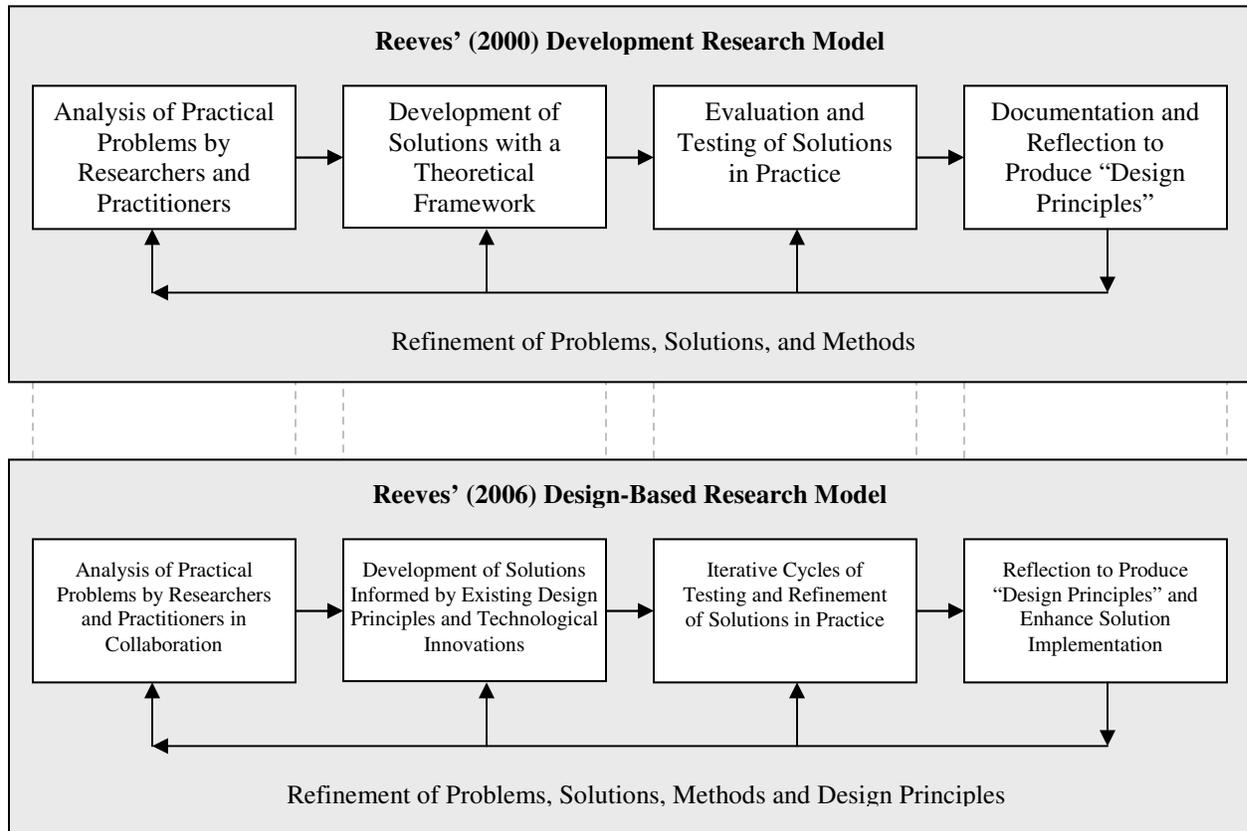*Evaluation and Testing of Solutions in Practice*
The third phase of Reeves' Design-Based Research model involved evaluating and testing the developed solution in a real world setting. This step initially appeared straight forward, however in practice, if Reeves' model was to be closely followed it was hard to implement as the model did not allow for any small changes in the development of the solution without going on to the next phase. An example of this issue came from an expert review of the developed solution (i.e., the EPSS). Expert reviews are considered the "life blood" of the development process (Reeves & Hedberg, 2003) and are an essential component as they have the ability, not only to provide feedback about whether a developed system meets its objectives, but they also provide a form of quality control (Clark, 1995). This necessary procedure in the development the EPSS, and the subsequent modifications of the EPSS, forced the researcher to amend Reeve's model and take a step backwards to redevelop and modify the solution without producing any design principles. An example of this backwards step can be seen after Stage 4.2 in Figure 2 where the flow does not correspond with Reeves' model. If Reeves' model was to be followed exactly design principles should have been produced directly after this step, instead the EPSS was refined before being evaluated and tested.

Documentation and Reflection to Produce "Design Principles"
The final phase of Reeve's model involved the production of a series of design principles. This phase proved to be the strength of the model as these practically tried and scientifically tested design principles actually do provide solutions to real world problems. No issues were found with this phase.

Comparisons between Reeves' 2000 model of Design-Based Research and his 2006 Model

During the time taken to conduct this research, Reeves' (2006) has refined his Design-Based Research model. This superior model, while structurally the same the newer version does contain a number of significant modifications. An overview of this evolution can be seen in Figure 3.

Reeves' (2000) Development Research Model

| Analysis of Practical Problems by Researchers and Practitioners | → | Development of Solutions with a Theoretical Framework | → | Evaluation and Testing of Solutions in Practice | → | Documentation and Reflection to Produce "Design Principles" |

Refinement of Problems, Solutions, and Methods

Reeves' (2006) Design-Based Research Model

| Analysis of Practical Problems by Researchers and Practitioners in Collaboration | → | Development of Solutions Informed by Existing Design Principles and Technological Innovations | → | Iterative Cycles of Testing and Refinement of Solutions in Practice | → | Reflection to Produce "Design Principles" and Enhance Solution Implementation |

Refinement of Problems, Solutions, Methods and Design Principles

Figure 3 The evolution of development research into design-based research

The similarities of the two models shown in Figure 3 are obvious through the design and layout of the models, however the minor changes in the descriptions involved in each step are significant, particularly the second and third steps. The second step in Reeves' 2006 Design-Based Research model includes the introduction of existing design principles. Interestingly, the concept of including existing design principles directly mirrors the issues associated with this Phase in this study. The other major change in Reeves' current model is the iterative cycles introduced in the third step. Interestingly again, this change can also be seen to directly mirror the design, development, expert review and subsequent modifications seen in Stage 4 of this study. The reason why these two points are interesting is that the changes Reeves made to his original model accurately reflect the necessary steps involved in this real-world study, indicating support for the modifications of Reeves' (2006) Design-Based Research model.

In conclusion the issues associated with implementing Reeve's development research model appear to have been resolved in his revised Design-Based Research model. Although to what extend will only be decided through future testing and research.

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