Design-Based Research

11

Chapter Outline

- Characters of design-based research
- The process of design-based research
- DBR and traditional empirical research methods.

By the End of This Chapter, You Should Be Able To

- Clarify the characteristics of design-based research
- Use design-based research (DBR) to design research procedures
- Identify the differences of DBR and traditional empirical research methods.

Main Learning Activities

1. Think about when one would do design research and how to do a design-based research in educational technology. Try to think of such an effort in the context of a specific technology-based implementation.
2. After you learn the characters and process of DBR (design-based research), please draw a mind map to illustrate the relationships between the key steps of DBR. Please discuss with your peers about the differences of DBR and the traditional predictive research methods. When you are carrying out educational technology research, what methods will you use and why?

11.1 Introduction

There are two main types of educational research. The first is basic research, which is also referred to as an academic research approach. The second type is applied research (or contract research). Both of these research types have different purposes which influence the nature of the respective research.

The basis for educational research is the scientific method. The scientific method uses directed questions and manipulation of variables to systematically find information about the teaching and learning process. This scenario questions are answered by the analysis of data that are collected specifically for the purpose to answer these questions. The two main types of data that are used under this method are qualitative and quantitative.

Qualitative research uses data which are descriptive in nature. Tools that educational researchers use in collecting qualitative data include observations, conducting interviews, conducting document analysis, and analyzing participant products such as journals, diaries, images, or blogs. Quantitative research uses data that are numerical and are based on the assumption that the numbers will describe a single reality. Statistics are often applied to find relationships between variables. Both quantitative and qualitative research are/or can be consistent with a basic or traditional scientific approach aimed at uncovering the relationship between variables and factors involved in an implementation and learning outcomes.

The element of design in learning and educational research has been paid more attention recently. One of the traditional factors addressed is the extent to which an approach or design contributed to or inhibited outcomes. Previously, that aspect was addressed by formative evaluations. Recently, the quality of the design process itself has come under closer scrutiny. Design-based research and design methodology are becoming more and more important for educational technology research and educational product development. The following sections will introduce the design-based research in details.

11.2 The Concept of Design-Based Research

Design-based research (DBR) was proposed as design experiments in articles by Brown (1992) and Collins (1992). And now, it is a type of research methodology commonly used by researchers in the learning sciences. Design-based research is a systemic approach to the planning and implementing of innovations that emphasize an iterative approach to design with ongoing involvement collaboration with practitioners. DBR goes beyond formative evaluation research as the focus is on the rationale for design decisions and changes in the design as a technology-based learning effort evolves, although DBR can still be considered a kind of formative evaluation research (Spector & Yuen, 2016).

The solutions that result from educational design research can be educational products (e.g., a multi-user virtual world learning game), processes (e.g., a strategy for scaffolding student learning in online courses), programs (e.g., a series of workshops intended to help teachers develop more effective questioning strategies), or policies (e.g., year-round schooling). Researchers attempt to solve significant real-world problems while at the same time they seek to discover new knowledge that can inform the work of others facing similar problems (Spector & Yuen, 2016).

Within design-based research methodology, interventions are conceptualized and then implemented iteratively in natural settings to test the ecological validity of the dominant theory and to generate new theories and frameworks for conceptualizing learning, instruction, design processes, and educational reform.

11.3 Key Characteristics of DBR

Design-based research exhibits the following characteristics: pragmatic, grounded, interventionist, iterative, collaborative, adaptive, and theory-oriented (Cobb et al., 2003).

Pragmatic: it is concerned with generating usable knowledge and usable solutions to problems in practice.

Grounded: it uses theory, empirical findings, and craft wisdom to guide the work.

Interventionist: it is undertaken to make a change in a particular educational context.

Iterative: it evolves through multiple cycles of design, development, testing, and revision.

Collaborative: it requires the expertise of multi-disciplinary partnerships, including researchers and practitioners, but also often others (e.g., subject matter specialists, software programmers, or facilitators).

Adaptive: the intervention design and sometimes also the research design are often modified in accordance with emerging insights.

Theory-oriented: it uses theory to ground design, and the design and development work is undertaken to contribute to a broader scientific understanding.

11.4 The Process of Design-Based Research

The design-based research process has been described as iterative, as well as flexible (Kelly et al., 2008). While multiple cycles of activity are clearly present across most models and frameworks, flexibility is present in all models. Figure 11.1
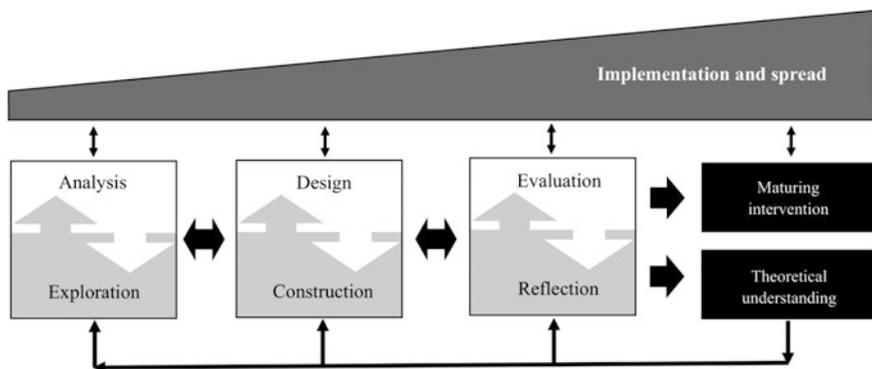
Fig. 11.1 A generic model for conducting design-based research. Adapted from McKenney and Reeves (2012)

shows the generic model for conducting design-based research, and it contains these features (McKenney & Reeves, 2012):

- Three core phases in a flexible, iterative structure: analysis, design, and evaluation.
- Dual focus on theory and practice: integrated research and design processes; theoretical and practical outcomes.
- Indications of being use-inspired: planning for implementation and spread; interaction with practice; contextually responsive.

11.4.1 Analysis and Exploration

The first phase of design-based research is the analysis and exploration, which includes problem identification and diagnosis. As noted by Bannan-Ritland (2003): "The first phase of design-based research is rooted in essential research steps of problem identification, literature survey, and problem definition" (p. 22). In line with the exploratory nature of design research, driving questions should, therefore, be open in nature. In this phase, people state problems through consultation with researchers and practitioners, analysis the research questions, and do a literature review.

The main products resulting from this phase are both practical and theoretical.

From the practical perspective, this phase generates a clear understanding of the problem and its origins as well as specification of long-range goals. In addition, partial design requirements are determined by exploring the opportunities and boundary conditions present; and initial design propositions are generated based on contextual insights.

From the theoretical perspective, this phase produces a descriptive and analytical understanding of the given class of problems, as manifested in this case within a particular context.

11.4.2 Design and Construction

The second phase is design and construction, which is a coherent process followed and documented to arrive at a (tentative) solution to the problem. Unlike the other two main phases which follow empirical cycles based on a research chain of reasoning, the microcycle of design and construction resembles that of creating (not testing) a conceptual model.

Design refers to generate potential solutions to the problem, develop draft principles to guide the design of the intervention. Construction refers to the process of taking design ideas and applying them to actually manufacture the solution. This generally takes place through a prototyping approach, where successive approximations of the desired solution are (re-)created.

The results of this phase are a research proposal, which includes details of the methodology of the intervention, implementation, and evaluation of the proposed solution, as it largely constitutes the data collection and analysis stages of the study.

From the practical perspective, the intervention is conceived and assembled. From a theoretical perspective, the frameworks underpinning design as well as the justification for design decisions are articulated.

11.4.3 Evaluation and Reflection

The third phase is evaluation and reflection. Evaluation refers to the empirical testing that is done with a design or a constructed intervention (that is, the embodiments of design in the initial, partial, or final form).

Reflection involves active and thoughtful consideration of what has come together in both research and development (including theoretical inputs, empirical findings, and subjective reactions) with the aim of producing theoretical understanding. Reflection is benefited most when approached through a combination of systematic and organic techniques.

The results of empirical findings, as well as critical reflection are then used to accept, refine, or refute the conjectures, frameworks, or principles that are portrayed in design documents (e.g., design frameworks) or embodied in actual (prototypes of) interventions. McKenney and Reeves (2012) depicted the elements and outcome of three phases of DBR in Table 11.1.

Table 11.1 Elements and outcome of three phases of DBR

Phase of design-based research	Elements	Outcome
Phase 1: Analysis and exploration	Statement of problem • Consultation with researchers and practitioners • Analysis research questions • Literature review	• Statement of problem or Introduction or Rationale or background • Research question and review
Phase 2: Design and construction	Solution framework • Development of draft principles to guide the design of the intervention • Description of proposed intervention • Design principles Implementation of intervention • Participants • Data collection • Data analysis	• Design principles • Designed intervention • Intervention program
Phase 3: Evaluation and reflection	• Evaluation • Critical reflection • Artifact(s) refinement • Intervention refinement • Professional development	• Maturing interventions • Theoretical understanding

11.4.4   Interaction with Practice: Implementation and Spread

The three core processes (analysis and exploration; design and construction; and evaluation and reflection) are interacting with practice through the (anticipation of) implementation and spread of interventions.

Researchers and practitioners jointly anticipate and plan for it from the very first stage of analysis and exploration, e.g., by tempering idealist goals with realistic assessments of what is possible; by taking practitioner concerns seriously; and by studying what intrinsic motives and natural opportunities are already present in the target setting.

This can include many kinds of professionals whose work relates to educational practice, such as teachers, administrators, teacher educators, examination agencies, inspectorates, policy makers, and textbook publishers. During analysis and exploration, this involvement is geared primarily toward clarifying the problem and shaping and understanding of constraints within which design will have to operate.

11.4.5   Two Main Outputs

In design-based research generic model, there are two main outputs: maturing interventions and theoretical understanding. Both outputs ripen over time and can be more locally relevant or more broadly applicable.

The intervention itself contributes directly to practice (by addressing the problem at hand) and indirectly to theoretical understanding (as one example of how specific, articulated, design frameworks can be reified). The theoretical understanding is produced through (usually several) micro and/or mesocycles of design research.

The empirical findings and resulting conjectures provide important building blocks for theory, and can also contribute indirectly to practice as these ideas may be shared among professionals and used to build new interventions.

11.5   Dbr and Traditional Empirical Research

Reeves (2006) draws a clear line between research conducted with traditional empirical goals and that inspired by development goals leading to "design principles," as shown in Fig. 11.2.

The traditional empirical research proposed the hypotheses based on observation and existing theories, which is tested by the design experiment. Then, the theory is refined based on the test results. Finally, practitioners apply the refinement theory. The cycle of traditional empirical research is the specification of new hypotheses.
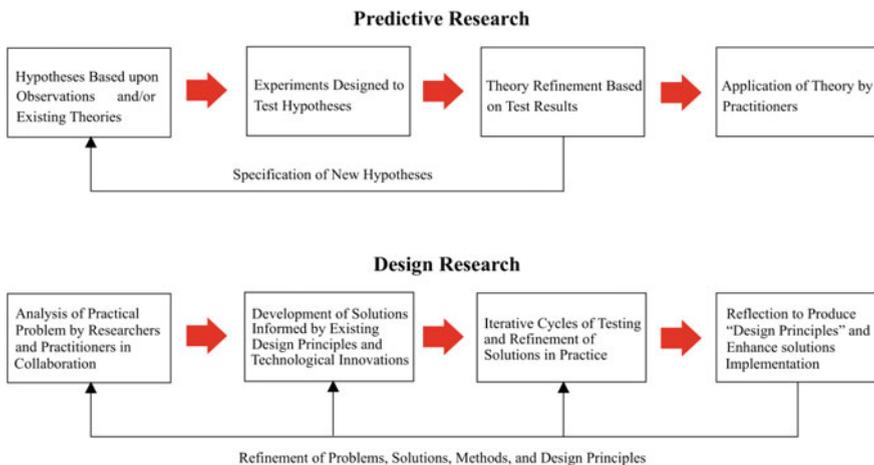
Predictive Research

| 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

Design Research

| Analysis of Practical Problem 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 solutions Implementation |

Refinement of Problems, Solutions, Methods, and Design Principles

Fig. 11.2 Differences between design research and predictive research. Adapted from Reeves (2006)

The design-based research is based on the analysis of practical problems by researchers and practitioners in collaboration. Then, combine with the existing design principles and technology innovation to develop the solution, test and refine solutions iteratively in practice. Last, reflect the implementation of design principles and solutions. Design-based research is not for testing hypotheses, but for refining of problems, solutions, methods, and design principles.

11.6   Case Study

Different research reports are used here to illustrate the variety of educational design-based research conducted within the field of educational technology.

The first case is conducted by Thomas et al. (2009), with substantial funding from the National Science Foundation and other sources. He put his efforts to refine a theory of transformational play while at the same time seeking to develop advanced forms of interactive learning games. It contains three qualitative studies focused on the challenges and successes involved in implementing Quest Atlantis, a 3D multi-player virtual environment (MUVE), which serves as the primary vehicle for instantiating Barab's transformational play learning theory and for allowing it to be refined through iterative design-based research.

The second case is co-led by an at-the-time early career assistant professor, Klopfer and Squire (2008), with start-up funding from Microsoft and other sources. It is a multi-year project to enhance student learning related to environmental science through the development and refinement of learning games that are accessed with handheld devices such as PDAs and smart phones. In addition to developing an array of learning games, the project has sought to develop and refine a theoretical framework called "augmented reality educational gaming" that can be applied by other game designers. Meanwhile, it focuses on iterative design cycles based on five case studies conducted in real high school classrooms.

The third case is carried out by Oh (2011), working with one other doctoral student and a practitioner with no funding beyond a graduate teaching assistantship. It pursued two primary goals: (1) optimizing collaborative group work in an online graduate-level course focused on "E-Learning Evaluation," and (2) developing a refined model of group work in online courses and identifying design principles for supporting online collaborative group work among adult learners. Oh use mixed methods to apply across several semester-length iterations of an online course to yield multiple distinct design principles for supporting group work by adults.

For each case, the problem addressed, the primary focus of the research, the intervention that was developed, the theoretical contributions, the methods used, and the scope of the intervention involved as well as its practical contribution are summarized in Table 11.2.

Table 11.2 Comparison of three different cases

	Thomas et al. (2009)	Klopfer and Squire (2008)	Oh (2011)
Problem	Middle school students were relatively unengaged in meaningful scientific inquiry	High school and college students were frequent users of handheld devices such as smart phones, but were not using them to learn	Graduate student collaboration in online learning course was super facial and unproductive
Research main focus	Investigating the implementation of a technology-rich educational innovation in a public elementary school in the USA	Developing innovative applications for mobile computing for environmental science education	To optimize collaborative group work and student learning in an online higher education learning environment
Research methods used	Observations Interviews Surveys Document analyses Three qualitative case studies	Observations Interviews Focus groups Discourse analysis Case studies	Participant observations Questionnaires Interviews Three sequential case studies Design narratives
Intervention developed	Quest Atlantis: a 3D multi-player virtual environment	A series of games that can be played on handheld devices such as PDA and smart phones	"E-learning Evaluation" course based on authentic tasks for online delivery
Knowledge created	Theory of transformational play	Theoretical framework called "augmented reality educational gaming."	Multiple design principles and associated strategies to enhance group work in online courses
Implementation and spread	This design research initiative has been underway for more than a decade. As of 2010, Quest Atlantis had been used by 50,000 students in more than a dozen countries	The design research study has been underway since 2001, and started with this project is now part of the games, learning, and society group at the University of Wisconsin where numerous learning games can be found	An online course design for a graduate-level course based around authentic tasks was developed with substantial support for group work, which lasted two years

Key Points in This Chapter

(1) Design-based research is a systemic approach to the planning and implementing of innovations that emphasize an iterative approach to design with ongoing involvement and collaboration with practitioners.
(2) Design-based research exhibits the following characteristics: pragmatic, grounded, interventionist, iterative, collaborative, adaptive, and theory-oriented.
(3) Three core phases of DBR include analysis and exploration, design and construction, evaluation and reflection.

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