

Adapting Design-Based Research as a Research Methodology in Educational Settings

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Abstract

Recently, design-based research has received a significant amount of attention in educational research literature. Accordingly, we aim from this paper at reviewing design-based research literature in order to provide the educational researchers with different aspects of this research methodology that might contribute to guiding them to use effectively this methodology to address the critical issues that occur in their educational settings. These aspects involve (1) research paradigms and design-based research, (2) design-based research in terms of its emergence, (3) definition, (4) purposes and characteristics, (5) the procedure for conducting it, (6) ensuring the required rigour in the findings, (7) the participants, and (8) data collection and analysis techniques. Finally, a conclusion is included.

Keywords: design-based research, research, methodology, education

1. Research Paradigms and Design-Based Research

The literature on research processes points out that a researcher has to set out with a clear vision with regard to paradigms or worldviews, which generally provide researchers with philosophical, theoretical, instrumental, and methodological foundations that underpin the paradigms of their studies. These will shape decision-making and enable the researcher to successfully carry out the research process (Burrell & Morgan, 1985; Myers, 2000; Schuh & Barab, 2007). More specifically, Dills and Romiszowski (1997) stated:

Paradigms define how the world works, how knowledge is extracted from this world, and how one is to think, write, and talk about this knowledge. Paradigms define the types of questions to be asked and the methodologies to be used in answering them. Paradigms decide what is published and what is not published. Paradigms structure the world of the academic worker, provide its meaning and its significance. (p. 11)

Ontology, epistemology, methodology, and methods characterise any research paradigm (Creswell, 2007; Guba & Lincoln, 1994). In this context, ontology is “the starting point of all research” (Grix, 2004, p. 59). “Epistemology should inform methodology, which in turn, informs methods” (Henn, Weinstein, & Foard, 2006, p. 18).

Generally, there are various philosophical assumptions that undergird any decision to adopt a given research paradigm and conduct research accordingly (Grix, 2004; Guba, 1990; Mackenzie &

Knipe, 2006; White, 1999). A paradigm, according to Neuman (2007), is an “integrated set of assumptions, beliefs, models of doing good research, and techniques for gathering and analysing data” (p. 41). On the other hand, positivism (objectivism, and realism); interpretivism (constructivism, naturalism, idealism, and rationalism); critical theory (transformativism, and relativism); and pragmatism (functionalism) comprise the main educational research paradigms (Grix, 2004; Henn, et al., 2006; Luo, 2011; Mackenzie & Knipe, 2006; Neuman, 2007; Schuh & Barab, 2007; White, 1999).

Education research is conducted to achieve different purposes and functions, such as describing, comparing, evaluating, explaining, designing, and developing elements of the teaching and learning process (Plomp, 2007). These purposes and functions can be accomplished by using different research methodologies, which refer generally to “principles, procedures, and practices that govern research” (Marczyk, DeMatteo, & Festinger, 2005, p. 22). However, Plomp (2007) suggested the following purposes that can be served by using the various research methodologies indicated:

- Survey: to describe, to compare, to evaluate;
- Case studies: to describe, to compare, to explain;
- Experiments: to explain, to compare;
- Action research: to design/ develop a solution to a practical problem;
- Ethnography: to describe, to explain;
- Correlational research: to describe, to compare;
- Evaluation research: to determine the effectiveness of a programme; and
- Design research: to design/develop an intervention (such as programmes, teaching-learning strategies and materials, products and systems) with the aim to solve a complex educational problem and to advance our knowledge about the characteristics of these interventions and the processes to design and develop them. (p. 12)

The majority of writers in the literature on research methodologies agree that pragmatism is an appropriate paradigm for underpinning design-based research (Barab & Squire, 2004; Juuti & Lavonen, 2006). Furthermore, the term pragmatism “is derived from the Greek words ‘pragmein’ and ‘pragma’ (thing and fact) which literally mean ‘to do.’ The emphasis is on what is done; on outcomes rather than ideas or ideals” (Mouton, 1996, p. 8). In addition, pragmatism “was first introduced through the works of Charles Sanders Peirce (1839–1914), and then further developed by William James (1842–1910), and John Dewey (1859–1952)” (Given, 2008, pp. 671-672). The pragmatic paradigm was founded by the above philosophers “in order to provide an answer to the mind-body-problem: how our immaterial mind can acquire knowledge of a material world” (Juuti & Lavonen, 2006, p. 57). That indicates that the philosophy of pragmatism is concentrated on the neutral of truth. Thus, the pragmatists believe that “truth is found in ‘what works’ and that truth is relative to the current situation” (Given, 2008, p. 672).

Finally, the pragmatic paradigm has a set of characteristics that distinguish it from other research paradigms; Creswell (2007) sums up these characteristics as follows:

- Pragmatism is not committed to any one system of philosophy and reality.
- Individual researchers have a freedom of choice. They are ‘free’ to choose the methods, techniques, and procedures of research that best meet their needs and purposes.
- Pragmatists do not see the world as an absolute unity.
- Truth is what works at the time; it is not based in a dualism between reality independent of the mind or within the mind.

- Pragmatist researchers look to the ‘what’ and ‘how’ to research based on its intended consequences—where they want to go with it.
- Pragmatists agree that research always occurs in social, historical, political, and other contexts.
- Pragmatists have believed in an external world independent of the mind as well as those lodged in the mind. But they believe that we need to stop asking questions about reality and the laws of nature. (p. 23)

2. The Emergence of Design-Based Research

Overall, there is a strong and complicated relationship between theory and practice in educational research (Moore, 1982). Theory, according to Neuman (2007), is “a system of interconnected abstractions or ideas that condenses and organises knowledge about the social world” (p. 24). Hence, Pring (2004) emphasised that educational research should generally contribute to building up the theory and then, this theory should be put into practice.

Recently, the majority of educational research literature has acknowledged that educational research is often divorced and alienated from our educational issues and daily practices (Juuti & Lavonen, 2006; Sari & Lim, 2012). Indeed, different reasons have been advanced to explain this issue; one of these reasons is that much educational research concentrates mainly on “research about education” (Juuti & Lavonen, 2006, p. 54) that aims at understanding educational problems, rather than “research for education” (Juuti & Lavonen, 2006, p. 54) that aims to bridge the gaps between the theoretical aspect and the practical aspect of research within the educational environment (Henn, et al., 2006).

As design-based research has emerged as a reaction against the failure of some traditional research methodologies to link theory and practice within educational research, and as a means of generating useful knowledge to guide educational practice (Design-Based Research Collective, 2003; Dix, 2007; Lai, Calandra, & Ma, 2009; Ma & Harmon, 2009). In addition, Parker (2011) stated that design-based research “is being used more and more in education” (p. 1) because it “combines research, design, and practice into one process, resulting in usable products that are supported by a theoretical framework” (Bowler & Large, 2008, p. 39).

Finally, there is total agreement across the research literature that design-based research is a research methodology (Herrington, McKenney, Reeves, & Oliver, 2007; O’Donnell, 2004; Wang & Hannafin, 2005). Likewise, the Design-Based Research Collective (2003) supported this agreement by indicating that design-based research is “a coherent methodology that bridges theoretical research and educational practice” (p. 8).

3. Definition of Design-Based Research

Design-based research is not new, but recently, given the reasons discussed above, it has received a significant amount of attention in educational research. The literature on research methodologies shows that design-based research is also known as design experiments, design research, design studies, design science, development research, developmental research, fermentative research, fermentative inquiry, fermentative experiments, and ermentative evaluation (Andriessen, 2007; O’Donnell, 2004; Parker, 2011; Sari & Lim, 2012; van den Akker, 1999). Hence, throughout this paper, we preferred to use design-based research instead of another term because it is most commonly used in the research literature and, as the Design-Based Research Collective (2003) mentioned, using it helps to avoid confusion with “studies of designers.”

In addition to the above, Collins (1992) in his report entitled *Toward a design science of education*, and Brown (1992) in her article entitled “Design experiments: Theoretical and

methodological challenges in creating complex interventions in classroom settings,” were the first authors who introduced design-based research as a methodology in education research (O’Donnell, 2004). Moreover, Herrington, et al. (2007) suggested that, according to Collins and Brown, design-based research involves:

- 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. (p. 4090)

Finally, a wide range of definitions of design-based research have been presented in the literature. For example, Shavelson, Phillips, Towne, and Feuer (2003) mentioned that design-based research is “based strongly on prior research and theory and carried out in educational settings, seeks to trace the evolution of learning in complex, messy classrooms and schools, test and build theories of teaching and learning, and produce instructional tools that survive the challenges of everyday practice” (p. 25). In addition, Barab and Squire (2004) stated that design-based research is a “series of approaches, with the intent of producing new theories, artefacts, and practices that account for and potentially impact learning and teaching in naturalistic setting” (p. 2). Further, Wang and Hannafin (2005) defined it as “a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories” (pp. 6–7).

It appears from the above definitions of design-based research, that Wang and Hannafin’s definition is most persuasive because it provides comprehensive details about design-based research from different perspectives.

4. Purposes and Characteristics of Design-Based Research

Generally, the main purpose that design-based research aims at achieving is to “address complex problems in educational settings”(Sari & Lim, 2012, p. 2) in order to “build a stronger connection between educational research and real-world problems”(Amiel & Reeves, 2008, p. 34), while “supporting design and development of prototypical products to solve complex authentic context-specific problem”(Lai, et al., 2009, p. 120).

More specifically, by using design-based research, different outcomes can be obtained (Design-Based Research Collective, 2003; Juuti & Lavonen, 2006). One of these outcomes is the production of design principles (Bowler & Large, 2008; Juuti & Lavonen, 2006), which as mentioned above, “can be implemented by others interested in studying similar settings and concerns”(Amiel & Reeves, 2008, p. 35) in order to address complex problems in educational settings. In addition, it can offer beneficial methodological tools for researchers who seek to understand different variables within a naturalistic context (Instructional Technology Ph.D students at the University of Georgia, 2006b). Furthermore, design-based research can generate new theories or help to develop existing ones (Bowler & Large, 2008; Juuti & Lavonen, 2006), but generating new theories according, to Amiel and Reeves (2008), can “only occur after long-term engagement and multiple design investigations” (p. 35). For that reason, Barab and Squire (2004) stated that design-based research “requires more than simply showing a particular design works but demands that the researcher (move beyond a particular design exemplar to) generate evidence-based claims about learning that address contemporary theoretical issues and further the theoretical knowledge of the field” (pp. 5–

6). Accordingly, Edelson (2002) pointed to three types of theories that can be generated from design-based research. These include:

- **Domain Theories:** A domain theory is the generalisation of some portion of a problem analysis. Thus, a domain theory might be about learners and how they learn, teachers and how they teach, or learning environments and how they influence teaching and learning;
- **Design Frameworks:** A design framework is a generalised design solution. Although design theories are descriptive, design frameworks are prescriptive. They describe the characteristics that a designed artefact must have to achieve a particular set of goals in a particular context;
- **Design Methodologies:** A design methodology is a general design procedure. Like a design framework, it is prescriptive. However, a design methodology provides guidelines for the process rather than the product. (pp. 113–115)

Finally, design-based research has some similarities with other research methodologies such as participatory action research, formative evaluation research, ethnography, and positivist experiments (Hoadley, 2011; MacDonald, 2008). Yet, design-based research has a set of characteristics that distinguish it from these methodologies. Thus, Wang and Hannafin (2005) summarised these characteristics as shown in Table 1.

Table 1. Characteristics of Design-based Research

Characteristics	Explanations
Pragmatic	<ul style="list-style-type: none"> • Design-based research refines both theory and practice. • The value of theory is appraised by the extent to which principles inform and improve practice.
Grounded	<ul style="list-style-type: none"> • Design is theory-driven and grounded in relevant research, theory, and practice. • Design is conducted in real-world settings and the design process is embedded in, and studied through, design-based research.
Interactive, iterative, and flexible	<ul style="list-style-type: none"> • Designers are involved in the design processes and work together with participants. • Processes include iterative cycles of analysis, design, implementation, and redesign. • Initial plan is usually insufficiently detailed so that designers can make deliberate changes when necessary.
Integrative	<ul style="list-style-type: none"> • Mixed research methods are used to maximise the credibility of ongoing research. • Methods vary during different phases as new needs and issues emerge and the focus of the research evolves. • Rigour is purposefully maintained and discipline applied appropriate to the development phase.
Contextual	<ul style="list-style-type: none"> • The research process, research findings, and changes from the initial plan are documented. • Research results are connected with the design process and the setting. • The content and depth of generated design principles varies. • Guidance for applying generated principles is needed.

Note. Adapted from Wang and Hannafin (2005, p. 8).

5. Conducting Design-Based Research

Different designs for conducting design-based research have been suggested throughout the design-based research literature (Juuti & Lavonen, 2006; Wang & Hannafin, 2005), but the majority of researchers indicated that design-based research lacks an established process for its conduct because it is still an emerging methodology (Joseph, 2004; Ma & Harmon, 2009). However, Instructional Technology Ph.D students at the University of Georgia (2006a) pointed to nine general steps that should be taken into account when conducting design-based research. These are described as follows: (a) begin with a meaningful problem, (b) collaborate with practitioners, (c) integrate

robust theory about learning and teaching, (d) conduct literature review, needs analysis, etc., to generate research questions, (e) design an educational intervention, (f) develop, implement, and revise the design intervention, (g) evaluate the impact of the intervention, (h) iterate the process, and (i) reporting the findings of design-based research. Furthermore, the intervention in design-based research could include “programmes, teaching-learning strategies and materials, products, and systems” (Plomp, 2007, p. 13), and other similar types.

More specifically, McKenney (2001) suggested three phases for conducting design-based research; these involve (a) needs and context analysis, (b) design, development, and formative evaluation, and (c) semi-summative evaluation. In addition, Collins, Joseph, & Bielaczyc (2004) developed guidelines for carrying out design-based research, which include (a) implementing a design, (b) modifying a design, (c) identifying multiple ways of analysing the design, (d) measuring dependent variables, (e) measuring independent variables, and (f) reporting on design research. Moreover, there is another design for conducting design-based research that is commonly cited in many studies that have used design-based research (e. g., Ashford-Rowe, 2008; Dix, 2007; Hood, 2008; Mantei, 2008; Parker, 2011; Sari & Lim, 2012). This design, however, was developed by Reeves (2000; 2006) who suggested four phases for carrying out design-based research, as Figure 1 shows; these include (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.’

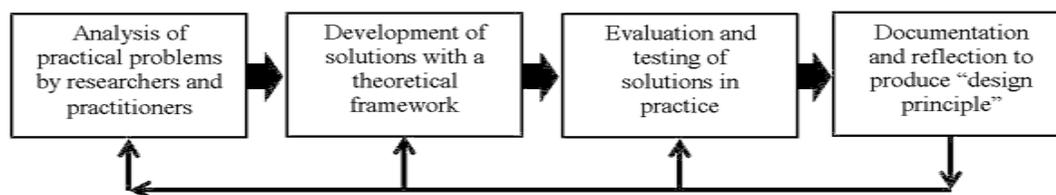


Figure 1. Reeves’s phases in the conduct of design-based research

Note. Adapted from Reeves (2000).

Finally, Plomp (2007) examined the above designs for conducting design-based research and concluded that the majority of writers cited in the literature agree that design-based research should comprise the following three phases:

- Preliminary research: needs and context analysis, review of literature, development of a conceptual or theoretical framework for the study;
- Prototyping phase: iterative design phase consisting of iterations, each being micro-cycle of research with formative evaluation as the most important research activity aimed at improving and refining the intervention;
- Assessment phase: (semi-) summative evaluation to conclude whether the solution or intervention meets the pre-determined specifications. As also this phase often results in recommendations for improvement of the intervention, we call this phase semi-summative. (p. 15)

From the guidelines discussed above for conducting design-based research, Plomp’s three phases constituted an appropriate design because it seemed that these phases covered all different activities and iterative cycles that a study based on design-based research principles should take into account.

6. Rigour in Design-Based Research

As with any other research methodologies, design-based research faces different challenges that might threaten the rigour of its findings (Design-Based Research Collective, 2003; Dix, 2007; Juuti & Lavonen, 2006; Plomp, 2007). These are reflected in data collection and analysis techniques, which represent “the heart of rigour” (Hoadley, 2004, p. 203). Accordingly, Design-Based Research Collective (2003) indicated that design-based research is “empirical research,” so the objectivity, validity, and reliability are all necessary to make the findings of design-based research meet acceptable standards.

Indeed, design-based research literature has not yet provided strict criteria for evaluating the rigour of the findings of design-based research in terms of objectivity, validity, and reliability; rather it includes discussions of these issues and some suggested strategies that can be used for achieving that rigour (Juuti & Lavonen, 2006; Plomp, 2007). Therefore, Kelly (2004) emphasised that design-based research experts should pay considerable attention to developing clear criteria that can be employed for ensuring objectivity, validity, and reliability in the findings of design-based research.

As mentioned above, design-based research is generally viewed as empirical research, so Plomp (2007), Shavelson, et al. (2003), and Wang and Hannafin (2005) pointed out that design-based research’s researchers have to meet and apply the guiding principles for scientific research in order to maintain the necessary rigour in their findings. Accordingly, Plomp (2007) suggested employing Shavelson and Towne’s guiding principles for scientific research. In this regard, Shavelson and Towne (2002) developed six guiding principles that underlie all scientific inquiry, including education research. These guiding principles suggest that a researcher should

- pose significant questions that can be investigated empirically;
- link research to relevant theory;
- use methods that permit direct investigation of the question;
- provide a coherent and explicit chain of reasoning;
- replicate and generalise across studies; and
- disclose research to encourage professional scrutiny and critique. (pp. 3–5)

More specifically, with regard to achieving objectivity, which “deal[s] with the idea of neutrality or the extent to which the research is free of bias in the procedures and the interpretation of results” (Ary, Jacobs, Sorensen, & Razavieh, 2010, p. 504). Nevertheless, achieving objectivity in design-based research is not an easy task (Akilli, 2008; Design-Based Research Collective, 2003; Hoadley, 2011; O’Donnell, 2004) because “researchers conducting design-based research usually, if not always, need to immerse themselves in the research context and intensely interact with participants. As a consequence, it is difficult to keep being objective and neutral” (Instructional Technology Ph.D students at the University of Georgia, 2006c, para. 2). However, employing triangulation by using multiple sources and kinds of data can maintain and increase the objectivity in the findings of design-based research (Akilli, 2008; Design-Based Research Collective, 2003; O’Donnell, 2004; Thurmond, 2001; Wang & Hannafin, 2005).

Validity, on the other hand, concentrates mainly on two aspects. The first aspect is external validity, which refers to “the extent to which the findings of a study can apply to a wider population. Research which is generalisable enables the results and implications of a study to be brought into more general use” (Bloor & Wood, 2006, p. 93). However, design-based research literature agrees completely that the findings of design-based research cannot be generalised from a sample to a large population (Akilli, 2008; Barab & Squire, 2004; Hoadley, 2011; O’Donnell, 2004; Plomp, 2007) because design-based research has a “highly contextualised research agenda and its

heavy reliance on thick description for data analysis” (Instructional Technology Ph.D students at the University of Georgia, 2006c, para. 3). Therefore, the literature suggests that design-based research should result in generalisable theory from its context to other contexts; as mentioned earlier, this theory might include domain theories, design frameworks, and design methodologies (Bowler & Large, 2008; Edelson, 2002; Plomp, 2007).

The second aspect is internal validity, which refers generally to “the degree to which the investigator’s conclusions correctly portray the data collected” (Bloor & Wood, 2006, p. 148). There are different factors that may threaten the validity of design-based research, so Hoadley (2004) suggested that validity has a larger sense, involving “the likelihood that our interpretation of the results accurately reflects the truth of the theory and hypotheses under examination” (p. 204). Therefore, adopting many iterations of the phases of design-based research over time as well as repeating the analysis through cycles of iterations can result in strengthening the internal validity of the findings of design-based research (Bloor & Wood, 2006; Design-Based Research Collective, 2003; Dix, 2007; Instructional Technology Ph.D students at the University of Georgia, 2006c).

Reliability, refers generally to “the extent to which research produces the same results when replicated” (Bloor & Wood, 2006, p. 147). Achieving reliability in design-based research also faces challenges, so using triangulation through multiple data sources contributes to improved reliability in the findings of design-based research (Design-Based Research Collective, 2003; Dix, 2007; Instructional Technology Ph.D students at the University of Georgia, 2006c).

7. Participants in Design-Based Research

Generally, design-based research should be based on three elements: (a) a designer (e.g. the researcher), (b) a practitioner (e.g. a teacher), and (c) an artefact (e.g. a framework for improving different aspects of teachers’ performance) (Juuti & Lavonen, 2006, p. 55). As a consequence, the design-based research literature emphasises that the collaboration between researchers and practitioners represents the essential element for conducting design-based research (Ma & Harmon, 2009; Wang & Hannafin, 2005). On the other hand, the practitioners in design-based research “are not ‘subjects’ assigned to treatments but instead are treated as co-participants in both the design and even the analysis” (Barab & Squire, 2004, p. 3).

Indeed, design-based research literature does not support parametric techniques for selecting samples in the design-based research process; rather, it points out that design-based research will be successful if conducted “with a single setting over a long time” (Design-Based Research Collective, 2003, p. 7).

8. Data Collection and Analysis Techniques in Design-Based Research

Data collection and analysis refer generally to “the techniques or procedures used to gather and analyse data related to some research question or hypothesis” (Crotty, 1998, p. 3). However, appropriate research methodology literature was consulted and this indicated that methods of data collection in design-based research “are not necessarily different from those in other research [methodologies]” (van den Akker, 1999, p. 9).

Overall, there are three approaches for collecting and analysing research data, which involve, (a) quantitative, (b) qualitative, and (c) mixed methods approaches (Migiro & Magangi, 2011). As mentioned above, the pragmatic paradigm underpins design-based research, so from the point of view of pragmatism, a researcher “should use whatever works” (Fraenkel & Wallen, 2009, p. 559). Therefore, MacDonald (2008) states that design-based research “pragmatically employs qualitative [and/]or quantitative research methods that are congruent with the research questions” (p. 430). That

indicates that a researcher who uses design-based research can use any research approaches—quantitative, qualitative, or a combination of the two.

Indeed, the majority of design-based research literature agrees that the mixed methods approach is an appropriate one for collecting and analysing design-based research's data because it can maximise the validity as well as increase the objectivity, and reliability of ongoing research (Bell, 2004; Design-Based Research Collective, 2003; Wang & Hannafin, 2005). However, a mixed methods approach, according to Migiro and Magangi (2011), is “research in which the researcher uses the qualitative research [approach] for one phase of a research study and the quantitative research [approach] for another in order to understand a research problem more completely” (p. 3757).

On the other hand, Amiel and Reeves (2008, p. 35) pointed out that collecting data in design-based research should aim at achieving three purposes as follows: (a) re-define the problems, (b) explore possible solutions, and (c) consider the principles that might best address them.

9. Conclusion

In conclusion, it seems that design-based research has emerged as a reaction against the failure of some traditional research methodologies to link theory and practice within educational research, and as a means of generating useful knowledge to guide educational practice.

According to the above discussion, we encourage all educational researchers to adopt design-based research to investigate the different issues that face them in their educational settings because it will contribute effectively to addressing these issues as well as bridging the gaps in research between theory and practice.

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