

**Design-Based Research (DBR) in educational enquiry and
technological studies: A version for PhD students targeting the
integration of new technologies and literacies into educational
contexts**

By

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Abstract.

This article discusses educational design-based research (DBR) as an emerging paradigm/methodology in educational enquiry that can be used as a mixed-method, problem-oriented research framework, and thus can act as an alternative to other traditional paradigms/methodologies prominent within the Egyptian context of educational enquiry. DBR is often referred to as a long-term research endeavour and

perhaps because of this is rarely employed in PhD studies. We therefore propose a version of DBR specifically for PhD studies using as an example of this a recent PhD study conducted at the Graduate School of Education, University of Exeter, UK based on the Egyptian context of Assiut University College of Education. Through a detailed comparison of DBR with some existing paradigms/methodologies, we provide a rationale for using it as a research framework with the two-fold purpose of developing learning theories and improving educational practice. We delineate DBR as an independent methodology by comparing it with other methodologies including experimental design and action research. To make DBR workable for PhD students, a version of DBR is suggested to guide future researchers into how to plan for employing DBR within their educational studies.

Keywords: *Design-Based Research (DBR), PhD students, Egypt, new technologies, pre-service language teacher education, new literacies, technology integration, Web-based new literacies.*

1. Introduction

There is a growing interest in educational Design-Based Research (DBR)¹ as a new approach for educational enquiry which can stand alone as an independent paradigm. In relation to the still influential and frequently referred to dichotomy between quantitative and qualitative paradigms, and which some authors (Crotty, 2003) describe as a ‘false dichotomy’, DBR is neither purely postivist nor purely interpretivist in orientation. Instead, it draws on pragmatic

¹ One of the problematic issues of DBR is that there are many labels attached to it, such as ‘design experiments’, ‘design research’, and ‘developmental research’. To facilitate matters, we will restrict ourselves to the label ‘design-based research’ (DBR) after the Design-Based Research Collective (DBRC, 2003).

assumptions according to which the problem of the study and the research objectives are the main drive that guides the research process. This interest is reflected in many approaches and terms that have been emerging to capture the essence of DBR since Brown (1992) and Collins (1992) published their articles on design experiments as an attempt towards a design science in the field of education and educational research. In this sense, DBR largely came about because of the lack of meaningful impact that educational researchers were having on the act of education. Thus, few implications were taken into account in educational practice to change and/or improve existing teaching/learning practices (see also Nieveen, 2007; Plomp, 2007; Reeves, 2000).

Here we will delineate this emerging approach and contextualise it within the real context of educational enquiry. This will involve comparing this approach with other dominant paradigms/approaches, and subsequently present a specific version of it that can be utilised by future researchers with similar orientations. Then, based on a PhD study, we will present a DBR three-phase research framework that should have many methodological implications for educational researchers and practitioners.

Compared with other similar approaches and methodologies (e.g., experimental design, developmental research, action research, and formative evaluation) that might be used to address the same research questions/problem, DBR is different. Though there could be a common ground connecting these approaches together (e.g., targeting the improvement of educational practices and starting from a complicated problem to which there are no ready-made solutions), DBR stands as a distinct approach that has its own peculiar characteristics. Thus, the same educational problems can be revisited from a DBR perspective

Unlike experimental research, DBR does not target the mere implementation of theories, designs, and models in a controlled fashion. Rather, it seeks to improve both theory and the

educational context itself which is seen as a messy reality that should be studied as it is. After all, learning is a human, social phenomenon that cannot always be studied effectively using the same scientific and objective standards applied to physical phenomena.

Tracing the development of DBR, we noted that it has always been associated with technology and new innovations in education (see also Wang & Hannafin, 2005), especially because it arose among researchers who were building computer-based learning environments (Collins, personal communication, 2009). It attempts to create a new paradigm for educational research that relies on progressive refinement of design of environments and theories of learning in tandem. In this way, it is a valuable option to use if new interventions, innovations, and educational practices based on new ICTs are to be investigated (Walker, 2006; Wang & Hannafin, 2005).

Quite recently, the nature of education as a complex and situated human activity that requires continuous refinements and improvements has called for a research paradigm that can provide contextualised knowledge and take into account complex interactions. Therefore, DBR has been embraced with enthusiasm as a flexible approach enabling researchers to relate theory to practice, philosophy to reality, and abstract ideas to real contexts. In this sense, it is a never-ending virtuous circle linking theory to practice and practice to theory through implementing theory in practices which are then tested in interventions leading to insights that refine the theory so leading to improved designs and to improved practices.

To distinguish DBR, some definitions were provided; the most comprehensive one that captures the overall philosophy and procedures of DBR was provided by Wang and Hannafin (2005: p6):

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.

From another perspective, Shavelson et al (2003) identify DBR as a type of research strongly based on prior research and theory and carried out in educational settings. It 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 challenges found in everyday practice.

Similarly, Barab and Squire (2004: p2) view DBR as "a methodological toolkit" for deriving "evidence-based claims" from naturalistic learning contexts that are engineered in ways that allow for generating and improving these claims with the intent of "producing new theories, artefacts, and practices that account for and potentially impact learning and teaching".

From a methodological standpoint, Bannan-Ritland (personal communication, 2009) perceives DBR as "a meta-methodology combining different methods at different points in the innovation cycle".

Based on these definitions, one of the authors (Abdallah, 2011: p47) could signpost the core of DBR as follows:

DBR is a new paradigm or methodology in educational research that is based on both theory and previous research with the aim of improving educational practice. It is conducted in the real, complex, and messy learning/teaching contexts through iterative cycles of analysis, design, development, and implementation mediated by some interventions. It originates from real educational problems and/or challenges supported by educational theories, and ends with design principles and/or learning

theories subject to continuous refinement and improvement. Thus, the products/outputs of DBR are design principles, learning theories, interventions, curricular products, instructional tools, and/or practical solutions/prescriptions.

2. DBR and the range of possibilities

Before going any further, it seems appropriate here to provide a brief summary of the target PhD study conducted by one of the authors (Abdallah, 2011):

With the dominance of the Web in education and English language learning, new literacies have emerged. This thesis was motivated by the assumption that these literacies need to be integrated into the Egyptian pre-service EFL teacher education programmes so that EFL student teachers can cope with the new reality of language teaching/learning. Along with this, it is motivated by a realistic problem represented in the poor literacy practices demonstrated by many Egyptian EFL student teachers in Assiut. Therefore, the main objective of the study was to develop a theoretical understanding of the relationship between Web-based new literacies and the teaching of TESOL in a way that would support the possibility of expanding Egyptian pre-service EFL student teachers' language-related literacy practices by integrating some Web-based new literacies into their education programme, with specific reference to the context of Assiut University College of Education (AUCOE). This required accomplishing minor objectives represented in: (1) identifying the range of those Web-based new literacies that Egyptian EFL student teachers need in this ICT-dominated age; (2) identifying those Web-based facilities beneficial to them, and why and how they can be beneficial; and (3) generating framework for EFL curriculum design based on both literature and empirical data.

To accomplish this, a design-based research (DBR) methodology drawing on a pragmatic epistemology was developed and employed as the main research paradigm informing this design study. Thus, the research design involved a flexible three-stage research framework (see also Figure 1 below): (1) the preliminary phase, which acted as a theoretical and empirical foundation for the whole study, and informed a preliminary design framework; it involved reviewing relevant literature and obtaining empirical data through documentary analysis (100 documents), online questionnaire (n=50), and semi-structured interviews (n=19); (2) the prototyping phase that involved two iterations (36 participants in the first iteration, and 30 in the second) conducted in the Egyptian context to test the proposed design framework. Each iteration acted as a micro-cycle of the whole design study, and thus involved its own objectives, learning design, research methodology and procedures (in line with the main DBR methodology), and results; (3) the assessment/reflective phase which, based on the prototyping phase results, presented a final design framework for expanding EFL student teachers' language-related literacy practices. This had implications for the EFL curriculum design process within the Egyptian context in general, and AUCOE in particular.

Results indicated that throughout the two iterations, it became evident that the process of expanding EFL student teachers' language-related literacy practices by integrating some Web-based new literacies into the AUCOE pre-service programme was quite feasible once some design principles were considered. Some significant conclusions and educational implications were provided, along with some main contributions to knowledge in TESOL/TEFL, language-learning theory, research methodology, and educational practice as far as the Egyptian context of pre-service EFL teacher education was concerned.

From this summary, DBR looks an appropriate option that should help with accomplishing the above mentioned research objectives. Before launching the study, we had a thought about a wide range of possible paradigms/methodologies which might have fitted in with our

research purposes, such as interpretivist research, experimental research, action research, and formative evaluation. At first glance, those approaches/methodologies that seemed quite similar to DBR might have helped with realising the main goal of this PhD. However, realising this range of possibilities should have helped us to identify the main rationale underlying the choice of DBR over those similar methodologies as well as the core features of DBR as a distinct approach.

The *Experimental Research Design* (ERD) is the most popular approach used in educational research in Egypt, which is often confused with *Design Experiments*, another label of DBR. Therefore, following the Design-Based Research Collective (2003), we use the term ‘design-based research’ (DBR) to avoid any misinterpretation or confusion. At first glance, ERD might seem suitable as a research design for our purposes, especially because it can involve pre-post testing which is likely to produce statistically accurate results. However, a deeper look reveals that it is not the right fit for our context; the studied phenomenon is complicated and, consequently, strict experimental control is hard to realise since variables cannot be clearly distinguished and isolated within such messy, realistic learning situations.

In this regard, Lagemann (2002) argues that the traditional experimental paradigm derived from psychology has striven for experimental control at the expense of fidelity to learning as it actually occurs. Realising this problematic issue, Brown (1992), Collins (1999), Collins et al. (2004), and Kelly (2006) present some major differences distinguishing the two approaches from each other: First, while ERD entails a strong level of controlling variables, DBR, which addresses many dependent variables, characterises variables without controlling them. Second, while ERD is based on artificial, laboratory situations which are always structured in a way so that contaminating and distracting effects are avoided, DBR is conducted within messy, natural situations in a real teaching/learning context. Third, DBR flexibly refines design rather than following a set of fixed procedures. Fourth, DBR values

social interaction over isolated learning. Fifth, DBR generates/cultivates hypotheses, rather than testing them. Last, DBR is a context of discovery, rather than being a context of verification (see also Table 1 below).

Table 1: Comparison of experimental design and design-based research

Category	Experimental Research	Design-Based Research
Orientation	Controls variables	Characterises the situation
Location	Artificial laboratory settings	Messy, natural learning/teaching situations
Procedures	Follows fixed procedures	Follows flexible procedures to refine designs
Learning	Values isolated learning	Values social interaction
Hypotheses Testing	Tests hypotheses	Generates/Cultivates hypotheses

In other words, studying learning as it occurs in its real context has been disregarded for a long time for the sake of applying scientific methods to learning as a social phenomenon that is assumed to be subjected to the same rules used in natural/physical sciences. In this respect, Brown (1992) stresses the inherent limitedness of insights scientifically driven from experimental and laboratory educational research in their ability to explain or predict learning in the classroom. Also, Walker (2006) argues for the inconvenience of the conventional psychological theories that have been dominating educational research (e.g., behaviourism) for studying learning in context to achieve reform and advances. In addition, DBR methods,

as Kelly et al. (2008) argue, can help to accomplish what experimental designs, especially randomised controlled trials, cannot; they include conceptual and relational/semantic analyses, and are theoretically grounded, and thus, allow researchers to build models of learning and teaching interactions.

Comparing between experimental designs and DBR, Collins et al. (2004) identify seven contrasting points as follows: (1) Laboratory settings vs. messy situations; (2) a single dependent variable vs. multiple dependent variables; (3) controlling variables vs. characterising the situation; (4) fixed procedures vs. flexible design revision; (5) social isolation vs. social interaction; (6) testing hypotheses vs. developing a profile; and (7) experimenter vs. co-participant design and analysis.

In line with these arguments, Juuti and Lavonen (2006) criticise the conventional trust of the accuracy of the findings obtained from (quasi-)experimental research designs favouring a DBR design to be used in science education. They argue for the difficulty of controlling all the variables involved in teaching and learning, or treating any complex learning/teaching phenomenon as an independent or dependent variable. Many uncontrollable factors (e.g., physical, psychological, social, emotional, and financial) may interfere with the teaching/learning process. These include: classroom settings, social and psychological atmosphere, pupils' motivation, attitudes towards learning topics or schooling in general, and students' experiences outside the school, such as discussions with their parents, and the media.

From the above argument which clearly shows the significant differences between ERD and DBR, it becomes evident that ERD may not help us with our main goal of generating a design framework that includes some guidelines/principles for integrating Web-based new literacies into the target context with the aim of expanding student teachers' language-related literacy

practices. Generating such a framework requires cycles of testing, evaluation, and refinement. These cannot be conducted within an experimental design framework that is restricted to only one phase of intervention. This usually involves a pre-post test to statistically measure the effect that the intervention might have on students and their learning/achievement. Besides, instead of relying solely on numerical results, a space of narratives and reflections in which the learning experience is widely explored and elaborated by both teachers and students is needed in our study to inform the target framework.

On the other extreme, and contrary to ERD as a positivist methodology, the Interpretivist Research Paradigm might seem a good alternative. It is sometimes argued that interpretivist research has emerged in reaction to the dominance of positivism with the goal of studying learning phenomena in great depth (Crotty 2003; Flick 2006; Grix 2004). Generating a design framework might need this great depth and analysis enabled by this paradigm. However, a significant consideration makes it totally unsatisfactory and far from being the best fit; in spite of the in-depth analytical accounts it provides and, sometimes, the models/designs it suggests for practice (see, for example, Flick 2006), it does not interfere directly to change or improve educational reality by examining theory in context. In this regard, Barab and Squire (2004) argue that DBR is a methodology where the research moves beyond simply observing to involve systematically engineering learning contexts in ways that allow us to improve and generate evidence-based claims about learning (see also Van den Akker et al. 2006). This feature, as Collins et al. (2004) argue, distinguishes DBR from ethnographic research which, though set in natural learning environments, produces rich descriptions and understandings of learning situations with no attempt to change educational practice.

In terms of connecting theory to practice, there are two approaches, namely action research and formative evaluation, both of which are closely related to DBR (Bielaczyc & Collins 2007) and which might be appropriate for the purposes of our study. A persistent argument

(e.g., Järvinen 2005) has been whether DBR is the same as action research, which also aims to bridge the gap between research and practice in education (Somekh 1995) through investigating and understanding reality with its associated complexities and problems, and implementing interventions to solve realistic problems, and thus, improve educational practices in local teaching/learning settings (Cohen et al. 2007). Bielaczyc and Collins (2007) argue that what makes DBR different is that its goal is not simply to refine a design intervention toward improving practice, but also to refine theory, a main concern in our study. The same idea is asserted by Orrill (personal communication, 2009) who contends that unlike action research and other similar approaches, DBR aims to refine a theory (typically about learning) that is embodied in a designed intervention (e.g., curriculum or software programme). Thus, the designed thing is not the end product; instead, it is merely a vehicle for the development of the theory. Hence, it turns out that these designed interventions often end up being nice by-products of the theory development process worthy of existence on their own.

Another difference relates to the roles of the participants in each: While in DBR researchers usually take the initiative in the research process as both researchers and designers (Wang & Hannafin 2005), in action research the research process is usually initiated by practitioners in the field who feel with a problem that needs to be solved, and then researchers' roles become evident when they come to help with facilitating the research process (Cohen et al. 2007).

Formative evaluation is also closely relevant to DBR as both are naturalistic, process-oriented, and iterative processes that involve creating a tangible design that works in complex social settings. However, formative evaluation does not entail theory generation as a goal; rather, its goal is to improve the practice of design (Barab & Squire 2004). That is why formative evaluation is employed as a main methodology under the umbrella of DBR, not the other way around (Nieveen 2007; Plomp 2007; Wang & Hannafin 2005). In other words, in

DBR, assessment may be used formatively in order to dynamically determine progress toward mastery of disciplinary knowledge (Cobb & Gravemeijer 2008) and/or to guide the design of a prototype and to inform its iterative redesign as necessary (Kelly et al. 2008). Hence, Nieveen (2007) defines formative evaluation in the context of DBR as "a systematically performed activity (including research design, data collection, data analysis, reflection and reporting) aiming at quality improvement of a prototypical intervention and its accompanying design principles".

3. DBR in PhD Studies

DBR is often written about as if it must be a long-term, time-consuming research endeavour (e.g., Collins et al., 2004; DBRC, 2003). Some challenges related to time span and context made many PhD students reluctant to adopt DBR as a main paradigm. In this regard, Herrington et al. (2007) state that though DBR is avoided by doctoral students who are expected to complete their degrees in 4-5 years, it is, in a sense, feasible for them when they adjust it to suit the context and particular conditions of their studies. Therefore, doctoral students should be encouraged to engage in it. Based on this argument, we suggest that a flexible, format or version of DBR compatible with the time span, the researcher's context, and the specific circumstances of the PhD study, should be employed. The model that Herrington et al. (2007) present for PhD proposals seems compatible with the main research components that any research proposal should address (i.e. identifying research problem and objectives, reviewing literature, stating methods of data collection and analysis, and presenting the research results) since it views the research process from a developmental perspective. However, it does not seem for us flexible enough to address or involve the peculiarity of each PhD study on the one hand, and the flexible nature of the DBR methodology itself.

The good news is that DBR has been recently employed by a few PhD studies in the field of education and training. For example, Class (2009) used it under the label "developmental research" to design, implement, and describe a blended socio-constructivist course for interpreter trainers. This involved formulating a theory, in terms of design rules, for any adult training course set in an activity-based learning environment with a face-to-face component. Findings of the study led to the development of a new design framework, referred to as the "component model of activity-based training". From a design perspective, this framework was the result of both empirical findings and recent theories in educational technologies.

Another recent PhD study was conducted by Hanghøj (2008) with the aim of clarifying what status educational games have within the context of formal schooling. More specifically, the study aimed to promote a contextual turn within educational game research, which moves beyond celebration by critically examining the pros and cons of educational gaming through empirical studies. DBR was used in this context as a methodological approach to explore the empirical problems and possibilities of educational gaming through a series of design interventions with 'The Power Game', an ICT-supported debate game on parliamentary elections to be used in Danish upper secondary education.

3.1 A Version of DBR for PhD studies

Our main goal is to outline a version of DBR suitable for PhD studies which we illustrate through a recent study. Our implementation of this new model springs from a pragmatic orientation that makes use of the fact that DBR is such a flexible methodology that it can be adjusted to fulfil the purposes of a PhD study.

Compared with Herrington et al.'s (2007) model, our model does not suggest that there should be a specific format of implementing DBR in doctoral studies. Rather, the model flexibly outlines realistic methods and procedures followed in the study under the DBR umbrella. In other words, rather than presenting an anticipating viewpoint of how DBR should look like, we present a simplified model of DBR as applied in a specific context to accomplish certain objectives.

Hence, our model suggests that DBR is not an absolute, independent set of rules to be strictly followed and applied in all DBR studies, but rather is a contextual methodology that is highly dependent on the specific context, nature, and objectives of the study. This position is highly emphasised by Sandoval (personal communication, 2009) who rejects the existence of unified, fit-for-all principles for DBR that can be easily adopted in all studies employing this methodology. He argues that DBR is really "more about a set of commitments to the questions worth asking and the kinds of answers possible to those questions, than it is about a specific set of methodological principles". This flexibility can be noticed in some early DBR studies utilising DBR methodologies as an alternative to the experimental design to address specific design and learning purposes (e.g., studies by: Brown & Campione 1994 & 1996; and Joseph 2000).

Reeves (2006) depicts the DBR approach as a process which starts from the identification and analysis of problems by researchers and practitioners in collaboration; and then goes through the development of prototyping solutions informed by theories, existing design principles, and technological innovations; then involves iterative cycles of testing and refinement of solutions in practice; and finally, results in reflection to produce design principles and enhance solution implementation in practice.

Figure 1 below illustrates the main phases of the target PhD study (Abdallah, 2011) as well as the specific details that reflect the adjustments made to the DBR methodology to address the specific purposes of the study. The idea of having three main phases was derived from Plomp (2007) who suggests that a DBR study should be conducted in the light of three main stages: the preliminary phase, the prototyping phase, and the assessment/reflective phase. In what follows, we will outline each phase based on the real methods and procedures we used in line with the main DBR methodology:

1-The preliminary research phase in which the procedures of needs and content analysis, review of literature, development of a conceptual or theoretical framework for the study were conducted. As indicated in Figure 1 below, this stage involves identifying and formulating the problem of the study through: online interactions with participants; a review of relevant empirical studies to identify the gap; and real interactions with both EFL student teachers and their educators (a long-term process that started already a few years ago). It also involves doing a comprehensive review of literature that serves two main purposes: (1) clarifying the key research terms (e.g., Web-based new literacies, EFL teacher education, and curriculum design); and (2) providing a theoretical foundation for the concurrent documentary analysis process. Finally, it involves collecting preliminary empirical data at this stage through: (1) a documentary analysis process that leads to a list of Web-based new literacies; (2) semi-structured interviews (conducted online) that leads to some Web-based facilities. Both products are necessary for informing the preliminary design framework that should guide the next stage of this design study (i.e. the prototyping phase). The arrows in Figure 1 below illustrate such relationships, and thus provide a conceptual diagram of how the process goes.

2-The prototyping phase (the iterative design phase), which consisted of two iterations, each being a micro-cycle of research with formative evaluation as the most important research activity aimed at improving and refining the intervention. As Figure 1 shows, this phase is

guided by a preliminary design framework concluded in the preliminary phase. This is followed by a screening questionnaire administered for purposive sampling. Each research cycle (as the arrows in Figure 1 indicate) leads to a revised framework based on results, and which guides the next cycle, until a final design framework is reached.

3-The assessment/reflective phase, with the aim of concluding whether the solution or intervention meets the pre-determined specifications, resulting in recommendations for improving the intervention. In this phase, a final design framework is reached throughout a comprehensive assessment of the two iterations or research cycles conducted in the previous stage. This framework (as the arrows indicate) involves implications for EFL curriculum design, along with contributions to theory, practice, and methodology.

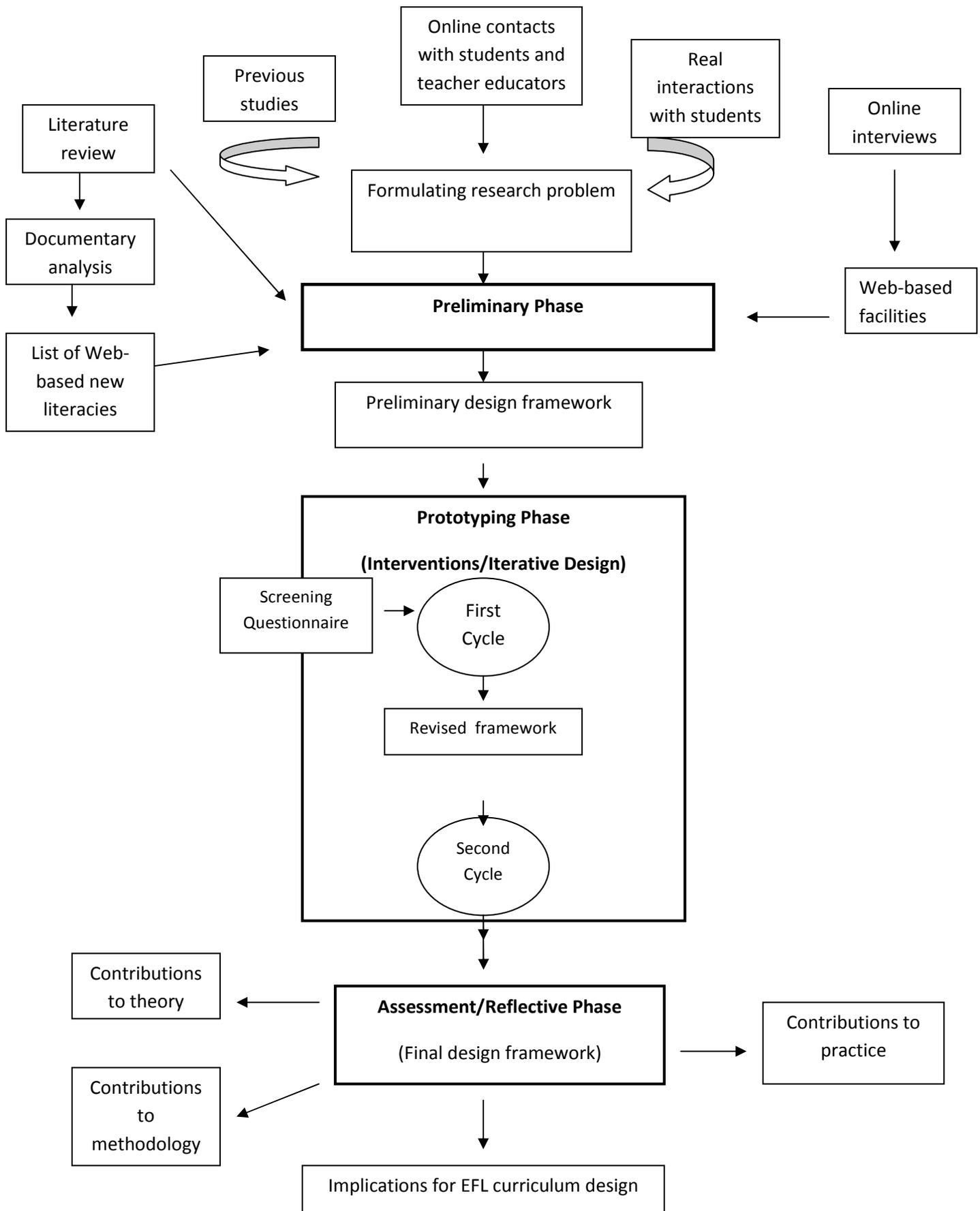
This three-phase research framework was consistent with our main research objective represented in generating a final form of a design framework that aims at expanding EFL student teachers' language-related literacy practices at Assiut University College of Education in Egypt, by integrating some Web-based new literacies into their pre-service teacher education programme at the undergraduate stage. This main goal entailed some minor objectives represented in:

1. Identifying the range of Web-based new literacies that EFL student teachers need to cope with the increasing use of ICTs in TESOL;
2. Identifying the Web-based facilities that those student teachers need in the context of their pre-service teacher education programme;
3. Designing small interventions informed by design frameworks derived from both literature and empirical data obtained in the preliminary research phase;

4. Experimenting the small interventions in the real messy context of pre-service teacher education at Assiut University College of Education;
5. Refining the frameworks based on the results obtained from the interventions;
6. Deriving some implications for theory, practice, teacher education, and curriculum design based on the obtained results.

Accomplishing these objectives needs a three-phase DBR research framework that entails a dialogic approach to data collection and analysis. Hence, this approach should highlight the complicated relationship between literature and empirical data without losing sight of the main objective of the study. This means that the research process within this flexible design is not totally sequential entailing logical linear procedures, but instead ‘dialogic’ in the sense that iterative interactions within data should exist with the aim of accomplishing the research objectives. For example, literature review, followed by documentary analysis, was employed to generate a list of those Web-based new literacies that student teachers might need (see Figure 1 below). This qualitative analysis was followed by a quantitative analysis in the form of a questionnaire to check how teacher educators and student teachers in the real Egyptian context of teacher education would rate these new literacies in terms of importance. This was followed by a semi-structured interview to identify the Web-based facilities that student teachers might need. Together, results obtained from both streams were employed in a dialogic, complementary fashion to inform the generation of the preliminary design framework that guided the first iteration that acted as a micro-cycle in this DBR study.

Figure 1: Diagram of the PhD study



Based on the results obtained from the first iteration, the preliminary design framework was revised to guide the next iteration. Thus, at the end of each iteration, a thoughtful discussion of the main strengths and weaknesses in the light of the main design principles guiding the iteration was provided. This took the form of some lessons learned which were cycled back into the next iteration, especially as far as the new design principles were concerned. Eventually, a final design framework that entails implications for language learning theory, educational practice, and EFL curriculum design, was obtained.

4. Conclusion

In this review, we have established and delineated DBR among similar research paradigms and/or methodologies employed in educational enquiry, such as Experimental Research, Action Research, and Formative Research, to highlight its main characteristics and attributes. We have also argued for the feasibility of using this paradigm as a research framework in PhD studies and projects. In this regard, we have proposed a version of DBR as used in a recent PhD study to guide future researchers who might plan to adopt this methodology. In keeping with the constraints of the PhD this version of DBR focussed on three phases, 1) integrating literature and exploratory research to develop and initial theoretical framework for design, 2) implementing this with careful evaluation of processes as well as products in two iterations, using the results of the study of the first iteration to refine the second iteration and 3) finally using the results of the second iteration to produce a new and improved theoretical framework for design ready for further research study presented as the main outcome of the thesis. This version emphasised the importance of considering the flexible nature of the DBR methodology as well as the specific circumstances and context of each PhD study, and hence, the specific research problem and objectives that should guide the whole research process.

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