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ORIGINAL ARTICLE

A Systematic Analysis of Design-based Research in Technology-enhanced Language Learning (TELL)

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Abstract
This research study employed a systematic quantitative literature review of studies using design-based research in the field of technology-enhanced second or foreign language learning, published in SSCI-cited journals between 2013 and 2018. The purpose of the study is to gain insights in the light of these previous studies and to produce a comprehensive picture of what has been investigated related to the amalgamation of technology and educational theories, and to address educational problems in context. This article provides an overview of relevant issues such as context, problems, technologies (interventions), and theoretical understanding, and thus identifies emerging trends in the field. It concludes with suggestions on how to employ design-based research to its full potential and provides directions that can guide future research in technology-enhanced language learning (TELL).

Keywords: Computer-assisted language learning, design-based research, systematic literature review, technology-enhanced language learning

Introduction

It is very common for educational researchers to employ comparative studies in searching for solutions and effectiveness of new technological applications toward the problem being addressed. However, according to Clark's theory (1994), studies which aim to prove a significant difference between technological applications actually conclude "no significant difference," as it is not the choice of medium that determines whether there has been an impact on learning but rather the method used via the chosen medium (Ramage, 2002). In this respect, it is evident that the research methodology employed should lend itself to investigate the method used via any type of medium, to conclude that it has significant difference. Reeves (2006) in his seminal paper on design-based research (DBR), criticized Bernard et al. (2004) for examining student achievement in distance education courses in comparison with face-to-face instruction. He argued that the Bernard et al. (2004) review relied too heavily on

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comparative studies in which the results were statistically significant but fell short of providing practitioners with guidelines on how to develop more effective learning environments.

A similar criticism can be leveled at studies of technology-enhanced second or foreign language learning (TELL)* environments. Leading journals in the field often feature studies that inform only on the relative success or failure of technology in achieving learning outcomes in contrast to face-to-face instruction. In many cases, research findings attribute successful learning outcomes solely to the technology employed, without considering the broader pedagogical methods employed in the learning environment. Passig and Schwartz (2007), for example, compared face-to-face writing instruction to online instruction with the use of a program called MS Groove. In the same vein, a study by Warschauer (1995) compared face-to-face and electronic discussions.

In addition to overemphasizing the role of technology and underplaying the importance of pedagogical dimensions, comparative studies of technology-enhanced learning with traditional face-to-face instruction also fail to adequately consider the role of teachers. Ellis (2012) conducted a detailed meta-analysis of comparative studies in TESOL and concluded that these studies tend to view teachers as "actors rather than as authors" (p. 52). In other words, these studies treated the primary role of the teacher as implementing the teaching method prescribed by theorists. Teachers are "expected to perform the 'script' dictated by the method rather than write their own script" (p. 52). Ellis (2012) argued that teachers themselves must be the authors of their own teaching methods, drawing on principles and techniques appropriate to their own specific contexts.

If studies that compare one approach (e.g., teaching with technology) to another (e.g., teaching without technology) are considered as the past in TELL research, then design-based research (DBR) can be considered as a path to the future, where "research is designed to truly inform practice" (Levy, 2013). Reeves and McKenney (2013) indicated three possible affordances of DBR within the context of Computer-Assisted Language Learning (CALL), viz., to develop effective interventions, extend theoretical understanding, and provide professional development. Reeves and McKenney (2013) also noted that there is little research using DBR in CALL literature. This paucity of DBR focused on language learning is also evident in Anderson and Shattuck's (2012) review. Anderson and Shattuck analyzed 47 DBR articles from 2002 to 2011 and found that only 5% of the studies were related to English language learning.

Zheng (2015) compared 162 DBR studies published over two timespans (2004–2008 to 2009–2013); however, Zheng (2015) did not indicate the number of

studies that were related to CALL. In our own research, only one study was identified that examined the application of DBR in CALL (Rodríguez, 2017). Rodríguez (2017) provided a synopsis of empirical research published between 2008 and 2013 and mainly focused on DBR and its affordances to CALL. Unfortunately, none of these three analyses of the DBR literature (Anderson & Shattuck, 2012; Rodríguez, 2017; Zheng, 2015) described the design principles provided in the research studies they analyzed.

Providing design principles is a crucial characteristic, as the primary purpose of DBR is to guide and inform future design and research. Our research aims to close this gap by providing a summary of design principles along with research contexts, problems, interventions, and relevant theories, to guide educators and researchers seeking to improve the design and research of TELL. We believe that such an analysis is needed to better inform practitioners and/or researchers in similar contexts. Unlike past DBR reviews, we aim to contribute to the understanding of how other TELL researchers have conducted DBR to address educational problems related to practice while at the same time improving theoretical knowledge, by refining reusable design principles.

Origins of Design-Based Research

A variety of terms is used to refer to DBR, such as *design experiments* (Brown, 1992), *development research* (Van den Akker, 1999), *design research* (Collins et al., 2004; Reeves, 2006), and *educational design research* (McKenney & Reeves, 2018). While each of these different terms differ slightly in focus, their underlying goals and approaches are similar (Wang & Hannafin, 2005). The characteristics that identify DBR are:

- DBR aims to improve educational practice through the design, development, and implementation of an educational intervention in collaboration with practitioners;
- DBR takes place in real-world settings and involves rigorous iterative testing and refinement of an intervention; and
- The initial design principles used in the development of an intervention are improved to yield enhanced context-based design principles.

An Important Product of Design-Based Research Design Principles

One critical characteristic that differentiates DBR from other research methods or approaches is the development and refinement of design principles. Unlike experimental research studies that conduct controlled experiments to prove whether predefined hypotheses have statistical significance, DBR aims to provide practitioners with guidelines–also referred to as design principles, design elements, or evidence-based heuristics–to develop effective learning environments (Herrington et al., 2007).

Therefore, any research utilizing DBR should ideally conclude with design principles as well as with a robust practical intervention. It is important to note that design principles are critical in every phase of DBR, beginning as draft principles derived from the literature and consultations with practitioners, then as revised heuristics in iterations of testing and refinement of the learning environment, and finally as a polished product of the DBR study (Herrington & Reeves, 2011).

Herrington et al. (2010) argue that design principles advance both the practical and the theoretical understanding of the problem area, which sets DBR apart from other research approaches (such as action research). Paliwoda-Pękosz and Stal (2015) compared DBR research with action research and concluded that although both these approaches belong to applied research and are characterized by solving practical problems, "action research is conducted by teachers and seeks to solve a specific problem in the classroom, whereas DBR involves researchers and practitioners and focuses on producing a general model on the basis of practical solutions" (p. 407).

Finding or creating initial design principles is a challenge for researchers. Herrington et al. (2010) recommend starting a principle with a verb, such as "allow, provide opportunities for, promote, enable, support, etc." (pp. 181–182), to allow researchers to provide actionable guidelines for implementation in real-world educational settings. In this respect, the methodological principles for CALL proposed by Doughty and Long (2003) provide an example that clearly illustrates the use of verbs while composing the design principles, for example: *use* tasks, not texts, as the unit of analysis; *promote* learning by doing; *elaborate* input. For this reason, this research is significant in terms of helping researchers and practitioners be informed about the theoretical principles suggested by other researchers to address educational problems.

Many models have been suggested to utilize DBR to its full potential (Bannan-Ritland, 2003; Collins et al., 2004; McKenney & Reeves, 2018; Reeves, 2006). The term *model* is used to define the phases of DBR and the specific actions to be taken in each phase. One of the most widely used and simplest DBR models is Reeves' (2006) four-phase model (Figure 1). Although a commonality among the different DBR models is that the outcome of each phase becomes the input of the next, it is not unidirectional and there may be a need to loop back through an earlier phase, based on the findings of subsequent phases.

Methodology

This study employed a systematic quantitative literature review, which is used to survey the literature to identify the current status, theory, and methods in a field, and to reveal gaps in the literature, as suggested by Pickering and Byrne (2014).

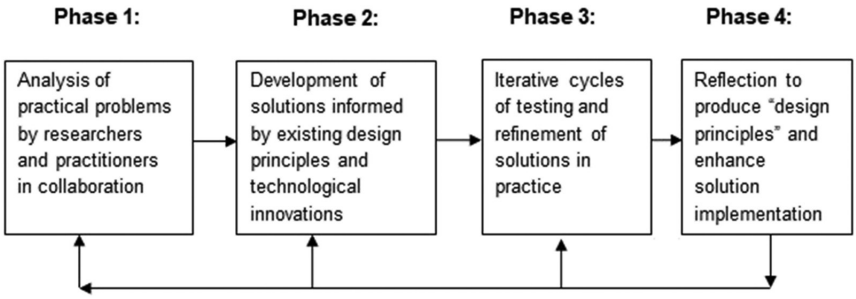

Figure 1.
Design-Based Research Model (Reeves, 2006).

Building on research conducted by Rodríguez (2017) who analyzed publications between 2008 and 2013, we analyzed studies published between 2013 and 2018. During the article identification process, we collected research articles in English targeting TELL published in SSCI-cited journals. We analyzed studies published between 2013 and 2018. The journal articles selected for this research context were also reviewed to ensure that they used the DBR approach. Leading journals in the field, for example, AJET, BJET, CALL, Computers & Education, ELT, IJCALLT, Journal of Educational Technology & Society, Language Learning & Technology, Language Teaching, ReCALL, System, TESOL Journal and TESOL Quarterly, and relevant databases such as JSTOR, Oxford Journals, ProQuest, SAGE Journals Online, Springer Link, Taylor and Francis, Web of Science (ISI) and WILEY Online Library were searched. Some of the key words used during the article identification process were *Design research*, *Design-based research*, *Educational Design Research, Developmental design*, *DBR and CALL*, *DBR and TELL*, *DBR and language*, *design-based research and CALL*, *design-based research and TELL*, *design research and CALL*, *design research and TELL*, *DBR and TEFL*, *DBR and TESOL*, and *DBR and TBLT*.

Moreover, within the initially collected articles, we searched the references for other research that employed DBR in L2 education and looked for signs of multiple publications, for example, "as our findings in the first cycle (Wong et al., 2010)" (Wong, 2013a) to include in this research. The journal articles that matched this research context were collected. However, other types of sources (non-SSCI-indexed) were excluded, to ensure that the studies included had gone through the rigorous journal review process. Applying the previously mentioned criteria, a total of 36 articles were identified for analysis.

The analysis resulted in findings classified according to the proportion of DBR studies by educational sector, target language context, targeted language skills, geographic focus, DBR model, iteration duration and frequency, interventions (and whether revisions were made to the interventions), and the design principles. The

analysis of context, intervention, educational problem, pedagogy, and design principles provide a general picture of the current research in TELL. The following research questions guided our literature review:

- RQ 1. How is DBR implemented in TELL in terms of the proportion of DBR studies by educational sector, target language context, targeted language skills, geographic focus, DBR model, iteration duration and frequency, revisions made to interventions, and the initial and revised design principles?
- RQ 2. What are the trends among the educational theories and interventions encompassed in DBR studies in the context of L2 education?
- RQ 3. What were the educational problems authors aimed to address with their DBR studies?
- RQ 4. In what ways can current DBR inform future research in TELL?

Results

The Proportion of Design-Based Research Studies by

Educational Sector

In the 36 articles we analyzed, the educational sectors covered were identified as preschool, primary school, middle school, secondary school, higher education, and other (Figure 2). It is evident that DBR has been applied at all levels of language education, with the largest proportion at the primary school level, at 47.2%, followed by 30.6% in higher education.

Target Language Context

Two of the 36 studies were conducted in contexts that included bilingual participants, namely, the students' mother tongue was different from the language they were learning at school, and school instruction targeted the further development of

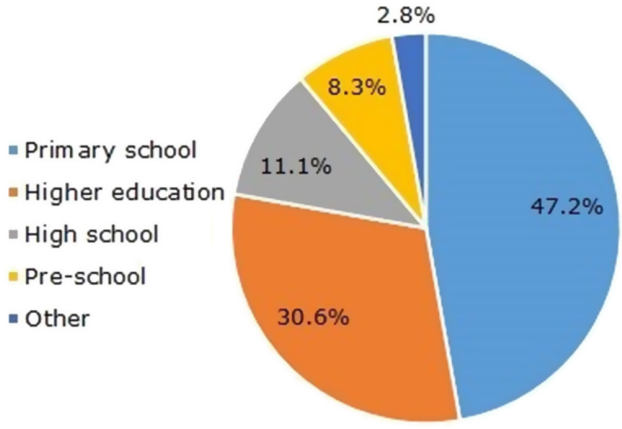

Figure 2.
Proportion of DBR Studies by Educational Sector.

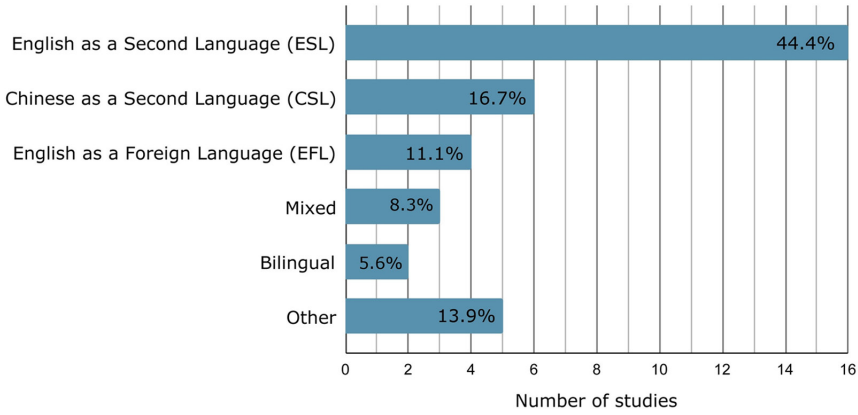

Figure 3.
Targeted Language Context.

these students' skills in L2. Figure 3 provides a breakdown of the research contexts showing that most of the research focused on English as a second language (ESL), with 44.4%, followed by Chinese as a second language (CSL), with 16.7%. Studies that targeted teaching more than one foreign/second language, such as Parmaxi et al. (2016), comprised 8.3%.

Targeted Language Skill

As shown in Figure 4, the analysis of the 36 studies revealed that there was less focus on a single skill in the studies reviewed, such as vocabulary (13.9%), writing (11.1%), speaking (5.6%), or reading (2.8%), with more focus on multiple skills (25%). The other areas of research (41.7%) either focused on fields such as constructionism (n = 2), Chinese character learning (n = 2), and metalanguage (n = 8), or they were other publications of the same authors reporting different aspects of their

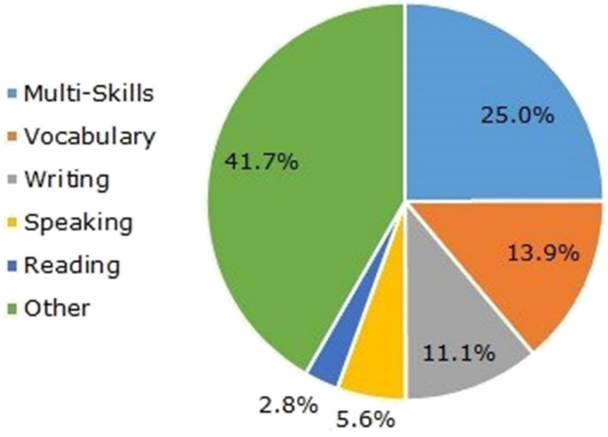

Figure 4.
Targeted Skills.

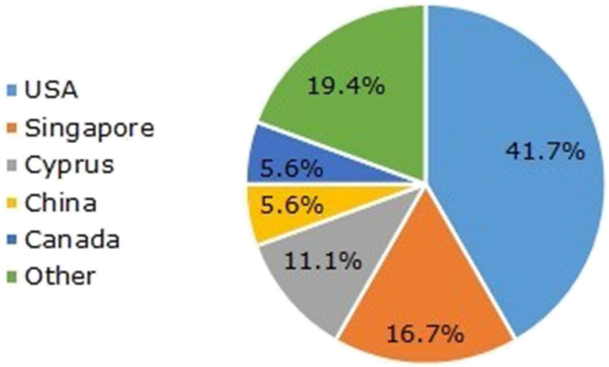

Figure 5.
Country of Origin.

research, such as reflections on past research (n = 1), artifact creation, and/or social interaction (n = 2).

Geographic Focus

As evident in Figure 5, the current study revealed findings similar to Anderson and Shattuck's (2012) review, namely, that most of the DBR was conducted in the United States (41.7%), followed by Singapore (16.7%) and Cyprus (11.1%). As for continents, no research was conducted in South America during the timeframe of this research.

Design-Based Research Model

While conducting this study, we searched for information regarding which DBR model was used so that we could better understand the types of activities researchers completed. As shown in Figure 6, while most of the authors (69.4%) did not mention which DBR model they used, 11.1% reported using Reeves' (2006) model and 2.8% reported applying the Bannan-Ritland (2003) model, whereas 16.7% of the studies highlighted the use of the general characteristics of DBR.

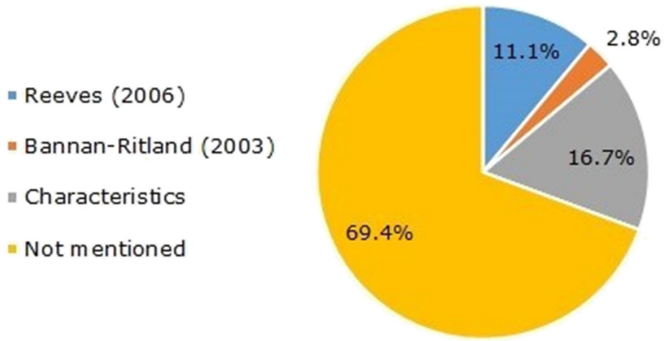

Figure 6.
Reporting the Use of a DBR Model.

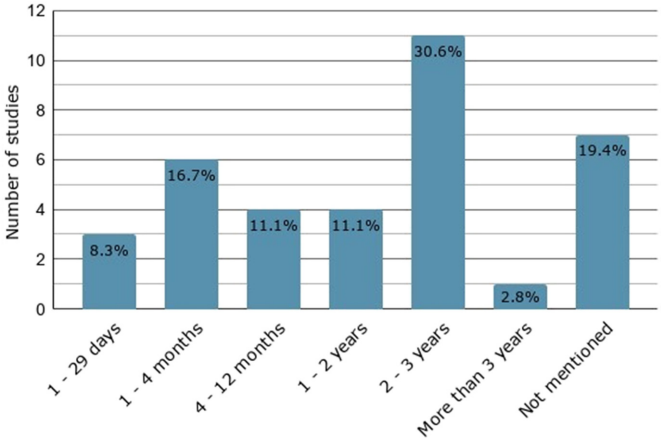

Figure 7.
Iteration Duration.

Iteration Duration and Frequency

DBR requires researchers to go through multiple phases and iterative cycles and collaborate with practitioners. Thus, it can be a daunting task to complete. However, the findings indicate that the implementation of each cycle can be as short as a day, or that the complete DBR project may last more than three years. Figure 7 summarizes the iteration duration, with most of the research being done in a two to three-year span (30.6%). Figure 8 presents the iteration frequency, with one-third of the research (33.3%) being implemented in two cycles. Notably, 19.4% of the studies did not provide any information about the research duration.

Products of Design-Based Research

DBR is grounded in constructivist research philosophy (Magoon, 1977). Design-based researchers (DBRers) construct their own understanding of education by reflecting on how theory and innovation can be integrated to help eliminate educational

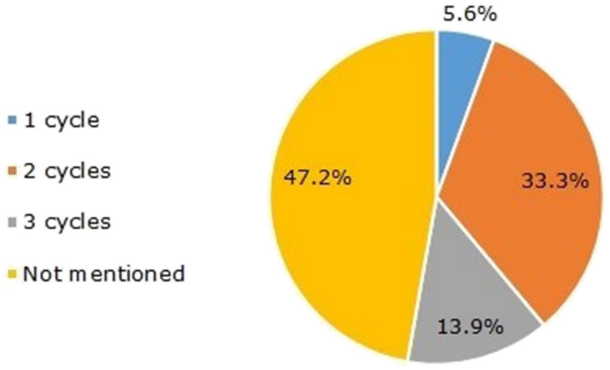

Figure 8.
Iteration Frequency.

problems. DBR is completed by articulating a set of design principles and revamping a prototype intervention based on "systematic reflection and documentation combined with rigorous data collection and analysis" (Hoven & Palalas, 2013, p. 145). Ideally, DBRers work in close collaboration with practitioners, and these collaborators can be empowered as authors of their own teaching methods rather than as simply the consumers of the learning theories or educational prescriptions proposed by others. A robust intervention and revised design principles are the two major outputs of DBR. Each is analyzed in detail subsequently.

Revamping the Intervention

An innovative intervention can be a book, an educative software, a classroom or technology-based pedagogical strategy, etc., and it is important to evaluate and refine the prototype intervention as the process unfolds. Makoe and Shandu (2018) describe the development of their intervention as follows:

> "Despite the myriad apps available in the market, none was considered appropriate for the purposes of vocabulary learning ... because they could not facilitate the principles which underpin the pedagogy of vocabulary teaching and learning…. [A] contextually relevant app was then developed to address the pedagogical … thrust and the technological … delivery. The app had to conform to the vocabulary learning principles of explicit vocabulary teaching…; rehearsal and practice as well as incorporating testing." (p. 211)

However, in some cases, it was not possible to make changes to the intervention. For example, Parmaxi and Zaphiris (2015) used social technologies (e.g., Facebook) as interventions, ruling out the possibility of making changes. Such cases are reported as "not applicable." As demonstrated in Figure 9, 38.9% of the research studies made changes to the intervention, whereas in 47.2% of the research, it was

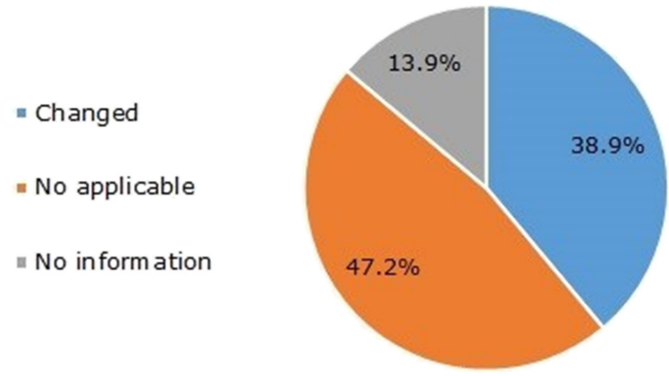

Figure 9.
Revisions Made to the Intervention.

not possible to make changes. The authors of five studies (13.9%) did not provide any information on the progressive evaluation and refinement of the intervention.

Revised Design Principles

A primary objective of DBR is to generate design principles and explain why and how design principles can be effective in a specific context to reduce specific educational problems, such as learners not spending sufficient time-on-task. While conducting the in-depth analysis, we first searched for information that indicated the development of the design principles and the design principles themselves. However, even though the revised design principles were explicitly provided in 18 studies, these were either not provided or were only implicitly understood in 18 articles.

Figure 10 demonstrates that 27.8% of the articles reported only the revised design principles; 22.2% reported both the initial and the revised design principles; 25% reported the initial design principles only, while the research theories were unclear in 5.6% of the research. Unfortunately, 19.4% of the research studies did not report any design principles, despite the implementation of a full cycle of DBR.

Table 1 sheds light on a number of aspects of focus in the current study. It provides an overview of the context, participants, educational problems, guiding theories, interventions, and the final design principles. The 36 articles were first grouped (26 groups) according to whether the research had multiple publications, and the publications were then ordered according to publication date and author name. For example, in row five, there are seven publications which have all derived from the same project; however, each study focuses on a different aspect of this project. Design principles in italics are deduced by the authors of the present research. Thus, the intended design principles may vary in wording and/or number. Consequently, readers are advised to refer to the original publications for more detail. Due to the word limit, the lengthy design principles of the study conducted by Rusman et al. (2018) have not been included here, and readers are therefore referred to the original document.

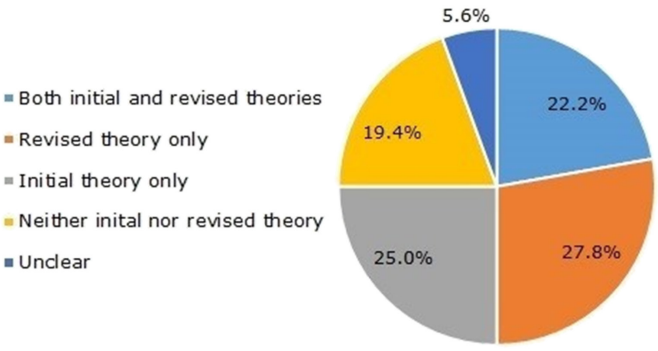

Figure 10.
Initial and Revised Theories.

Table 1.
Analysis of DBR in TELL Between 2013 and 2018

Group of Publications	Authors	1. Context 2. Participants (education level followed by number of participants) 3. The educational problem 4. Guiding theories 5. Intervention	Final Design Principles
1	Boticki et al. (2013); Wong and Hsu (2016)	1. CSL 2. Primary school • first cycle: 37 students • second micro cycle: 15 students • second cycle: 16 students 3. Social interaction; learning Chinese characters 4. mCSCL, scaffolding, ZPD, software architecture, social interdependence theory, Index of Learning Styles 5. Mobile apps (Form-A-One and Chinese-PP)	1. Facilitating the full cycle of 'pre-task–game–post-task' in each session, rather than just playing the game 2. Focusing on component-based character learning, not rote learning and memorization of overall patterns of individual characters 3. Promoting peer interactions throughout the games 4. Tapping into the advantages of trial and error
2	Caws (2013)	1. FSL 2. Higher education: 13 students 3. Dynamics of user interactions with Franco Toile 4. CALL, mediated activity theory, educational ergonomics 5. Web-based video corpus (Franco Toile)	1. Provide transcriptions and annotations 2. Provide opportunities to develop functional strategies to complete tasks 3. Use reading/scanning materials, inferring/guessing locations of items on the database, and remembering/noticing theme, speaker or words to develop critical literacy
3	Fettes (2013)	1. ESL 2. Five primary school teachers (number of students was not given) 3. Low academic success rates for aboriginal learners and oral language development 4. Oral language development theories, learning as a narrative 5. LUCID project	1. First encounter 2. Going deeper 3. Creating/inventing/re-imagining 4. Sharing and celebrating
4	Perren (2013)	1. ESL 2. Higher education (12 students participated in the survey; 89 reflections were analyzed) 3. The lack of service-learning activities in TESOL 4. Service-learning, post-structural theory 5. Service-learning program	Step 1: Planning and logistics Step 2: Obtaining materials and developing background information Step 3: Preparing for field experiences Step 4: Implementing field experience and civic engagement Step 5: Reflecting and connecting Step 6: Diversifying and repeating Step 7: Expressing gratitude and evaluating

5	Schleppegrell (2013); Moore and Schleppegrell (2014); O'Hallaron (2014); Palincsar, and Schleppegrell (2014); O'Hallaron et al. (2015); Schleppegrell (2016); Moore et al. (2018);	1. ESL 2. Primary school • year one: 8 teachers, 2 coaches, 200 students • year two: 21 teachers and 9 coaches, 300 students (from 12 classes) • year three: 20 teachers, 13 coaches and 500 students (from 5 schools) 3. Having few opportunities outside of school to learn or use the academic language needed for success 4. SFL, SLA, metalanguage 5. SFL metalanguage (Language & Meaning Project)	1. Support explicit, meaningful attention to the language of the text students read and write, in the service of achieving specific disciplinary goals of the curriculum 2. Develop teachers' explicit knowledge about language for purposes of supporting curricular learning 3. Support interaction between students and teachers to stimulate and support students' meaningful language use in disciplinary learning
6	Smith et al. (2013)	1. EFL 2. Higher education • first cycle: 3 students • second cycle: 57 students 1. Learning new vocabulary 2. Game-based approach, second-language vocabulary learning 3. Computer game	Not provided
7	Wong (2013a)	1. CSL 2. Primary school 3. Learning Chinese idioms 4. LGC, learning ecology 5. Wiki & smart phones (Move, Idioms!)	Not provided
8	Wong (2013b)	1. Post study reflections on Looi et al. (2010) (Project 1); Wong (2013a) (Project 2) 2. Project 1: (number of participants not mentioned); Project 2: 34 3. – 4. Seamless learning 5. Move, Idioms!, MLE	1. Develop learning processes that aim to change the mindsets of students 2. Consider formative assessment 3. Using spiral-style design (everything in current cycle, building on the previous cycle) 4. Equip students with the necessary critiquing skills 5. Teachers should have adequate professional development to understand seamless learning processes and relevant skills 6. Curriculum designers should incorporate a segment of activity that incorporates family involvement

(*Continued*)

Table 1.
Analysis of DBR in TELL Between 2013 and 2018 (Continued)

Group of Publications	Authors	1. Context 2. Participants (education level followed by number of participants) 3. The educational problem 4. Guiding theories 5. Intervention	Final Design Principles
9	Wang et al. (2014)	1. ESL and L1 2. Preschool: 28 students, 2 lead teachers and 3 assistant teachers in the design experiment class, and 1 teacher in the control class 3. Effective vocabulary practice 4. Sociocultural theory 5. A comprehensive model for early childhood vocabulary instruction	1. Vocabulary exposure and instruction • Define the word when it occurs in text • Teacher directs children's attention to the illustration of the target word while saying the word • Use questions to elicit the use of the target word • Contexts for meaningful exposure to vocabulary 2. Vocabulary-learning strategy instructionChildren (1) activate relevant prior knowledge; (2) make text to prior knowledge connections; and (3) articulate a possible word meaning and their reasoning for this deduction 3. Vocabulary-relations instructionUse a graphic organizer to organize-related concepts meaningfully 4. Opportunities to use newly learned vocabulary • Children dictate stories that the teacher scribes on the thematic topic being studied in the curriculum, and then illustrate and dictate labels for their illustrations • Two students use picture cues and recall to repeat familiar stories while 'reading' with a buddy 5. Word consciousness All methods across the component facilitated children's development of word consciousness
10	O'Connor et al. (2015)	1. ESL and L1 2. High school: 36 students and 5 teachers 3. Reading comprehension 4. Reading improvement focusing on coding, vocabulary and comprehension of expository text 5. BRIDGES (used for building strategies to improve performance in reading and history)	1. Providing feedback to students 2. Allowing multiple practice opportunities prior to individual assignments 3. Reviewing words and strategies 4. Actively engaging most students

11	Wong et al. (2015a); Wong et al. (2015b)	1. CSL 2. Primary school: 259 students (Wong et al., 2015); 37 students (Wong et al., 2015) 3. Limitations of conventional Chinese language teaching, such as the decontextualized and inauthentic learning processes that usually hinder reflection and deep learning 4. Mobile-assisted seamless language learning, situated learning, SLA, TPACK 5. Mobile- and cloud-assisted language learning (MyCLOUD)	1. Create opportunities for authentic activities among learners, within and beyond the classroom; 2. Interweave language input and output activities; 3. Interweave non-linear learning of linguistic knowledge, application and reflection process; 4. Draw learners' attention to both linguistic form and meaning, with meaning focused before form-focused; 5. Engage learners in activities that apply multiple language skills in different combinations and 6. Promote learner co-construction of linguistic knowledge.
12	Paliwoda-Pękosz and Stal (2015)	1. EFL, PSL 2. Higher education: • 433 students in 2011–2012 • 827 students in 2012–2013 and • 594 students in 2013–2014 3. Application of ICT in education in transition economies and investigating the feasibility of using VLE to support CLIL 4. CLIL, blended-learning 5. Self-designed VLE on Moodle	1. Encourage students to communicate with teachers (forum) and collaborate with other students (VLE workshop) 2. Encourage students to actively participate in lectures by initiating discussions and asking questions 3. Provide social activities to improve fluency 4. Separate long descriptions of assignments as blocks of text for each language 5. Provide collaboration and interactive learning 6. Allow the simultaneous observation of questions and answers in multiple languages 7. Encourage students to actively participate in forum discussions by awarding them
13	Parmaxi and Zaphiris (2015); Parmaxi et al. (2016)	1. GSL, GFL for academic purposes and English as a Foreign Language for Specific Academic Purposes 2. Higher education • Cycle 1: 4 students, 1 instructor • Cycle 2: 27 students, 2 instructors • Cycle 3: 43 students, 1 instructor 3. The use of social technology in teaching and learning is not framed in theory 4. (Social) Constructionism, CALL 5. Social technologies	1. Extension of the classroom walls 2. Merging physical and digital artifacts 3. Artifact-oriented task design 4. Real-life scenarios 5. Artifact stepping-stone 6. Powerful expertise 7. Valuing failure 8. Synergetic alliance of social technologies 9. Cultural trend 10. Unity (rather than diversity) in classroom dynamics 11. Communication between teacher and students 12. Sharing and reflecting 13. Duration of SC design

(*Continued*)

Table 1.
Analysis of DBR in TELL Between 2013 and 2018 (Continued)

Group of Publications	Authors	1. Context 2. Participants (education level followed by number of participants) 3. The educational problem 4. Guiding theories 5. Intervention	Final Design Principles
14	Daniel et al. (2016)	1. Emergent bilinguals 2. Kindergarten and primary school: 73 students, 8 teachers and 6 researchers 3. How to scaffold emergent bilinguals in literacy instruction 4. (Over-)scaffolding 5. A CAP	1. Reflect and act on classroom norms 2. Assess dynamically 3. Guide students toward productive peer-to-peer discussions 4. Teach metacognitive strategies 5. Provide a menu of scaffolding moves 6. Design curricular tools with scaffolding as process
15	Humphrey and Macnaught (2016)	1. EAP 2. Secondary school 3. Students' poor performance in the standardized National Assessment Program–Literacy and Numeracy; Teachers lacked knowledge of linguistic patterns 4. Metalanguage within SFL 5. SFL-informed metalanguage	Not provided
16	McPake and Stephen (2016)	1. Gaelic language 2. Preschool: 3 practitioners, 2 researchers, 1 fluent Gaelic speaker (no information provided on participating students) 3. Lack of educational resources to support Gaelic language learning and dependency on limited number of Gaelic-speaking practitioners 4. - 5. A tablet application (Our Story)	1. Expose learners to the target language 2. Provide opportunities to hear spoken Gaelic in contexts which are familiar and make sense to the children 3. Support children in retelling the stories themselves 4. Support children in constructing products using the target language (e.g., constructing new stories of their own or storyboards) 5. Use sources translated from English to enable learners to follow the story more easily and make connections between the words and phrases they already know in English 6. Use sources originally written in Gaelic to focus on alliteration, rhythm, rhyme or play on words 7. Provide scaffolding 8. Provide opportunity to collaborate 9. Promote performance practices

17	Ozverir et al. (2016); Ozverir et al. (2017)	1. EFL 2. Higher education • First cycle: 6 students and 2 teachers • Second cycle: 4 students and 1 teacher 3. Inert knowledge, lack of opportunities to use the target language outside the classroom 4. Authentic learning, task-based language teaching, SLA, constructivism 5. VLE on Moodle (City Newsletter)	Authentic activities: 1. Have real-world relevance 2. Are complex and ill-defined, requiring students to define the tasks and sub-tasks needed to complete the activity over a sustained period 3. Provide the opportunity for students to examine the task from different perspectives, using a variety of resources 4. Provide the opportunity to collaborate 5. Provide the opportunity to reflect 6. Lead beyond domain- and skill-specific outcomes 7. Are seamlessly integrated with assessment 8. Yield polished products that are valuable in their own right, rather than as preparation for something else 9. Are open-ended, allowing competing solutions and diversity of outcome 10. Are conducive to both learning and communicating 11. Provide motivational factors
18	Rowe and Miller (2016)	1. English as an Additional Language (bilinguals/biliterates) 2. Preschool: 1 teacher and 2 researchers • Cycle 1: 19 students • Cycle 2: 18 students 3. Supporting language and literacy skills 4. Theoretical assumptions about young children's digital composing (multimodal composing, multilingual composing, multiply-sponsored composing) and conditions likely to support it 5. eBook and affordances of iPads	1. Language-specific demonstrations 2. Personally sponsored demonstrations 3. Publicly valued demonstrations 4. Explicit support for metalinguistic awareness
19	Symons (2017)	1. ESL 2. Primary school: 1 fourth-grade teacher and 21 students (13 boys and 8 girls) 3. Students' problems in writing argumentative text 4. SFL theory and metalanguage 5. SFL metalanguage	Not provided

(*Continued*)

Table 1.
Analysis of DBR in TELL Between 2013 and 2018 (Continued)

Group of Publications	Authors	1. Context 2. Participants (education level followed by number of participants) 3. The educational problem 4. Guiding theories 5. Intervention	Final Design Principles
20	Hung (2017)	1. EFL 2. Higher education: 43 students 3. The application of flipped classroom to language education settings through the theoretical lens of SLA 4. Flipped learning, SLA, communicative language teaching 5. Friends (sitcom)	The F principle of a flexible language learning environment: 1. Provide comprehensible input with flexibility, accommodating individual preferences and proficiency levels, as a means for creating acquisition-rich flipped classrooms for L2 learners. The L principle of a language learning culture: 1. Offer interaction opportunities by using active learning strategies to increase learners' L2 exposure and use in the flipped classroom. The I principle of intentional linguistic content: 1. Design a mechanism with intentional content focusing on target meanings and forms of L2 to connect the pre-class and in-class activities of the flipped classroom. The P principle of a professional language educator: 1. Maintain up-to-date professional knowledge and skills to build a transformative learning community in the flipped classroom that empowers L2 learners to be active and responsible for their own learning.
21	Daniel and Eley (2018)	1. ESL 2. High school: 6 students and 1 teacher 3. Making connections between multiple ideas in texts 4. - 5. WISE program (to engage teens in writing identity texts that can be used while applying for college or a job)	1. Plan and implement designed-in scaffolds 2. Use the connective press responsively 3. Encourage collaborative, peer-mediated scaffolding with the connective press 4. Support learners in developing self-questioning using the connective press as a means for autonomous, strategic writing development
22	Jesson, McNaughton, Rosedale, Zhu, and Cockle (2018)	1. ESL 2. Primary school 3. Teaching writing in a digital learning environment in low-income schools 4. Digital literacy and writing 5. Blog posts	Not provided

23	Makoe and Shandu (2018)	1. ESL 2. Higher education: 18 students 3. Vocabulary learning 4. Vocabulary teaching, ODL 5. A vocabulary app (VocUp)	Principles regarding vocabulary development 1. Explicit vocabulary teaching 2. Rehearsal and practice 3. Testing Principles regarding technical qualities 1. Availability 2. Flexibility 3. Quick response 4. Connectivity 5. Reliability 6. Functionality 7. Usability 8. Security
24	Lo and Jeong (2018)	1. EFL 2. Secondary school: 1 teacher, 52 students 3. Students' inability to respond in English fluently 4. Genre-based pedagogy CLIL 5. Genre-based pedagogy	Not mentioned
25	Rusman et al. (2018)	%3. GSL %3. Primary school: 34 children and 14 adults (parents and scout supervisors) %3. Pronunciation and vocabulary %3. Mobile-assisted language learning, game-based language learning, situated/contextualized learning, seamless learning %3. Mobile game (ELENA Goes Shopping)	*See the design principles in Table 1 page 92–93 in the original publication.*
26	Zheng et al. (2018)	1. ESL 2. Higher education: 3 students 3. The project seeks to understand how space/place, technologies, and people function together as a system for language learners to experience events 4. Vygotsky's sociocultural theory of cognitive development 5. Mobile game	Not provided

Note. CSL = Chinese as a Second Language; mCSCL = mobile computer-supported collaborative learning; ZPD = zone of proximal development; FSL = French as a second language; CALL = computerassisted language learning; ESL = English as a second language;, learning for understanding through culturally inclusive imaginative development; TESOL = teaching English as a second language; SFL = systematic functional linguistics; SLA = second language acquisition; EFL = English as a foreign language;, learner-generated context; MLE = mobile learning environments; BRIDGES = building reading interventions designed for general education subjects; TPACK = technological, pedagogical, and content knowledge;, Polish as a second language; VLE = virtual learning environment; CLIL = content- and language-integrated learning; GSL = Greek as a second language; GFL = Greek as first language; CAP = Cross-age peer-tutoring program; EAP = English for academic purposes; ODL = open distance learning; GSL = German as a second language.

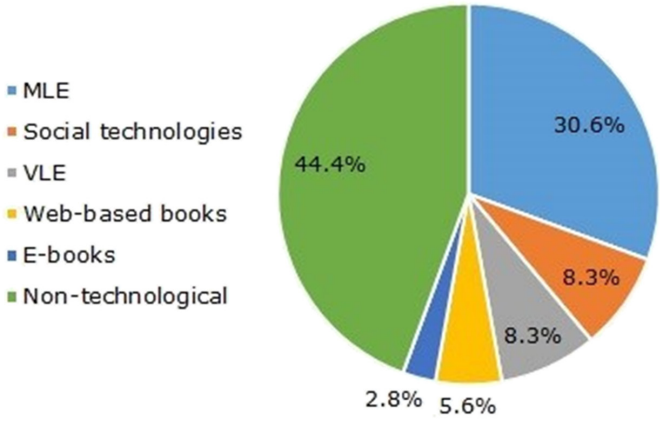

Figure 11.
Interventional Trends.

Interventional and Pedagogical Trends and Problems Addressed by Studies

Figures 11, 12, and 13 present the interventional and pedagogical trends along with the problems addressed, with the aim of answering research question two. Based on these results, two major categories were identified: technological trends and non-technological trends. As shown in Figure 11, among technological trends, mobile learning environments (MLE) (30.6%) were the most popular; these were followed by social technologies (8.3%), virtual learning environments (VLEs) (8.3%), web-based books (5.6%), and e-books (2.8%). Non-technological interventions were identified as material development and methodological approaches (44.4%), such as Fettes (2013), O′Connor et al. (2015), and Wang et al. (2014).

In terms of the theoretical frameworks for the DBR, we found that most of the studies used more than one educational theory in their research. In this respect, as

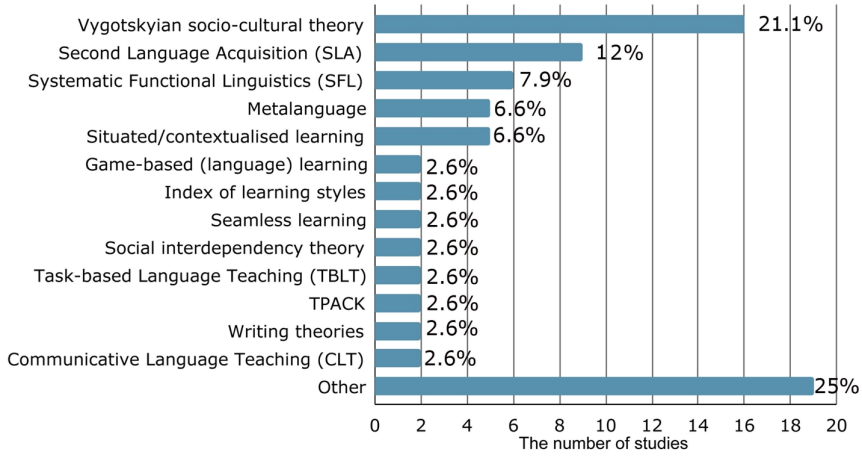

Figure 12.
Pedagogical Trends.

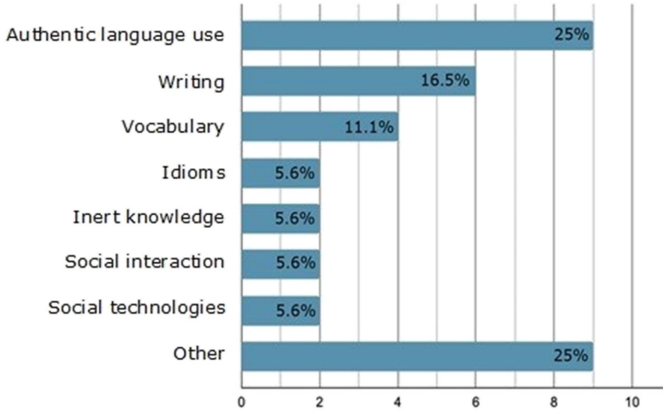

Figure 13.
Problems Addressed.

shown in Figure 12, Vygotsky's sociocultural theory was the most popular (21.1%), which was followed by Second Language Acquisition (SLA) theories (12%) and Systematic Functional Linguistics (SFL) (7.9%). The other category refers to educational theories used only once.

Overall, it can be deduced from the data that a certain trend among the problems addressed has also emerged. As it can be seen in Figure 13, authentic language use (25%) appears to be the most widely addressed issue. The second most addressed problem is shown to be writing (16.5%) and thirdly, vocabulary (11.1%). The other category refers to problems addressed only once, such as flipped classroom (Hung, 2017), oral language development (Fettes, 2013), and reading (O'Connor et al., 2015).

Discussion, Conclusion, and Recommendations

This study analyzed 36 DBR articles concerning L2 education published between 2013 and 2018 in SSCI-cited journals. This review can be particularly useful for researchers in L2 education as it maps the proportion of DBR studies by educational sector, target language context, targeted language skills, geographic focus, DBR model, iteration duration and frequency, interventions, educational problems, design principles, and current technological and pedagogical trends, along with educational problems in L2 education. Therefore, the following discussion not only informs practitioners about the current DBR activities in TELL, but also sets an agenda for future research.

We attribute the increase in DBR studies in language education to two reasons. First, we believe that the monograph published by CALICO in 2013 became a milestone in introducing DBR to the field. Anderson and Shattuck (2012), who focused on research studies that employed DBR before the publication of this monograph,

found only two studies that employed DBR in language education. Second, we attribute the increase in DBR studies in language education to the systematic examination of the research literature. As previously discussed, while Anderson and Shattuck (2012) found only two studies, Zheng (2015) found four and Rodríguez (2017) found 13 studies that employed DBR in language education. These reviews clearly revealed a gap in the field, which might have attracted the attention of TELL researchers, and resulted in 36 DBR articles being published in SSCI-cited journal publications between 2013 and 2018.

The personal interests of a few DBRers also affected the number of publications in the areas that were investigated in research question one, such as the proportion of DBR studies by educational sector, target language context, target skill, country of origin, and revisions made to the intervention. For example, 17 of the 36 studies were conducted at the primary school level, with Lung H. Wong participating in six and Mary J. Schleppegrell also participating in another six of these studies. Additionally, two publications–O'Hallaron (2014) and Symons (2017)–were based on the research study in which Schleppegrell also participated. This means that only four studies were conducted by other researchers at the primary school level. Similarly, in the targeted skills category, Schleppegrell and her fellow researchers focused on the use of metalanguage in language education, leading to seven publications, all recorded under the category of *other*.

Anderson and Shattuck (2012) analyzed the predominance of publications across disciplines using DBR according to the country of origin of the first-stated author, and concluded that "the major original work on DBR" (p. 20) was from the United States. Although we found no special issues on using DBR in L2 education, we also noted that most of the DBR was conducted in the United States; nevertheless, it seems that there has been an increase in the number of countries where DBR research is implemented.

One aspect that has not been examined by other systematic reviews in DBR is the targeted skill in language education. The results revealed that focusing on multiple skills and other areas of research, such as social interaction, artifact creation, Chinese character learning, metalanguage, and self-efficacy is more popular than focusing on just one language skill. Consequently, more DBR is needed to analyze design principles focusing on a single skill. Researchers are advised to use the design principles reported in Table 1 to conduct further research on certain skills. This, in turn, would provide sufficient data for future systematic analyses.

Anderson and Shattuck (2012) and Zheng (2015) argue that the iterative structure of DBR has the potential to go beyond the resources or the time available to researchers. However, unlike the assertion that DBR requires a long period of time

to complete, and in line with Herrington et al. (2007) who argued that DBR can be used by student researchers such as PhD students, this study revealed that DBR can not only be completed within the time limit of a PhD program, but can also be used in smaller-scale research. Wong and Hsu (2016) demonstrated that it is possible to implement DBR in a reasonable time frame without exceeding the resources or the time available to researchers or funding bodies, with the design of activities that would last from a few hours to a month. Nevertheless, our findings on iteration duration and frequency indicated that, in general, DBR is preferred for larger research projects. If DBRers focus on truly serious educational problems in TELL, their research agendas are likely to last for several years rather than months.

DBR interventions evolve through multiple cycles of design and implementation refinements (Anderson & Shattuck, 2012). In DBR processes, there is always room for growth; thus, it is always difficult to know when the research is completed. One of the challenges that we experienced was related to reporting the iteration duration, an issue which was also raised by Anderson and Shattuck (2012). This was due to some research studies not reporting the time frame at all; other research studies reported the time spent on the activity that was completed as part of the research, whereas others indicated the time spent on a phase, cycle, or for the entire project. This made it a daunting task for us, too, while categorizing the time frames and drawing clear conclusions. Consequently, we would like to suggest that researchers *indicate the time spent on designing the artifact, the educational activity, each phase, cycle, and the research project,* clearly, whenever possible.

In line with Zheng (2015), who reported a significant downward trend in the revision of interventions, this study found that less than half of the research studies made changes to their interventions. This finding can be attributed to the fact that researchers prefer to use technology that is readily available, such as social media, as opposed to self-developed interventions. Those DBRers who reported revisions used self-developed artifacts such as virtual learning environments, mobile applications, or educative software programs. Regarding implications for future research, we recommend that researchers *provide the revisions made to the intervention* or *the reasons for not revising the intervention*, because the final version of the intervention and the design principles are the major points of interest for subsequent research or practice.

Regarding the DBR model, the present study drew attention to the effect of the difference between the characteristics and models of DBR on the outcome of one's research. Some studies were out of the scope of DBR, because they did not suggest any design principles, despite the full iteration of the research. This may derive from researchers' using the characteristics of DBR rather than a model as their guide. Consequently, it is recommended that researchers *explicitly write up the final*

design principles (as recommended by Herrington et al. (2010) and preferably at distinct points) with the aim of making them clear for successive researchers and practitioners.

Another significant finding is that DBR provides the opportunity for researchers and practitioners to collaboratively become the authors of their teaching methods by constructing their own knowledge and pedagogy in specific social contexts. This opportunity addresses the concern voiced by Ellis (2012), who argued that comparative studies in TESOL show teachers to be the actors of other scriptwriters rather than being the authors of their own scripts. This aligns well with Canagarajah's (2016) findings that the trend in teacher development is moving toward reflective and situated practice. Probably no research approach is more suitable for this purpose than DBR. Consequently, we recommend that *researchers and collaborating practitioners use DBR if they aim to reflect on their teaching practice in the light of educational theories, and develop their own pedagogical innovations.*

Most of the research studies reviewed used more than one theoretical framework in order to address an educational problem. The most popular were Vygotsky's sociocultural theory, SLA, SFL, metalanguage, and situated learning theories. Using a variety of learning theories helped researchers develop rich design principles that addressed multiple issues such as student–student, student–teacher, student–intervention interaction, transfer problem, and developing an intervention based on sound theories. It is noteworthy that the emphasis was not on focus-on-forms (i.e., form-focused) but rather on focus-on-form (i.e., meaning-focused) approaches (Ellis et al., 2002) and on the social context in and out of school. This finding parallels the findings of Canagarajah (2016), who states that teaching methods are moving toward socialization and ecological models.

Our review found that DBRers have used technological interventions more than non-technological ones, which was also found by Anderson and Shattuck (2012). This highlights the fact that researchers tend to opt for available resources and technologies to solve educational problems. The fact that students have their own mobile devices makes MLEs the most popular technology. Palalas and Hoven (2013) criticized the lack of systematic processes that "incorporate the design, development, and testing of appropriate [Mobile Enhanced Language Learning (MELL)] instructional materials at the same time as developing a prototype system as an instantiation of the theory" (p. 42). However, the current study revealed that there is growing interest in designing, developing and implementing MLEs and the instantiation of the theory, as evident in the work of Makoe and Shandu (2018), who provide both pedagogical and technological design principles, and others such as McPake and Stephen (2016), Rowe and Miller (2016) and Rusman et al. (2018). These studies can shed light on future MELL research.

While analyzing the data related to interventions and pedagogical trends, one cannot but notice that there is an emerging trend among the problems addressed in the studies. Interestingly, within our time frame (2013–2018), most of the studies focused on the lack of opportunities for authentic language use in and out of the classroom as the educational problem (Caws, 2013; Ozverir et al., 2016, 2017). This highlights how practitioners in the last decade or so have started to realize the hindrance of not providing foreign or second language learners with opportunities to use language authentically and how this fact disadvantages language development (Ozverir and Herrington, 2011). The attempt to address the issue of writing also surfaced as a frequent problem tackled by many studies. Undoubtedly, writing is a concern for many L2 educators, as it is one of the most valued skills to master in academic settings and is also very demanding for many learners. Thus, practitioners have been pursuing an optimal method to enhance learners' writing, as it constitutes one of the skills of language proficiency (Palviainen et al., 2012). Along with writing, vocabulary was also valued as a skill that needs to be addressed, since it is foundational to learning a language (Chiu, 2013). Without appropriate lexis, learners are unable to acquire the language. It is evident that the problems addressed by DBR in TELL coincide with the pedagogical trends which have surfaced.

To summarize, our literature review can guide researchers to start their research from different vantage points: a problem, a theory, technology, context, or gap. For example, if researchers and their collaborating practitioners:

- are in the context of ESL and higher education, then they can construct their own design principles using Makoe and Shandu (2018), Parmaxi and Zaphiris (2015), or Perren (2013);
- want to use CLIL as a teaching approach, then they can adapt design principles suggested by Paliwoda-Pękosz and Stal (2015);
- have middle school students with disabilities, then they can explore the principles suggested by O'Connor et al. (2015);
- think inert knowledge is a problem in their context, then they can utilize the characteristics of authentic learning as suggested by Ozverir et al. (2016);
- want to develop their own mobile app, then they can use the principles of technical qualities suggested by Makoe and Shandu (2018);
- want to address a gap in the literature, then they can choose a problem, theory, or technology that has not been investigated before, such as interactive whiteboards.

We believe that researchers can use Table 1 to handpick a viable starting point to get involved in design-based research (Ozverir et al., 2016). However, the ideal starting point for DBR is a serious educational problem in the context in which the researchers and their collaborating practitioners co-exist (McKenney & Reeves, 2018).

This research has carefully reviewed the status of 36 DBR studies in the L2 context and found that well-designed DBR yields high-level, evidence-based, and research-informed design principles. The research reported here provides design principles that were found valuable in the authors' own contexts and have the potential to enhance L2 learning in TELL environments in similar contexts. Consequently, this research fills a significant gap by examining a substantial body of studies utilizing DBR and reporting design principles, which were not included in past DBR reviews, along with the problems, theories, technologies, and contexts. Drawing conclusions in the light of these previous studies will produce a comprehensive picture of what has been investigated related to the amalgamation of innovative interventions and well-established theoretical frameworks to solve serious educational problems in L2 learning. It is hoped that these results will be of use to educators wishing to improve their learning environments and teaching approaches, and to researchers in planning their future studies.

Notes

*We prefer to use the term TELL instead of CALL because the term TELL includes mobile devices, electronic dictionaries, simulations, interactive whiteboards, and any other technologies that can be used as part of the language learning process, whereas CALL is limited to the use of computers.

Peer review: Externally peer-reviewed.

Author Contributions: Concept – İ.Ö.; Design – İ.Ö., L.M.; Supervision – İ.Ö.; Data Collection and/or Processing – İ.Ö., L.M.; Analysis and/or Interpretation – İ.Ö., L.M.; Literature Search – İ.Ö.; Writing Manuscript – İ.Ö., L.M., A.Ö.; Critical Review – İ.Ö., L.M., A.Ö.

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