Innovations in Education and Teaching International
Vol. 48, No. 2, May 2011, 159–169

Routledge
Taylor & Francis Group

Design-based research: designing a multimedia environment to support language learning

Hsiu-Ting Hung*

Department of English, National Kaohsiung First University of Science and Technology, Kaohsiung, Taiwan

The present study examined 89 English language learners' experiences of reflective tasks in three systematically designed courses. Adopting a design-based research method, the purpose of this paper was to investigate a pedagogical design with a focus on tailoring digital video technology to support reflective tasks for language learning in multimedia environments. The reflective task featured in the present study went through an iterative design process with regard to task-completion formats and tools during 2006 to 2008. The main lessons learned from this research were discussed to provide insights into multimedia integration in language classrooms as well as to call for more design-based research in educational settings.

Keywords: design-based research; computer-assisted language learning; reflective practice; video technology; multimedia

Introduction

As an emerging methodology, Design-Based Research (DBR) allows educational researchers to systematically design and develop instructional interventions in authentic settings. According to the Design-Based Research Collective (2003) and many other advocates (e.g. Bannan-Ritland, 2003; Barab & Squire, 2004; Wang & Hannafin, 2005), the underlying assumption of DBR is that learning varies with the environment in which it takes place. The dual goal of DBR, therefore, is to develop appropriate designs of the learning environment, as well as to develop theoretical understandings that support learning in the designed intervention through iterative cycles of design, enactment, and redesign. Although the whole process of DBR can be time- and money-intensive, its results are worth the effort (Hoadley, 2005; Yutdhana, 2005).

Given that DBR is a relatively recent methodology, little research has been conducted using it in educational settings, and nowhere less so than in the field of computer-assisted language learning (CALL). Reeves (2006, p. 58) argued in favour of more design-based research and stated that DBR holds great promise for:

- addressing complex problems in real contexts in collaboration with practitioners;
- integrating known and hypothetical design principles with technological advances to render plausible solutions to these complex problems; and
- conducting rigorous and reflective inquiry to test and refine innovative learning environments as well as to define new design principles.

*Email: hhung@nkfust.edu.tw

ISSN 1470-3297 print/ISSN 1470-3300 online

DOI: 10.1080/14703297.2011.564011
http://www.informaworld.com

Recognising the potential of DBR for CALL studies, the purpose of this paper was to investigate a pedagogical design with a focus on tailoring digital video technology to support reflective tasks for language learning in multimedia environments through an iterative design process. A distinguishing feature of DBR is that its implementation process requires the researchers to use 'theory-driven design to create complex interventions that can be tested with empirical methods as well as contribute to better understanding of the underlying theory' (Yutdhana, 2005, p. 176). Following this thinking, the present research relied on a language-learning theory and a cognitive theory of multimedia learning to ground the investigation in the context of foreign language classrooms in Taiwan.

The article begins with a discussion on the theoretical framework for the DBR project, followed by a presentation of the research questions. The DBR methodology and the implementation process are then described, with a focus on the task design. The results of the DBR project are presented in response to the research questions, followed by the theoretical implications with regard to both generalising design principles and for advancing language-learning theories.

Design framework for the theory-driven instructional intervention

This instructional intervention aimed to embed the learning of subject-matter literacy (in this case, English as a foreign language, [EFL]) in multimedia environments. To this end, design principles related to multimedia and language learning were used to guide the present study. Moreno (2006) discussed 10 empirically-based instructional-design principles derived from the widely accepted cognitive theory of multimedia learning (Mayer & Moreno, 2003), with one set of principles for reducing extraneous cognitive processing and the other for increasing essential cognitive processing. Specifically, the present research follows the design principles for increasing essential cognitive processing as advocated by Moreno (2006, p. 65). These principles, which centre on multimedia, personalisation, guidance, interactivity, and reflection, are outlined as follows.

- Students learn better from words and graphics than from words alone.
- Students learn better when explanations are personalised rather than nonpersonalised.
- Novice students learn better when given principle-based explanations than they do when asked to infer principles by themselves.
- Students learn better by manipulating the materials rather than by passively observing others manipulate the materials.
- Students learn better when given opportunities to reflect during the meaning-making process.

In terms of the domain theory, the learning principles proposed by Chapelle (2005, p. 57) on the basis of a broad theory of second language acquisition (SLA) served as guidelines for designing multimedia-rich environments that would:

- make key linguistic characteristics salient;
- offer modifications of linguistic input;
- provide opportunities for comprehensible output;
- provide opportunities for learners to notice their errors;

- provide opportunities for learners to correct their linguistic output;
- support modified interaction between the learner and the computer; and
- provide opportunities for the learner to act as a participant in L2 tasks.

Recognising the critical role of design in the development of research results and theories as advocated by Reeves (2006), this paper placed an emphasis on integrating known design principles in conducting a rigorous inquiry in order to refine innovative learning environments and new design principles.

Research questions

This research followed the three major stages of DBR cycles, design-enactment-redesign, to investigate an instructional innovation for enhancing language learners' experiences of reflective tasks in multimedia environments. Particularly, this research aimed to answer the following questions:

(1) How do the students perceive the usefulness of the focal pedagogical elements?
(2) How do different designs of reflective tasks affect the nature of the students' video-enhanced reflections?
(3) How can the pedagogical design be refined based on the students' perceptions?

In the first stage of the DBR process, this pedagogical design was developed based on the theory-driven design framework as outlined previously. The research questions above focus mainly on the enactment and redesign stages of DBR to evaluate, analyse, and refine the proposed pedagogical design.

Overview of the design-based research project

The DBR project was conducted at a public university in Taiwan, and lasted for three years. The course observed is called Communication and Presentation, and it is a required two-credit course for students who are studying English as a foreign language at the research site. Three groups of students were recruited to voluntarily participate in the study, including 26 students who enrolled in the speech communication course in Fall 2006, 28 students in Fall 2007, and 35 students in Fall 2008. A total of 89 students (76 females and 13 males) participated in the study, all of whom were junior English majors at the time of the research project. Moreover, all of the participants were native speakers of Chinese who had been receiving formal EFL education in Taiwan for an average of nine years.

Based on the DBR method, the implementation of the classes under investigation was identical. Three major pedagogical design elements include: (1) video cases for presentation training; (2) video recordings of student presentations; and (3) write-ups of video-enhanced reflection. At the beginning of the course, explicit instructions on presentation principles were provided to develop the students' knowledge of and strategies for giving effective presentations. During the training sessions, video cases of a variety of presentation scenarios were shown to the students to illustrate how these principles could be put into practice. These video-assisted lessons offered suggestions on how to enhance content delivery, physical delivery, and visual aids delivery of presentation. The lessons also introduced various organisational patterns of presentation, such

as cause and effect, compare and contrast, problem and solution, and scientific methods. In each session, one or two target presentation strategies were demonstrated by instructional videos or modelled by the course instructor, who was also the researcher. Next, all the students were paired up, and each was asked to individually perform a 15-minute presentation based on an assigned organisational pattern of presentation. The students were free to select topics of interest to themselves and were asked to conduct their presentations twice, with one serving as a rehearsal, presented out of class, and the other in class for the formal course assessment. Both presentations were video recorded by their presentation partner onto DVDs, using a digital camcorder provided by the instructor. After the presentations, the students engaged in a featured task in completion of their video-enhanced reflections, to be described in the next section.

It should be emphasised that multimedia is an 'umbrella' term that can refer to media contents (e.g., video clips), media storages (e.g., CDs), media programs (e.g., Windows Media Player), and media devices (e.g., digital cameras). A multimedia environment is defined here as a learning environment in which multiple forms of the above-mentioned multimedia are integrated into the context of learning. A multimedia environment, therefore, is often distributed and complex. In terms of the physical setting of the present study, each observed classroom was fully equipped with two microphones, a ceiling-mounted LCD projector, and a network-connected computer with multimedia capacity. Due to the interest in implementing video to support language learning, designing a multimedia environment in the context of this paper focuses on the three major elements of pedagogical design as enabled by a variety of digital video technologies.

Design of the reflective task for language learning

The reflective task featured in the present study required the students to review and reflect on recordings of their own presentations. The task designs were identical but differed with regard to task-completion formats and tools among the three classes under investigation, due to the iterative nature of DBR (see Table 1).

The students' reflective practice took different formats. For Classes 1 and 2, the reflective task was an individual assignment, while the students from Class 3 worked in pairs to complete the task. In terms of task-completion tools, the initial design of the reflective task in Fall 2006 required the students to review their presentations in a multimedia player (e.g., Windows Media Player) and compose their reflective analyses in a word-processing program (e.g., Microsoft Office Word). The second design, in Fall 2007, employed a stand-alone video-analysis program (vTrans) developed by the researcher's colleague specifically for the reflective task. This tool, sharing basic features of video-analysis software for qualitative research, allowed the students to

Table 1. The task designs implemented in the three classes under investigation.

	Task-completion tools	Task-completion formats
Class 1	Word-processing program in combination with a multimedia player	Self reflection (individual work)
Class 2	Stand-alone video-analysis program	Self reflection (individual work)
Class 3	Video-sharing website with an annotation feature	Collaborative reflection (pair work)

make notes in a text editor side-by-side with a video playback window. The third design, in Fall 2008, incorporated a video-sharing service (YouTube) which offers many features to make video sharing interactive. Of particular relevance to the present study, the commentary function on YouTube let the students post their comments within the platform, and the newly-launched annotation feature allowed the students to add text overlays or speech bubbles to their videos.

The video footage of the students' presentation performances in and out of the classroom formed the basis for their reflective practice in support of language learning. Since the students performed the same presentation twice, the reflective task was repeated. To facilitate the students' reflection, the teacher-researcher met with individual students in teacher–student conferences outside the class to offer feedback on their presentations and provide guidance on writing-up their video-enhanced reflections. The guiding questions for the first written video-enhanced reflection focused on the students' mastery of presentation strategies and skills. These prompts for reflection were given as follows.

(1) *Content Delivery*: How well did you do in terms of opening, organising, and ending the presentation? Did you make use of any strategies and discourse markers to enhance the content delivery of the presentation?
(2) *Physical Delivery*: How well did you do in terms of your outfit, eye contact, posture, gestures, and movements? Did you make use of any strategies to enhance the physical delivery of the presentation?
(3) *Visual Aids Delivery*: How well did you do in terms of preparing and delivering your visual aids? Did you follow general design principles when preparing your visual aids? Did you follow general delivery guidelines to make sure that you handled the visual aids professionally?

The second written video-enhanced reflection focused mainly on the students' presentation strengths, weaknesses, and improvements. A rather general guiding question, 'What did you notice?', was used to scaffold the students' responses for this task.

Data collection and analysis

Data collected for the DBR study included: (a) 54 observation field notes completed by the teacher-researcher after each class meeting; (b) approximately 30 hours of audio recordings of 89 teacher–student conferences conducted outside class with individual students in the students' native language to assist them in reflective practice; (c) approximately 45 hours of video recordings of all the students' out-of-class rehearsals and in-class presentations for their subsequent written reflections; (d) 144 entries of written reflections on the video recordings of the students' own presentations completed by the students in the target language, English; and (e) 89 responses of a course evaluation questionnaire completed by the students in the last class meeting, providing their views on how useful they felt the pedagogical design was in improving their oral presentation skills.

These multiple sources of data were used to ensure the trustworthiness of the present research. Likewise, the data analysis methods were triangulated to provide additional rigour, with the approaches used mainly qualitative and interpretive, supplemented by quantitative information to describe the data. More specifically, the questionnaire data was analysed quantitatively by extracting the mean values of the

students' ratings based on a five-point Likert scale. The students' perceptions gathered from: (a) their written comments to the open-ended questions in the questionnaire; (b) their utterances made in the teacher–student conferences; and (c) their write-ups of video-enhanced reflections were taken together and analysed qualitatively by identifying analytical units to provide insights with regard to the research questions outlined previously. A unit was determined by the extent to which it conveyed meaningful, topical information of direct relevance to the research focus. Additionally, the teacher-researcher's observation field notes and the video recordings of student presentations both served as the secondary data to triangulate the students' reported perceptions of their learning experiences.

Research findings

The results of the DBR project are presented and discussed below according to the three research questions.

How do the students perceive the usefulness of the focal pedagogical elements?

The students were asked to describe their perceptions about the usefulness of the major elements of the pedagogical design (i.e., video cases for presentation training, video recordings of student presentations, and write-ups of video-enhanced reflection) in relation to their language-learning experiences in multiple data sources as mentioned earlier. The data analyses indicated that the overall pedagogical design provided support for reflection, with each element playing a specific role in facilitating the students' processes of language learning.

The students generally felt that the focal pedagogical elements involved in the study were helpful for their language-learning development. Firstly, the students reported that the video cases demonstrated in the training sessions made the tacit knowledge of presentation principles explicit to them, and thus revealed how the related theories could be put into practice, allowing them to model various presentation strategies. Secondly, the students strongly endorsed the use of video recordings of their presentations as a way of visually representing their learning processes. According to the students, the video recordings allowed them to observe the strengths and weaknesses of their own performances, which they might otherwise have overlooked. Thirdly, the students regarded the video-enhanced reflections as helpful prompts which guided them in analysing and evaluating their learning performances. The students reported that this reflective practice focused their attention on specific aspects of their presentations, allowing them to develop a deeper understanding of their learning processes, and thus better refine and enhance their future performances.

In short, the pedagogical design was very well received by the students in all the three classes under investigation. This result confirms that of Lin, Hmelo, Kinzer, and Secules (1999) who suggested four technology design features to support reflection: process displays, process prompts, process models, and reflective social discourse. In the present pedagogical design, the video exemplars used in the training sessions manifested the design feature of process modelling, in that they used the expert's process of thinking and learning 'as a model for novice students who are learning about the same domain' (p. 50). The video recordings of the students' presentation performances were related to a process display, which 'shows learners explicitly what they are doing to solve a task or learn a concept' and makes their own learning 'an

object for reflection' (p. 47). The write-ups of the video-enhanced reflection served as a process prompt that brought the students' attention to 'specific aspects of process while learning is in action' (p. 47) and engaged them in an inquiry process through the use of guiding questions. As indicated by the participants' overall positive comments, process prompting is an effective design feature that helps learners monitor and analyse what they do and how they do it before, during, or after the learning process they have engaged in.

It can be concluded that the pedagogical design of the present research, featuring elements of process modelling (i.e., video cases for presentation training), process displaying (i.e., video recordings of student presentations), and process prompting (i.e., write-ups of video-enhanced reflection) was not only theory-driven, but also empirically supported by the research data. The positive results with respect to the first research question suggest that the proposed pedagogical design is worth implementing in courses that aim to develop students' oral proficiency, particularly those that emphasise the reflective aspect of learning with the mediation of video technology.

How do different designs of reflective tasks affect the nature of the students' video-enhanced reflections?

This research question was created, in part, to examine if different task designs affect the nature of the students' video-enhanced reflections. In a broader sense, the question also sought to find out if engaging the students in reflective tasks could possibly contribute to their language-learning processes.

The students' written reflections on their presentations were content-analysed to identify reflective units pertaining to the research focus. These analytical units were further coded based on Hatton and Smith's (1995) reflection framework, including descriptive reflection, dialogic reflection, and critical reflection. A quantitative analysis was also undertaken to describe the number and proportion of the students' reflective units. The results revealed that the design of the reflective tasks had an impact on the students' reflective responses (see Table 2). More specifically, the first type of reflective task, which utilised a multimedia player and a word-processing program, generated a high percentage of descriptive reflection (89%) along with occasional instances of dialogic reflection (11%). The second type of reflective task, which used a stand-alone video-analysis program, also produced a predominant amount of descriptive reflection (75%), and a small proportion of dialogic reflection (24%) was found in this reflective task. In contrast, the third type of reflective task, which employed a video-sharing website with an annotation feature, generated a greater amount of dialogic reflection (43%) and more instances of critical reflection (5%). However, similar to Task Types 1 and 2, descriptive reflection was still found most frequently (52%) in Task Type 3.

As shown in Table 2, descriptive reflection was the most common type of reflective writing identified in the participants' contributions across all three different reflective tasks. One plausible explanation for the predominance of descriptive reflection was that the participants relied on contextual clues to reflect on and make sense of their learning experiences. In this case, the participants focused on descriptions of occurrences when visual representations of what had happened were not available. As Hatton and Smith (1995) stated, descriptive reflection 'served to establish the context in an initial accounting for what took place, providing for a change of stance within the writing' (p. 41).

In terms of the hierarchy of reflectivity suggested by Hatton and Smith (1995), dialogic and critical reflections are considered higher levels of reflective thinking that

Table 2. Reflective units identified in different types of reflective tasks.

Reflective tasks	Descriptive reflection	Dialogic reflection	Critical reflection	Total
Type 1 (Class 1)	89 %	11 %	0 %	100 % (n=376)
Type 2 (Class 2)	75 %	24 %	1 %	100 % (n=395)
Type 3 (Class 3)	52 %	43 %	5 %	100 % (n=293)

are more desirable than descriptive reflection. Interestingly, the percentage of descriptive reflection decreased and that of dialogic and critical reflections increased from Task Types 1 to 3. Furthermore, the reflective task that was carried out in pairs (Type 3) produced a relatively higher rate of dialogic reflection than the individually done reflective tasks (Task Types 1 and 2). The variability may be attributed to the extent to which immediate mediation of visual representation via video was available in the different types of reflective task, which also increased from Task Types 1 to 3. Another possibility is that engaging the students in collaborative rather than individual tasks was more likely to promote dialogic and critical reflections. Based on the data analysed here, we can only conclude that the nature or reflectivity of the students' video-enhanced reflections was shaped by task design because the task-completion tools and formats were taken as a whole in designing the featured task rather than two separate elements to be investigated in the present study. Therefore, this finding presents a potentially interesting line of inquiry into various elements of task design that warrants further consideration.

How can the pedagogical design be refined based on the students' perceptions?

To answer the third research question, the results for the first and second questions were re-examined with a focus on the students' thoughts and feelings about the featured task carried out in the study. It is encouraging to note that the students reported having successfully learned about presentation principles and strategies through the reflective tasks. The students felt that engaging in the reflective tasks enhanced their motivation and attention to their processes of language learning, which assisted in their preparation for oral presentations in the target language. The students expressed overwhelmingly positive opinions of the reflective task, with frequent positive comments as to the helpfulness of the video recordings. For instance, one participant noted in the course evaluation questionnaire, 'This course was extremely helpful to me. The video recordings showed me the strong and weak points of my presentation, which guided me how to do better next time.' Likewise, as another participant stated,

> The use of video recordings was a great method to help me improve my presentation. If there were no video recordings, I guess I would keep making the same mistakes over and over again while giving a presentation. All in all, I really learned a lot from my teacher, my classmates, and my video.

In addition, it is worth mentioning that the task carried out in pairs (Task Type 3) generated not only more positive feedback but also higher levels of reflective thinking

than the ones conducted by individual students (Task Types 1 and 2). Overall, the results indicated that the reflective tasks supported the students' language-learning processes and were also perceived favourably by them, regardless of the task-completion format or technological medium.

All of the research findings have practical implications for the refinement of the pedagogical design in a similar course. First, an overall infrastructure of the course must be designed to support reflective learning. Second, students must have access to visual representations of their own language performance, preferably captured by digital video cameras, as the recordings thus produced can easily be distributed and reproduced, in order to facilitate their reflection process. Third, technological tools for students to compose reflections must be able to provide immediate visual representations of focal points for learning in order to enhance the reflectivity of learning toward a critical state of mind. Fourth, collaboration or cooperation when undertaking tasks must be taken into consideration when making design decisions, as a means to better engage students in reflective practice and to better promote the reflectivity of their learning.

Theoretical implications and conclusions

In summary, the DBR project set out to explore the experiences of 89 Taiwanese EFL learners enrolled in speech courses as they participated in reflective tasks designed to improve their oral presentation skills in classroom settings. Given that the dual goal of DBR is to develop a theory-driven design and advance underlying theories of such design, it is thus imperative to revisit Moreno's (2006) multimedia principles and Chapelle's (2005) language-learning principles which guided the design of the DBR project. Drawing from the present research findings, the main lessons learned are illustrated as follows. The proposed set of guidelines blend Moreno's (2006) and Chapelle's (2005) principles and can be used to design a multimedia environment to support computer-assisted language learning.

(1) The input principle: The learning task requires learners to comprehend the input with the guidance of teachers or others, and technology is employed to make key linguistic characteristics salient through modification or visual representation of the input.
(2) The output principle: The learning task requires learners to produce comprehensible output through negotiation of meaning with others, and technology is employed for learners to modify their use of the target language for greater comprehensibility.
(3) The noticing principle: The learning task requires learners to attend to the target forms and functions of language, and technology is employed for learners to monitor their learning and notice their errors.
(4) The reflection principle: The learning task requires learners to reflect on their learning experiences, and technology is employed for learners to visualise the learning process and to articulate what they have learned.
(5) The interactivity principle: The learning task requires learners to participate actively by social interaction with others as well as direct manipulation of information, and technology is employed to support interactivity among learners (i.e., interpersonal interactivity), between learners and learning materials (i.e., informational interactivity), or between learners and computers (i.e., human–computer interactivity).

(6) The multimedia principle: The learning task is focused around learners' exposure and participation in multimedia-rich contexts where multimedia is embedded to provide inherent scaffolding for learning.

The first three principles mentioned above are of direct relevance to language learning, and the second three pertain to learning in general. I believe that the current work has generated some potential design principles to facilitate learners' language-learning processes. Although the DBR project was situated in the context of foreign language education, the theoretical understandings derived from this paper can apply to other fields (along with discipline-based approaches). It should be noted that the present study is limited by homogeneous sampling (i.e., EFL college students in Taiwan) and self-reported measures of learning assessment to refine the proposed pedagogical design. More empirical studies, therefore, are needed to investigate different groups of learners' points of views and to determine the effectiveness of any proposed design through other measures, such as tests, in order to validate the design principles derived from the present study. Given the interest in applying reflective tasks to language learning, it is also recommended that future research be specifically designed to assess the relationship between task design and task performance to provide further empirical support for language learning in multimedia environments.

More ambitiously, aspects of the design principles produced in this work can serve as a basis for future research design, which I hope will give rise to more design-based research in wider fields of study. As scepticism about the rigour and effectiveness of conventional media comparison research has gradually increased in recent years (Oppenheimer, 2003), it is time for educational researchers to reform traditional research practices. This paper has demonstrated that the robust approach of DBR holds enormous potential for rigorous inquiry and practice. As an emerging methodology, DBR has been considered a more socially responsible form of inquiry (Wang & Hannafin, 2005; Reeves, 2006) because it 'does not just evaluate an innovative product or intervention, but systematically attempts to refine the innovation while also producing design principles that can guide similar research and development endeavours' (Amiel & Reeves, 2008, pp. 34–35). Accordingly, this paper concludes that DBR represents a promising direction for the further pursuit of socially responsible research.

Notes on contributor

Hsiu-Ting Hung is an assistant professor at the National Kaohsiung First University of Science and Technology in Taiwan. Her current research interests include English learning in multimedia environments and technology-mediated professional development for language teachers.

References

Amiel, T., & Reeves, T.C. (2008). Design-based research and educational technology: Rethinking technology and the research agenda. *Educational Technology & Society, 11*(4), 29–40.

Bannan-Ritland, B. (2003). The role of design in research: The integrative learning design framework. *Educational Researcher, 32*(1), 21–24.

Barab, S., & Squire, K. (2004). Design-based research: Putting a stake in the ground. *Journal of the Learning Sciences, 13*(1), 1–14.

Chapelle, C. (2005). Interactionist SLA theory in CALL research. In J.L. Egbert & G.M. Petrie (Ed.), *CALL research perspectives* (pp. 53–64). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Design-Based Research Collective. (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational Researcher, 32*(1), 5–8.

Hatton, N., & Smith, D. (1995) Reflection in teacher education: Towards definition and implementation. *Teaching and Teacher Education, 11*(1), 33–49.

Hoadley, C.M. (2005). Design-based research methods and theory building: A case study of research with SpeakEasy. *Educational Technology: The magazine for managers of change in education, 45*(1), 42–47.

Lin, X., Hmelo, C., Kinzer, C.K., & Secules, T.J. (1999). Designing technology to support reflection. *Educational Technology Research and Development, 47*(3), 43–62.

Mayer, R.E., & Moreno, R. (2003). Nine ways to reduce cognitive load in multimedia learning. *Educational Psychologist, 38*, 43–52.

Moreno, R. (2006). Learning in high-tech and multimedia environments. *Current Directions in Psychological Science, 15*(2), 63–67.

Oppenheimer, T. (2003). *The flickering mind: The false promise of technology in the classroom and how learning can be saved.* New York: Random House.

Reeves, T.C. (2006). Design research from a technology perspective. In J.V.D. Akker, K. Gravemeijer, S. McKenney, & N. Nieveen (Eds.), *Educational design research* (pp. 52–66). New York: Routledge.

Wang, F., & Hanafin, M.J. (2005). Design-based research and technology-enhanced learning environments. *Educational Technology Research and Development, 53*(4), 5–23.

Yutdhana, S. (2005). Design-based research in CALL. In J.L. Egbert & G.M. Petrie (Ed.), *CALL research perspectives* (pp. 169–178). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.