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Designing and developing a mobile teacher professional development course for digital game-enhanced language learning

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Abstract

While digital games hold promise for language learning, teachers often lack the knowledge and confidence to integrate them into their curriculum. Existing professional development opportunities are scarce and not always accessible. In this study, a mobile teacher professional development course on Digital Game-Enhanced Language Learning was designed, developed, and evaluated through three iterative cycles. The research employed a Type 1 design and development research methodology. Three groups of language instructors teaching English at the tertiary level participated in the iterative cycles. Data collection included course evaluation questionnaires, achievement tests, lesson plan development, and participant interviews. The findings indicated that the mobile teacher professional development course was effective in improving teacher perceptions of the course content, usability, and self-efficacy in integrating digital games into their teaching. The course also led to a significant increase in participants' knowledge of Digital Game-Enhanced Language Learning concepts. Overall, the mobile teacher professional development course has the potential to be a valuable tool for equipping language teachers with the skills and confidence needed to leverage digital games in their classrooms. This is particularly relevant considering the growing need for accessible and flexible professional development opportunities, such as during a global crisis.

Keywords: Digital game-enhanced language learning, Commercial off-the-shelf games, Mobile teacher professional development, Design and development research

Introduction

The fact that young people spend considerable time playing digital games has attracted the attention of researchers, leading to various studies conducted in two ways: some have explored the theoretical frameworks (Peterson et al., 2021; Pitarch, 2018; Sykes &



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Reinhardt, 2013), while others have examined their real-world applications (Sundqvist, 2019) to harness this potential to facilitate language learning and teaching. The literature also highlights that the effective use of digital games in language learning is strongly tied to the quality of the instructional design (Martín del Pozo et al., 2017; Reinhardt, 2019; Vlachopoulos & Makri, 2017) and that teacher competency in integrating games into teaching is of fundamental importance (Dehaan, 2020; Foster & Shah, 2020).

One of the key factors influencing teachers' decision to use digital games in the classroom is their lack of knowledge regarding game integration (Stieler-Hunt & Jones, 2019; Takeuchi & Vaala, 2014). Until teachers are provided with evidence-based strategies for integrating games, using digital games in education will be viewed as nothing more than a passing fad (Van Eck, 2006). When developing game-enhanced interventions, the educational benefits of games should always be given priority. Therefore, it is crucial to educate language teachers about the phenomenon of digital gaming and raise awareness of its potential (Sykes, 2018). They need to know how to integrate digital games into their teaching and need to feel confident in their abilities to do so (An & Cao, 2017; Becker, 2007; Deng et al., 2020; Denham, 2019; Musaoğlu-Aydın & Akkuş-Çakır, 2022).

Evidence suggests that teacher professional development (TPD) focused on integrating digital games into the curriculum effectively changes teachers' perceptions toward using games and increases their self-efficacy and behavioral intentions to use them (An, 2018; Stieler-Hunt & Jones, 2019). Teachers hesitate to integrate digital games to their teaching even though they believe this could be useful for their students (Koh et al., 2012; Takeuchi & Vaala, 2014), largely because they do not learn how to use digital games through pre-service or in-service training programs. Instead, they rely on more informal ways, such as learning from colleagues or self-learning and face challenges (Takeuchi & Vaala, 2014). This highlights the need for more TPD experiences, including a wide variety of pedagogical strategies to enhance and facilitate the integration of digital games in teaching (Koh et al., 2012; Takeuchi & Vaala, 2014). However, TPD opportunities to integrate games into teaching are scarce (Foster & Shah, 2020) and not always easily accessible (Mathe et al., 2022). Examining the design and implementation of TPD offered online is necessary considering the challenges teachers face to reach effective PD opportunities (Powell & Bodur, 2019). Acknowledging this need, this article proposes a practical approach by designing, developing, and evaluating a mobile teacher professional development (mTPD) course on Digital Game-Enhanced Language Learning (DGELL) through three iterative cycles. The research questions were:

1. What are the perceptions of the language instructors about the mTPD course on DGELL?
 - a. What are the perceptions of the language instructors about the content of the mTPD course on DGELL?

- b. What are the perceptions of the language instructors about the usability of the mTPD course on DGELL?
 - c. What are the perceptions of the language instructors about the effectiveness of the mTPD course on DGELL?
2. To what extent do the language instructors' perceptions about the use of digital games in language learning change after the implementation of the mTPD course?
3. To what extent do the language instructors' knowledge of DGELL change after the implementation of the mTPD course?

Literature review

Digital Game-Enhanced Language Learning

Digital Game-Based Language Learning (DGBLL) builds learning around two different types of digital games; serious games and commercial off-the-shelf (COTS) games (Becker, 2017). Serious games are designed for specific purposes, such as formal education, while COTS games are designed for commercial goals with pure entertainment purposes (Van Eck, 2006). Sykes and Reinhardt (2013) argued that it is necessary to distinguish between games designed for language learning and commercial games. They proposed theoretical foundations underlying the pedagogical practices of COTS games and coined the term Digital Game-Enhanced Language Learning (DGELL) to refer to language learning facilitated by COTS and/or non-educational digital games. The distinction between DGBLL and DGELL lies in their foundational approaches: DGBLL focuses on games specifically designed to foster language learning, while DGELL emphasizes the use of existing COTS games, integrating them into educational contexts to enhance learning outcomes.

Recent studies related to data (Dixon et al., 2022; Govender & Arnedo-Moreno, 2021; Sundqvist, 2019) and theory (Sykes, 2018) have shown that DGELL has significant potential and different aspects of DGELL have been investigated in the literature, such as opportunities for contextualized learning (Godwin-Jones, 2016; Lombardi, 2012; Peterson, 2013); mastering language skills such as listening and reading (Chen & Huang, 2010; Chen & Yang, 2013); and improving vocabulary (Chen & Yang, 2013; Peterson et al., 2022; Reinhardt, 2013; Schlasberg, 2020). The literature also highlights language teachers' concerns about the use of digital games in teaching, such as integrating COTS games into school curriculum (Becker, 2007), choosing the right kind of COTS games for their context (Van Eck, 2006), and designing lessons that incorporate COTS games (Foster & Shah, 2015; Van Eck, 2009).

However, despite its potential to provide meaningful practice of language, research on TPD about DGELL is not prevalent (Foster & Shah, 2020; Hwang & Wu, 2012). Existing

research offers important insights into the essential components that should be included in a TPD program on DGELL, such as fostering a community of teachers where gameplay is encouraged (Kuhn & Stevens, 2017), including practical activities where teachers can prepare their own lessons with digital games (Becker, 2007; Stieler-Hunt & Jones, 2019), exposing teachers to well-designed DGELL environments to help them understand about its implementation in a real-world settings (An, 2018), and providing a consistent dialogue between teachers and TPD facilitators to support teachers' knowledge of the resources available in the TPD (Callaghan et al., 2018). The literature also points out that by using their technological pedagogical content knowledge, teachers can effectively implement digital games in their teaching (Duvall & Foster, 2015; Meletiou-Mavrotheris & Prodromou, 2016). Frameworks such as the Play, Curricular Activity, Reflection, and Discussion (PCaRD) can facilitate the integration process by providing teachers with a robust and effective structure to use digital games in the classroom and ultimately increase students' involvement in learning based on their interests (Foster & Shah, 2015).

Mobile teacher professional development

The developments in mobile learning technologies and the application of these technologies in education have motivated researchers to utilize them to transform teachers' skills (Polly & Hannafin, 2010). Mobile learning has the potential to offer numerous benefits for TPD, such as increasing collaboration and peer feedback, facilitating reflection on teaching practices, sharing classroom experiences, and assessing performance (Dahri et al., 2021). It can also improve teachers' confidence and interest in mobile learning, as well as their practical skills, knowledge, and attitudes toward integrating technology into teaching and learning (Hafour, 2022; Power et al., 2016). Mobile learning, with characteristics such as mobility, access, immediacy, situativity, ubiquity, convenience, and contextuality (Baran, 2014), enables teachers to overcome physical barriers and develop their teaching, while also fostering collaborative professional learning environments through being situated, ubiquitous, and contextual (Jung, 2015). The impact of mobile professional development on teachers' professional and academic achievement and performance can be positive, leading to a rising number of qualified teachers irrespective of time, space, and financial constraints (Dahri et al., 2021).

By incorporating research-informed sources, it is possible to develop a robust mobile course design for TPD programs. This design can leverage the dimensions of the iPAC pedagogical framework of mobile learning, thereby enhancing the overall teaching and learning experiences within mobile learning environments (Kearney et al., 2012). This framework emphasizes personalization, authenticity, and collaboration as key dimensions influencing individuals' teaching and learning experiences when using technological

devices. Meaningful and authentic mobile pedagogies can be designed or evaluated by using these signature pedagogies (Koenraad, 2019).

While mobile learning refers specifically to educational experiences facilitated by portable devices such as smartphones, tablets and laptops (Naveed et al., 2023), remote learning is a broader term that includes any form of learning conducted away from a centralized physical location, encompassing devices including desktops and PCs (Nguyen et al., 2021). Unlike mobile learning, remote learning may lack the immediacy and flexibility of mobile devices and often involves a more stationary approach, particularly with PCs. This distinction is essential for this course, as mobile learning's adaptability directly supports the course goals of accessibility, context-aware learning, and learner-centered design.

Method

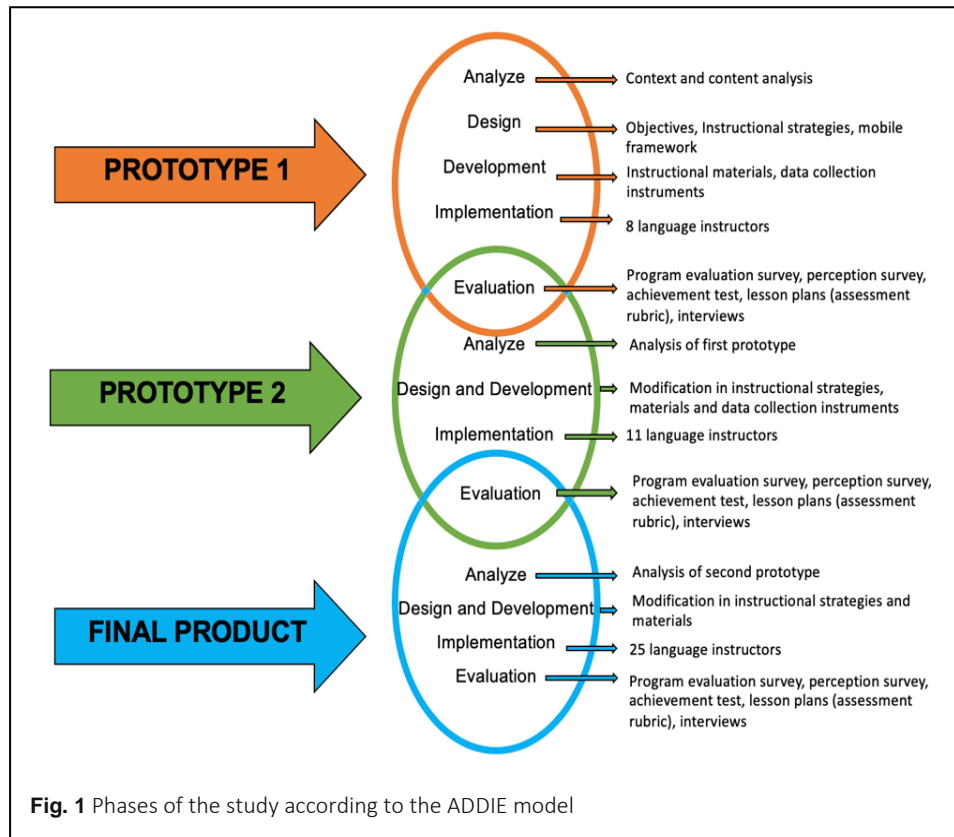
Research design

This study employed the Type 1 Design and Development Research (DDR) methodology. This methodology is particularly relevant in the field of instructional design and educational technology, where the focus is on creating effective and efficient learning experiences (Seels & Richey, 1994). The Type 1 DDR methodology also emphasizes the importance of evaluation in the design and development process to understand the effectiveness of the instructional program, using both formative and summative assessment methods. The researchers followed the steps in line with design research principles (Reeves, 2006). The instructional design of the study was based on the ADDIE instructional design approach (Davis, 2013) (Figure 1).

After implementing each prototype, the data were analyzed, and necessary changes were made to the content and design of the mTPD course (Appendix A). The iterative cycles of implementation established a cohort and problematic areas of the course were identified and addressed immediately. The prototypes of the mTPD course ended after the second prototype because only minor modifications were needed at the end of the second prototype. The final version of the mTPD course was implemented to understand how effectively the course fulfilled the language instructors' needs.

Participants

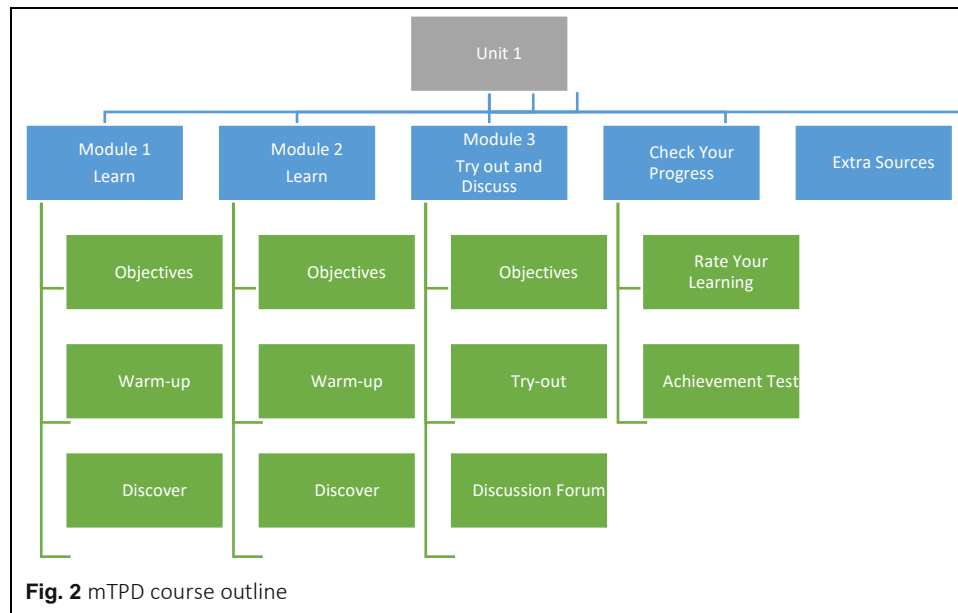
Three groups of language instructors teaching English at different universities in Türkiye were included in the implementation cycles of this study. Convenient and criterion sampling strategies were used to choose the participants of the study (Lindlof & Taylor, 2011). There were two criteria, (1) teaching English as a foreign language in a university and (2) having at least a basic level of skills to use technology. Eight participants were



assigned to the first prototype, 11 were assigned to the second prototype, and 25 were assigned to the final implementation. All procedures performed in the study involving human participants were in accordance with the ethical standards of the institutional research committee. Informed consent was obtained from all individual participants included in the study.

Developing the mTPD course

The mTPD course was implemented asynchronously in three iterations using Schoology®, chosen for its user-friendly interface and diverse content support, enabling participants to access content on both mobile devices and PCs. The mTPD course design adopted the iPAC Framework (Kearney et al., 2012) incorporating mobile learning pedagogies. The program was structured into small, modularized units (see Appendix C for a sample lesson plan). The content of each unit was divided into four sequential units to provide bite-sized chunks of new information. Each unit included three modules, the first two focusing on the theoretical aspects (see Figure 2). A course syllabus (Appendix B) was provided to detail course expectations.



Course content was structured around core objectives related to DGELL principles and designed to progress from theoretical foundations to practical applications.

Welcome Package: This introductory section provided essential resources for participants, including a course syllabus, detailed instructor information, expectations, and an FAQ section for troubleshooting. The Welcome Package helped familiarize participants with the course format and the technology used in Schoology©.

Instructional Content: The instructional units followed a theory-to-practice sequence, designed according to the Cognitive Systems Approach. Each unit contained three modules:

Module 1: Introduced foundational concepts through concise readings and video lectures led by subject-matter experts. Topics included defining DGELL, the roles of digital games in language acquisition, and essential frameworks (e.g., TPACK and PCaRD).

Module 2: Provided further exploration of the theoretical aspects, focusing on the integration of games into instructional design. This module involved additional expert-led lectures, focusing on identifying, assessing, and selecting digital games suitable for language learning contexts.

Module 3: Focused on application and reflection. Participants engaged in try-out tasks (e.g., game assessment and lesson plan creation using DGELL strategies) and participated in a structured discussion forum. Forums incorporated a rubric to guide meaningful exchanges, enhancing collaborative reflection and idea-sharing.

Pedagogical Framework: The iPAC Mobile Learning Framework informed the design, emphasizing personalization (allowing learners to control their learning pace), authenticity (engaging with real-world tasks), and collaboration (using forums and peer discussions).

Course Reflection: At the end of the instructional content, participants completed a structured reflection activity, encouraging them to critically assess their learning experiences, challenges, and potential applications of DGELL in their teaching.

Theoretical information was delivered to the language instructors through readings and video lectures presented by prominent researchers who had relevant expertise in the topics (Figure 3). The participants applied the theory to the learning tasks with various hands-on activities. The duration of each video and the reading time was kept between 3-10 minutes to keep the learners engaged and increase their attention span.

The third module in each unit included two parts; (1) activities in which the learners were able to use the theoretical information in practice and (2) a discussion forum (Figure 4). The ‘Check your progress’ part included two parts in which learners could evaluate their learning and assess how much they learned the new content by taking an achievement test. At the end of each unit, additional readings and materials were provided to the learners who wanted to deepen their understanding of the content.

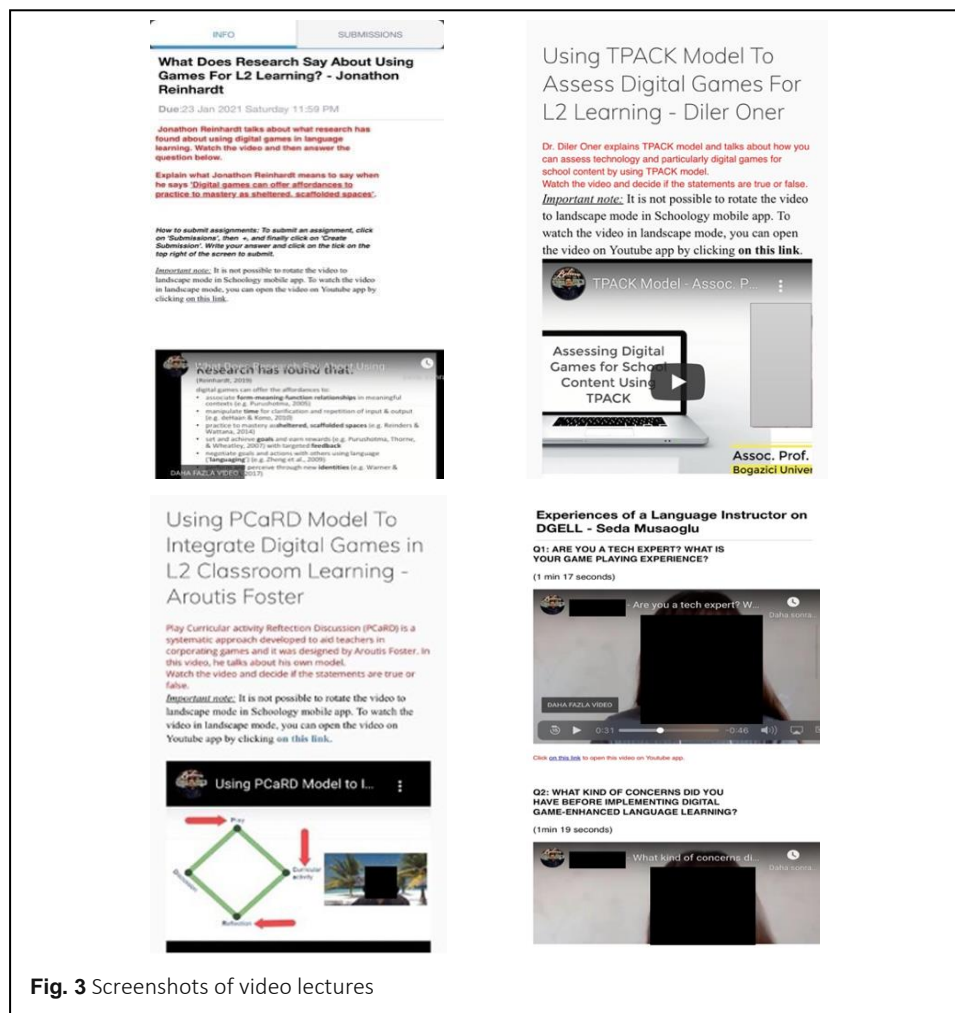


Fig. 3 Screenshots of video lectures

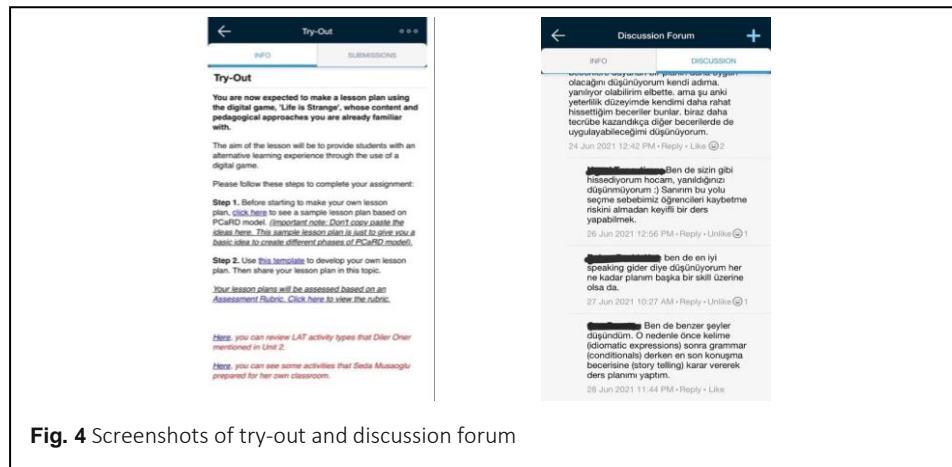


Fig. 4 Screenshots of try-out and discussion forum

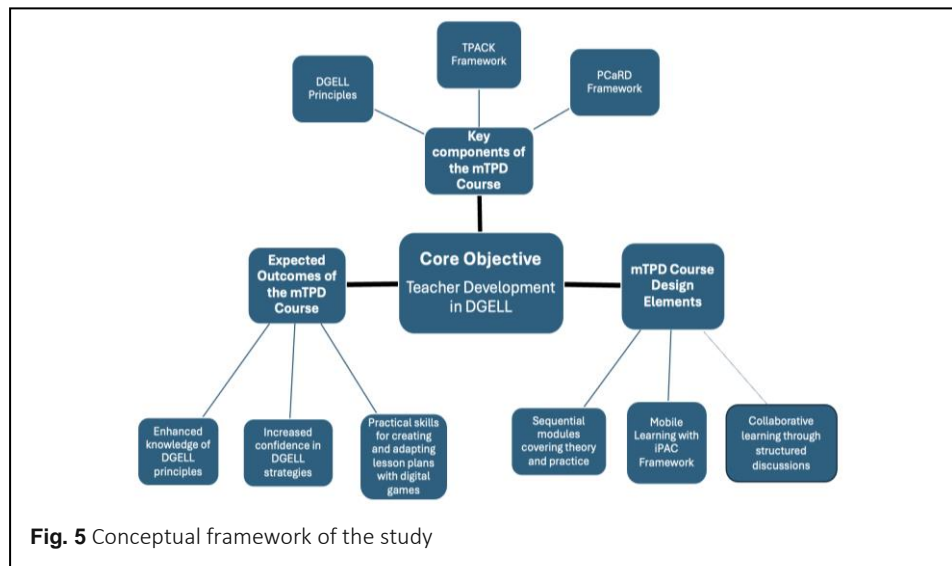


Fig. 5 Conceptual framework of the study

In designing the mTPD course, we structured content and activities around the core objectives of developing teacher competency in DGELL. The conceptual framework (Figure 5) illustrates the relationships between the core objective, key components, design elements, and expected outcomes of the course. This framework provided a guiding structure for the course development, ensuring alignment between theoretical foundations and practical applications.

Data collection

Data collection in each iteration included: (1) a course evaluation questionnaire, (2) a questionnaire about digital games in teaching, (3) an achievement test, (4) lesson plan development, and (5) participant interviews. The course evaluation questionnaire was developed based on previous research focusing on the design, development, and evaluation of a specific product and was administered at the end of each iteration to identify the

problematic areas of the course. The Digital Games in Teaching Questionnaire, developed by De Grove et al. (2012), includes five-point Likert scales ranging from ‘totally agree’ to ‘totally disagree’. It assesses teachers’ perceptions of digital game use in teaching across five dimensions: ease of use, usefulness, experience, behavioral intention, and learning opportunities. It was applied as pre-and post-tests in all cycles. To control for inflated Type 1 error, the p -value in all cycles was adjusted using Bonferroni correction.

To understand the impact of the course on participants’ DGELL knowledge, a standardized achievement test was developed following Simonson et al. (1987)’s guidelines, focusing on the content knowledge to assess teachers’ understanding of the subject. All questions were created following the curricular validity of the outcome measure (Confrey, 2006). Recognizing that content knowledge alone might offer a limited understanding of the DGELL knowledge of the participants, they were also required to develop lesson plans which were evaluated with a holistic rubric developed by the researchers and an expert, adhering Timmerman et al. (2011)’s guidelines for content validity, and they reviewed by two other experts.

Semi-structured interviews were conducted after each implementation to gain a deeper understanding of the participants’ perceptions of the course. The interview protocol, developed after an extensive literature review, adhered to Kvale’s (1996) stages. To ensure the validity and reliability of the data collection tools, two researchers worked together, and all data collection tools were reviewed by two domain experts (curriculum specialists and instructional designers with expertise in digital games). To ensure participants could fully express their thoughts and emotions, all interview responses were conducted in their native language, Turkish. The initial translations of participant quotes into English were completed by the researchers, with subsequent review by two additional experts proficient in both Turkish and English to ensure accuracy and authenticity in reflecting participants’ perceptions and experiences.

Results

Perceptions toward the mTPD course (RQ1)

Course content

Participants in the first prototype completed 80% of all the content, while the completion rate increased to 92% in the second prototype and 98% in the final implementation. The average time devoted to each unit in all cycles ranged from one to two hours. Perceptions about the content of the course changed positively as the program was redeveloped in each iterative cycle (Table 1). In all cycles, participants were content with the quality of the warm-up tasks, texts, videos, try-out tasks, and achievement tests.

Table 1 Total score of items about the quality of content in all cycles

	Prototype 1			Prototype 2			Final Product		
	n	M	SD	n	M	SD	n	M	SD
Total Score	8	32.74	6.11	11	34.92	3.73	25	36.92	3.94

Note: Items about the content included clarity of content; logical order; and effectiveness of warm-up tasks, video lectures, written lectures, rubrics, try-out tasks, discussion forums, and achievement tests.

Interview data were also congruent with the data provided by the course evaluation questionnaire. The results indicated that the course content fulfilled participants' expectations and helped them demonstrate an understanding of the subject. "To the point" and "compact" were frequently mentioned descriptors for the content, with eight interviewees emphasizing these qualities. One interviewee said:

I took the course at my own pace, fitting in study sessions whenever I had free time. If the video had been longer, like half an hour for example, I would have likely been interrupted more frequently. I watched one or two videos at a time, taking breaks to do other tasks in between before returning to finish the task. (P4)

Interviewees in the second prototype and final implementation reported that they got a better understanding of the course topics after engaging in practical activities such as lesson planning and game-playing. For example, one interviewee said:

I found the try-out parts helpful in applying what I learned from the course. I particularly enjoyed them. For example, the task of playing the game for an hour and then reflecting on it was something that I was very excited to do. (P12)

In the prototypes, participants verbally stated that they could not use the discussion forums effectively. However, in the final implementation, participants stated that they used the discussion forums constantly and learned new things from other people's posts – hence they had less anxiety.

Usability

The mean value of total scores of participants' perceptions about usability showed an increase from the first prototype through the final implementation (Table 2). As the usability features of the course were being developed, the perceptions of participants changed positively in each iterative cycle.

Table 2 Total score of items about usability in all cycles

	Prototype 1			Prototype 2			Final Product		
	n	M	SD	n	M	SD	n	M	SD
Total Score	8	19.48	3.66	11	21.1	2.26	25	22.56	2.18

Note: Items about usability included easiness of using the course interface, watching videos, logging into Schoology, sharing assignments, and communicating with others.

In the interviews, opinions about usability changed positively in each implementation, owing to the improvements made in each cycle. The only problem mentioned by the participants in all cycles was the challenge experienced due to the small screen of mobile devices. One interviewee said: *“I don’t like to do things on the phone, I like to use the computer... It is easier to drag and drop, where I can see and place everything well.”* (P2)

To eliminate this limitation of mobile devices, Corlett et al. (2005) recommended using mobile devices with larger screens, as well as optimizing the format of the course by allowing learners to annotate, save and share their notes. This solution was followed in this study, and participants who had problems with the screen size switched to laptops which provided a larger display allowing a better user experience.

Course effectiveness

Participants in the second prototype were more willing to participate in future mTPD courses than the participants in prototype 1 and the final implementation (Table 3). Participants in all cycles were still indecisive about preferring mTPD programs to in-person TPD programs. To better understand how participants engaged with the mTPD course, data on device usage was collected in the final implementation. Among the 25 participants, 18

Table 3 Results of the course evaluation questionnaire about effectiveness in all cycles

	Prototype 1			Prototype 2			Final Product		
	n	M	SD	n	M	SD	n	M	SD
1. I am thinking about taking another mTPD course in the future.	8	2.50	1.20	11	3.91	0.30	25	2.84	0.85
2. In this mTPD course, I learned as much as I would in an in-person TPD course.	8	3.25	0.89	11	3.55	0.52	25	2.96	1.06
3. I prefer mTPD courses to in-person TPD courses.	8	2.87	1.13	11	2.82	0.60	25	2.52	1.19
4. Mobile learning is a productive and convenient approach for TPD programs.	8	3.12	0.84	11	3.45	0.69	25	3.08	0.70
Total Score	8	11.74	3.58	11	13.73	1.56	25	11.40	3.25

Note: Completely agree (5) ; completely disagree (1).

primarily accessed the course through mobile devices, while seven participants utilized PCs or laptops. PC-based learners stated that they preferred a more traditional learning experience, typically completing modules in stationary settings like home or office environments.

Participants who used both mobile devices and PCs or laptops complained about technical difficulties during the training, such as downloading the game or sharing their homework on Drive. Based on Shohel and Power (2010)'s study, this problem was handled by offering remote assistance 24/7 on different platforms (WhatsApp, voice calls, texting, or LMS).

Despite their indecisiveness, all participants stated that the mTPD course provided an equally valuable learning experience compared to an in-person course and that mobile learning was a convenient approach for TPD programs.

Interviewees in all cycles stated that the mTPD course gave them opportunities to learn anytime and anywhere at their own convenience and stated that had it been an in-person course, they wouldn't have been able to attend the program. One interviewee said *"One benefit for me was that I could listen to videos with headphones while doing other tasks, like cooking. This allowed me to fit a lot of learning into my day without causing too much disruption."* (P3)

Interviewees also reported that the mTPD course offered them a safe environment and enabled autonomous learning where they were able to control their learning by making decisions according to the circumstance. One interviewee said:

I like this course because it offers the opportunity to learn independently. For example, I made a mistake on a question that caught me off guard. If we were in a traditional in-person setting, I might have felt self-conscious about my error in front of my peers. (P5)

The mTPD course also enabled the realization of using digital games as authentic learning sources. Participants reported that using digital games in language learning carried great potential, but they had never thought that they could integrate them into class as a learning source. As one interviewee put it:

Before this course, I had prejudices about using digital games as a tool for teaching English, but I now see that it is actually doable. This course has helped me to change my perspective and opened my eyes to new possibilities. I guess that was the best part. (P32)

In relation to this, another participant mentioned a preference for the final unit of the mTPD course, which featured the experiences of a language instructor who successfully implemented digital games in a real classroom. They said:

What I appreciated most about the course was the interview with our experienced teacher, as it provided a concrete example of using this game. (P30)

Interviewees in all cycles expressed their satisfaction with preparing a lesson plan that they could implement directly in the classroom right after learning the theoretical information. One interviewee said:

I really liked the balance of theory and practice. Many trainings I have attended in the past tend to focus heavily on theory, so it was refreshing to have hands-on activities in this course. The combination of theory and practice was very well-done. (P26)

The mTPD course also helped the participants connect with other teachers in the discussion forums. One interviewee in the final implementation reported that they felt safer because they were able to share their experiences with their colleagues. The interviewee said:

I liked the interaction in the discussion activities. I liked to see the ideas of others, chat with them and give each other feedback. I benefited from them a lot. It created a safe zone for me, the things discussed there made me feel that I was not alone. (P29)

Participants had one concern about the integration of digital games in their classroom; how to integrate digital games into their fast-flowing curriculum. Talking about this issue, one interviewee said:

I work at a state university, and we have a curriculum that does not give us much freedom; that's why I didn't implement the lesson. (P9)

Perceptions about using digital games in teaching (RQ2)

The analysis results indicated significant changes in participants' perceptions regarding the use of digital games in classrooms in the second and final implementation (Table 4). In the second implementation, there was a significant change in participants' perceptions about the ease of use of digital games in teaching before ($M = 5.83$, $SD = 1.54$) and after ($M = 8.64$, $SD = 1.03$) the course $t(10) = 4.95$, $p < 0.01$. In the final implementation, the perception scores of participants about the ease of use of digital games in teaching were also significantly higher in the posttest ($M = 6.96$, $SD = 1.77$) than in the pretest ($M = 4.44$, $SD = 1.69$), $t(24) = 5.18$, $p < 0.001$.

Table 4 Results of prototype 2 and final product about participants' perceptions of digital games

	Prototype 2					Final Product				
	Before		After		p	Before		After		p
	M	SD	M	SD		M	SD	M	SD	
Usefulness	18.36	3.04	21.64	3.04	0.015	18.76	3.38	18.60	3.12	0.855
Ease of use	5.83	1.54	8.64	1.03	0.001*	4.44	1.69	6.96	1.77	0.000*
Experience	3.91	2.70	4.09	1.92	0.866	4.48	2.33	3.40	1.50	0.074
Learning opportunities	23.36	2.80	27.09	2.55	0.014	22.92	3.135	25.08	2.23	0.006*
Curriculum relatedness	6.18	1.54	7.45	1.81	0.094	6.36	1.29	7.32	1.41	0.025
Behavioral intention	7.82	1.72	8.91	1.30	0.147	7.40	1.47	7.44	1.61	0.922

Note: Mean parameter values for each of the analyses are shown for the participants in prototype 2 ($n=11$) and the final product ($n = 25$), as well as the results of t-tests comparing the scores before and after the course. p-value was adjusted for multiple comparisons with Bonferroni. * $p < .008$

In the final implementation, perceptions about the learning opportunities of digital games changed significantly in the pretest ($M = 22.92$, $SD = 3.13$) and in the posttest ($M = 25.08$, $SD = 2.23$), $t(24) = 3.04$, $p < 0.01$.

Notably, however, perceptions of the usefulness and experience of using digital games exhibited slight declines in mean scores from pre- to post-assessment, though neither change was statistically significant. In the final product group, the usefulness scores decreased from $M = 18.76$ ($SD = 3.38$) to $M = 18.60$ ($SD = 3.12$), while experience scores saw a more noticeable reduction from $M = 4.48$ ($SD = 2.33$) to $M = 3.40$ ($SD = 1.50$).

Knowledge of using digital games in teaching (RQ3)

Achievement test scores in all cycles increased significantly after taking the course. The achievement test scores in the first prototype indicated a significant change, $z = 2.21$, $p < .05$, $r = .78$. The median of the ranks of the pretest was 10.50, while the median of the ranks of the posttest was 15.50. In the second prototype, achievement test scores indicated a significant change in the pretest ($M = 8.45$, $SD = 3.75$) and in the posttest ($M = 16.55$, $SD = 2.58$), $t(10) = 4.68$, $p < 0.01$. In the final implementation, the results indicated a significant change in the pretest ($M = 6.92$, $SD = 3.95$) and in the posttest ($M = 15.32$, $SD = 2.67$), $t(24) = 9.47$, $p < 0.001$.

Lesson plans were assessed with a holistic rubric, and participants' achievement of the task was determined by giving an overall score (Table 5). A score of 4 indicated full application of the model, while a score of 1 suggested minimal application. In the first prototype, none of the participants were able to get a full score. The lesson plan task was

Table 5 Lesson plan assessment scores in all cycles

	Prototype 1 (N = 4)		Prototype 2 (N = 9)		Final Product (N = 20)	
	n	%	n	%	n	%
4	-	-	6	67	17	85
3	1	25	1	11	2	10
2	2	50	1	11	1	5
1	1	25	1	11	-	-

Note: Scores range from 1 to 4, with 4 indicating full mastery of the lesson planning task based on the PCaRD model.

redeveloped after getting feedback from the participants in the first prototype, and these statistics changed in the other cycles, with 67% of the participants in the second prototype and 85% of the participants in the final implementation getting a full score. In the final implementation, none of the participants received 1 point, which means that all the participants in the final implementation were able to apply at least some of the components of the PCaRD model in their lesson plans.

Discussion

The positive change in participant perceptions about the course content indicates the effectiveness of the iterative development process. The shift from reluctance to a preference for mTPD course over each session indicates the potential of mobile learning in providing convenient and flexible professional development opportunities for educators (Baran, 2014).

Participants expressed positive perceptions regarding the integration of theoretical and practical activities within the course. The balance of theory and practice, as well as the incorporation of practical activities like game-playing and lesson planning, may have contributed to a well-received learning experience. The participants' satisfaction with the integration of both theoretical knowledge and hands-on practice emphasizes the importance of practical applications in TPD programs in altering teacher perceptions about the content (Alyaz & Genc, 2016; Becker, 2007; Kuhn & Stevens, 2017; McNeil, 2018).

Findings indicated that the mTPD course fostered connections among participants, especially through discussion forums. The literature highlights the significance of such interactions among teachers in TPD programs (Kearney et al., 2012; Lutrick & Szabo, 2012; Sarac, 2015; Schrum & Levin, 2013), as participants have the chance to share information and resources (Kearney et al., 2012). Such reflections facilitate self-awareness and an understanding of others' perceptions, attitudes, and reflections on the shared concept (Royle et al., 2014). The course also positively impacted participants' self-directed learning

and fostered a safe learning environment, suggesting that well-designed mTPD courses can effectively engage educators (Power et al., 2016).

One key aspect that moved beyond theoretical potential was the inclusion of a real-world example from a language instructor who demonstrated the successful integration of the COTS game *Life is Strange* into her classroom. This instructor shared classroom materials and insights on aligning game content with learning objectives, offering participants a concrete model of game-based learning in practice. Teachers observed the direct application of theory, engaged in discussions about pedagogical decisions, and gained practical insight into addressing challenges. This hands-on experience helped address skepticism about digital game-based learning and provided valuable evidence for how it can be implemented effectively.

Findings also showed that the participants' ability to use discussion forums was more effective in the final implementation, highlighting the importance of interactive elements that provoke collaboration in the design of online discussions (Andresen, 2009; Jung, 2015). To facilitate interaction, a participation assessment rubric was included in the discussion forums of each unit. Moreover, learners were allowed to use their first language (Turkish) to participate in the discussions. Additionally, they were expected to post at least one question or comment and respond substantively to at least one other post (Smith, 2008).

Findings also indicated a positive trend in participants' perceptions of usability throughout the iterations, underscoring the importance of refining and optimizing the mobile learning platform. Addressing technical challenges, such as small screen sizes, and providing 24/7 remote assistance might have contributed to a smoother user experience (Corlett et al., 2005; Shohel & Power, 2010).

Although there was an increase in the number of participants considering taking mTPD courses in the future, there was also a degree of indecisiveness about preferring mTPD to in-person sessions. Parsons et al. (2019) reported that even though they found online TPD useful, some teachers can prefer in-person PD. This hesitation might be influenced by teachers' characteristics, as their attitudes and interests are important determinants in professional development (Dille & Røkenes, 2021). This could also be partly due to the technical issues teachers faced in mTPD. Three participants complained about technical difficulties during the training, such as downloading the game or sharing their homework on Drive. Teachers might need technical support during their mTPD (Aubusson et al., 2009).

Similarly, the findings revealed that while teachers recognized the potential of digital games in language learning, they still had concerns about the integration of digital games into their curriculum. These concerns were not solely about needing further proof of successful integration; rather, they were related to practical challenges, such as teachers' lack of experience with digital games, limited computer skills, and the availability of time

and technological equipment (Harmandaoğlu Baz et al., 2018). In fact, participants' perceptions of the 'usefulness' and 'experience' of digital games showed a slight decline in the final implementation, potentially highlighting a growing awareness of the complexities involved in integrating games into teaching. Besides, teachers reported concerns about how to integrate digital games within their fast-paced curricula and they said they were not feeling confident enough to integrate digital games into their teaching (Gutierrez et al., 2023; Koh et al., 2012; Takeuchi & Vaala, 2014). Participants' perceptions about the use of digital games significantly improved in iterations suggesting that exposure to hands-on activities and real-world examples helped alleviate initial concerns about the feasibility of digital games in language learning. Adopting innovative learning methods can be challenging and teachers might show resistance to changing their habits and adopting technology. However, as they feel comfortable using technology and are motivated and supported to participate in mTPD as much as possible, they can gradually adapt to the changes (Gado et al., 2006).

The analysis showed that participants' perceptions in both the second prototype and final implementation changed positively about integrating digital games in classrooms, with a significant increase in their perceptions about the ease of use of digital games. This finding is supported by the research that TPD specifically targeting digital game integration can effectively change their perceptions toward integrating games into their teaching and increase their intentions to use digital games (An & Cao, 2017; An, 2018; Stieler-Hunt & Jones, 2019). The shift from initial skepticism in the first prototype to recognizing the potential of digital games in other cycles is a crucial outcome, as they play a significant role in integrating digital games (DeHaan, 2020; Foster & Shah, 2020; Huizenga et al., 2017).

The observed improvement in achievement test scores and lesson plan assessments across all cycles indicates a significant enhancement in participants' knowledge and application of DGELL concepts. The iterative development of the lesson plan task, leading to higher scores in subsequent cycles, suggests the efficacy of incorporating participant feedback into course refinement. Bragg et al. (2021) reported that one of the design elements of successful online TPD is the application of knowledge and skills where teachers can connect and apply the new knowledge or skills to their teaching practice. Similarly, De Kramer et al. (2012) stated that it is important to focus on both teachers' content knowledge and pedagogical knowledge and offer opportunities for active learning in TPD. The findings of this study are consistent with this statement. Participants not only extended their content knowledge about using digital games in language learning but also prepared a lesson plan, which led them to develop new ways of thinking about how to integrate digital games into their classrooms. This finding also aligns with Foster and Shah's (2015)

assertion that learning pedagogical skills necessary for digital game integration can provide teachers with a robust structure and facilitate the integration of digital games.

Conclusion and recommendations

As emphasized by the literature when the importance of teachers' knowledge in using digital games is considered (An & Cao, 2017; Becker, 2007; Deng et al., 2020; Denham, 2019; Sykes, 2018; Stieler-Hunt & Jones, 2019; Takeuchi & Vaala, 2014), it can be concluded that this mTPD course could facilitate teacher competencies in integrating games into their teaching and lead to the development of more positive perceptions about DGELL. Participants had concerns about how to properly integrate digital games into their teaching before the course. However, as they gained knowledge and practical opportunities, they began to feel more positive and confident. This transformation signifies the course's effectiveness in addressing the perceived challenges and equipping instructors with the skills and confidence needed to embrace and successfully integrate digital games into their teaching.

Especially during the global Covid-19 crisis, language teachers were forced to teach from their homes, and they needed alternative ways to access in-person TPD to improve their professional skills and develop new ones. The results of this study indicated that participants believed their learning experience in this mTPD course was as effective as an in-person TPD. This finding could have implications for designing low-cost, more affordable, and accessible mTPD opportunities for teachers. While developing prototypes of this mTPD course, we used related research and literature to develop the features that could facilitate language instructors' perception development more positively (Kearney et al., 2012; Koenraad, 2019). During similar design and development studies for mTPD courses, practitioners can make use of some of the solutions this mTPD course took into consideration.

Limitations and future research

This study has several limitations that may affect the interpretation of its findings. Firstly, the course implementation was conducted during the school semester, meaning participants were managing additional teaching responsibilities. This might have constrained participants' engagement and completion rates, impacting their ability to thoroughly absorb and apply DGELL strategies. This scheduling also limited the feasibility of in-class applications or observations, restricting insights into how DGELL concepts translate into classroom practices. The absence of classroom implementation impacts our ability to evaluate the practical application and long-term efficacy of DGELL strategies taught during the professional development course. This limitation highlights the distinction between influencing teacher perceptions and motivation versus observing tangible changes

in classroom behavior and student outcomes. Future research could incorporate direct observations to capture practical implementation and outcomes by incorporating longitudinal designs that follow teachers from professional development through to classroom implementation.

The course was delivered on the free version of Schoology®, which offered limited customization options. While the platform's basic functionalities supported mobile learning, enhanced customization might have better tailored the experience to specific instructional needs, potentially impacting participants' engagement levels. Finally, the small sample size across prototypes may limit the generalizability of findings. Although the iterative feedback process enhanced course usability and relevance, larger, more diverse samples would provide greater insight into the broader applicability of DGELL in varying educational contexts.

Abbreviations

TPD: Teacher Professional Development; mTPD: Mobile Teacher Professional Development; DGELL: Digital Game-Enhanced Language Learning; DGBLL: Digital Game-Based Language Learning; COTS: Commercial off-the-shelf; PCaRD: Play, Curricular Activity, Reflection, and Discussion; DDR: Design and Development Research.

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Authors' contributions

All authors contributed to the study's conception and design. Material preparation, data collection, and analysis were performed by Emrah B. Basoglu. The first draft of the manuscript was written by Emrah B. Basoglu, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

Figshare. Appendices. <https://doi.org/10.6084/m9.figshare.22290382.v1>

The repository contains the appendices with the following underlying materials: modifications made after each prototype implementation, mTPD course syllabus and sample lesson plan for the mTPD course.

Figshare. Data Collection Instruments. <https://doi.org/10.6084/m9.figshare.27330966.v1>

The repository contains the appendices with the following underlying materials: mTPD course evaluation survey, DGELL perception survey, interview protocol, achievement test and lesson plan assessment rubric.

Other data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Competing interests

The authors declare that they have no competing interests.

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