

Opening the “Black Box”: How Out-of-Class Use of Duolingo Impacts Chinese Junior High School Students’ Intrinsic Motivation for English

ECNU Review of Education
2024, Vol. 7(2) 283–307
© The Author(s) 2023
Article reuse guidelines:
sagepub.com/journals-permissions
DOI: 10.1177/20965311231171606
journals.sagepub.com/home/roe



Cheng Zeng (曾成)  and Linda Fisher

University of Cambridge

Abstract

Purpose: Mobile-assisted language learning (MALL) apps such as Duolingo have great potential for promoting learners’ motivation to learn a second language (L2). However, little research has investigated how this motivational impact takes place. Additionally, despite the flexibility of mobile learning, most existing studies are conducted in classroom settings, with less attention paid to out-of-school technology usage.

Design/Approach/Methods: To address these gaps, we present a model based on self-determination theory and propose the idea of “motivational transfer” to explain the psychological mechanism underpinning the impact of technology. To examine the model, we conducted a case study with 20 Year 8 Chinese junior school students who used Duolingo to learn English as a foreign language (EFL) after school for 6 weeks.

Findings: Questionnaire and group interview data support our hypothesized mechanism: learners’ activity-specific intrinsic motivation (IM) for using Duolingo and their underlying psychological need for autonomy and competence can be transferred to a more general level, thereby enhancing learners’ global IM for L2.

Corresponding author:

Cheng Zeng, 184 Hills Road, Cambridge CB2 8PQ, UK.

Email: cz352@cantab.ac.uk



Creative Commons Non Commercial CC BY-NC: This article is distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 License (<https://creativecommons.org/licenses/by-nc/4.0/>) which permits non-commercial use, reproduction and distribution of the work without further permission provided the original work is attributed as specified on the SAGE and Open Access page (<https://us.sagepub.com/en-us/nam/open-access-at-sage>).

Originality/Value: The proposed theoretical model expands our understanding of how digital technology stimulates learners' L2 motivation; it can help L2 educators design better technological affordances to promote learners' motivation both in and outside the classroom.

Keywords

Digital game-based learning, L2 motivation, MALL, self-determination theory

Date received: 28 February 2022; revised: 19 September 2022; accepted: 1 March 2023

Introduction

The rapid advancement in digital technology has been transforming the way we learn a second language (L2). With the explosion in the use of mobile devices like smartphones and tablets, mobile-assisted language learning (MALL) has become increasingly popular around the world. Regarding the effects of this new way of learning, Ushioda (2013) has pointed out that “the potential value of mobile technologies may lie instead in motivating and facilitating frequent (rather than deep) engagement in language learning or language use opportunities” (p. 3). Many prior studies have investigated the question of *what* the motivational influence of technology is and have found a positive impact of MALL on L2 motivation. Despite this, the question of *how* this motivational impact takes place has not yet been answered. Only by knowing why the use of technology can stimulate learners' motivation can L2 educators design better MALL activities and manipulate the specific features to promote L2 motivation. Thus, there is a warrant for investigation into the “black box” of the digital technology and L2 motivation interface.

In addition, among the diverse types of MALL activities, online applications, or apps, have seen a surge in interest over the past 15 years (Kukulska-Hulme et al., 2017; Loewen et al., 2020). Despite their popularity, the effectiveness of L2 learning apps has been underexplored (Isbell et al., 2017), with most studies focusing on researcher-designed MALL activities in classroom contexts (Demouy et al., 2016). Duolingo, which features free gamified activities and flexibility, is one of the most popular MALL apps in the world, with nearly 1.5 million user accounts¹ globally. Given the substantial number of learners using these commercial apps outside classrooms, many scholars have called for further investigation into their effectiveness (Heift & Chappelle, 2012; Plonsky & Ziegler, 2016). Although some studies have revealed the positive motivational impact of apps like Duolingo, how this happens remains unknown. Given the ubiquitous afterschool use of MALL apps and their motivational value, this study aims to examine the impact of Duolingo on learners' L2 motivation and the mechanism underpinning this process. To this end, we first developed a new conceptual framework to open the “black box” and then looked at it with an empirical study.

Literature review

MALL and gamification

Since the early days of MALL, many researchers have investigated the student experience of learning with them (Rosell-Aguilar, 2018). The use of technology is positively perceived by users and has great potential to improve learners' motivation and engagement (see the seminal review by Golonka et al. [2014]). Recent reviews by Hwang and Fu (2019) and Shadieff and Yang (2020) also found that learners tend to hold positive perceptions of technology usage and have increased L2 motivation and interest when assisted by technology.

To promote learners' motivation and encourage practice, digital game-based learning (DGBL) has become the most frequently used technology integrated into MALL activities (Shadieff & Yang, 2020; Zhang & Zou, 2022) and many studies have shown these to be effective in enhancing learners' engagement and motivation. For example, in Cho and Castañeda (2019), university participants improved significantly in their intrinsic goal orientation, self-efficacy, and enjoyment of learning after taking an 8-week Spanish course employing a mobile game-like application. Similar results can also be found in Chen et al. (2019), Cruaud (2018), and Liu and Chu (2010).

Many commercial language learning apps, such as Rosetta Stone, Bussu, and Duolingo utilize game mechanisms to draw users' attention and stimulate their motivation. For instance, in the 12-week study by Loewen et al. (2019), nine university participants were asked to learn Turkish with Duolingo for at least one hour per week. Participants generally regarded Duolingo's flexibility and gamification as motivating, consistent with findings from other studies such as Ajisoko (2020), Falk and Götz (2016), Gadanez (2018), Rachels and Rockinson-Szapkiw (2017), and Vesselinov and Grego (2012).

Although mobile technologies feature the freedoms of time, place, and pace of learning (Chang, 2007), most MALL activities investigated in the field are instructor-centered and conducted in formal settings (Demouy et al., 2016). Significantly fewer studies have paid attention to mobile learning outside classrooms (Rosell-Aguilar, 2018; Steel, 2015), including commercial L2 learning apps, despite their large number of users (Isbell et al., 2017). As learners' self-directed MALL can be quite different from formal instruction, there have been calls for more research on student-centered out-of-class mobile learning (Shadieff et al., 2017). In addition, previous studies on mobile apps were predominately conducted with university students, with other groups of L2 learners underrepresented. These are the research gaps that this study aims to address.

Activity motivation and global motivation

Although many scholars have investigated learners' L2 motivation in the context of MALL, after detailed examination of the existing studies, we found out that the construct of motivation under

discussion differs. There are in fact two types of motivation under investigation. One is learners' motivation toward the specific activity of using a technology to learn a language; the other is the general motivation for L2 learning, be it with or without digital technologies. We define the former as "activity motivation" and the latter "global motivation."

Regarding activity motivation, it is task-specific and usually shown as learners' increased engagement in, and positive attitudes toward, the process of using technology in certain learning activities. Examples of such motivation are as follows: learning activities with ubiquitous games that participants in Liu and Chu (2010) thought interesting and useful; the multimodal learning environment of Duolingo, which learners in Falk and Götz (2016) perceived as motivating; learning English with the app Vine, which participants in Kurt and Bensen (2017) thought motivating and effective. This type of motivational impact is usually evaluated after practice has been completed, either with qualitative explorations (Kurt & Bensen, 2017), quantitative assessments (Falk & Götz, 2016), or a mixture of both (Liu & Chu, 2010).

Studies on activity motivation help us understand how the use of technology can help enhance learners' engagement and motivation toward certain learning activities. Nevertheless, it remains unknown whether learners are driven only to use the new technology or whether beyond the specific MALL activity they also feel inspired to learn the language in daily learning settings.

The other type of motivation found in the literature—global motivation—is learners' general motivational disposition for language learning. Compared to the state-like task motivation that is situation-specific, global motivation is more trait-like and decontextualized. Research has demonstrated that the use of technology can improve learners' motivation for language in general. For instance, students in Cho and Castañeda (2019) exhibited significantly higher intrinsic goal orientation for learning Spanish after engaging in game-like activities. Learners in Yang et al. (2012), who used voice-over instant messaging in class, developed a more positive attitude toward English learning compared to the control group. The impact on global motivation in this strand of research is often measured quantitatively by the changes in learners' scores in scales adapted from sophisticated L2 motivational theories (e.g., the Motivated Strategies for Learning Questionnaire in Cho and Castañeda, and the Foreign Language Learning Motivation Scale in Yang et al.).

Although studies of this kind have demonstrated that specific activities with technology can have positive effects on learners' global motivation, why the usage of technology can spark learners' global motivation for L2 learning remains underexplored. The trap of ascribing learners' development to technology while neglecting how technology is exploited to promote gains was criticized by Burston (2015) as "technocentricity" (p. 16). Without robust conceptualizations of the motivational effects arising when L2 learning involves digitally mediated interactions, the digital technology-L2 motivation interface remains somewhat of a "black box" (Henry, 2019).

Furthermore, despite the large amount of research on the motivational impact of technology, very little prior scholarship has noticed the distinction between these two types of motivation, except Morton and Jack (2010), Stockwell (2013), and Ushioda (2013). Although Morton and Jack (2010) examined both participants' activity motivation and global motivation for L2 learning, they did not delve deeper to investigate the relationship between the two motivational constructs. By contrast, though Stockwell (2013) pointed out that "motivation to use a technology could very well lead learners to develop motivation to learn a language" (p. 163) and Ushioda (2013) also noted two types of motivation for why learners might engage with technology—an inherent interest in technology and a strong motivation for language learning—they did not empirically investigate these two kinds of motivation. Thus, we used a new framework to empirically examine the relationship between MALL, activity motivation, and global motivation.

Self-determination theory (SDT)

As there are two types of motivation involved when technology makes impact on L2 learners, we found that one theory, SDT, which can explain people's motivation either in an activity-specific context or at the general level, can be utilized to uncover the underlying mechanism between mobile technology and L2 motivation.

SDT is a general theory of motivation and human growth. It has been empirically validated in a wide range of contexts, including education and technology, and across gender, age, and culture (Deci & Ryan, 2015; Kebritchi et al., 2010). It defines one type of motivation—intrinsic motivation (IM)—as a self-determined state where an individual does something because it is "inherently interesting and enjoyable" (Ryan & Deci, 2000, p. 55). As mentioned above, participants generally consider the MALL experience to be satisfying and interesting, and thus feel more driven to learn. This psychological state is what SDT refers to as IM, which is the focus of the present research.

Cognitive evaluation theory (CET), a sub-theory of SDT, is specifically concerned with how IM is generated. According to CET, when an individual's two basic psychological needs for autonomy (i.e., experiencing choices and feeling like the initiator of one's own actions) and competence (i.e., perceived efficacy at optimally challenging tasks and the capacity to attain desired outcomes) are satisfied, his/her IM is supported. On the contrary, events and conditions that diminish a person's sense of autonomy or competence will undermine his/her IM (Ryan & Deci, 2017).

In terms of learners' global motivation for L2 learning, many prior studies have demonstrated the applicability of SDT for L2 motivation research. The seminal research by Noels et al. (2003) showed that the motivational constructs proposed by SDT, including CET, were empirically testable

and stood up well in the context of L2 learning. Research conducted in the Asian context and with younger participants also supports the motivational mechanism proposed by CET (see Carreira [2012], Fryer and Oga-Baldwin [2018], and Wu [2003]).

At the activity level, SDT is also one of the most established theoretical frameworks adopted by game motivation and gamification research to explain what makes games and game-like environments so engaging (Deterding, 2015; Mekler et al., 2017). For instance, in the experimental research of Peng et al. (2012), some game features could support learners' need to satisfy autonomy and competence, and such a need was found to mediate the impact of the game features on participants' motivation and engagement outcomes. Studies (e.g., Francisco-Aparicio et al., 2013; Hew et al., 2016; Sailer et al., 2017) have shown that features like positive feedback, optimal challenges, badges, and leader boards can improve learners' perceived competence, while avatars, profiles, and alternative activities can enhance their perceived autonomy. Although SDT has been widely adopted in research on gamified learning, virtually no prior studies in the field of MALL have adopted this framework to investigate the motivational impact of technology usage.

Given the applicability of SDT to explain learners' motivation at the global and activity levels, we propose a theoretical model grounded in CET to explain how the motivational impact of a gamified MALL app, Duolingo, takes effect.

Conceptual framework and research hypothesis

The proposed model of how the use of Duolingo can influence learners' IM is depicted in Figure 1. The left and right sides of the "black box" represent learners' IM at the activity and global levels, respectively; IM is built upon the psychological need for autonomy and

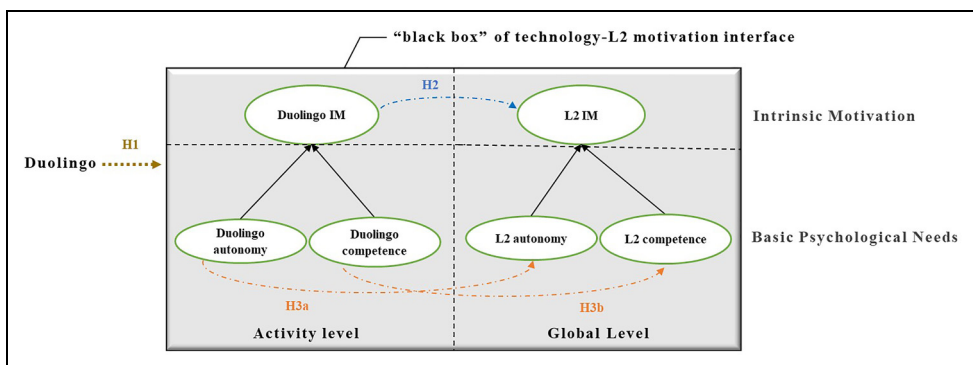


Figure 1. The hypothesized model of the motivational impact mechanism of Duolingo.

competence. The dashed arrows denote the impact mechanism postulated by this study, which is illustrated in detail below.

Our first hypothesis (H1) is that the use of Duolingo can have a positive impact on learners' L2 IM. This is a common finding from previous studies and only deals with the surface of the technology-L2 motivation "black box." If H1 is supported, we first look at the upper level inside the box. As IM exists at both the activity and global levels, Hypothesis 2 (H2) holds that learners' IM generated by Duolingo (hereafter, Duolingo IM) can lead them to develop IM for learning English (hereafter, L2 IM). We define this potential causal relationship from the activity to the global level as the "transfer" of motivation. To be specific, transfer means that the use of Duolingo could first stimulate learners' IM toward learning with the interesting app itself, and through such activity motivation, it then sparks their IM toward L2 learning more generally.

If H2 is verified, we then delve deeper into the psychological process underpinning how Duolingo IM is transferred to L2 IM. Our third hypothesis (H3) is that the basic need for autonomy and competence underlying IM and satisfied by Duolingo (hereafter, Duolingo autonomy and Duolingo competence) can also be transferred to the global level to fulfill learners' need for competence and autonomy in learning English (hereafter, L2 autonomy and L2 competence). In other words, behind the IM transfer is the transfer of perceived autonomy (H3a) and competence (H3b).

In brief, the motivational impact model proposed by this study opens the technology-motivation "black box" step by step at three hierarchical layers: It starts from the external perspective of whether MALL can bring about motivational changes, then moves to a more inside view on the connection between activity and global motivation, and finally inspects the underlying basic psychological needs behind IM. This study aims to investigate how the motivational impact of MALL takes place by testing the following three hypotheses:

H1: Duolingo can have a positive influence on learners' L2 IM.

H2: Learners' Duolingo IM can be transferred to their L2 IM.

H3a: Learners' Duolingo autonomy can be transferred to their L2 autonomy.

H3b: Learners' Duolingo competence can be transferred to their L2 competence.

Research design

We used a qualitative case study to examine the feasibility of the proposed model. As "an intensive, holistic description and analysis of a single entity, phenomenon, or social unit" (Merriam, 1988, p. 16), this approach enabled us to explore in depth how Duolingo stimulates learners' motivation to learn English.

Duolingo

Duolingo is a popular self-directed MALL app with free subscription fees and gamified learning. When users register and finish a brief placement test on the platform, they are directed to a learning unit that suits their own proficiency level on the home page of *curriculum*. The unit consists of three or four lessons, and one lesson takes about five minutes. The lessons cover various topics such as catering, people, and school and contain diverse exercises like matching images to words, translation, and dictation (see Figure 2). If learners encounter a new word in these exercises, they can obtain the translation by simply clicking on the word. Feedback on users' performance is immediate, multimodal, and adaptive, such as a green flag plus applause or cheering voices for correct answers and encouraging words from the fictional character *Duo*, a cartoon owl mascot (see Figure 3). If learners make a mistake, the app will provide the correct form and similar exercises for practice until users acquire the necessary language points and make no more mistakes. After completing a lesson, learners can gain rewards like *badges* and *experience points (XP)* to rank high on the global *leader board*, *crowns* to level up and unlock *short stories*, and *lingots* to buy special functions or costumes for *Duo* in the *shop* (see Figure 4). Duolingo also allows teachers to track students' learning data if they join a designated virtual classroom (see Figure 5).



Figure 2. Curriculum, translation, and dictation exercises (from left to right).

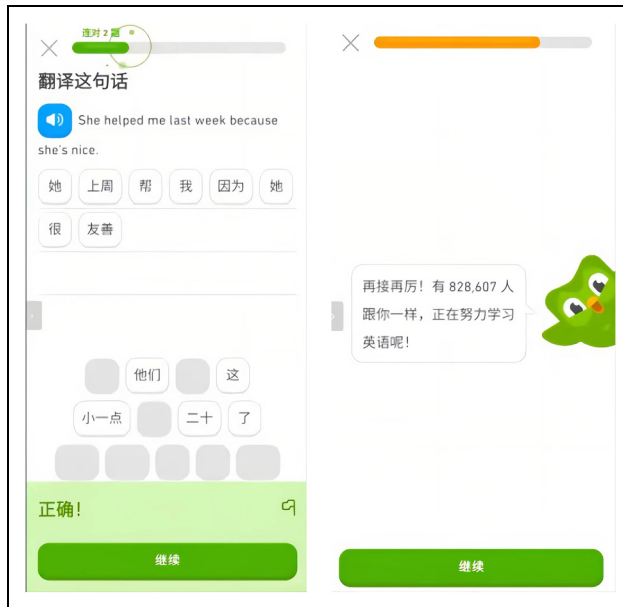


Figure 3. Feedback on accurate answers and encouraging words from Duo.

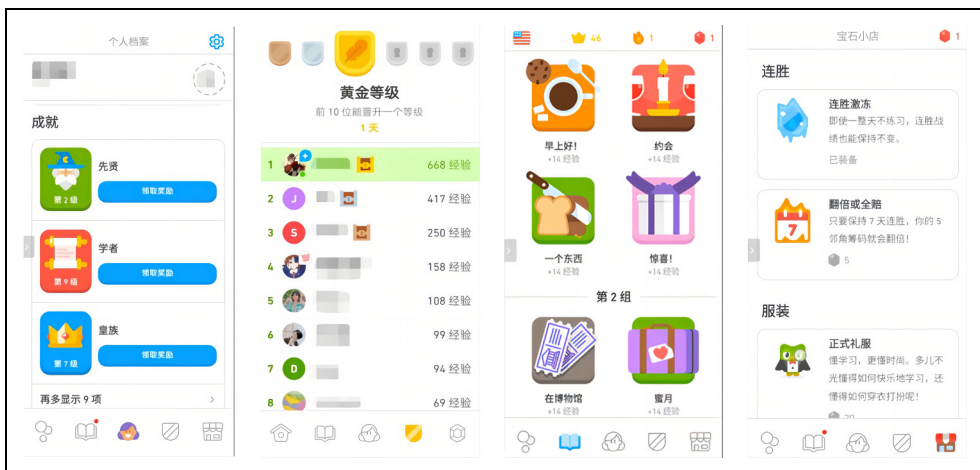


Figure 4. Badges, leader board, short stories, and shop (from left to right).

Research context

We conducted this study with Year 8 junior high school students (aged 13–14) in a southern province in China. The participants generally started to learn English as a foreign language (EFL) starting in Year 1 in elementary school. They had one English session every day, which is the main place where students used the language in daily life. Language learning in this research context was

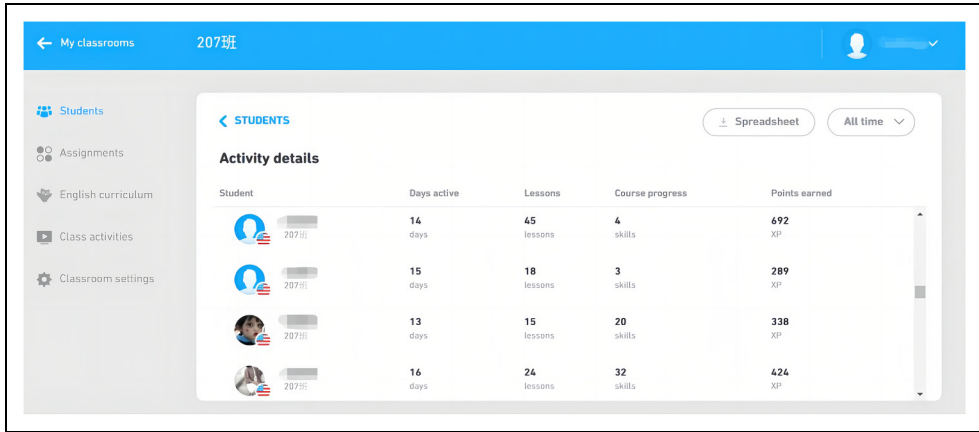


Figure 5. Virtual classroom in Duolingo.

relatively test-oriented. The teaching pedagogy in class was somewhat didactic and students needed to finish many drills in workbooks after class. The junior high school was also a state boarding school where mobile devices are forbidden on campus, so participants can only use Duolingo when they are back home on Friday evening, Saturday, and Sunday. None of the participants had used Duolingo on a regular basis in the last six months before the treatment.

Procedure

This study started in March in 2021 and was conducted remotely due to COVID restrictions. After seeking informed consent and parental permission, 103 students from two intact classes completed an online questionnaire to investigate their L2 motivational levels. The questionnaire was translated from a scale of Fryer and Oga-Baldwin (2018) to examine junior high school students' IM to learn English. It contains three items: "I learn English because English is fun," "I learn English because I enjoy learning English," and "I learn English because I'm interested in English." The items are rated on a 5-point Likert scale from "not at all true" (1 point) to "very true" (5 points) and respondents' L2 IM levels are the average scores of them (Cronbach's alpha = 0.89).

Next, we invited the students to register in a Duolingo virtual classroom and learn in Duolingo for 5 minutes (the duration of a lesson) every day when they were back home for 6 weeks (a total of 18 days). After cleaning the data of the questionnaire and the Duolingo user logs, 80 students who had been active on Duolingo for more than 9 days were qualified for the next phase of the research. Subsequently, we used maximum variation sampling to select the participants. Based on the data from the questionnaire, we divided the respondents into five groups ranging from the lowest to highest L2 IM levels. We then randomly chose four participants in each group as the cases investigated by this study (see Table 1).

Table 1. Information of the participants.

Group	Name (pseudonym)	Gender	L2 IM
G1	Kai	Female	5
G1	Ying	Female	5
G1	Qi	Female	5
G1	Jie	Male	4.67
G2	Zhi	Female	5
G2	Xue	Male	4
G2	Wen	Female	4
G2	Cheb	Female	4
G3	Yi	Female	4
G3	Xu	Male	3.67
G3	Bao	Male	3.67
G3	Ming	Male	3.33
G4	Jun	Female	3
G4	Yong	Male	3
G4	Le	Male	3
G4	Ning	Female	2.67
G5	Lin	Female	2
G5	Hong	Male	2
G5	Tian	Female	1.67
G5	Zhuo	Male	1

As a time-efficient method that is also less intimidating for young participants than individual meetings (Greig & Taylor, 1999), we used group interviews to elicit participants' learning experiences with Duolingo (see Appendix 1 for the interview protocol). The interviews were carried out and videotaped online on a Chinese videoconferencing platform called Tencent Meeting. As suggested by Morrison (2013), the interviews were conducted during school time and on the school premises. We respectively invited the five groups of participants with similar L2 IM levels to sit in front of a big computer with a camera in an activity room at the school and to join the remote interviews. The interviews were conducted in the students' mother tongue, Chinese and lasted between 22 and 32 minutes.

Data analysis

We first transcribed the interview data into text following the guidance of intelligent verbatim transcription (Poland, 1995). After double checking the transcripts, we then coded them using a hybrid process of inductive and deductive thematic analysis (Fereday & Muir-Cochrane, 2006) with NVivo 12. Constant comparison analysis was adopted to inductively code the data

(Glaser, 1992; Strauss & Corbin, 1998). At the first stage of open coding, we made free nodes extracted from the interviewees' accounts to guarantee the preservation of their voices. The nodes were then compared, revised, and assembled in new ways via axial coding. Regarding the final stage of selective coding, we applied key constructs in this study (like IM, perceived autonomy, and perceived competence) to connect with the themes emerging from the data where appropriate. For example, nodes like "become more active in English class" were categorized under the new thematic code of "increased L2 IM," "sense of achievement from the *leader board*" under "need for competence supported by Duolingo," and "feel confident in English capability" under "increased sense of L2 competence." In addition, while transcripts were in Chinese, coding was conducted in English. We only translated excerpts used in this dissertation into English.

Findings

H1: Increased L2 motivation after using Duolingo

Most participants indicated in the interviews that they were more intrinsically driven to study English after using Duolingo, except two in G2 and one in G4. To be specific, all participants in G1, G3, and G5 acknowledged the positive impact of Duolingo on their L2 motivation. For example, G3 participants did not consider English to be boring as before. They became more intrinsically motivated to learn the subject in daily life. This was also true of interviewees in other groups. Jie (G1), Yong, and Ning (G4), and Hong, Tian, and Zhuo (G5) mentioned that they became more focused and less likely to get distracted in English class because they found English more interesting to study. Due to word limits, only quotes from G3 are presented in Table 2.

Despite the positive feedback from most of the participants, Zhi and Wen (G2) and Jun (G4) said that they did not experience significant changes in their L2 IM. For example, Zhi said in the interview, "*I have always been very interested in learning English, so whether I use Duolingo or not doesn't have much impact on my motivation.*" This was also true of Wen. However, detailed analysis of their later accounts shows that the reason behind their small degree of motivational change lies in their lack of autonomy and competence gained from Duolingo. This result is in fact consistent with the hypothesized mechanism of motivational impact, which we further discuss in the following sections on H2 and H3. Thus, as most participants found it more enjoyable to learn English after using Duolingo, it is still reasonable to conclude that Duolingo can generally promote learners' L2 IM, thereby supporting H1.

H2: IM transfer from Duolingo to L2

Except for the three deviant participants, all interviewees across the groups considered the activities in Duolingo to be enjoyable and intrinsically motivating. The word they used most frequently to describe Duolingo was "interesting" ($N=31$), and the Duolingo features they considered most

Table 2. Quotes from G3.

Name	Quotes
Yi:	<i>Regarding my studies, generally, I think Duolingo has improved my interest in English a bit. Before I used Duolingo, I didn't like English very much ... English was a little boring for me. But after using Duolingo, I find it more relaxing to learn, as mentioned just now. I also gain more knowledge.</i>
Bao:	<i>Before, I just learned English as required, without any other thought. If I encountered something I didn't know, I wouldn't address it. But after using Duolingo, I find there are so many things unknown to me, so I think I should improve my English ... I look up [words] in a dictionary more often at school.</i>
Ming:	<i>I just learned what was in textbooks before. After using Duolingo, what I have learned is far beyond the textbook. I learn much more. And all of these can be applied in daily life ... Previously, my interest in English was just so-so, but now it has increased quite a lot.</i>
Xu:	<i>I think it did improve my interest, because it at least taught me that English is not that dull. I at least find English a bit more interesting.</i>

attractive were *short stories*, the fictional character *Duo*, and the level-up game mechanics of *curriculum*. Participants in G3, G4, and G5 found it attractive to learn English through dialogues and pictures in *short stories*, and interviewees in G1, G2, and G5 said they enjoyed the amusing plots and content very much. Additionally, all groups loved the cute and humorous *Duo* and its feedback. They were also inspired to level up by taking lessons to gain rewards like *crowns* and *lingots* and unlock more *short stories*.

Such pleasant learning experiences in Duolingo directly changed the learners' perceptions of language learning. Take G5, for example (see the interview excerpt below). After having an enjoyable learning experience in the app, when participants were back at school, they realized the language that they were learning in class was in essence the same interesting thing they had encountered on Duolingo, so they felt motivated to study even without the app thereafter. This demonstrates that learners' IM toward Duolingo at the activity level can be transferred to the general level of L2 learning, which verifies H2.

Tian: *... Previously I didn't like English. Although at present I am still not very fond of English, I at least don't hate English as before. Now I feel English is something I want to learn, instead of what I need to learn because of the exam.*

Interviewer: *That's great. Why did you experience such changes?*

Tian: *Maybe because I enjoyed studying English in Duolingo very much, and then [I wondered] why I didn't like the English course [at school]? Later I realized they were actually the same thing. So I started to listen attentively to the teacher in class.*

Interviewer: *Any different or similar ideas from other students?*

Zhuo: *So am I. Kind of like the love for Duolingo, toward English, is transferred into our daily lives. Before using Duolingo I didn't want to study English. It was very dull. But now I feel it is OK, so I'd like to see whether I can learn it well.*

Interviewer: *Why do you think English is OK now? How did Duolingo impact you?*

Zhuo: *Because English in Duolingo is interesting, and then I find what teachers teach in class is less boring. Kinda like the transfer of interest.*

H3: Transfer of perceived autonomy and competence from Duolingo to L2

When we asked follow-up questions about why the participants found certain features of Duolingo attractive and how Duolingo changed their general motivation toward English, their answers were all related to the two antecedents of IM. This supports H3 that behind the transfer of IM was the transfer of the sense of autonomy and competence. In each category of basic needs, we also found two different ways in which Duolingo can affect learners' need satisfaction in acquiring an L2.

H3a: Transfer of perceived autonomy. The group interviews indicated that if participants felt autonomous in Duolingo, they would also gain a stronger sense of autonomy when learning English, and such a transfer took place by affecting learners' freedom in choosing the content and method of learning.

Choices in content of learning. All five groups pointed out that the *curriculum* and *short stories* in Duolingo provided various topics for them to learn. This can be best illustrated by Ning (G4): *"There are many categories in the curriculum. I can select what I want to learn based on my needs, which is different from [a course] being designated and restricted to learning something in class."*

In addition to the freedom to choose a variety of content, the nature of such content also contributes to learners' sense of autonomy. Take the quotes from G1 in Table 3, for example. Unlike the school curriculum, which focused on textbooks and exam preparation, the participants found the content in Duolingo to be more closely related to their daily lives. This helped them realize that English was more than some limited and rarefied stuff simply related to an exam. Instead, it was an interesting subject with diverse attractive and useful knowledge with practical functions. When they became aware of the pragmatic value of English and the myriad content available for learning, they no longer felt they were forced to learn the subject for exams only and therefore developed a sense of autonomy in learning.

Table 3. Quotes from G1.

Name	Quotes
Qi:	<i>The English lessons at school here are boring . . . They put a huge amount of pressure on you and you feel that learning English is just for good grades. But when you use Duolingo, you will find this is not true. You will find the cultures of other countries lovely and fascinating . . . It did have some impacts on me. I want to travel abroad. And the teaching style in Duolingo is also different from our school lessons. When I felt the classes at school were boring and then I went to Duolingo, I found the other interesting facets of English and thus become fonder of the language.</i>
Kai:	<i>For me, I realized that English is a tool for international communication and going abroad. It is very useful.</i>
Ying:	<i>My idea is similar to Qi's. I am more interested in the content of the app. In my daily life, I became more interested in English-language cultures because of Duolingo. I also found that what is taught in class is indeed fairly boring. The teacher just talks in a monologue. This is pretty different from Duolingo, which has diverse content and elements.</i>
Jie:	<i>The relaxing and humorous teaching style of Duolingo is different from what our English teacher taught in class. In Duolingo we can learn different types of English, which I think is free and funny, so the app enhances my interest in learning English.</i>

In sum, the wide range of practical content in Duolingo loosened the ropes that tightly bound learners to the restricted content and syllabus at school. Duolingo enabled learners to realize that English is more than textbooks and exams, and there is a much larger world of English waiting for them to explore.

Choices in methods of learning. Learning activities in Duolingo come in varied forms such as taking lessons in *curriculum* and reading the *short stories*, which also incorporate game elements. Such methods of learning were favored by all interview groups, which were disparate from the school routine: attending fixed sessions, reading textbooks, and doing designated homework. Thus, when participants experienced the variety of learning methods provided by Duolingo, they realized that studying was not limited to the relatively monotonous approaches used at school. Instead, they had far more options. Quotes from one interviewee in each group are presented in Table 4 as examples.

In addition to learning methods, the way participants studied in the app was also very flexible. The second most frequently used word by all groups to describe Duolingo was “relaxing” ($N = 20$). Unlike the homework designated by teachers that should be finished within a set time, Duolingo gave participants the freedom to learn anything at any time and at their own discretion. For example, in G3, Ming said he felt relaxed enough to use Duolingo because it did not take much time and he could complete as many or as few tasks as he liked whenever he had time available. Xu agreed that Duolingo was not as rigid as school assignments because he was able to choose

Table 4. Quotes from the five groups.

Name	Quotes
Ying: (G1)	<i>When I used Duolingo, I felt learning [in the app] was very relaxing and free. I had somewhat more choices on the platform than at school because our English sessions are a bit dull. The lessons are always in the same pattern.</i>
Yu: (G2)	<i>Duolingo has all kinds of learning tasks and functions. You won't feel bored with this app. I think it is very interesting. Its teaching methods are not monotonous, which is very suitable for students like us.</i>
Ming: (G3)	<i>Previously I thought English was all about repeatedly writing down new words to memorize them. Now, I find that methods to learn English, just like those in Duolingo, are very flexible. You can learn through short stories. You can reinforce your knowledge through the translation exercises.</i>
Yong: (G4)	<i>In Duolingo, each unit of lessons teaches topics on different aspects of daily life. In every lesson, there are several tasks like listening, speaking, translation, filling-in-the-blank, sentence-making, etc. Before using Duolingo, we hadn't tried such comprehensive exercises in English. After using it, we now have more methods to learn different things about the subject. It is diversified.</i>
Zhuo: (G5)	<i>I love reading short stories. The way I have learned vocabulary since I was young is relatively boring. But short stories are fascinating and practical. When English words are linked with stories, they become more interesting for me to learn.</i>

what to learn by himself. Yi added that she did not need to take the lessons in fixed sequences in Duolingo. She was allowed to skip some lessons, unlock new units, and come back to old ones later. Yong (G4) also considered it flexible and convenient to study on his mobile phone in the pockets of time he spent waiting or queuing, with no need to carry a big textbook and to study only at a specific time and at specific locations.

Such free choices of when, where, and what to learn in Duolingo made the participants realize that the way they learn English can be under their own control rather than under that of teachers, and there are many diverse ways to learn English beyond what takes place in the classroom and through textbooks. This mitigated learners' feelings of being controlled when learning English and boosted their perceived sense of autonomy toward the subject.

H3b: Transfer of perceived competence. The interview data suggest that the sense of competence generated by Duolingo can make participants feel more capable of learning English in general. There are two different ways in which such an impact took place: the direct transfer of perceived competence and transfer by applying knowledge.

Direct transfer. In the interviews, all groups pointed out that the elements and mechanics of Duolingo provided them with a sense of achievement. Such a sense of competence gained from the MALL activity can be directly transferred to the global level, enabling participants to feel confident about their language learning skills.

For example, Kai (G1) said, “*After answering questions, the expressions of, and feedback from, the character Duo always made me feel encouraged.*” She noted that the encouragement gained from Duolingo made her feel competent in learning English. Other group members agreed. Ning (G4) pointed out that the game-like mechanics of Duolingo’s levels and rewards allowed her to see clearly how much progress she made over time. By contrast, at school, a comparison was usually made between peers, so she always felt inferior to others when some classmates earned full marks while she only got a few. Thus, Duolingo gave her the sense of accomplishment and confidence that she lacked—but longed for—at school. Such experiences with Duolingo directly changed Ning’s perception of her own English capacity.

Further, several participants said that the lessons on Duolingo were suitable for their English proficiency and therefore provided them with a sense of competence in learning the subject. For instance, Lin (G5) said:

The homework assigned by our teacher is sometimes very difficult. In that case, I don’t want to finish it at all. But the tasks in Duolingo are relatively easy. I can choose the difficulty level [suited to me]. This made me more motivated to use Duolingo and learn English.

Lin’s group member Tian also commented that, unlike a class assignment that always took up a lot of time, the 5-minute learning activities on Duolingo seemed much more achievable, so she sometimes spent more time on it unconsciously and felt more competent and motivated to learn English after class.

Nevertheless, Zhi (G2) did not find that there were lessons suitable for more advanced learners like her at the bottom of the page of *curriculum*, so she just finished some very easy units. Also, she did not know what the rewards gained from completing the lessons could be used for. Thus, she received little sense of accomplishment from Duolingo. In this regard, failing to satisfy the need for competence can explain why she did not have increased L2 IM after the treatment.

In brief, these cases demonstrate that when learners gained a sense of competence from performing tasks in Duolingo, they correspondingly experienced greater self-efficacy at learning English more generally and vice versa.

Transfer by applying knowledge. A large majority of participants noted that what they learned on Duolingo can support their studies at school, which increased their perceived competence in mastering English. For example, Hong (G5) said that he had previously considered English to be very dull and was always absent-minded in class. He thought the subject was very difficult and had little confidence in his performance. However, after using Duolingo, Hong found that sometimes what was taught in class was something he already knew from Duolingo. This remarkably built up his confidence in his ability to learn English. Similarly, over half of the participants in

G1, G3, and G4 also indicated that Duolingo helped them to understand and review language points that were unclear to them in class. Thus, when they were back at school, the students found that they became competent in completing the English tasks assigned by their teachers. This made them feel proud and gradually increased their self-efficacy concerning English studies more generally.

In addition to the school context, the knowledge gained from Duolingo can be applied to the participants' daily lives. For instance, Bao (G3) said that when he was able to use the vocabulary learned from Duolingo to answer his parents' questions and read some English articles online, he felt more driven to learn English. Other participants like Yi (G3) and Ning (G4) also pointed out that they felt more competent and fonder of learning English when they were able to put what they had learned in Duolingo into practice and can speak some English in daily interactions.

Overall, participants' accounts indicate that when the knowledge gained from Duolingo is used at school and in everyday life, they can perceive a sense of accomplishment and competence in learning English. This supports our hypothesized transfer of perceived competence between Duolingo and L2 (H3b).

Discussion

In the group interviews, the participants provided detailed accounts of their motivational changes before and after they used Duolingo, which demonstrates the positive impact of Duolingo on learners' global motivation. This confirms H1 that out-of-school usage of Duolingo can stimulate participants' general motivation to learn a language, which is consistent with Cho and Castañeda (2019), Falk and Götz (2016), and Yang et al. (2012), among others. Given the scarcity of research into learners' out-of-school MALL usage and its impact on classroom learning, this study helps fill that void, showing that mobile learning outside formal schooling can promote learners' global L2 motivation and positively affect their language learning at school.

After confirming the positive effect of Duolingo on learners' general motivation toward learning English, we delved deeper into the unexplored question of how this motivational impact takes place. By discovering two types of motivation involved in the process, we suggest the key idea of "transfer" and utilize SDT to reveal the mechanisms underpinning the motivational influence.

At the surface level of the "black box" of the technology-L2 interface is the transfer of IM from the activity level to the global level: Participants who consider learning with Duolingo to be interesting could become more intrinsically driven to learn English after using Duolingo (H2). These findings help address the underexplored issue in the MALL literature on activity motivation as to whether learners are driven merely to complete a particular task involving new technology, or whether they can develop more general motivation for learning a language even without the aid of technology in other instructional settings. This study also provides empirical evidence to

support Stockwell's (2013) argument that "motivation to use a technology could very well lead learners to develop motivation to learn a language" (p. 163).

To dive deeper into the question of how IM is generated, we drew on CET and discovered a relationship between technological features and the two antecedents of IM: Activity motivation is first generated from the basic psychological need for autonomy and competence satisfied by Duolingo, and then learners' sense of autonomy and competence gained at the activity level is transferred to the global level, which consequently sparks their L2 IM.

Initially, Duolingo was found to fulfill learners' need for autonomy by providing the freedom to learn what, when, where, and how they like. The sense of autonomy perceived in Duolingo subsequently affected participants' global perception of L2 learning, so they correspondingly perceived more control over their own studies. To be specific, Duolingo offered the participants various choices in the content of learning, which is also life-oriented rather than test-oriented, enabling participants to feel more autonomous in their studies.

In addition to rich learning content, Duolingo provided learners with the flexibility in choosing how to learn, such as doing tasks in *curriculum* or learning from *short stories*. In addition, Duolingo permits learners to learn whenever and wherever they like. This flexibility is one of the major advantages found in the literature of MALL to support learners' autonomy and interest in learning (Cruaud, 2018; Godwin-Jones, 2011; Norbrook & Scott, 2003; Sandberg et al., 2011). L2 teachers could also encourage students to utilize the flexibility of MALL to promote their sense of L2 autonomy.

Likewise, we found that the game design elements used in Duolingo could satisfy users' basic needs for competence, which is then transferred to the global level and bolsters learners' confidence in their language learning capacity. The interviewees' accounts show that instant feedback on users' performance, the leader board, and rewards can generate learners' sense of competence in Duolingo, in line with findings from earlier studies (e.g., Falk and Götz [2016], Gadanez [2018], and Loewen et al. [2019], who found instant feedback to be an essential element in gamification to increase users' confidence and motivation). Falk and Götz (2016) also noted that the user's interaction with the MALL program via a fictional character can help promote IM, while other studies (e.g., Hew et al., 2016; Li et al., 2021; and Peng et al., 2012) have shown that a positive competitive environment with leader boards and rewards can promote a sense of competence).

In addition, learners can gain personalized learning experiences in Duolingo from lessons (and extra exercises) that suit their proficiency level and feedback based on their own performance. When each user was provided with individualized optimal challenges and appropriate scaffolding, they were able to make progress in their own zone of proximal development (Vygotsky, 1978) and thus build up their confidence. The positive impact of personalization (or "individualization" or

“adaptation”; Bodnar et al., 2016, p. 207) in technology-enhanced language learning systems is also supported by previous research (Stockwell, 2013; Zhang & Zou, 2022; Zou et al., 2021). As MALL has been widely used around the world, by knowing how technology stimulates learners’ IM through the fulfillment of their basic psychological needs, L2 educators can better exploit technological affordances to support their students’ language learning either in or outside the classroom.

Conclusion

We investigated how the out-of-class use of Duolingo affects Chinese junior high school students’ IM for English. We first distinguished the two types of motivation involved when learners participate in MALL activities and then drew upon SDT and proposed a new idea of “transfer” to connect learners’ IM constructs at the activity and global levels. The interview data support our hypothesized psychological mechanisms underpinning the motivational impact of technology: Duolingo first satisfies users’ need for autonomy and competence at the activity level and thus supports their Duolingo IM. Subsequently, the need satisfaction at the activity level can be transferred correspondingly to the global level, which supports learners’ perceived L2 autonomy and competence, leading to their increased IM for language learning more generally. During this process, we also discovered that the transfer of perceived autonomy is driven by the freedom to choose the learning content and learning method in Duolingo, and that the transfer of perceived competence takes place either directly from the activity to the global level or by applying knowledge.

One limitation of this study lies in the self-reported data. Although in the interviews we tried to create a friendly atmosphere where participants were given sufficient time to recall and talk about their authentic experiences with no right or wrong answers, the precision of learners’ accounts is still hard to guarantee. Future research could use methods like journaling to triangulate the data. Nevertheless, this study certainly adds to our understanding of how mobile technology impacts learners’ L2 IM. Educators can utilize the impact mechanism revealed by this study to design and exploit better MALL activities both at and after school to stimulate learners’ motivation.

Contributorship

Cheng Zeng conducted the empirical research (including but not limited to the research design, data collection, and data analysis), while Linda Fisher contributed to supervising the whole project (including but not limited to providing advice and editing the manuscript).

Declaration of conflicting interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.


Ethical statement

This study was conducted in full compliance with the ethical guide approved by the Higher Degrees Office, Faculty of Education, University of Cambridge. Informed consent was obtained from all the participants and their parents/carers.

Funding

The authors disclosed receipt of the following financial support for the research of this article: This work was supported by the China Scholarship Council (Grant No. 202006380078). The authors would also like to thank Weiyang Cheng for her invaluable help in recruiting participants for this study.

ORCID iD

Cheng Zeng  <https://orcid.org/0000-0002-4909-8163>

Note

1. <https://www.duolingo.com/courses>

References

- Ajisoko, P. (2020). The use of Duolingo apps to improve English vocabulary learning. *International Journal of Emerging Technologies in Learning (iJET)*, 15(7), 149. <https://doi.org/10.3991/ijet.v15i07.13229>
- Bodnar, S., Cucchiari, C., Strik, H., & van Hout, R. (2016). Evaluating the motivational impact of CALL systems: Current practices and future directions. *Computer Assisted Language Learning*, 29(1), 186–212. <https://doi.org/10.1080/09588221.2014.927365>
- Burston, J. (2015). Twenty years of MALL project implementation: A meta-analysis of learning outcomes. *ReCALL*, 27(1), 4–20. <https://doi.org/10.1017/s0958344014000159>
- Carreira, J. M. (2012). Motivational orientations and psychological needs in EFL learning among elementary school students in Japan. *System*, 40(2), 191–202. <https://doi.org/10.1016/j.system.2012.02.001>
- Chang, L. L. (2007). The effects of using CALL on advanced Chinese foreign language learners. *CALICO Journal*, 24(2), 331–353. <http://www.jstor.org.ezp.lib.cam.ac.uk/stable/24147915>
- Chen, C., Liu, H., & Huang, H. (2019). Effects of a mobile game-based English vocabulary learning app on learners' perceptions and learning performance. *ReCALL*, 31(2), 170–188. <https://doi.org/10.1017/s0958344018000228>
- Cho, M.-H., & Castañeda, D. A. (2019). Motivational and affective engagement in learning Spanish with a mobile application. *System*, 81, 90–99. <https://doi.org/10.1016/j.system.2019.01.008>
- Cruaud, C. (2018). The playful frame: Gamification in a French-as-a-foreign-language class. *Innovation in Language Learning and Teaching*, 12(4), 330–343. <https://doi.org/10.1080/17501229.2016.1213268>
- Deci, E. L., & Ryan, R. M. (2015). Self-determination theory. In J. D. Wright (Ed.), *International encyclopedia of the social and behavioral sciences* (2nd ed., pp. 486–491). Elsevier. <http://ebookcentral.proquest.com/lib/cam/detail.action?docID=1963260>

- Demouy, V., Jones, A., Kan, Q., Kukulska-Hulme, A., & Eardley, A. (2016). Why and how do distance learners use mobile devices for language learning? *The EuroCALL Review*, 24(1), 10. <https://doi.org/10.4995/eurocall.2016.5663>
- Deterding, S. (2015). The lens of intrinsic skill atoms: A method for gameful design. *Human-Computer Interaction*, 30(3-4), 294-335. <https://doi.org/10.1080/07370024.2014.993471>
- Falk, S., & Götz, S. (2016). *Interactivity in language learning applications: A case study based on Duolingo*. <https://www.researchgate.net/publication/325546461>
- Fereday, J., & Muir-Cochrane, E. (2006). Demonstrating rigor using thematic analysis: A hybrid approach of inductive and deductive coding and theme development. *International Journal of Qualitative Methods*, 5(1), 80-92. <https://doi.org/10.1177/160940690600500107>
- Francisco-Aparicio, A., Gutiérrez-Vela, F. L., Isla-Montes, J. L., & Sanchez, J. L. G. (2013). Gamification: Analysis and application. In V. M. R. Penichet, A. Peñalver, & J. A. Gallud (Eds.), *New trends in interaction, virtual reality and modeling* (pp. 113-126). Springer London. https://doi.org/10.1007/978-1-4471-5445-7_9
- Fryer, L., & Oga-Baldwin, W. L. Q. (2018). Assessing motivation and instruction for languages at Japanese JHSs. In P. Clements, A. Krause, & P. Bennett (Eds.), *Language teaching in a global age: Shaping the classroom, shaping the world* (pp. 78-85). JALT.
- Gadanez, P. (2018, August 22-24). The nature of positive emotions via online language learning. 2018 9th IEEE International Conference on Cognitive Infocommunications (CogInfoCom), Budapest, Hungary.
- Glaser, B. G. (1992). *Discovery of grounded theory*. Aldine.
- Godwin-Jones, R. (2011). Emerging technologies: Mobile apps for language learning. *Language Learning and Technology*, 15(2), 2-11. https://scholarspace.manoa.hawaii.edu/bitstream/10125/44244/1/15_02_emerging.pdf
- Golonka, E. M., Bowles, A. R., Frank, V. M., Richardson, D. L., & Freynik, S. (2014). Technologies for foreign language learning: A review of technology types and their effectiveness. *Computer Assisted Language Learning*, 27(1), 70-105. <https://doi.org/10.1080/09588221.2012.700315>
- Greig, A. D., & Taylor, J. (1999). *Doing research with children*. Sage.
- Heift, T., & Chapelle, C. A. (2012). Language learning through technology. In S. M. Gass & A. Mackey (Eds.), *The Routledge handbook of second language acquisition* (pp. 555-569). Routledge.
- Henry, A. (2019). Online media creation and L2 motivation: A socially situated perspective. *TESOL Quarterly*, 53(2), 372-404. <https://doi.org/10.1002/tesq.485>
- Hew, K. F., Huang, B., Chu, K. W. S., & Chiu, D. K. W. (2016). Engaging Asian students through game mechanics: Findings from two experiment studies. *Computers & Education*, 92-93, 221-236. <https://doi.org/10.1016/j.compedu.2015.10.010>
- Hwang, G., & Fu, Q. (2019). Trends in the research design and application of mobile language learning: A review of 2007-2016 publications in selected SSCI journals. *Interactive Learning Environments*, 27(4), 567-581. <https://doi.org/10.1080/10494820.2018.1486861>
- Isbell, D. R., Rawal, H., Oh, R., & Loewen, S. (2017). Narrative perspectives on self-directed foreign language learning in a computer- and mobile-assisted language learning context. *Languages*, 2(2), 4. <https://doi.org/10.3390/languages2020004>
- Kebritchi, M., Hirumi, A., & Bai, H. (2010). The effects of modern mathematics computer games on mathematics achievement and class motivation. *Computers & Education*, 55(2), 427-443. <https://doi.org/10.1016/j.compedu.2010.02.007>

- Kukulska-Hulme, A., Lee, H., & Norris, L. (2017). Mobile learning revolution. In C. A. Chapelle & S. Sauro (Eds.), *The handbook of technology and second language teaching and learning* (pp. 217–233). Wiley & Sons. <https://doi.org/10.1002/9781118914069.ch15>
- Kurt, M., & Bensen, H. (2017). Six seconds to visualize the word: Improving EFL learners' vocabulary through VVVs. *Journal of Computer Assisted Learning*, 33(4), 334–346. <https://doi.org/10.1111/jcal.12182>
- Li, R., Meng, Z., Tian, M., Zhang, Z., & Xiao, W. (2021). Modelling Chinese EFL learners' flow experiences in digital game-based vocabulary learning: The roles of learner and contextual factors. *Computer Assisted Language Learning*, 34(4), 483–505. <https://doi.org/10.1080/09588221.2019.1619585>
- Liu, T., & Chu, Y. (2010). Using ubiquitous games in an English listening and speaking course: Impact on learning outcomes and motivation. *Computers & Education*, 55(2), 630–643. <https://doi.org/10.1016/j.compedu.2010.02.023>
- Loewen, S., Crowther, D., Isbell, D. R., Kim, K. M., Maloney, J., Miller, Z. F., & Rawal, H. (2019). Mobile-assisted language learning: A Duolingo case study. *ReCALL*, 31(3), 293–311. <https://doi.org/10.1017/s0958344019000065>
- Loewen, S., Isbell, D. R., & Sporn, Z. (2020). The effectiveness of app-based language instruction for developing receptive linguistic knowledge and oral communicative ability. *Foreign Language Annals*, 53(2), 209–233. <https://doi.org/10.1111/flan.12454>
- Mekler, E. D., Brühlmann, F., Tuch, A. N., & Opwis, K. (2017). Towards understanding the effects of individual gamification elements on intrinsic motivation and performance. *Computers in Human Behavior*, 71, 525–534. <https://doi.org/10.1016/j.chb.2015.08.048>
- Merriam, S. B. (1988). *Case study in education: A qualitative approach*. Jossey-Bass.
- Morrison, K. (2013). Interviewing children in uncomfortable settings: 10 lessons for effective practice. *Educational Studies*, 39(3), 320–337. <https://doi.org/10.1080/03055698.2012.760443>
- Morton, H., & Jack, M. (2010). Speech interactive computer-assisted language learning: A cross-cultural evaluation. *Computer Assisted Language Learning*, 23(4), 295–319. <https://doi.org/10.1080/09588221.2010.493524>
- Noels, K. A., Pelletier, L. G., Clément, R., & Vallerand, R. J. (2003). Why are you learning a second language? Motivational orientations and self-determination theory. *Language Learning*, 53(S1), 33–64. <https://doi.org/10.1111/1467-9922.53223>
- Norbrook, H., & Scott, P. (2003). Motivation in mobile modern foreign language learning. In J. Attewell, G. Da Bormida, M. Sharples, & C. Savill-Smith (Eds.), *MLEARN 2003: Learning with mobile devices* (pp. 50–51). Learning and Skills Development Agency.
- Peng, W., Lin, J., Pfeiffer, K. A., & Winn, B. (2012). Need satisfaction supportive game features as motivational determinants: An experimental study of a self-determination theory guided exergame. *Media Psychology*, 15(2), 175–196. <https://doi.org/10.1080/15213269.2012.673850>
- Plonsky, L., & Ziegler, N. (2016). The CALL-SLA interface: Insights from a second-order synthesis. *Language, Learning and Technology*, 20(2), 17–37. <https://doi.org/10.125/44459>
- Poland, B. D. (1995). Transcription quality as an aspect of rigor in qualitative research. *Qualitative Inquiry*, 1(3), 290–310. <https://doi.org/10.1177/107780049500100302>

- Rachels, J. R., & Rockinson-Szapkiw, A. J. (2017). The effects of a mobile gamification app on elementary students' Spanish achievement and self-efficacy. *Computer Assisted Language Learning, 31*(1–2), 72–89. <https://doi.org/10.1080/09588221.2017.1382536>
- Rosell-Aguilar, F. (2018). Autonomous language learning through a mobile application: A user evaluation of the *busuu* app. *Computer Assisted Language Learning, 31*(8), 854–881. <https://doi.org/10.1080/09588221.2018.1456465>
- Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology, 25*(1), 54–67. <https://doi.org/10.1006/ceps.1999.1020>
- Ryan, R. M., & Deci, E. L. (2017). *Self-determination theory: Basic psychological needs in motivation, development, and wellness*. The Guilford Press. <https://doi.org/10.1521/978.14625/28806>
- Sailer, M., Hense, J. U., Mayr, S. K., & Mandl, H. (2017). How gamification motivates: An experimental study of the effects of specific game design elements on psychological need satisfaction. *Computers in Human Behavior, 69*, 371–380. <https://doi.org/10.1016/j.chb.2016.12.033>
- Sandberg, J., Maris, M., & de Geus, K. (2011). Mobile English learning: An evidence-based study with fifth graders. *Computers & Education, 57*(1), 1334–1347. <https://doi.org/10.1016/j.compedu.2011.01.015>
- Shadiev, R., Hwang, W., & Huang, Y. (2017). Review of research on mobile language learning in authentic environments. *Computer Assisted Language Learning, 30*(3–4), 284–303. <https://doi.org/10.1080/09588221.2017.1308383>
- Shadiev, R., & Yang, M. (2020). Review of studies on technology-enhanced language learning and teaching. *Sustainability, 12*(2), 524. <https://doi.org/10.3390/su12020524>
- Steel, C. (2015). Students' perspectives on the affordances and constraints of using mobile devices and applications for learning languages. In A. M. G. Sanz, M. Levy, F. Blin, & D. Barr (Eds.), *WorldCALL: Sustainability and computer-assisted language learning* (pp. 230–243). Bloomsbury Academic.
- Stockwell, G. (2013). Technology and motivation in English-language teaching and learning. In E. Ushioda (Ed.), *International perspectives on motivation* (pp. 156–175). Palgrave Macmillan. https://doi.org/10.1057/9781137000873_9
- Strauss, A., & Corbin, J. (1998). *Basics of qualitative research: Techniques and procedures for developing grounded theory*. Sage.
- Ushioda, E. (2013). Motivation matters in mobile language learning: A brief commentary. *Language Learning & Technology, 17*(3), 1–5. <https://doi.org/10.125/44333>
- Vesselinov, R., & Grego, J. (2012). *Duolingo effectiveness study: Final report*. https://static.duolingo.com/s3/DuolingoReport_Final.pdf
- Vygotsky, L. S. (1978). *Mind in society: Development of higher psychological processes*. Harvard University Press. <https://doi.org/10.2307/j.ctvjf9vz4>
- Wu, X. (2003). Intrinsic motivation and young language learners: The impact of the classroom environment. *System, 31*(4), 501–517. <https://doi.org/10.1016/j.system.2003.04.001>
- Yang, Y., Gamble, J., & Tang, S. (2012). Voice over instant messaging as a tool for enhancing the oral proficiency and motivation of English-as-a-foreign-language learners. *British Journal of Educational Technology, 43*(3), 448–464. <https://doi.org/10.1111/j.1467-8535.2011.01204.x>

- Zhang, R., & Zou, D. (2022). Types, purposes, and effectiveness of state-of-the-art technologies for second and foreign language learning. *Computer Assisted Language Learning*, 35(4), 696–742. <https://doi.org/10.1080/09588221.2020.1744666>
- Zou, D., Huang, Y., & Xie, H. (2021). Digital game-based vocabulary learning: Where are we and where are we going? *Computer Assisted Language Learning*, 34(5–6), 751–777. <https://doi.org/10.1080/09588221.2019.1640745>

Appendix I. Interview protocol.

Questions on Duolingo experiences:

1. What do you think of Duolingo?
你觉得多邻国这个软件怎么样呢？
2. Which features in Duolingo did you use most frequently?
你最常用多邻国什么功能呢？
3. Which features in Duolingo do you enjoy the most? Why?
你最喜欢多邻国的什么功能呢？为什么？

Questions on the impact of Duolingo on L2 motivation:

1. Were there any changes in your English learning before and after you used Duolingo? If so, why?
在使用多邻国之前和之后，你的英语学习情况是否发生了变化？如果有，是为什么呢？