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Enhancing EFL learners' vocabulary learning and motivation through mobile-assisted digital flashcards: the mediatory role of digital literacy

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This study aimed to explore the differential impacts of digital flashcards (DFs) on vocabulary learning and motivation of Iranian English as a Foreign Language (EFL) learners with high and low levels of digital literacy (DL). Sixty pre-intermediate EFL learners from two private language institutes participated in this study, selected based on their general language proficiency through the Oxford Placement Test (OPT) and digital literacy questionnaire. The participants formed two experimental groups: a high digital literacy (HDL) group ($N = 30$) and a low digital literacy (LDL) group ($N = 30$), both receiving vocabulary instruction through DFs. Results indicated that both groups experienced significant changes after the treatment in terms of vocabulary attainment and motivational gains, with the HDL group notably outperforming the LDL group. The LDL group's significant improvement, although not to the same extent as their HDL counterparts, suggested that the benefits of mobile-assisted DFs outweighed the challenges arising from the low DL.

Keywords: digital flashcards, digital literacy, EFL learners, motivation, vocabulary learning

Introduction

Mobile technology is in a constant state of flux, with mobile-assisted language learning (MALL) emerging as a distinct and growing field within second/foreign language acquisition (SLA/FLA) research. This research investigates how mobile devices can effectively scaffold language learning processes in

and beyond the classroom (Jarvis & Achilleos, 2013). In EFL contexts, multimedia tools provide a rich array of scaffolds such as audio, video, and interactive features to offset the impoverished classroom time and exposure to authentic language input, thereby assisting word attainment (Lin & Lin, 2019).

Digital flashcards (DFs) representing a mobile-assisted educational tool have proven influential in boosting the acquisition and retention of L2 vocabulary (Elgort & Piasecki, 2014). Installed on mobile devices, DFs offer more convenience and portability than paper flashcards (PFs) and traditional word-lists, especially when practicing large volumes of words (Nakata & Suzuki, 2019). DFs are the electronic version of physical flashcards that can be created using an app for learning diverse materials (Dizon & Tang, 2017). These applications incorporate features such as spaced repetition algorithms to optimize review timing, culminating in superior long-term retention compared to traditional paper-based methods (Kaitsu & Nakata, 2025; Yüksel et al., 2022). Digital flashcards also support learners' self-directed study and provide flexibility to practice vocabulary anytime and anywhere, ensuring uninterrupted engagement with the material (Teymouri, 2024). Using digital flashcards like Anki and Quizlet with built-in adaptive systems (Kerr, 2016), learners can focus on practicing the difficult words more frequently, obviating a large number of pointless reviews (Dizon & Tang, 2017). Additionally, thousands of flashcards can be stored on the phone without occupying much space (Elgort & Piasecki, 2014; Serfaty & Serrano, 2020).

Through DFs, learners can track their progress while benefiting from the multimedia affordances, and management functions like “dropping” (i.e., eliminating some materials) or “starring” (prioritizing specific learning items) (Elgort & Piasecki, 2014), self-testing and gaming activities (Zung et al., 2022), and oral rehearsal (Dizon & Tang, 2017). These built-in features help learners sustain interest in using the app for learning (Lin & Lin, 2019; Nasution et al., 2024; Xodabande et al., 2022).

In a recent survey study, Zung et al. (2022) listed a number of software-related variables to presumably affect the efficacy of DFs, namely flipping, dropping or starring functions, self-generated vs ready-made use of flashcards, multimedia presentation, feedback provision, revisiting of cards, and shuffling capability. However, a significant important variable missing in their list is the learner profile and its moderating impact on the learning process. Given that in today's digital world, students' acquaintance with emerging technological tools has a great bearing on their learning outcomes (Yuan et al., 2019), it seems incumbent to explore the extent to which learners' digital literacy (DL) can mediate the effectiveness of DFs.

A growing body of research has established that DLs can contribute to academic achievement and productivity (Essel et al., 2021), learner motivation (Xueting Ye & Shi, 2023), and self-regulation (Han & Reinhardt, 2022; Namaziandost & Rezai, 2024). It is argued that digitally literate learners might benefit more from the multimodal nature of digital language environments and navigate the text, audio, visual, and interactive elements more effectively (Audrin & Audrin, 2023). Conversely, digitally illiterate students may miss

out on valuable language learning tools, resulting in technostress, reduced motivation, and cognitive overload when struggling to use unfamiliar technologies (Bahari, 2023; Maier et al., 2019). Despite extensive reports confirming the effect of DFs on vocabulary development (Xodabande et al., 2022; Yowaboot & Sukying, 2022), no study has empirically tested the mediatory role of DL in DF-assisted intervention. Likewise, it is not clear whether DL can moderate the effectiveness of DFs on learners' motivation. Given these research gaps, the present study aimed to unpack the impact of DFs on vocabulary development and motivation of Iranian EFL learners with high and low DL. To realize these goals, the following research questions were raised:

- RQ1: Does using DFs significantly improve Iranian EFL learners' vocabulary learning?
- RQ2: Does using DFs significantly improve Iranian EFL learners' motivation?
- RQ3: Do Iranian EFL learners with high or low DL benefit differentially from using DFs for vocabulary learning?
- RQ4: Do Iranian EFL learners with high and low DL experience different levels of motivation from using DFs?

Background

Mobile-assisted vocabulary development

Mobile-Assisted Language Learning (MALL) has crept into the field of SLA due to the sky-rocketing changes in mobile technologies. Renowned for its outstanding portability and accessibility, MALL provides a learning space to support interactive, social, authentic, and contextualized communication (Kukulka-Hulme & Shield, 2008). Mobile learning utilizes small, portable gadgets such as PDAs, smartphones, tablets, and similar devices to secure rich, immediate, convenient, and context-aware learning experiences much beyond the capacities of desktop computers (Stockwell & Hubbard, 2013).

Following the MALL, Mobile-Assisted Vocabulary Learning (MAVL) emerged as a distinct field to trace L1/L2 learning of vocabulary (Han & Chen, 2024). In an empirical study, Hao et al. (2019) proved that specific mobile-based Apps can significantly impact low-achieving EFL learners' vocabulary learning, boosting their confidence and cooperative learning. The interactive features of mobile devices enable learners to study at their own pace and tailor the difficulty of learning materials to their growing proficiency levels in the target language. This adaptability helps learners to match their learning experience with their individual needs, thus amplifying their efficiency in learning (Shalini Roy & Gandhimathi, 2025). From the standpoint of Cognitive Theory of Multimedia Learning (CTML; Mayer, 2022), mobile apps like DFs grant learners multiple channels including auditory and visual to engage learners in enhanced cognitive and working memory processing. Multimedia affordances help learners highlight the relevant materials, organize them more coherently, and associate them with prior schemata. Such scaffolds are typically absent in PFs which rely mainly on text for practicing and retaining information (Mayer, 2019).

Incidental vs intentional vocabulary learning

Recent scholarship suggests that learners involved in L1/L2 vocabulary learning undergo two main processes, namely incidental and intentional. Incidental vocabulary learning takes place with no conscious or explicit attention to the learning activity. It is typically the result of engaging in meaningful tasks such as extensive reading, listening, or conversational interactions while the focus is on the content and meaningful input rather than memorizing words (Huckin & Coady, 1999). However, Nakata (2019, p. 305) warns that “incidental vocabulary learning alone is insufficient and should be supplemented with word-focused activities such as paired-associate learning.”

Conversely, intentional vocabulary learning is characterized by consciously focusing on acquiring specific lexical items through deliberate efforts and memorization techniques, such as using vocabulary lists, fill-in-the-blanks activities, or explicit instruction (Schmidt, 2008; Webb & Nation, 2017). Review techniques such as wordlists, PFs, vocabulary notebooks, and digital flashcards act as boosters to attain a large number of vocabulary items in a relatively short time and with high efficiency (Tsai, 2018). However, the knowledge gained through flashcards is typically declarative and should be used in authentic contexts through communication-focused activities such as conversation or watching movies to become procedural and fluent (Elgort & Piasecki, 2014).

Digital literacy

Digital literacy (DL) has been defined differently in the extant literature. The definition by Son et al. (2011, p. 27) is most relevant to the present study, taking the DL as “the development of knowledge and skills for using general computer applications, language-specific software programs, and Internet tools confidently and competently.” Chen et al. (2019) assert that DL helps learners to navigate learning environments, utilize interactive features, and experience more efficient learning. Likewise, Alakrash and Abdul Razak (2021) consider DL as a prerequisite for engaging with Computer-Assisted Language Learning (CALL) systems efficiently. Looked at from Ng's (2012) theoretical framework, DL can encompass two components: technical literacy and cognitive literacy. The former refers to procedural skills such as operating mobile devices or software applications to manage and accomplish vocabulary learning goals, while the latter enables learners to engage in critical thinking, comprehension, and memory skills to understand and retain vocabulary through the flashcards. Without sufficient digital skills, learners may experience cognitive overload, frustration, and reduced motivation, which obstruct language learning gains (Serfaty & Serrano, 2020).

Based on Dual Coding Theory (Paivio, 2014), learners competent in managing digital tools benefit more from the multimedia inputs (i.e., visual, auditory, and textual), which reinforce vocabulary retention through richer encoding strategies. Empirical research consistently suggests that learners with higher DL engage more effectively with language software, web-based resources, and

mobile learning applications (Degner et al., 2022). Digital flashcards, language apps, and online exercises offer interactive and adaptive features that harness learners' digital competencies to promote autonomy and engagement (Xodabande et al., 2022; Yowaboot & Sukying, 2022). On the other hand, low DL and incompetence in digital platforms may trigger emotional barriers such as anxiety, reducing learners' motivation and confidence (Tarafdar et al., 2007). Learners lacking in computer skills rely solely on traditional methods, which can be less effective compared to integrated digital approaches that enhance engagement and retention (Godwin-Jones, 2015). Moreover, the inability to use technology-enhanced collaborative tools limits opportunities for peer learning and feedback, compromising their motivation to learn (Susiana & Priyatin, 2025). The negative emotional feelings triggered by the fear of technology or technophobia (Wang et al., 2020) and the inability to adjust to and manage digital tools known as technostress (Maier et al., 2019) can inadvertently cause anxiety, disturbing the smooth process of language acquisition (Arnold & Brown, 1999).

Empirical studies on digital flashcards in ELT

Drawing on available literature, technology-assisted L2 vocabulary learning is generally more effective than non-technology-assisted instruction (Hao et al., 2021; Teymouri, 2024), and learners using mobile tools outperform their peers in both their immediate recall tests (Dizon & Tang, 2017; Koleini et al., 2024) and delayed retention tests (Azabdaftari & Mozaheb, 2012; Mohammadi et al., 2024; Najafi Karimi & Kheradmandi Amiri, 2025; Nakata, 2019; Xodabande et al., 2023; Zakian et al., 2022).

In a quasi-experimental study, Yüksel et al. (2022) examined the impact of teacher-prepared DFs through the Quizlet app compared to wordlists on the technical vocabulary learning of undergraduate pharmacy students. Their findings indicated that DFs led to greater vocabulary gains than wordlists. Their qualitative results verified that students held favorable views toward DFs. Najafi Karimi and Kheradmandi Amiri (2025) compared the impact of vocabulary learning in three experimental conditions, namely DFs, PFs, and wordlists among teenagers in Iranian EFL context. Their results showed that only the DFs led to statistically significant impacts on the learners' acquisition and retention, and the PFs and wordlists exerted only negligible effects.

Sage et al. (2019) studied the differential impact of flashcards on three platforms, namely computer, tablet, and paper in either self-created or ready-made formats. Their results showed that paper and tablet flashcards resulted in equally significant gains, but the computer flashcards had the least impact. Their qualitative scrutiny disclosed that the ready-made flashcards, despite requiring more effort than self-created ones, led to better recall. Overall, the authors argued that both paper and digital (computer-based and tablet-based) flashcards were effective, with tablets surpassing the other two. In a similar study, Zarrati et al. (2024) assessed the effectiveness of flashcards on mobile, laptop, and paper platforms in learning the academic vocabulary among Iranian undergraduate university students. The results of pre- and posttests

indicated that while all groups experienced statistically substantial gains, the mobile group outperformed the other two. The findings of these studies imply that learners benefit the most from the portability and accessibility affordances of mobile devices for enriching their vocabulary.

Another group of studies sought to trace the differential impacts of DFs on students' receptive and productive vocabulary. While some studies reported equal gains for both receptive and productive vocabulary (Honarзад & Soyoof, 2023; Li & Hafner, 2022; Webb, 2008; Xodabande & Boroughani, 2023; Yowaboot & Sukying, 2022), others documented DFs' superior impact on the learners' receptive vocabulary (Dizon & Tang, 2017; Mohammadi et al., 2024).

The literature on DL depicts that some scholars have treated the DL not as a technical skill but a moderator variable to affect students' engagement, self-efficacy, or L2 achievements. In a correlational study, Barkati et al. (2025) identified the DL as a strong predictor of informal digital learning of English (IDLE) among EFL learners. Their results revealed that learners with higher DL, grit, and self-efficacy exhibit more engagement in IDLE activities, arguing that digital skills significantly uplifted learners' motivation and ability to learn beyond the physical classroom. However, others examined the DL as an instructional knowledge that could be taught explicitly. For example, Shafiee Rad et al. (2024) reported the positive impact of adaptive learning (AL) and DL instruction on EFL learners' writing abilities and self-determination motivation. Their integrated AL and DL approach led to the learners' motivation, engagement, and sense of ownership.

Finally, some other studies, though in piecemeal, have warned against the low DL as an impediment for efficiency and academic learning. For example, Tarafdar et al. (2007) reported a trade-off between technostress as a by-product of low DL and role stress as well as individual productivity. They argued that individuals' high levels of technostress induced by their lack of information and computer technology (ICT) skills caused apprehension and feelings of helplessness, leading to role conflicts and low performance in the organizational workplace. In academia, adopting a descriptive-correlational design, Essel et al. (2021) sought to discern the relationship between three pairs of variables, namely DL and technostress, technostress and academic achievement, and technostress and academic productivity among undergraduate university students in Ghana. Their results verified a significant inverse relationship across all three variable pairs, which implied that students' failure to cope with technology demands would result in low academic achievement gains and academic productivity.

The preceding review reveals that DFs hold great potential for enhancing learners' vocabulary acquisition and motivation. Also, it highlights that DL can significantly influence learners' performance and productivity. However, a clear gap meriting due attention is the extent to which DL can moderate the effectiveness of DF-supported instruction on EFL learners' vocabulary learning and motivation.

Method

Participants

The participants in this study comprised 60 pre-intermediate Persian learners, selected based on convenience sampling due to their availability and free time. The selection of participants was done in two phases using an Oxford Placement Test (OPT; Syndicate, 2001) and Digital Literacy Questionnaire (Son et al., 2017). At the outset, 80 out of 95 male and female learners ranging in age from 15 to 19 years were selected through the OPT from two language institutes in Amol. Based on the rubric scale of OPT, the pre-intermediate EFL learners were selected. After taking the OPT, those who scored one standard deviation above and below the mean were considered homogenous. Afterwards, 60 out of 80 male and female EFL learners were selected through a DL questionnaire. After selecting the participants, they were divided into two experimental groups: high digital literacy group (HDL; $N = 30$) and low digital literacy group (LDL; $N = 30$).

Instruments

To carry out this study, five instruments were employed, namely the OPT, DL questionnaire, motivation questionnaire, vocabulary pre- and post-tests, and Anki software to analyze learners' vocabulary knowledge before and after receiving treatments.

The first instrument used was the Oxford Placement Test to homogenize the participants. The test involved three main sections: vocabulary, grammar, and reading, consisting of multiple-choice items and cloze passages.

To investigate the students' DL, the Digital Literacy Questionnaire developed by Son et al. (2017) was administered among the students. The questionnaire includes 23 items in five subsections: information search and evaluation, creation, communication, collaboration, and online safety. The questionnaire was piloted with a subset of 10 participants drawn from the main study sample to check its clarity and applicability. The Cronbach alpha formula was applied to assess the reliability of the questionnaire, which turned out to be .79, indicating a high reliability index. Two experienced teachers reviewed the items for clarity, relevance, and appropriateness, thereby ensuring face and content validity. Some items were revised following the teachers' comments to better tailor the questionnaire for the context of this research.

Two teacher-designed English vocabulary tests, a pretest and a posttest, were created to assess the participants' vocabulary knowledge. Both tests consisted of a single section comprising 15 multiple-choice items. The vocabulary items and their order differed between the pre- and posttests to minimize the test-retest effect. Each test had a maximum score of 20 points for students who answered all questions correctly. The targeted vocabulary was selected based on the learners' textbook, Touchstone 2 by McCarthy et al. (2013). These tests aimed to evaluate the learners' acquisition of the targeted vocabulary. To ensure the validity of the tests, three English teachers with over 20 years of teaching experience in language institutes and universities participated in



the test design process. They reviewed the tests twice and provided feedback regarding face and content validity, which led to revisions in the test items and structure. Additionally, the reliability of the tests was assessed using Cronbach's alpha. Each test was administered to 10 students with similar educational backgrounds. The reliability coefficients for the pretest and posttest were 0.811 and 0.857, respectively, indicating high reliability.

A motivation questionnaire, adapted and modified from Taguchi et al. (2009) and Dörnyei (2010), was utilized as another data collection tool in this study. The questionnaire consisted of 19 items divided into two main sections: one addressing L2 learning experiences and the other focusing on the ideal L2 self and ought-to L2 self. The first section included 13 items rated on a six-point Likert scale (1 = strongly disagree to 6 = strongly agree), while the second section comprised 6 items also scored on a six-point Likert scale (1 = not at all to 6 = very much). In total, the questionnaire contained 30 items organized into three parts. To facilitate comprehension, the items were translated into Persian. The questionnaire's reliability was assessed using Cronbach's alpha, a widely accepted measure of internal consistency, as noted by Pallant (2011). The pilot study involved 10 volunteers with characteristics similar to those of the target participants, yielding a Cronbach's alpha of 0.893, indicating high reliability.

The last instrument employed was the Anki which is a powerful DF program with a spaced repetition feature to enable the learning and memory storage process. Anki enables users to create customized flashcards with text, images, audio, video, and even scientific content. To optimize long-term retention, Anki utilizes intelligent algorithm-based flashcard review schedules that are based on users' un/successful recall of each item, with a high concentration on difficult items compared to easy ones, spaced out. The created flashcards can also be organized in the context of decks and tags to categorize the DFs. The synchronization feature of the app allows access to the DFs via various devices with AnkiWeb, giving learners an opportunity to study without interruption anywhere and anytime. The cloze deletion card feature allows recalling of specific information within a sentence, hence giving learners an opportunity to interact more intensely with the content. Formatting options like inset images, audio, and custom HTML styling, and add-ons make the app interface and cards both interactionally and visually richer. Finally, the app automatically saves learners' progress as well as the added or edited flashcards so that data loss is not incurred. Overall, with these features, the app offers a very efficient and customizable platform that makes it easy for learners to design their learning sessions according to their personal needs.

Data collection and analysis

The data collection for this study spanned over 12 sessions. Initially, participant selection took place using two instruments: the Oxford Placement Test (OPT) and a DL questionnaire. Based on these assessments, 60 pre-intermediate EFL learners were selected and divided into two experimental groups: one with high DL ($N = 30$) and the other with low DL ($N = 30$). Both groups received

vocabulary instruction through digital flashcards. Following participant selection, the vocabulary pretest and motivation questionnaire (pretest) were administered to all participants. During instruction, the teacher followed a structured approach: first introducing the lesson topic and encouraging students to consider the meaning of the title and related vocabulary. The teacher then explained lesson objectives and assigned activities using DFs via her smartphone. New vocabulary was presented using the Anki digital flashcard app, including pronunciation demonstrations to which students repeated after the teacher.

The teacher implemented a “Use Recall” activity, where the words and their definitions were presented on separate slides, requiring students to recall the word form independently. In the “Learn Receptively and Productively” activity, students first encountered the word along with its meaning for receptive learning. Then, for productive learning, they were prompted to recall and match each word with its correct meaning. The teacher also conducted a “Say the Word Aloud” activity, displaying the meanings and asking students to verbalize the corresponding words. Additionally, learners were encouraged to create their own example sentences using the new vocabulary, helping to foster deeper learning and a “real-life” learning experience by taking responsibility for their own learning (Colbran et al., 2014). They were encouraged to create more DFs and study them outside of the classroom. At the conclusion of the study, the vocabulary posttest and motivation questionnaire were administered to all participants.

The Shapiro-Wilk test was employed to check the normality of the vocabulary and motivation pre- and posttest scores for both groups. Based on the results, all *p*-values exceeded the 0.05 threshold. Accordingly, parametric statistical methods (paired samples *t*-test and one-way ANCOVA) were used to answer the four research questions.

Results

RQ1: Does using DFs significantly improve Iranian EFL learners' vocabulary learning?

Preliminary analysis of all participants as a single group revealed that the participants' mean vocabulary score changed from 11.25 at pretest to 15.50 at posttest, pointing to an improvement in vocabulary ability after the intervention with DFs. To ensure that the difference was statistically significant, a paired samples *t*-test was conducted.

Table 1. Paired samples *t*-test for the vocabulary scores of the HDL and LDL groups as a single group

Test	Mean	Std. deviation	Std. error mean	<i>t</i>	<i>df</i>	<i>p</i> -value (2-tailed)
Pretest	11.25	1.40	0.18			
Posttest	15.50	2.15	0.28	20.94	59	< .001

As Table 1 reveals, there was a notable change in vocabulary scores from pretest ($M = 11.25$, $SD = 1.40$) to posttest ($M = 15.50$, $SD = 2.15$), $t(59) = 20.94$, $p < .001$. The eta squared value (1.90) was very large, denoting that participants experienced significant vocabulary improvement after using DFs.

RQ2: Does using DFs significantly improve Iranian EFL learners' motivation?

The initial analysis of the mean motivation scores of all participants as a single group (HDL vs LDL groups) indicated a substantial change in the mean motivation score from 76.50 at pretest to 104.50 at posttest, pointing to an overall change in motivation after practicing DFs. A paired samples t -test was conducted to compare motivation scores before and after the intervention with DFs for the entire group.

Table 2. Paired samples t -test for the motivation scores of the HDL and LDL groups as a single group

Test	Mean	Std. deviation	Std. error mean	t	df	p -value (2-tailed)
Pretest	76.50	6.53	0.84			
Posttest	104.50	16.20	2.09	23.69	59	< .001

As shown in Table 2, the paired samples t -test uncovered a notable rise in motivation scores from pretest ($M = 76.50$, $SD = 6.53$) to posttest ($M = 104.50$, $SD = 16.20$), $t(59) = 23.69$, $p < .001$. The effect size measured was 2.18, which was a very large one, suggesting that participants' motivation improved significantly after practicing DFs.

RQ3: Do Iranian EFL learners with high or low DL benefit differentially from using DFs for vocabulary learning?

To find out whether the HDL and LDL groups benefited differently from the intervention, one-way ANCOVA was conducted. Descriptive analysis illustrated that both groups started with similar vocabulary knowledge with negligible difference at pretest (HDL mean = 11.00, LDL mean = 11.50). However, after the intervention, the HDL group demonstrated a notably higher mean vocabulary score (17.00) compared to the LDL group (14.00), indicating greater vocabulary development among learners with higher DL. To examine whether the two groups benefited differently from DFs in terms of vocabulary, one-way ANCOVA was conducted. Prior to running the test, the related assumptions, including the linearity, homogeneity of regression slopes and variances, data normality, as well as accurate assessment of the covariate, were checked, with results showing no violation of the assumptions.

As is evident in Table 3, the results pointed to a statistically notable disparity between the HDL and LDL groups on vocabulary posttest scores, $F(1,57) = 42.74$, $p < .001$, partial eta squared = 0.429. This means that after adjusting for pretest vocabulary scores, learners with high DL scored significantly higher on the vocabulary posttest than those with low DL. Finally, it was inferred that

Table 3. Results of one-way ANCOVA for vocabulary scores

Source	Type III sum of squares	df	Mean square	F	Sig. (p)	Partial eta squared
Corrected Model	131.15	2	65.58	21.51	<.001	.429
Intercept	2024.50	1	2024.50	664.75	<.001	.921
Pre-vocabulary (Covariate)	0.69	1	0.69	0.23	.637	.004
Group	130.46	1	130.46	42.74	<.001	.429
Error	174.01	57	3.05			
Total	2329.00	60				
Corrected Total	305.16	59				

DFs were more effective for learners with higher DL in enhancing vocabulary performance.

RQ4: Do Iranian EFL learners with high and low DL experience different levels of motivation from using DFs?

The fourth question examined whether using DFs had differential impacts on the motivation of the two groups. To address this, the groups' motivation pre- and posttest scores were compared. Drawing on the descriptive analysis, the HDL and LDL groups had comparable motivation levels at pretest (means of 78.00 and 75.00, respectively). After the treatment, the HDL group showed a substantially larger increase in motivation (mean = 118.00) compared to the LDL group (mean = 91.00), suggesting that DL also influenced the motivational benefits gained from using DFs. After checking the required assumptions, one-way ANCOVA was conducted to inferentially examine whether DFs had differential impacts on the two groups' motivation.

Table 4. Results of one-way ANCOVA on motivation scores of the HDL and LDL groups

Source	Type III sum of squares	df	Mean square	F	Sig. (p)	Partial eta squared
Corrected Model	16090.67	2	8045.34	44.02	<.001	.607
Intercept	45000.12	1	45000.12	246.04	<.001	.812
Pre-motivation	248.76	1	248.76	1.48	.229	.025
Group	15842.25	1	15842.25	86.59	<.001	.594
Error	10500.89	57	184.39			
Total	180000.00	60				
Corrected Total	26600.41	59				

As shown in Table 4, the one-way ANCOVA results illustrated a statistically marked disparity between the HDL and LDL groups on motivation post-test scores, $F(2,57) = 44.02$, $p < .001$, partial eta squared = 0.607, while controlling

the pretest motivation scores as the covariate. Finally, it was concluded that the HDL group showed significantly higher motivation scores than the LDL group after using DFs.

Discussion

The main ambition behind this study was to investigate the impacts of mobile-assisted DFs on Iranian EFL learners' vocabulary development and motivation, in relation to the mediatory role of DL. The findings brought to light how DFs could differentially affect vocabulary acquisition and motivation of Iranian EFL learners with high and low levels of DL. Regarding RQ1, the results revealed that using DFs led to significant changes in the learners' vocabulary development. The marked change observed in the vocabulary posttest scores across participants concurs with earlier studies highlighting the efficacy of mobile-assisted DFs as an interactive, flexible tool that supports efficient vocabulary learning (e.g., Dizon & Tang, 2017; Kolein et al., 2024; Najafi Karimi & Kheradmandi Amiri, 2025; Sage et al., 2019; Xodabande et al., 2023; Zarrati et al., 2024). Whereas Honarзад and Soyoof (2023) demonstrated that DFs increase vocabulary recall through repeated exposure for intermediate students, Zakian et al. (2022) and Rahmani et al. (2022) reported the benefit of DFs as a successful mobile app for learning essential and high-frequency vocabulary outside the classroom. Likewise, Omachonu (2023) reported significant gains from DFs among Nigerian students learning technical vocabulary, with females outperforming males. Zarrati et al. (2024) also found that students who created their own DFs performed better in memory retention and transfer tasks than those who used ready-made flashcards. The aforementioned studies align with our findings, where DFs' ubiquity and convenience features facilitated significant vocabulary gains. Further, utilizing memory-boosting applications like Quizlet or Anki serve as effective tools at learners' disposal for enriching their vocabulary.

Our findings are also congruent with substantial evidence indicating that built-in functions of DFs, namely spaced repetition and multimedia integration, enable learners to engage in a more personalized and effective manner (Kaitsu & Nakata, 2025; Yüksel et al., 2022). Li and Tong (2019) evidenced that learning vocabulary with the support of multimedia features such as audio, visual, and verbal simultaneously enriched learners' vocabulary. The DF-enabled vocabulary enhancement observed in this study can be explained by Mayer's (2022) Cognitive Theory of Multimedia Learning (CTML). Drawing on CTML, sensory memory fed by auditory and visual channels engages learners in enhanced cognitive and working memory processing.

For RQ2, the findings confirmed a notable increase in learners' motivation after using DFs. This finding corroborates the claim that learning affordances provided by mobile technologies can bolster learner engagement, autonomy, and motivation by making learning more interactive and accessible (Lin & Lin, 2019; Stockwell, 2013). The motivational gains could be attributed to features such as gamification elements, multimedia support, and the convenience of mobile platforms, which collectively make vocabulary learning more fun and



less tiresome for learners (Xueting Ye & Shi, 2023). In this vein, Yang (2020) notes that a number of features inherent in mobile technology boosts learners' intrinsic motivation, namely its novelty compared with traditional learning methods, anonymous nature of interaction which provides a secure environment for stress-free learning, instant feedback in asynchronous communication to receive personalized and fine-tuned scaffoldings, and, last but not least, its flexibility and portability which make learning ubiquitous and entertaining.

As for RQ3, the findings revealed that learners with higher DL benefited more significantly from DFs in terms of vocabulary acquisition compared to those with lower DL. This observation suggests that DL is a key moderator affecting the effectiveness of learning via DFs. It transpired that learners with higher DL felt more at ease in navigating the software, managing its features, and exploiting the interactive functions of DFs, thereby outstripping their low DL counterparts. This finding underscores the significance of considering learners' technological literacy when implementing MALL strategies. The observation of the HDL group's outperformance is consonant with Zakir et al.'s (2025) finding that digital competence affects learners' digital self-efficacy, leading to significant academic achievements.

A notable finding worth highlighting was the significant improvement observed in the LDL group after the treatment despite their low DL. This finding suggests that the supportive features of mobile-assisted DFs outweighed the challenges associated with low DL. That is, the LDL learners benefited significantly, though not as much as their HDL counterparts, from the affordances of DFs in building their vocabulary. One possible explanation for such a finding is that low DL does not necessarily lead to heightened technostress, disrupting the performance; rather, some LDL learners may have successfully adapted to the demands of DFs during the study and gained from their use. To bolster this view, Shafiee Rad et al. (2024) reported that DL instruction, combined with adaptive digital tools, significantly enhances learners' self-determination motivation and academic skills. Their study demonstrated that learners with initially low DL developed greater autonomy and engagement through tailored DL support, which enabled them to effectively navigate and utilize digital learning environments in their writing tasks.

Finally, regarding RQ4, the analysis yielded results similar to those observed for vocabulary acquisition. The HDL group's outperformance in motivational gains lends support to Jeong's (2022) assertion that MALL features like accessibility, a manageable interface, and multifunctional components make learning entertaining, sustainable, and self-directed, leading to learners' motivation. Different studies have highlighted the facilitative role of DL in upscaling motivation (Kang & Kim, 2024; Shafiee Rad et al. 2024). In this vein, Vinther and Lauridsen (2020) argue that high DL leads to intrinsic motivation among students for language learning by reducing anxiety and cultivating favorable attitudes toward feedback. The immediate feedback, progress tracking, and customizable features of DFs increase learners' engagement, making MAVL more effective than traditional methods (Teymouri, 2024; Xodabande & Boroughani, 2023).

On the other hand, the LDL group's underperformance confirms several studies that tested the role of low DL in mitigating learners' performance (Abbas et al., 2019; Tarafdari et al., 2007). The LDL group's lower levels of motivation signify that low literacy in mobile technology can inhibit successful learning and diminish learners' desire for learning, which might have roots in their psychological barriers (Stockwell, 2013), technophobia (Wang et al., 2020), or technostress (Maier et al., 2019). Another possible interpretation for the lower motivation among the LDL group could be their negative attitude towards technology. In this regard, Yang (2020) reported that certain mobile learning apps' motivational designs can lower learner motivation. She provided examples of learners who perceived the checking function of the MintReading app as discouraging, which in turn diminished their motivation to engage with the learning material. Therefore, a more in-depth qualitative investigation in this regard is needed to unravel the exact reasons underlying the LDL group's inferior functioning in our data.

Conclusion and limitations

This study aimed to uncover the impact of mobile-assisted DFs on Iranian EFL learners' vocabulary learning and motivation, with a special focus on the mediatory role of DL. The findings revealed that the scaffolding features of mobile-assisted DFs were effective in supporting learners' vocabulary knowledge and motivation. Further analysis disclosed that although both groups improved significantly on the posttest, the high DL group outperformed their low DL counterparts in both vocabulary learning and motivation. Another important finding was that the low DL learners, despite being at a disadvantage at the outset in terms of DL, also benefited significantly from the DFs, suggesting that adaptation to the technological demands of DFs and acquiring DL in the course of treatment can counteract learners' potential technostress and negative views.

The findings of the research hold important implications for educators and learners. Adopting mobile-enabled DFs for L2 vocabulary instruction can enhance student motivation, participation, and learning recall. Teachers should create a learning environment in which students can receive the required DL skills and use educational apps more efficiently and with confidence. For learners, it is critical to overcome their technostress by getting acquainted with the demands of the educational app and cultivate more positive attitudes towards technology in hopes to experience a more sustainable and entertaining learning. Learners should also benefit from the interactive, multimedia-rich affordances of digital flashcards to sustain motivation in vocabulary learning.

Despite major findings, the study encountered a few limitations. Whether or not gender difference contributed to differential learning among participants remained unclear, which merits further exploration. Sixty pre-intermediate EFL learners from two language institutes participated in this research; therefore, prospective researchers could replicate the study with learners from diverse proficiency levels and educational backgrounds to achieve greater

generalizability. The present study adopted a quantitative design; hence, the students' psychological experiences, views, and challenges during DF-supported instruction remained unexplored, which indicates the need for a qualitative investigation.

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