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# Impact of an EFL Digital Application on Learning, Satisfaction, and Persistence in Elementary School Children

Rikito Hori[1,2] · Makoto Fujii[2] · Takaaki Toguchi[1] · Steven Wong[1] · Masayuki Endo[2]

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**Abstract**
There is a lack of research evaluating the effects of digital textbooks and digital apps on learning for early elementary school learners. Therefore, this study conducted a randomized controlled trial to evaluate how an iPad application for learning English as a foreign language impacted children's grammar understanding, satisfaction, persistence, and confidence compared to a digital textbook. A total of 119 Japanese first- and second-graders participated in the study. They were randomly divided into groups studying English using "digital books" or "applications" over five days. Pre- and post-intervention tests and questionnaires were used to measure their understanding of the study content, satisfaction, persistence, and confidence in English. Application-based learning was more effective than digital books in terms of grammar comprehension and was significantly better for satisfaction and persistence. The results suggested the use of specific criteria for selecting multimedia learning materials, including a high degree of learner control, autonomy to manipulate the learning environment, feedback on learning activities, and guaranteed interactions with the learning materials.

**Keywords** English as a foreign language · Early childhood education · Intrinsic motivation · Multimedia · Interactive educational materials · Innovative teaching methods

## Introduction

In recent years, several elementary schools worldwide have taught English as a foreign language (EFL), with some offering EFL programs for very young children (Edelenbos et al., 2006; Fenyvesi, 2020; Jaekel et al., 2017; Johnstone & Kubanek, 2006). Since 2021, Japanese elementary schools have commenced EFL classes for students in first grade and above (Japan Ministry of Education, Culture, Sports, Science and Technology (MEXT, 2017). A reason for this early start of EFL classes is that children at this age are more receptive to and motivated in language learning (Djigunović, 2012). Djigunović (1993) showed that 6- to 7-year-olds liked learning English more than 9- to 10-year-olds did, and early learners maintained more favorable attitudes than late learners during the 3-year study period. However, this motivation can easily diminish (Costa & Pladevall Ballester, 2020; Edelenbos et al., 2006; Johnstone & Kubanek, 2006; Mosavi Miangah & Nezarat, 2012). Heinzman (2014) suggests that young learners' motivation can shift from being primarily intrinsic to more instrumental over time, which indicates a loss of motivation over the years. This highlights the need to devise appropriate learning content and methods to meet the learning needs of students to maintain their inherent high motivation (Cameron, 2001).

This study involved a randomized controlled trial (RCT) to evaluate the learning effects of digital textbooks and mobile apps among first and second-grade (aged 6–8 years) EFL learners, with a secondary focus on learning satisfaction and persistence, and to measure how the use of mobile apps differs from digital textbooks in EFL education. This study exclusively used digital materials and did not involve "old school" physical books. The study investigated the efficacy of iPad apps previously and currently used in participants' schools and evaluated their usefulness in EFL education. Furthermore, this study was designed as a rigorous RCT based on the CONSORT 2010 statement (CONSORT) (Schulz et al., 2010). The following studies were used as references in designing the mobile-assisted language learning

✉ Rikito Hori
r.hori@kansai-u.ac.jp

[1] Elementary School, Kansai University, 7-1 Hakubai-cho, Takatsuki-shi, Osaka 569-1098, Japan

[2] Division of Health Sciences, Graduate School Medicine, Osaka University, Suita, Japan

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(MALL) and RCT protocols for this study. A previous study (Brooks et al., 2006) evaluated whether an intervention with additional information and communications technology (ICT) support could help improve literacy (spelling and reading) achievement among seventh-graders in a secondary school. This study is methodologically innovative in design and data reporting (Torgerson, 2009). Regarding the study content of the current research, the focus was on grammatical aspects (Cameron, 2001). The research questions (RQs) formulated in this study were as follows:

RQ1: Is learning with digital applications in MALL as effective as learning with digital textbooks for early elementary school students in acquiring grammatical knowledge?

RQ2: Is learning with digital applications in MALL as effective as learning with digital textbooks for early elementary school students in terms of intrinsic motivation, specifically "satisfaction" and "persistence"?

RQ3: What factors are necessary for learners to continue using digital applications in MALL?

## Literature Review

Learning content varies by grade and, to some extent, a country's educational guidelines. It is not considered appropriate to formally teach EFL grammar rules at the early elementary school level; instead, methods should be devised to make students aware of the rules (Cameron, 2001). In Japan, the curriculum guidelines do not stipulate specific learning content for first- and second-graders; however, the guidelines do emphasize interactions with informal materials during foreign language activities (MEXT, 2022). Traditional language learning requires repetitive routine work, which may not always be enjoyable or suitable for all learners, especially those in the lower elementary grades (Purgina et al., 2020). A study (Mihaljević Djigunović & Lopriore, 2011) comparing specific EFL activities preferred by students found that learners as young as 7 years old prefer "play activities." Therefore, several EFL programs use mobile learning (M-learning), which leverages technology to reduce cognitive load and provide a more interactive way of learning (Lin & Lin, 2019; Sweller, 2020).

M-learning is defined as the use of mobile technology to acquire knowledge or skills, anytime, anywhere (Geddes, 2004). It is characterized by the use of mobile devices for learning, which makes it ubiquitous, personalized, and more spontaneous (Mosavi Miangah & Nezarat, 2012). In today's world, M-learning is easily enabled by delivering a variety of educational materials and content to learners through mobile devices (Mosavi Miangah & Nezarat, 2012). Mobile devices are portable and easy to carry, allowing students to access, edit, and modify learning content (Jeno et al., 2019a, b). Several previous studies have shown that mobile devices can be advantageous for learners as they contribute to better learning outcomes, stronger motivation, and enhanced learning persistence (Chachil et al., 2015; Chang et al., 2021; Hori & Fujii, 2021; Huang et al., 2012; Klimova & Poláková, 2020; Kumar et al., 2019; Liu et al., 2020; Plass et al., 2015; Yaghoobi & Razmjoo, 2016). Technology has become deeply embedded in our lives. Mobile devices are widely used in training, learning, and education and are often used in language learning (Loewen et al., 2019). The adaptation of M-learning to language learning is called mobile-assisted language learning (MALL) (Okumuş Dağdeler et al., 2020). Evidence suggests that MALL helps students learn languages more effectively (Solihin, 2021). Through MALL, learners can engage in independent reading of the learning materials at convenient intervals (Steel, 2012; Sung et al., 2016). It has been suggested that MALL is effective in EFL vocabulary learning, grammar learning, and listening (Darsih & Asikin, 2020; Lin & Lin, 2019; Ozer & Kılıç, 2018; Clay, 2022). Interactive affordances built into mobile devices allow learners to learn at their own pace and adjust the difficulty level of the material to their language proficiency level (Hung et al., 2012).

Recent EFL education with M-learning has seen a shift from mechanical, repetitive, teacher-driven learning to self-directed learning that is learner-initiated and sustained (Lin & Lin, 2019; Rosell-Aguilar, 2018). Technology use is primarily a self-selected activity and, thus, by definition, an intrinsically motivated activity (Rigby & Ryan, 2017). This background information is related to the self-determination theory (SDT). Several studies in the field of education have adopted the SDT as a research framework because it provides a strong theoretical background for understanding student motivation (Jeon, 2022). SDT assumes that students' motivation to learn and persist is largely related to the extent to which the three basic psychological needs (BPNs) of autonomy, competence, and relatedness are met in the environment (Ryan & Deci, 2017). Furthermore, previous studies have shown that MALL supports a dynamic learning process by providing opportunities for choice and modification while promoting spontaneous emotions that meet the need for autonomy (Jeno et al., 2018). Learning materials used in M-learning are called M-learning tools. "Mobile applications" are the most common materials in English M-learning (Elaish et al., 2017). The number of language learning applications has substantially increased in recent years (Jeon, 2022), primarily because of the increasing popularity of smartphones that enable widespread access to software applications (hereafter, apps) for language learning. Although researchers have investigated rubrics for evaluating preschool educational apps (Bentrop, 2014; Papadakis et al., 2017), limited standards or evaluation rubrics exist. Since several apps have been created and are commonly used in EFL education, it is important to identify the key factors

for selecting apps that can be used effectively, even at the early elementary school level.

"Digital textbook" is selected as the object of comparison to evaluate the efficacy of the application in this study. Digital textbooks are used in the same manner as e-books and are defined as digital objects containing text and other content, with commonly available features, such as search and cross-reference functions, hypertext links, bookmarks, annotations, highlighting, multimedia objects, and interactive tools (Hsieh & Huang, 2020). Digital textbooks have been used extensively as technology-based learning tools with proven learning and motivation efficacy (Huang et al., 2012). Myrberg and Wiberg (2015) conducted an experimental study with two groups of students to compare students' preferences for printed books versus e-books. When they were tested for comprehension, it was found that the students preferred e-books. Zhang et al. (2020) examined 52 language-based learning studies conducted over the past decade and found that e-books have positive effects on language learning. Twelve weeks of e-book instruction was found to increase students' motivation to read, as measured by pre- and post-test questionnaires. Thus, e-books have been used as M-learning tools and have shown positive effects on both learning and the motivation to learn. In Japan, the Amendment to the School Education Act (Act No. 39 of 2018) was enforced on April 1, 2019. Under the amended Act, digital textbooks may be used as needed, while paper textbooks remain the primary learning source, ahead of the implementation of the new National Curriculum Standards (MEXT, 2016). Thus, the shift from traditional paper textbooks to digital textbooks is recommended in Japan. In M-learning, a study by Zhang et al. (2020) compared "digital textbooks" with "applications" from the lens of the self-selection theory and analyzed the factors that were effective for learning outcomes and motivation. An RCT within this study investigated how different interactivity approaches affected learning outcomes and motivation, focusing on textbooks, e-books, and applications. The results showed that M-learning tools, including apps, were more intrinsically motivating than digital or traditional textbooks, increasing learners' psychological desire for autonomy, competence, and relevance. Deci & Ryan (1995) points out that "a sense of competence" and "a sense of autonomy or self-determination" are important for enhancing "intrinsic motivation," and states that the "reward" of such intrinsic motivation are "enjoyment" and "a sense of achievement." The optimal state of being intrinsically motivated is called the "flow state," that is, a state of strong concentration in an activity where one is intrinsically motivated and finds pure pleasure and enjoyment in the activity itself and feels a strong sense of control and competence over one's actions and the surrounding environment (Nakamura & Csikszentmihalyi, 2002; Deci & Möller, 2005). The results discussed above indicate that the perspectives of "satisfaction (enjoyment)" and "competence (confidence)" are significant in motivation through the use of M-learning, and "persistence" is important to continue learning based on these perspectives (Deci & Ryan, 1995; Nakamura & Csikszentmihalyi, 2002). Although this study was conducted with college students, the authors were unable to find any studies using similar research methods to test the effectiveness of EFL education at the early elementary school stage. It is necessary to investigate how different technology tools affect achievement and intrinsic motivation for learners at a younger age (Jeno, 2019a, b).

## Methods

### Study Design

This RCT was designed with pre- and post-intervention tests to evaluate the efficacy of an iPad app for first- and second-grade (aged 6–8 years) EFL students by comparing digital textbooks and digital app methods of learning. Two researchers conducted the randomization process, assigning interested students to the intervention or control groups using the permuted block method with two block sizes. These participants were stratified according to whether they had attended international schools. To prevent bias, the group allocations were not revealed to the participants. The intervention group used an EFL app on an iPad and the control group used e-book content compliant with traditional textbooks. The iPads used in this study were not owned by the participants. They were owned by the school and loaned to the participants. All the iPads had the same settings. This study conformed to the CONSORT guidelines for conducting RCTs (Schulz, 2010).

### Participants and Setting

The study sample consisted of 119 first- and second-grade (6–8 years old) students, 40 boys and 79 girls, from a private elementary school in Osaka, Japan (Table 1). The total number of students in the school was approximately 360, with each class consisting of approximately 30 students. The participants' parents purchased the iPad in June 2020. Since then, the participants have used these tools both at school and home. When the students were unable to physically attend school due to the COVID-19 outbreak, they were able to learn through online classes. Daily classes are conducted in Japanese. First- and second-graders study English in daily 15-min modules, third- and fourth-graders in 45-min units three times per week, and fifth- and sixth-graders in 45-min units four times per week. Among the stratified participants, some attended

**Table 1** Baseline characteristics of the intervention and control groups

| | Intervention group (n = 55) n (%) | Control group (n = 56) n (%) | *p* value |
|---|---|---|---|
| Students who attended an international school | 19 | 21 | 0.6466 |
| Students who did not attend an international school | 36 | 35 | |

international kindergartens where they were exposed to instruction primarily in English. In the school where this study was conducted, most of the children were of Japanese nationality, although there were a few children of foreign nationalities. Eligible students and their parents were invited to participate in this study using the following inclusion criteria: (1) the child was attending an elementary school; (2) the child possessed vision, hearing, and language skills that did not interfere with participation in the education program; and (3) the parents and child consented to participate in the study.

## Intervention

### Intervention Group: EFL Application

The intervention consisted of an EFL app called Rabbits (Rabbits. (n.d.). Osaka, Japan: Takaaki Toguchi), which presents different scenarios, requiring learners to answer questions or identify illustrations using English vocabulary and grammar. When users select and drag an illustration to the center of the screen, the app verbalizes an associated programmed utterance. Users can choose from multiple illustrations in various units (e.g., nouns, verbs, etc.). One of the app's features allows the conversion of nouns into plural forms and inserts conjunctions to create longer sentences. It has both the typing and speech recognition modes. In the latter, users can select an illustration and hear the app vocalize the word in English. They can then tap the microphone button and speak the word in English to record their vocalization. The app repeats the proper English vocalization and displays a sentence including the word, hence, the users can confirm whether their verbalizations are correct. They can tap the app or learner speaker buttons to listen, test, and compare their utterances with those presented in the app. When there is a match between the user's and the app's spoken sentence, the user can tap the "+" button to save a screenshot for record keeping (Fig. 1).

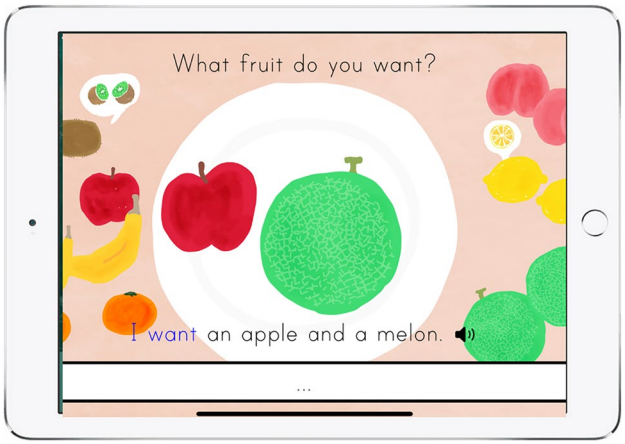


**Fig. 1** Screenshot of the EFL app used by the intervention group

### Control Group: Digital Textbook

The control group used an iPad, presenting digital textbook materials created by organizing and arranging relevant vocabulary and grammar with graphics and audio. The digital textbook materials used in this study were exclusively developed for this experiment. This digital textbook was exported in EPUB format. It was installed on the iPads of the control group and made available for manipulation by the participants. The users could tap an object to play audio, swipe between objects, and change words from singular to plural forms. They could swipe the pages back and forth, similar to a traditional book. The defined structure ensured that the users learned the content in a specific order (Fig. 2). Using this function, vocabulary can be practiced by matching the words with pictures of fruits, such as apples and oranges, and pronouncing the words. Since audio examples are provided to show how to pronounce the words in singular

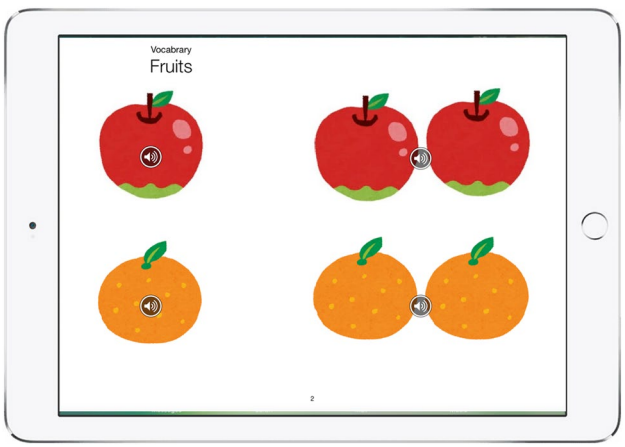


**Fig. 2** Screenshot of the digital textbook-type materials used by the control group

and plural forms, the user can practice by imitating the pronunciation. Since the user can swipe back and forth, they can repeatedly review the content to address any inadequacies. The sequential structure of the book allows users to learn without losing sight of the learning.

Both the app and the digital textbook used the theme of fruits for vocabulary and the grammar items covered singular and plural noun changes and indefinite articles.

#### Roles in Intervention Facilitation

The researcher ensured that the digital application and the digital book had the same content. They created scripts for the intervention, directed the intervention and control groups, and conducted the study from separate rooms to facilitate participation with minimal differences. A native EFL teacher was responsible for reading out the pre- and post-test questions that were common to both groups.

### Outcome Measures

This study evaluated the usefulness of tablets in EFL education based on how well the participants understood the content, how satisfied they were with their learning progress, their learning persistence, and their confidence in English.

The primary outcome was the change in comprehension scores. The comprehension questions were based on the Courses of Study for Foreign Languages (MEXT, 2022), approved English textbooks, and the Eiken Test in Practical English Proficiency (https://www.eiken.or.jp/eiken/en/). The specific learning content included listening comprehension (fruit vocabulary), singular and plural forms, indefinite articles, and sentence structure conventions. The test consisted of 17 multiple-choice questions (score range: 0–17).

A self-reported survey on satisfaction and motivation was conducted, in which participants were asked to rate five items: (1) "You enjoyed today's learning" (learning enjoyment), (2) "You would like to continue this learning at home" (willingness to continue EFL learning at home), (3) "You would like to try different content" (willingness to try different content), (4) "Using the iPad to study English is fun" (enjoyment of using the iPad to study English), and (5) "Studying English on the iPad has increased your confidence in English" (whether studying English on the iPad increased their confidence in English). Participants rated the items using a 5-point Likert scale (1 = strongly agree, 2 = agree, 3 = undecided, 4 = disagree, and 5 = completely disagree). Questions (1) and (4) apply to satisfaction evaluation, questions (2) and (3) to persistence, and question (5) to confidence. This scale is based on the theory of intrinsic motivation; however, since the scale was created by the researcher for this study, there is no prior psychometric information. The participants provided demographic information about their age, gender, and international school affiliation.

### Sample Size

There are no similar RCTs that have examined the educational benefits of interactive multimedia-based mobile applications for elementary school students in the first and second grades (6–8 years). The sample size of 112 was determined by assuming a standard deviation of 2.5, a one-sided significance level (α) of 0.1, and non-inferiority that could be judged as established within 1 point. A total of 120 cases were considered to allow for dropouts.

### Data Collection

Data for this study were collected between February 19 and March 5, 2021. The intervention period was five days each, from February 19 to February 26 for first-grade students and from March 1 to March 5 for second-grade students. All the participants were required to take the same comprehension test on the first (pre-intervention) and last (post-intervention) days of the study to assess their prior and subsequent knowledge levels. The test included a questionnaire that measured their satisfaction, willingness to continue learning, and confidence levels.

### Statical Analysis

The chi-square test was used to analyze pre-intervention baseline characteristics for the intervention and control groups. The Wilcoxon test was used to compare the two groups' learning satisfaction. A generalized linear mixed model was used to compare the two groups' changes in knowledge of the content. The group variable, the pre–post intervention test category, and the interaction terms were included as fixed effects in the model, with the subject ID nested in the intervention category as a random effect. Restricted maximum likelihood was used as an estimation method. A paired *t*-test and student's *t*-test were conducted to compare knowledge about the learning contents within and between groups, respectively. Differences significant at $p < 0.05$ were considered, and all the statistical analyses were conducted using JMP (Version 16.2.0; Cary, NC, USA: JMP Statistical Discovery LLC).

### Ethical Considerations

The Research Ethics Review Board of XX approved this study before commencing data collection and recruitment. The study was registered with the XXX Registry (XXX). The study was described to all the participants and their parents, and they were explained that no academic credit

would be granted for participation. The students in the control group were informed that they could use the interventional application once the data collection process was complete. Written informed consent was obtained from all the participants and their parents.

## Results

### Study Sample and Participant Characteristics

The study included 119 participants (Fig. 3). They were stratified into those who had graduated from international schools (41 participants) and those who had not (78 participants). Seven participants (four from the control group and three from the intervention group) who did not complete both the pre- and post-intervention tests were excluded. One participant was excluded from the control group for not completing the questionnaire survey. The final sample consisted of 111 participants.

### Main Outcomes

Noninferiority was established with mean differences of 0.69 and 0.39 in the pre-intervention and post-intervention tests, respectively, for the intervention type. The number of participants analyzed and effect sizes were almost as designed a priori. The type of intervention had no significant effect on the comprehension of the learned content ($p = 0.714$). Both intervention types significantly improved participants' comprehension of the learned content ($p < 0.001$). There was a significant interaction between intervention type and pre- and post-intervention comprehension ($p = 0.048$). The variance estimate for random effects and residual errors in the intervention was 2.63 (95% CI 1.28, 3.98), accounting for 38% of the total variation (Table 2). The results supported the hypothesis that application-based learning was not inferior to traditional learning methods in terms of learner comprehension. In addition, the intervention group felt more satisfied with their learning and exhibited a higher state of persistence.

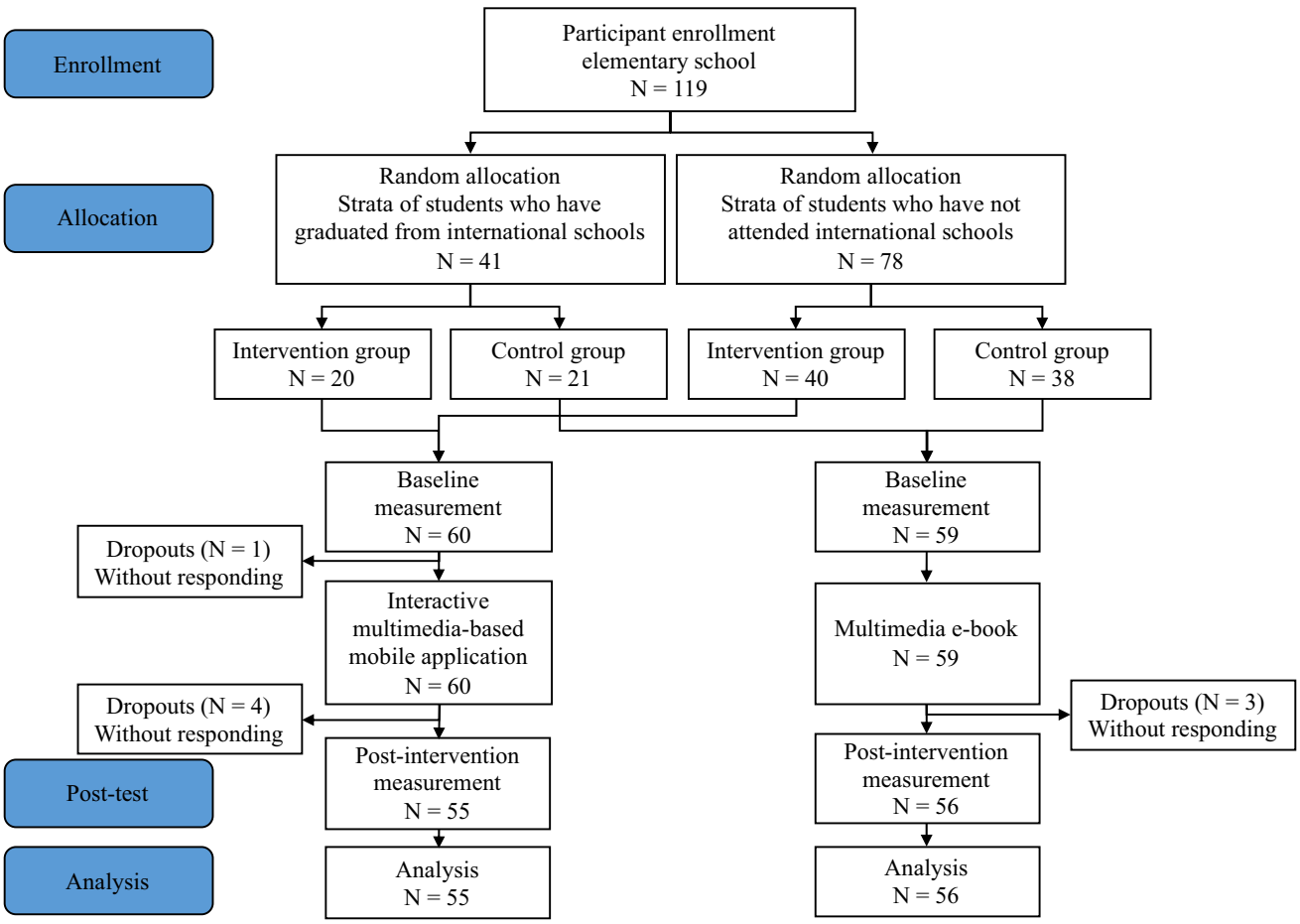


**Fig. 3** Flowchart of the participant selection and group allocation processes

## Knowledge of Learning Content Before and After the Intervention

The intervention and control groups' mean scores in the pre-intervention tests on learning content knowledge (processing singular and plural, *a* and *an*) did not differ significantly ($p = 0.11$) (Table 3). Both groups' mean scores increased significantly after the intervention ($p < 0.001$). A comparison of the groups showed no significant differences in the pre- or post-intervention test scores ($p = 0.48$).

## Comparison of the Groups' Post-intervention Motivational Scores

Table 4 compares the two groups' learning satisfaction, as expressed in the questionnaire survey in conjunction with the post-intervention test. The intervention group had significantly higher scores (mean: 4.72, SD: 0.60, median: 5 (5–5)) than did the control group (mean: 4.36, SD: 0.80, median: 5 (4–5) for learning enjoyment ("I enjoyed learning today") ($p = 0.004$). The same was true for persistence ("I want to continue learning at home"), with the intervention

**Table 2** Comparison of knowledge about the learning content within and between groups via the generalized linear mixed model

| Term | | Estimate | *SE* | *p* value |
|---|---|---|---|---|
| Intercept | | 7.86 | 0.21 | < 0.0001 |
| Group [intervention] | | 0.08 | 0.21 | 0.714 |
| Pre-post [post] | | 1.43 | 0.14 | < 0.0001 |
| Interaction | | − 0.27 | 0.14 | 0.048 |
| Random effect | Var ratio | Var component (95% CI) | *SE* | *p* value |
| ID [Group] | 0.64 | 2.63 (1.28, 3.98) | 0.69 | 0.0001 |
| Residual | | 4.08 (3.18, 5.42) | 0.55 | |
| Total | | 6.71 (5.54, 8.30) | 0.69 | |

*Var* variance, *SE* standard error

**Table 3** Comparison of knowledge about the learning contents within and between groups via the simple main effect test

| | Within groups | | | | | | Between groups | |
|---|---|---|---|---|---|---|---|---|
| | Intervention group ($n = 55$) | | | Control group ($n = 56$) | | | | |
| | Baseline | Post-intervention | | Baseline | Post-intervention | | Baseline | Post-intervention |
| | Mean (SD) | Mean (SD) | *p* value | Mean (SD) | Mean (SD) | *p* value | *p* value | *p* value |
| Knowledge of learning content | 6.78 (2.54) | 9.09 (2.61) | < 0.0001 | 6.09 (1.96) | 9.48 (3.11) | < 0.0001 | 0.11 | 0.48 |

*SD* standard deviation

*$p$ value via paired *t*-test

†$p$ value via student's *t*-test

**Table 4** Comparison of learning satisfaction between groups

| | Intervention group ($n = 55$) Median (IQR) | Control group ($n = 56$) Median (IQR) | *p* value |
|---|---|---|---|
| EnjoymentEnjoyment | 5 (5–5) | 5 (4–5) | 0.004 |
| Persistence | 5 (5–5) | 4 (3–5) | 0.0001 |
| Willingness to try different contents | 5 (5–5) | 5 (5–5) | 0.3482 |
| Using the iPad to study English is fun | 5 (5–5) | 5 (4.25–5) | 0.0102 |
| Whether studying English on the iPad has increased their confidence in English | 5 (5–5) | 5 (3–5) | 0.0249 |

*IQR* Interquartile Range

group obtaining a mean score of 4.65 (SD: 0.78) and a median score of 5 (5–5) and the control group obtaining a mean score of 3.86 (SD: 1.20) and median score of 4 (3–5); the difference between the two groups was significant ($p = 0.0001$). Furthermore, the scores for whether using the iPad to study English was fun were significantly higher for the intervention group, with a mean of 4.74 (SD: 0.59) and a median of 5 (5–5), than the control group, with a mean of 4.32 (SD: 0.92) and the median of 5 (4.25–5) ($p = 0.010$). Regarding whether studying English on the iPad increased their confidence in English, the intervention group's mean score was 4.50 (SD: 0.93) and the median score was 5 (5–5), whereas the control group's mean score was 4.05 (SD: 1.17) and the median score was 5 (3–5), showing a significantly lower difference ($p = 0.025$). There was no significant difference ($p = 0.348$) between the two groups' willingness to try different contents, with the intervention group's mean score being 4.67 (SD: 0.95) and median being 5 (5–5) and the control group's mean being 4.64 (SD: 0.67) and median being 5 (5–5).

## Discussion

### RQ1

Is learning with digital applications in MALL as effective as learning with digital textbooks for early elementary school students in acquiring grammatical knowledge?

This study involved a rigorous RCT to evaluate an iPad app designed for EFL learning for first- and second-grade students in Japan, focusing on learning efficacy, satisfaction, and persistence (all checklists of the CONSORT criteria were followed in design, implementation, and reporting). The results showed that both the intervention and control groups had higher post-intervention test scores, which is consistent with previous findings, suggesting that interactive multimedia promotes learning (Heidig et al., 2015). The findings supported the research hypothesis, indicating that apps were as effective for learning as digital textbook-type materials.

### RQ2

Is learning with digital applications in MALL as effective as learning with digital textbooks for early elementary school students in terms of intrinsic motivation, specifically "satisfaction" and "persistence"?

The intervention group had significantly higher scores than the control group on the self-reported questionnaires for both satisfaction ("enjoyed learning") and persistence ("want to continue learning at home"), with particularly significant results for the latter. The more significant result for "persistence" indicates that the group's learners were in a flow state and intrinsic motivation was more stimulated (Nakamura & Csikszentmihalyi, 2002). In addition, evidence suggests that interactivity increases motivation (Skulmowski & Xu, 2022), which is positively associated with higher learning persistence (Schnotz et al., 2009). Previous studies have shown that apps (i.e., M-learning tools) can better fulfill learners' psychological needs, including autonomy and competence, than digital textbooks (Jeno et al., 2019a, b). Furthermore, the SDT predicts that individual motivation, performance, and well-being increase when basic psychological needs are met (Jeno et al., 2019a, 2019b).

### RQ3

What factors are necessary for learners to continue using digital applications in MALL?

The app used by the intervention group in this study allowed them to manipulate the learning environment with a high degree of control, such as creating English sentences by combining objects. Snow et al. (2015) found that user choice was one of the most compelling features of an educational game. Autonomously regulated activities are often intrinsically motivated (Deci et al., 2017) and engagement can increase motivation (Domagk et al., 2010; Heidig et al., 2015; Villalobos-Zúñiga & Cherubini, 2020).

The control group was provided with digital textbooks similar to traditional books, albeit with a multimedia component. The users could not control the order of content presentation, had fewer choices, and were more regulated by external forces (Domagk et al., 2010; Heidig et al., 2015; Jeno et al., 2019a, b). These led to lower satisfaction and learning persistence (Loewen et al., 2019). The digital textbook-type materials were specialized for listening. In contrast, the app was designed for active learning. It included a speech input function, allowing users to input vocalizations. Hence, directly appealing to multisensory processing encourages active learning (Skulmowski & Rey, 2018).

Users in the intervention group could speak and record English sentences that the app displayed alongside the correct English sentences, providing immediate accuracy feedback. This allowed the learners to recognize problem areas and identify positive directions for improvement, which can be a motivating factor (Domagk et al., 2010; Villalobos-Zúñiga & Cherubini, 2020). Supporting autonomy and competence implies support for learner choice and feedback, which enhance intrinsic motivation (Deci & Möller, 2005). These results are consistent with previous evidence suggesting that M-learning tools increase learners' psychological desires for autonomy, competence, and relevance more than digital and traditional textbooks (Jeno et al., 2019a, b). Leszczyński et al. (2018) found that interactive materials were more effective when they required substantial effort

and dedication and provided immediate feedback. In contrast, applications (including e-book-type materials) that consist primarily of drills and repetitive practice may facilitate rote fact-learning, however, are unlikely to promote a deep conceptual understanding (Hirsh-Pasek et al., 2015).

## Research Implications

Based on the results, this study recommends the following measures that can be applied to EFL in M-learning. First, app-based education should not rely primarily on rote memorization through drills and repetitive learning practice. Second, it should give users autonomy in manipulating the learning environment and a high degree of control over the presentation order. Third, it should provide feedback on the learning activities. In these ways, learners should be able to interact dynamically with the learning materials and receive feedback on their activities. In addition, digital textbooks were confirmed to be effective for learning in lower elementary grades. However, considering that continuity is reduced when there is little room for choice and autonomy, this study suggests that more thought needs to be given to the interactivity of the teaching materials in MALL.

## Limitations

This study has several limitations. The participants were all recruited from a single private elementary school in Japan, which limits the generalizability of the results. Several participants had previously experienced English learning, suggesting prior high motivation and interest. All the participants were Japanese first- and second-graders learning English. Therefore, researchers should exercise caution in generalizing the study results to other elementary school students and other languages.

Since the questionnaire was designed for first- and second-graders, the questions were simple and limited in number, particularly since the children completing the survey had a limited vocabulary. Furthermore, the self-reported format might have affected the results. Future studies should establish the questionnaire's reliability and validity.

The young age of the participants meant that the intervention was short and the study period was brief because it was expected to be difficult to keep the children blind to the intervention and non-intervention for a long period. Thus, the measure of learning persistence might yield different results with a longer intervention or study period. Future studies should address this, given the general lack of evidence on the long-term effects of M-learning.

## Conclusions

The SDT was a helpful framework for reviewing the design of M-learning tools for EFL education for early elementary school students. The participants who studied with the app showed significantly higher satisfaction and persistence without any reduction in learning effectiveness than those who studied with digital textbook-type materials. All the participants used multimedia learning materials presented on digital devices. However, the methods differed in the degree of interactivity and autonomy, which affected learners' motivation. The results highlighted specific criteria for selecting EFL applications for early elementary school students – high user control and autonomy to manipulate the learning environment, feedback, and dynamic interactions with the learning materials.

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**Data Availability** The published article contains all the data that were generated or analyzed during the study.

## Declarations

**Competing interests** The authors have no competing interests to declare that are relevant to the content of this article.

**Ethical Approval** This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Research Ethics Review Board of Kansai University (Approval No. 2020–4). We registered the study with the UMIN Clinical Trials Registry (UMIN-CTR 000043031).

**Informed consent** Written informed consent was obtained from all the participants and their parents.

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