Using Duolingo in Teaching and Learning Vocabulary: A Systematic Review

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ABSTRACT
This systematic review examines the extant literature on the efficacy of the Duolingo application for vocabulary development in instructed second language (L2) contexts. Drawing on several empirical studies, the review synthesises findings related to (a) the comparative effectiveness of Duolingo versus traditional pedagogies, (b) the impact of Duolingo on learner motivation and engagement, and (c) practical implications for classroom integration. While the majority of evidence attests to measurable gains in receptive vocabulary knowledge, the findings must be interpreted with caution due to methodological limitations, including small sample sizes, short intervention periods, and construct underrepresentation. The motivational appeal of Duolingo's gamified interface emerges as a prominent theme, corroborated by self-report data. However, the limited research employing psychometrically robust motivational measures precludes definitive conclusions about the temporal stability and transferability of this motivational effect. Theoretically, the provision of individualised feedback aligns with interactionist theories, yet the restricted opportunities for the negotiation of meaning raise doubts about the depth of lexical engagement. Pedagogically, the reviewed studies advocate the careful integration of Duolingo as a supplementary tool within formal instructional contexts. However, optimal implementation strategies remain unspecified, necessitating further classroom-based research employing mixed-methods designs. Significant gaps are identified, including the lack of investigations into the differential impacts of Duolingo's features, vocabulary transfer to authentic communication, and the development of self-regulated learning strategies.

Keywords: classroom integration, Duolingo, gamification, learner motivation, vocabulary acquisition

INTRODUCTION
The study of vocabulary is crucial to the mastery of English by students who care about learning (Ajisoko, 2020). It is common to see students engage in sufficient vocabulary learning, as this will greatly increase their learning of other skills and languages with ease. Learning vocabulary is one of the keys to learning a language, as it finds its roots in learning various languages. If a foreigner within a new environment decides to learn the language of the environment without properly learning the vocabulary of that environment, the result will be that the foreigner will find it difficult to understand the language (Puspita & Sabiqoh, 2017). Thus, vocabulary learning is very important to any student who cares about learning a new language or skills. Education is driven by learning, gaining skills, and understanding a particular thing. Hence, learning English requires a unique technique or approach. Education has received technological advancements just like other areas of life globally. The

breakthrough in technological advancement has solved the problem of English learning; this technological advancement is based on the introduction of Duolingo.

The mission statement of the Duolingo Company is to make education free at all costs and accessible to all with fun. Lest you wonder, the Duolingo app is designed as a game with scientifically proven effectiveness that ensures the learning of languages possible (Ambara, 2020). Again, the platform created the Duolingo English Test (DET), which is convenient for learning the language and has an option for certification that is widely accepted in over 200 universities worldwide. Duolingo is a mobile phone application software that makes learning languages easy. This application is a new learning medium that has been created, can be downloaded, and can be installed on a smartphone. As extracted from the Duolingo web page, "Duolingo builds a world with free education and no language barriers. Users can learn languages for free while simultaneously translating web" (Jaskova, 2014). The Duolingo learner's software has been developed to enable the learning of various languages like Arabic, English, Spanish, Dutch, French, and other related languages that could be selected from the app for easy learning of language vocabulary (Botero, Questiner, & Zhu, 2019). Good enough, the Duolingo platform has an educator form where various users could interchange topics and subjects with any of them as either students or teachers to learn vocabulary in different languages (Gafni, Achituv, & Rachmani, 2017).

Today, Duolingo is very effective in learning and teaching vocabulary. As the Duolingo app allows learners to show a considerable response, which is excellent in the interest of learners, the app makes vocabulary easy to understand and gives all learners fair practical material that enables them to learn and practice better (Ajisoko, 2020). Duolingo has a way of eliminating boredom in the learning process as it encourages the growth of new ideas in learning. However, having given a philosophical introduction to the use of Duolingo in learning and teaching vocabulary, this study will review the works of other scholars who have written on the subject matter of Duolingo and vocabulary learning and teaching. The various pieces of literature for review shall cover the study years of 2018 to 2020. The review shall contain the authors' topics, research findings, and a critical section of all reviewed articles, as well as fill the gap in the literature.

LITERATURE REVIEW

In a study conducted by Kusumadewi and Widyastuti (2018) on the effects of using Duolingo towards student vocabulary mastery, the study was aimed at examining the effects of using Duolingo apps to build students`s vocabulary mastery and the expectations from teachers in using Duolingo to support an exciting language teaching experience. The study employed the experimental research method with the aim of finding the two groups of x and y where the effect of Duolingo is (x), and the controlled group is (y) for student vocabulary mastery. However, the study adopted a true experimental approach, where only the control group was used for a post-test. Again, the sampling method used was random sampling, in which 30 students were within the control group class. The findings of the study revealed that the use of the Duolingo application had a positive effect on students' English language learning compared to other conventional methods used officially for students. Thus, students who use the Duolingo app for the vocabulary mastery-learning course have higher scores than those who engage in textbooks and other conventional means of learning and mastering vocabulary. The study is limited by the technique used; only a post-test using an experimental design was conducted, while the pre-test was neglected, which failed to address the treatment group.

Guaqueta and Castro-Garces (2018) conducted another similar study to investigate the influence of using language-learning apps (Duolingo and Kahoot) as didactic tools in the context of EFL to improve vocabulary building. The study used a mixed-methods approach with a concurrent design for collecting, analysing, triangulating, and validating the qualitative and quantitative data. The frame time for the study was six months, and the target group was high school students. The study's findings revealed positive prospects for students' learning and building vocabulary, which they reported led to better improvement and growth in language

learning, which was beneficial not only for their current educational experience but also for the future. Hence, they concluded by stating that the strategy (use of the Duolingo app) had a positive influence on the students' learning generally and on enhancing and improving vocabulary skills. A major limitation of the study is the target group. This makes the recommendation likely unimportant in some scenarios. Furthermore, the sample size was relatively small, and sampling issues were not adequately addressed. Again, the quantitative aspects of the study were not efficient enough to establish an association or causality.

Astarilla (2018) conducted a descriptive mixed study by investigating university students' perceptions towards learning English through the Duolingo application. A total of 135 university students in Pekanbaru, Riau, Indonesia, taking English Level II courses, formed the study participants, with their information sourced through questionnaires and interviews. The study timeframe was one semester, with meetings conducted during the semester. The sample consisted of 66 female and 69 male students aged 19 to 21. The findings showed that there was an overall positive perception by students towards using the Duolingo application in learning English because it has several advantages in promoting students' learning process. However, as with similar studies reviewed, the study did not take into account critical issues relevant to quantitative conclusions, such as sampling, selection criteria, modelling and estimation techniques, and instrument reliability. The study also did not succeed in accounting for the effect of app usage time on learning English.

Botero, Questiner, and Zhu (2019) investigated informal, out-of-class engagement or learning activity with a MALL tool, that is, Duolingo, carried out research. An invitation to use the application was given to 118 higher education language students who accepted that their participation in the application would be tracked. The data used for the study was obtained from the applications dashboard, semi-structured interviews, and questionnaires. The study was also a mixed-methods study. Garrison's dimensions of self-directed learning (motivation, self-management, and self-monitoring) served as the lens through which the results were viewed. The findings showed discrepancies between what students think about the application and what they do with it. The outcome of the questionnaires indicated that through enjoyable activities and games, Duolingo can facilitate out-of-class learning, but the interviews showed a lack of continuous enthusiasm and motivation, self-monitoring, and self-management, reflected in the application's low use. However, the study is limited in ways, such as the failure to account for factors that could affect the use of the app, such as socioeconomic and psychological factors. Furthermore, about 273 out of the original 574 students reported not using Duolingo. This should have been investigated to find out possible reasons for the actions. Again, quantitative tools were largely descriptive and not associative or causal.

A study by Sousa, Barros Cardoso, and Toassi (2018) explored Duolingo's effectiveness as a tool for learning English as a foreign language. The study concentrated more specifically on improving writing vocabulary skills. The study employed an action research design of experimental design that involved evaluating different control groups of different participants. The participants in this study were divided into two groups: the experimental group of 23 students in the sixth grade (11 girls and 12 boys) and the control group of 28 students in the sixth grade (11 girls and 17 boys). The ages of these participants ranged between 10 and 13 years. The findings showed that using the Duolingo application motivated students to learn vocabulary through various engagements and developed more interest in classes as a result of the demonstration of the use of the application. Results from this research indicate that using Duolingo as a vocabulary learning tool appears to be a potential instrument for vocabulary improvement. It also tends to positively influence motivational aspects since students are more engaged using the app. The limitations of the study depend on the classes' length, where the period for teachers to fulfil the course plan as required is limited.

Psychogyiou and Krrasimos (2019) conducted a study to explore the effectiveness and efficiency of the Duolingo application for learning a foreign language and developing language skills online. The study was a mixed study that consisted of both qualitative and quantitative

procedures and techniques. Quantitative data were generated by highly structured techniques, such as questionnaires, while the qualitative data utilised were obtained via semi-structured interviews to improve effectiveness. A total of 31 individuals were sampled and used for the analysis and drawing of inferences. The results showed that most participants thought the application improved their vocabulary, grammar, and pronunciation learning. However, the study had many methodological defects, making it short on policy inferences and recommendations. For instance, the authors stated that there were quantitative techniques to be used in the study, which was not reflected in the study. Furthermore, the study's sample size is relatively small to make inferences from the results. Again, the study area and the data source were not clearly stated and reflected in the study. In addition, the participants used in the study were not more than 40 years of age, and the author failed to justify the reason or intuition for the choice of characteristics of the participants.

In their study, Hidayati and Diana (2019) surveyed the use of Duolingo and Hello English by 25 undergraduate students in their first and second years who were taking English language subjects in their respective programs of study. Besides that, the research concentrated on investigating students' motivation and interest in using the applications independently outside the classroom to learn English. The study had a mixed design in which data were generated through daily journals and questionnaires as instruments. The study lasted for 21 days. The results indicated that the students were very interested in using the applications. In addition, the students were very enthusiastic about the application and enjoyed its flexibility and practicality. They also found no statistically significant difference between the motivation groups concerning the time they spent using the applications. As with other studies reviewed, this study also has limitations. Its limitations are also similar to those of other studies. This includes issues of sampling, sample size, lack of justifications concerning the methods used, and the target group of the study. Finally, they did not examine how the application's use may have translated into better learning or vocabulary development. Although the researchers should be commended for trying to look into the app's time usage issues, they focused on time as the explained variable.

Ali and Deris (2019) conducted a study focusing on issues such as teacher acceptance, what application features are preferred, and possible problems with using the Duolingo application for vocabulary learning in Saudi Arabian universities. The total sample consisted of 20 females, with information elicited through questionnaires and interviews. The main findings from the qualitative and quantitative analysis were that the teachers showed positive attitudes towards teaching and learning through the use of vocabulary learning applications. The challenges that users usually face contributed to the unsuitability of these applications and teachers' reluctance to use them. However, as in other studies, the study is fraught with many limitations. For instance, the period given for the use of the application before an empirical examination is too short and cannot be relied upon. Furthermore, the quantitative tools used in the study fall short of statistically viable conclusions. Usually, association and causality inform statistical decisions. Again, all the respondents were females, which the researchers did not give and provide a clear justification for this bias in the selection process. The sample size is also relatively small, with the sample comprising only instructors.

At Ahmad Dahlan University, by eliciting information from the English Department students, Pramesti and Susanti (2020) conducted a study to explore the students' perceptions of using the Duolingo application for learning English and to reveal the benefits and drawbacks of Duolingo for learning English according to them. The qualitative research method was used, and data were obtained through interviews. The sample used for the study was six students from the English department. The findings showed that the participants have a positive impression of using Duolingo in terms of accessibility, context, control, flexibility, blending, material, technical assistance, and cost. This app is easy to use and encourages students to learn other languages. The participants also felt more comfortable and enjoyed learning English with Duolingo. In addition, most of the students confirmed that using the Duolingo app is helpful for learning English. Some of the highlighted advantages of the application include its

attractiveness, having fewer ads, and gaming content. While the disadvantages stress that it cannot be used without internet access, there is no further explanation in grammar, and it cannot be used primarily as a source of language learning. However, the study falls short of a policy paper due to issues such as sample size. The sample size was only six participants, which is very small. In addition, data analysis tools are not mentioned, and the data presented in this research is in the form of written text from the interview transcript and documentation.

Using a sample of 60 undergraduate students at Syiah Kuala University, Inayah, Yusuf, and Fibula (2020) investigated the perceptions of students toward using the Duolingo application in learning English. Purposive sampling techniques were used to obtain the sample for the study, and the data were collected through questionnaires and interviews. The study was also mixed, comprising qualitative and quantitative instruments. The results indicated that most students perceived using Duolingo to learn English positively. Furthermore, they found that students' view concerning the app's use was that it was a useful and helpful application and a motivational tool for learning English. Also noteworthy from the study was the discrepancy among students' perceptions and their acts in using the application. However, the study noticed the following limitations: First, the quantitative techniques, which are important for policy formulation, are largely descriptive rather than associative or causal. The study is also tilted towards a certain group: undergraduate students. In addition, the lack of a deep investigation into students' motivations for using the app is one of the study's major limitations, with a small sample size as well.

Aulia, Wahjuningsih, and Andayani (2020) conducted a study to explore the impact of the Duolingo application on students' mastery of English vocabulary using a quasi-experimental post-test design method. The respondents who formed the study sample were eighth-grade students in one of the junior high schools in Jember. Two groups were formed for the study. The treatment or experimental group used the Duolingo application, and the control group was taught as usual by using flashcards as the medium. The data collected and generated from the vocabulary test was analysed using an independent sample t-test using SPSS. The findings indicated that the use of Duolingo has a significant impact on students' mastery of vocabulary. The result of the analysis showed that a significant difference existed between students who used the Duolingo application and those who did not. The students in the experimental group, taught by Duolingo, have achieved better vocabulary skills than those in the control group. This means that the application for language learning helps students increase their vocabulary scores. The major limitations of the study include the scope of the study, which was streamlined to only eight grades, for which no strong justifications were stated. In addition, in the presentation of results, sensitive information such as descriptive statistics and characteristics of the study population were not provided. Again, the total sample size used for analysis was not equally determined. No model was clearly stated to determine whether other control variables can influence vocabulary mastery.

Habibie (2020) also conducted a mixed study with the main objective of investigating how Duolingo as an educational language tool can enhance the motivation of students to learn English. The study sample consisted of 40 students in the Department of English, which consisted of 30 females and 10 males. Data were collected using interviews and questionnaires. The results of the analysis showed that the Duolingo application was quite effective and could be used to enhance the motivation of students to learn English. However, the study is limited in certain ways. For example, the period used to administer and collect data for measuring the effectiveness of the application in motivating students was too short, being only three days. This is unlikely to capture changes that would occur, especially for time-dependent factors. Again, the balance of the sample seems to be tilted toward the females, which is likely to lead to gender balance in the analysis and not reveal the true nature of the relationship. Furthermore, the sample is also relatively small.

Araújo and Eddine (2020) also conducted a study on the usability and objectivity in the learning process reviews of users of the Duolingo application. The research design employed

was quantitative, where the users' comments on the application were extracted from the Google Play Store. Revising January 1, 2020, to January 31, 2020, which formed the period for the study, 10,943 comments were extracted and returned for analysis. The results showed that the learning application received a high rating. To be more precise, 85.13% of the users rated it with the highest score, which ranged from 1 to 5. It was concluded that the application could be used to teach a foreign language. This study is also fraught with many limitations. For instance, it focuses mainly on the comments of the application users, which may not give a true picture of the situation. Many questions can be raised concerning comments. For example, the user experience may vary; some are likely to be emotional about their comments. Others may just comment on "fulfilling all righteousness" and may not be users of the particular application. Again, the quantitative techniques used in the study are descriptive rather than causative.

At SMAN 2 Karangan, Ambara (2020) conducted another relevant study to determine the influence of using the Duolingo app in teaching English to increase the ability of students to learn vocabulary using a quantitative research design. The students of XI IPA 1 and XI IPA 2 at SMAN 2 Karangan formed the sample for the study. This study was conducted experimentally with an experimental research design. Data collection methods were tests (pre-test, post-test, and T-test). The major findings revealed that using the Duolingo application significantly affected vocabulary mastery. The results indicated further that using the application in teaching English had many positive effects on the students, chiefly that it increased their understanding of the materials they used and that they were more motivated to learn. Besides that, the results revealed that Duolingo application is more efficient in vocabulary teaching than traditional methods. Like other studies reviewed, the study had limitations too. These limitations included issues of sampling, the target population, the technique of analysis that was not causative, and the study period.

Ajisoko (2020) investigated the use of the Duolingo application to increase students' vocabulary and stimulate and create broad interest in learning English, mainly vocabulary, using a quantitative research design that was pre-experimental research with a pre-test and post-test. The study sample was nineteen learners in the Department of English education at the Borneo University of Tarakan who were in the second semester of the 2018–2019 academic year. The data used for analysis was generated using the questionnaire and test. The findings showed the significance of Duolingo as an efficient and effective application for improving English language learning, mainly vocabulary, in ways such as eliminating boredom, etc. The main limitations of the study include a small sample size, sensitive information such as descriptive statistics, and the characteristics of the study population not being made available.

Hernadijaya (2020) also conducted a study to explore using the MALL application, Duolingo, to increase students' knowledge and desire to learn English vocabulary via mobile devices. The research design used in the article was quantitative, which was quasi-experimental. The participants of this study were seventh-grade extracurricular students in SMPN 21 Surabaya. Thirty-four students were divided into two groups (EEC 1 and EEC 2). The data were analysed using the t-test calculation in SPSS. The study's main findings proved that Duolingo was effective in students' vocabulary mastery and could assist in the language learning process. The researcher also stated further that the application could be considered a beneficial language-learning app that can develop seventh-grade vocabulary skills. As with most studies, the sample size is small, with the population being only seventh graders.

Dahlan and Nurbianta (2020) examined the utilisation of the Duolingo app and the practice of vocabulary technique drilling for upgrading students' reading comprehension. The purpose of the study was to ascertain any influence of using the Duolingo application on the student's reading comprehension and, again, to determine if there is any influence of the Duolingo application and vocabulary enhancement on the student's reading comprehension. The study employed the partial correlation method, which was used to check if all variables, as noted in the objective, had a good correlation and were statistically significant. The findings emanating from the study showed that all data in the Duolingo application, reading, and

vocabulary are normally distributed while reading and vocabulary establish a linear relationship. In general, it could be concluded from the findings that Duolingo apps significantly influence vocabulary enhancement and student reading comprehension among tenth graders at SMA Muhammadiyah Tanjung Redeb. In summary, the study concludes that using the Duolingo application has enhanced vocabulary building, which facilitates the students' good reading comprehension and ability to understand the meaning. One of the limitations of the study is that it failed to investigate other groups while focusing only on upgrading students' reading comprehension.

Jaelani and Sutari (2021) aimed to describe students' perceptions of using the Duolingo application as a medium for learning vocabulary. The participants were 30 second-grade students from one junior high school in Bogor. Data was collected through a questionnaire and interviews. The results showed that most students had positive perceptions of using Duolingo. They found it an effective tool that was easy to use and could be accessed anytime, anywhere to learn English vocabulary interestingly and understandably. Students felt interested and motivated learning with Duolingo as it allowed them to be more active. Key advantages were learning vocabulary at home easily and practically applying their English skills. However, one main disadvantage was that Duolingo was difficult to use without an internet connection. Duolingo proved a considerably interesting and effective medium for students to learn English vocabulary.

Purwanto (2023) conducted a qualitative study to investigate students' perceptions of using the Duolingo application for learning English vocabulary at Madrasah Tsanawiyah 01 Darussalam Kepahiang in Indonesia. Using questionnaires and interviews with 25 eighth-grade students selected through purposive sampling, the study revealed overall positive perceptions towards Duolingo. Students found the app easy to use, accessible, and motivating for vocabulary learning, with over 80% agreeing it was user-friendly and increased their active participation. Around 70-80% of students reported increased passion for memorising vocabulary, better understanding of word meanings, and improved ability to apply English skills daily. The gamification elements were perceived as engaging. However, limitations were noted, such as difficulty using the app without an internet connection (77% agreed) and a lack of detailed grammar explanations. Despite these drawbacks, the researcher concluded that Duolingo was an effective vocabulary learning tool that enhanced students' interest and engagement, recommending further research at other educational levels and for different language skills.

Nasrul and Fatimah (2023) aimed to determine how the Duolingo application affects English learning motivation and vocabulary enrichment for 10th-grade students at SMKN 1 Padang. It employed a quantitative pre-experimental research method with 22 students from class X TKP A as the experimental group. Data were collected through a motivation questionnaire and vocabulary enrichment test before and after implementing Duolingo in the classroom for seven meetings. The results showed a significant increase in students' English learning motivation and vocabulary enrichment after using Duolingo, with mean scores of 81.82 and 82.50, respectively, compared to 47.86 and 48.91 before using the application. The paired sample t-test confirmed a positive effect, with sig. scores < .001 for both variables, leading to the acceptance of the alternative hypotheses. Thus, the study concluded that using the Duolingo application significantly enhanced the 10th-grade students' English learning motivation and vocabulary enrichment in the teaching-learning activities.

Apoko, Dunggio, and Chong (2023) investigated students' perceptions of using the mobile application Duolingo to improve English vocabulary mastery at the tertiary level in Indonesia. A mixed methods approach was employed, involving 95 undergraduate students from various faculties at private and public universities. Data were collected through online questionnaires and semi-structured interviews. The findings revealed that students had overall positive perceptions of using Duolingo to enhance their vocabulary, citing advantages such as ease of use, accessibility, interesting features, and the ability to motivate continuous practice.

Students appreciated Duolingo's gamified learning system and found it effective for learning everyday vocabulary through repetition. However, some limitations were noted, such as a lack of in-depth explanations and advanced vocabulary. The researchers concluded that Duolingo can be recommended as a supplementary tool for English vocabulary learning among university students, though critical guidance from instructors is still needed to maximise learning outcomes and sustain student engagement.

Irzawati and Unamo (2023) investigated students' perceptions and attitudes towards using the Duolingo language learning app for learning English as a foreign language (EFL). Twenty non-English major university students in Indonesia were surveyed and interviewed after using Duolingo regularly for at least three months. The results revealed highly positive perceptions and attitudes among the students. They found Duolingo easy, fun, engaging, and motivating for learning English. Students believed it helped improve their listening, speaking, reading, and writing skills, pronunciation, vocabulary, and grammar. The gamification aspects made learning enjoyable and reduced anxiety. Overall, students appreciated Duolingo's accessibility, varied resources, and exercises. While a few drawbacks were noted, like high data usage, the overwhelmingly positive feedback suggests Duolingo can be an effective supplementary tool for EFL learning when teachers integrate it thoughtfully. The study provides comprehensive insights into learners' views on Duolingo across multiple aspects of language learning.

Fitri, Melani, Roza, and Reflinda (2023) investigated the Duolingo application's effect on students' vocabulary mastery in the second grade of SMPN 1 Koto Besar in Indonesia during the 2021/2022 academic year. A quantitative quasi-experimental study was conducted with 65 participants divided into an experimental group (32 students) that used Duolingo and a control group (33 students) that did not. Pre-tests and post-tests were administered to assess vocabulary knowledge. The results showed that the experimental group using Duolingo had significantly higher post-test scores compared to their pre-test and compared to the control group's post-test. Statistical analysis confirmed there was a significant effect of using Duolingo on vocabulary mastery. The researchers concluded that Duolingo was an effective tool for improving English vocabulary, attributed to features like gamification, pronunciation practice, reminders, and challenges that kept students motivated and engaged in learning new words.

Borang, Maru, and Rorimpandey (2023) aimed to determine whether the Duolingo Application could help students improve their vocabulary mastery, especially with adjectives. The research was conducted quantitatively using a pre-test and post-test design with a written test on 31 students from SMP Negeri 1 Manganitu class 8B. The results showed that students' mean pre-test score was 43.32, with the highest score being 83 and the lowest 10. After implementing the Duolingo Application for treatment, the mean post-test score significantly increased to 79.80, with the highest score of 97 and the lowest of 63. The drastic improvement indicates the successful use of the Duolingo Application in increasing students' vocabulary mastery. The application's game-like features made learning vocabulary interesting and engaging for students. The findings align with previous studies demonstrating Duolingo's effectiveness in vocabulary learning, though with varying score ranges. Therefore, it can be concluded that the Duolingo Application is an effective medium for enhancing students' vocabulary ability.

Setiawati (2023) investigated the effectiveness of using the Duolingo application to improve English vocabulary among students at Hasanuddin University. Employing a pre-experimental design with pre-test, treatment, and post-test, the research involved 20 students from the 2021 batch who voluntarily participated in a 6-day treatment using Duolingo. Quantitative data was collected through tests and questionnaires to assess vocabulary improvement and student perceptions. The findings indicate a significant increase in students' vocabulary scores from the pre-test (mean 58.75) to the post-test (mean 79), with a difference of 20.25 points. Additionally, questionnaire results reveal positive student attitudes toward Duolingo as an effective and engaging tool for vocabulary learning, especially for those with

below-average English proficiency. The study concludes that Duolingo can be a more effective and interesting alternative to conventional vocabulary teaching methods.

Simanjuntak, Napitupulu, and Siahaan (2023) aimed to understand whether the Duolingo application enhances the understanding of English vocabulary among first-grade students at SMP Nusantara Lubuk Pakam. Employing a quasi-experimental design, the research involved two classes: two classes: an experimental class using Duolingo and a control class using conventional methods. The researchers also compared the pre-test and post-test results to gauge the participants' vocabulary gains. Results showed that the experimental class achieved significantly higher post-test scores (mean: 83. 28), which implies that Duolingo positively impacts vocabulary acquisition compared to the particular control class, whose mark was 41. 67. The pre- and post-vocabulary test scores were compared using the independent samples t-test, and it was found that there was a statistically significant difference between the two groups (Sig. 2-tailed < 0. 05), thus accepting the alternative hypothesis. For this reason, games such as Duolingo prove a viable medium for strengthening students' interest and performance while learning English vocabulary at school. Despite this, the study also highlighted certain limitations, including the need for a stable internet connection and additional equipment for classroom implementation.

FINDINGS AND DISCUSSION
Comparative effectiveness of Duolingo in vocabulary acquisition
Comparing the extent to which Duolingo is effective in perhaps the most fundamental component of language, vocabulary acquisition has been a cross-cutting finding in all the reviewed articles. Many scholars have looked into how effective Duolingo is compared to conventional learning techniques, and their studies have generated a common thread. In detail, Kusumadewi and Widyastuti (2018) uncovered those students using the Duolingo app in vocabulary mastery–learning courses got higher scores than those using books and other traditional media. According to Aulia, Wahjuningsih, and Andayani (2020), there was a significant difference in the students taught by Duolingo compared to one of the other students, with the former being higher. Subsequent research has only reinforced these findings from early observations. The authors Fitri et al. (2023) conducted an experiment on Duolingo and obtained a rise in post-test scores in the experimental group compared with the pre-test and post-test scores of the control group. Similarly, with the pretest used with high test items, Simanjuntak, Napitupulu, and Siahaan (2023) detected significantly higher mean post-test scores in the experimental class (83. 28) as opposed to the control class (41. 67) and under traditional approaches.

The effectiveness of Duolingo varies across educational contexts and student demographics, yet positive outcomes are consistently reported. Ambara (2020) found significant effects on high school students' vocabulary mastery at the secondary school level, while Hernadijaya (2020) demonstrated effectiveness with seventh-grade students. At the tertiary level, Setiawati (2023) reported a significant increase in university students' vocabulary scores post-Duolingo usage, with a mean difference of 20.25 points between the pre-test and post-test. Notably, students with below-average English proficiency showed particular improvement.

The comparative advantage of Duolingo often stems from its motivational and engagement aspects. Guaqueta and Castro-Garces (2018) highlighted Duolingo's positive influence on students' learning and vocabulary skills enhancement. Pramesti and Susanti (2020) found that students experienced increased comfort and enjoyment in learning English with Duolingo. Habibie (2020) concluded that the application effectively enhanced students' motivation to learn English. Nevertheless, the effectiveness of Duolingo in various scenarios is indisputable, although there are works that indicate that is far more beneficial when it is applied as an additional tool. In their study on the effectiveness of free language learning apps, Apoko, Dunggio, and Chong (2023) recommended Duolingo as a supplementary tool of

English vocabulary for university learners while urging tutors' guidance from instructors to maximise learning outcomes. This is a clear implication that there are variations of effectiveness depending on the nature of the context, as it would emphasise the proper implementation procedure. Other variables, which include internet connection, affirmed by Jaelani and Sutari (2021) and Simanjuntak, Napitupulu, and Siahaan (2023), might also affect Duolingo's effectiveness. Also, the duration and intensity of Duolingo usage in experiments were rather limited, variable, and varied from days to months, which could impact the results.

Thus, in terms of vocabulary acquisition, Duolingo performs better than traditional learning methods. What makes it effective is especially observed in the capacity to motivate and engage learners, which leads to improved vocabulary scores. Nonetheless, the best outcomes seem to be obtained when it is well-integrated as a supplementary tool used in the overall language learning approach, contingent on learner characteristics, skill development stages, and the use of technology. Consequently, findings suggest that while Duolingo offers significant advantages, its implementation should be strategic and context-sensitive to maximise its potential vocabulary acquisition.

Methodological approaches and limitations

The literature about Duolingo discussed in this paper consisted of different methodological approaches to vocabulary acquisition used in the reviewed studies. Such approaches include experimental, quasi-experimental, mixed methods, and qualitative designs. Each methodology provides information about Duolingo in learning foreign languages; however, each has drawbacks that need critique. Kusumadewi and Widyastuti (2018) used the experimental research method and had only a post-test for the control group. Although the study provided the facility to make a direct comparison, the following shortcomings were seen: a post-test-only design was adopted, thus excluding the pre-test, which is essential to determine the baseline of the treatment group. It is for this reason that the study should be taken with some caution. Aulia, Wahjuningsih, and Andayani (2020) employed a post-test-only quasi-experimental design, similar to the current study, but the method imposed the same constraints in comparing pre-existing knowledge gaps. To address this shortcoming, several researchers employed pre-test and post-test designs. Ambara (2020), Ajisoko (2020), and Fitri et al. (2023) integrated both into their research setups, making it possible for assessment of alterations in assuming vocabulary knowledge. Nonetheless, these studies had small sample sizes. As for the qualitative chosen studies, limitations such as small sample size can be identified: Ajisoko (2020) had only nineteen participants, and Ambara (2020) relied on only two classes of one school.

Mixed methods studies attempted to balance between quantitative data and qualitative data. Guaqueta and Castro-Garces (2018) employed the concurrent mixed methods design, which involved using qualitative and quantitative data to increase the reliability of results. Qualitative studies like Pramesti and Susanti (2020) and Apoko, Dunggio, and Chong (2023), coupled with interviews and open-ended questionnaires, provided rich data that could not otherwise be obtained. As helpful as they are towards understanding user experiences, they do not provide the statistically rigorous approaches required to measure Duolingo's efficacy conclusively. Another common drawback was the selected time frame being insufficiently long for the research. Habibie's (2020) study probably did not record any significant changes. Duolingo was implemented for only four days, as reported in Borang, Maru, and Rorimpandey research. This brief approach may not fully depict how the app may help the user progress in learning more vocabulary over a considerable period. The other major challenge in the studies was related to sampling. Some research sources were often limited in demographic coverage or centred on particular establishments. Without adequate reasons, male participants were excluded from Ali and Deris's study (2019). Academicians Inayah, Yusuf, and Fibula (2020) and Irzawati and Unamo (2023) focused on the undergraduate students.

Several studies lacked robust sampling techniques. Hidayati and Diana (2019) and Jaelani and Sutari (2021) adopted purposive and convenience sampling in their studies. Despite

being useful, all these methods incorporate sources of built-in selection bias and constrain generalizability. Some sources of bias showed that controlling confounding variables was not well done in most studies. Few researchers considered variables such as prior English exposure, socio-economic background, or concurrent language learning activities. Dahlan and Nurbianta (2020) used partial correlation to test several variables simultaneously, yet they failed to account for the potential influence of other variables. Several publications raise validity issues, especially due to some studies' overdependence on self-reported data. The study by Araújo and Eddine (2020), which analysed Google Play Store user comments, is innovative, but their research raises questions about data reliability since they depended on the comments users left behind.

The diverse research methods allow a multifaceted view of Duolingo's effectiveness in acquiring vocabulary, as well as reveal crucial drawbacks. Some significant limitations include small sample sizes, brief study durations, narrow demographic focus, and limited variable management that diminish the reliability and global applicability of many findings. For practical application, future research would be ideal if they are conducted on larger samples over the longer term, with stricter control of extraneous variables. Moreover, the integration of vocabulary assessment in all studies also increased the value of standardised tools, which, if used consistently, could improve comparison when evaluating the efficacy of Duolingo and other similar applications.

Impact on student motivation and engagement

The impact of Duolingo on student motivation and engagement in vocabulary learning emerges as a significant theme across the reviewed literature. Numerous studies have explored how the gamification and interactive elements of the application influence students' enthusiasm and sustained use for vocabulary acquisition. This section synthesises the key findings related to these aspects.

Ajisoko (2020) reported that Duolingo effectively improved English language learning, particularly vocabulary, by eliminating boredom. The application's design presents learning as a game with scientifically proven effectiveness and ensures that language learning remains possible and engaging (Ambara, 2020). Borang, Maru, and Rorimpandey (2023) further emphasised that Duolingo's potential as an engaging learning medium significantly improves vocabulary skills. The interactive nature of Duolingo fosters active participation among learners. Kusumadewi and Widyastuti (2018) observed that students using Duolingo showed considerable response and interest, finding vocabulary easier to understand due to the fair, practical material provided by the app. Jaelani and Sutari (2021) reported that over 80% of students agreed that Duolingo was user-friendly and increased their active participation in learning. Accessibility and flexibility have been identified as motivational factors. Pramesti and Susanti (2020) found that students felt more comfortable and enjoyed learning English with Duolingo. Hidayati and Diana (2019) reported high interest and enthusiasm among students, with flexibility and practicality being key attractions.

Duolingo's impact on sustaining learners' interest over time has yielded mixed results. Botero, Questiner, and Zhu (2019) found that while questionnaire responses indicated Duolingo facilitated out-of-class learning through enjoyable activities, interviews revealed challenges in maintaining continuous enthusiasm, reflected in low app usage over time. However, when integrated into formal learning contexts, Guaqueta and Castro-Garces (2018) reported that students perceived Duolingo as positively influencing their learning generally and vocabulary skills enhancement specifically, indicating long-term motivational effects.

The competitive and rewarding features of Duolingo are particularly engaging. Setiawati (2023) noted that students, especially those with below-average English proficiency, found Duolingo effective due to its game-like interface. The challenges, reminders, and reward systems motivated students to learn new words consistently. Irzawati and Unamo (2023) corroborated this, finding that Duolingo's gamification aspects made learning enjoyable and

reduced anxiety. Interestingly, Inayah, Yusuf, and Fibula (2020) discovered a discrepancy between students' positive perceptions of Duolingo as a useful, helpful, and motivational tool and their actual usage. This suggests that Duolingo's motivational influence might extend beyond direct app usage to general attitudes towards language learning.

Another aspect that has been associated with increased motivation corresponds with the concept of the personalised learning environment. All the respondents supported Duolingo in making it possible for learners to progress within the language learning application at their own pace, as they noted this as a motivating factor to practice. However, the new aspects of the apps were not motivating in all the parts that primarily constitute Duolingo. Several pieces of work have reported on constraints that may reduce interest, including a lack of in-depth grammar explanations (Nasrul & Fatimah, 2023), inability to use the application offline (Purwanto, 2023), and the learners' vocabularic enhancement without concern for cultural references (Simanjuntak, Napitupulu, & Siahaan, 2023).

The literature reviewed substantial evidence by showing a strong relationship between the use of gamification and interactivity, which, in this case, was applied to Duolingo and students' increased motivation and engagement rates when learning vocabulary. This is because the constructed application has a variety of interactive elements, such as a game-like interface, accessibility, flexibility, and a personalised learning experience. Difficulties maintaining long-term motivation were mentioned, particularly for learners engaging in informal learning contexts; studies regarding Duolingo's integration into formal education suggested that motivation was maintained even in a formal educational setting. These insights confirm that the operationalisation of motivational guidelines requires careful attention to gain the most benefit from Duolingo's motivational features. Given study limitations, future work can take advantage of longitudinal designs to explore motivational changes more circularly and reference different learning environments.

Practical implications for educators

The reviewed literature provides significant insights into the practical implications of integrating Duolingo into classroom settings for vocabulary acquisition. This section examines how educators can effectively incorporate Duolingo into their teaching practices, their potential challenges, and the solutions proposed in various studies. Several researchers recommend Duolingo as a supplementary tool in formal education. Apoko, Dunggio, and Chong (2023) suggested its use for English vocabulary learning among university students, emphasising that critical instructor guidance is still needed to maximise learning outcomes. This indicates that while Duolingo can enhance vocabulary learning, it should complement rather than replace traditional instruction.

Integration strategies vary across educational levels. Ambara (2020) found that using Duolingo in teaching English at the secondary level increased students' understanding of materials and motivation. Teachers can assign Duolingo activities as homework or additional practice, engaging classroom learning. Hernadijaya (2020) demonstrated its effectiveness with seventh-grade students, showing adaptability to younger learners. In tertiary education, Botero, Questiner, and Zhu (2019) further examined informal, out-of-class engagement and identified challenges in maintaining continuous enthusiasm and difficulties in self-management. Educators should monitor and encourage consistent usage by offering regular check-ins and progress discussions, integrating achievements, and ensuring that Duolingo achievements are included in the learners' performance assessment. The type of gamification Duolingo presents unique opportunities. Setiawati (2023) states that gamification is effective, especially for students with below-average proficiency. This can empower the learning process and can be used by teachers to design classroom competitions or motivate students by assigning prizes based on the progress in Duolingo. However, following such programs, educators have to overcome certain difficulties. Jaelani and Sutari (2021) mentioned that internet connectivity is a critical challenge. This raises the issue of whether enough technology is in place to support

the learning process. Having some lessons downloadable offline or offering contingencies that students with little to no internet can engage in could help eliminate this.

Another issue is that language learning often reaches only sufficient but not deeper levels. Nasrul and Fatimah (2023) highlighted the absence of in-depth grammar explanations, while Simanjuntak, Napitupulu, and Siahaan (2023) noted the lack of cultural context. While enhancing literacy in context, educators should use Duolingo with grammar explanations and culturally authentic resources to offer a wider perspective on language learning. A call for a strategic intervention emerged from the study conducted by Inayah, Yusuf and Fibula (2020), evidenced by the students' perceptions and actual usage. Gaps between the formal classroom and informal Duolingo learning can be dealt with by ensuring that learning goals are defined and progress discussed often, as well as relating Duolingo activities to course material.

Another aspect where Duolingo can also assist educators is differentiation. As highlighted by Irzawati and Unamo (2023), it is useful in enabling the learning process to suit everyone's learning capabilities. Assessment integration is crucial. For its part, Duolingo has its evaluation measurements, but they must relate to the curriculum objectives. Guaqueta and Castro-Garces (2018) also mentioned using Duolingo scores or progress as part of the formative assessment while comparing it with the summative assessment based on traditional assessment tools. Since Duolingo is primarily used individually, group work may be looked at in terms of what they can offer. Hidayati and Diana (2019) stated that the students found it highly enthusiastic. Teachers can use the learning pairs or small groups using the Duolingo assignments so that the learners learn together and support one another. Professional development is essential. In their study, Dahlan and Nurbianta (2020) showed how Duolingo affects the aspect of vocabulary improvement and reading comprehension; therefore, it is crucial to grasp its possibilities. Training on the features, creating guidelines on integrating such tools into work, and developing ways to deal with the difficulties that may occur assist in proper usage.

Gaps in the literature

Despite the considerable body of research on Duolingo's effectiveness in vocabulary acquisition, several gaps remain in the existing literature. This section highlights these gaps and outlines the potential focus of further research to answer unanswered questions and strengthen the understanding of Duolingo as a language learning application. One significant omission involves the lack of focus on longitudinal studies. It is worth mentioning that most reviewed research studies concentrated on interventions covering a period of not more than three months. For instance, Habibie's (2020) study collected data over only three days, while Borang, Maru, and Rorimpandey (2023) used Duolingo for only 4 days. While such brief interventions might be helpful, they do not convey how Duolingo influenced the participants' vocabulary retention and language proficiency development as they continued to learn languages. Gathering data collected at the same intervals that are consistent with students' progress over long periods, perhaps in terms of academic years, can give more evidence on how and to what extent the gained vocabulary may persist, as well as the changes in learners' interactions with the application as time progresses.

Another significant gap lies in the limited diversity of student populations studied. Many researchers concentrated on specific demographics or single institutions. Ali and Deris's (2019) study comprised only female participants, while Inayah, Yusuf, and Fibula (2020) and Irzawati and Unamo (2023) focused solely on undergraduate students. This narrow focus restricts the generalizability of findings. Future research should aim to include a broader range of participants across different age groups, proficiency levels, cultural backgrounds, and learning contexts. Comparative studies examining Duolingo's effectiveness across these diverse populations would enrich the literature.

The specific features of Duolingo that contribute most to vocabulary learning remain underexplored. While studies like Setiawati (2023) and Irzawati and Unamo (2023) highlighted

the motivational aspects of gamification, few have systematically investigated which particular elements (e.g., points, levels, streaks, or leaderboards) have the greatest impact on vocabulary acquisition. Experimental studies isolating these features and measuring their effects would provide valuable guidance for app developers and educators. Integrating Duolingo with other language learning resources and strategies requires further investigation. Most studies examined Duolingo in isolation or compared it to traditional methods. However, as Apoko, Dunggio, and Chong (2023) suggested, Duolingo's optimal use may be as a supplementary tool. Research exploring various blended learning models, combining Duolingo with different instructional approaches, could offer insights into the most effective integration strategies.

The current literature inadequately addresses the relationship between Duolingo usage patterns and learning outcomes. While some studies, like Botero, Questiner, and Zhu (2019), tracked app usage, few have correlated usage patterns (e.g., frequency, duration, time of day, or consistency of use) with vocabulary gains. Such analyses could reveal optimal usage strategies and inform personalised learning recommendations. Moreover, there is a dearth of research on transferring vocabulary learned through Duolingo to real-world language use. Most studies relied on Duolingo's internal assessments or vocabulary tests closely aligned with the app's content. Investigations into how well this vocabulary translates into improved performance in authentic communication tasks would significantly contribute to understanding Duolingo's practical efficacy.

The role of learner autonomy and self-regulated learning in Duolingo-based vocabulary acquisition also warrants deeper exploration. Inayah, Yusuf, and Fibula's (2020) observation of discrepancies between perceptions and actual usage hints at the complexity of self-directed learning. Studies examining the development of learner autonomy through Duolingo and identifying factors that promote or hinder self-regulation would be valuable. Additionally, the literature lacks substantial qualitative investigations into learners' and teachers' experiences with long-term Duolingo use. In-depth case studies and phenomenological research could provide rich descriptions of the challenges, adaptations, and evolving perceptions associated with prolonged engagement with the app. Finally, there is a notable absence of studies on Duolingo's effectiveness for languages other than English. Given the app's multilingual offerings, comparative research across different target languages could uncover language-specific factors influencing vocabulary acquisition through Duolingo.

While existing research offers valuable insights into Duolingo's role in vocabulary learning, significant gaps persist. Future studies addressing these gaps—through longitudinal designs, diverse populations, feature-specific analyses, integrated approaches, usage pattern correlations, real-world transfer assessments, autonomy investigations, qualitative explorations, and cross-linguistic comparisons—would substantially advance the understanding of Duolingo's potential and limitations in vocabulary acquisition. Such comprehensive research would contribute to theoretical knowledge and provide evidence-based guidance for educational practice.

CONCLUSION

The review of Duolingo's application in vocabulary acquisition yields insights of both theoretical and pedagogical import yet simultaneously underscores the need for more rigorous empirical investigation. The cumulative evidence, derived predominantly from quasi-experimental studies, suggests that Duolingo facilitates measurable gains in receptive vocabulary knowledge that surpass those of traditional instructional methods. However, the construct validity of these findings warrants scrutiny, given the frequent isomorphism between the app's content and the assessment measures employed.

A recurrent theme in the literature is Duolingo's motivational efficacy, putatively attributable to its gamified interface. Learners' self-reports indicate heightened task engagement, but such introspective data must be interpreted judiciously. The relative paucity of research utilising psychometrically robust instruments to quantify motivational constructs and their temporal stability constitutes a significant lacuna.

From a theoretical standpoint, Duolingo's provision of immediate, individualised feedback aligns with interactionist postulates on the facilitative role of negative evidence in language development. Nevertheless, the app's limited affordances for the negotiation of meaning and pushed output raise questions about the depth of processing and the transferability of lexical gains to communicative contexts. The methodological landscape, while informative, exhibits limitations that merit attention. Sample sizes are often modest, and participant profiles tend towards homogeneity, typically comprising tertiary-level learners. This demographic uniformity obscures potential interactions between individual difference variables (e.g., language aptitude, working memory capacity) and the efficacy of Duolingo-mediated learning. Moreover, the preponderance of short-term interventions precludes insights into the longitudinal trajectories of vocabulary development.

Integration of Duolingo into formal instructional settings emerges as a recurrent recommendation. However, despite its intuitive appeal, this proposition requires more robust empirical substantiation. Ideally, Classroom-based research employing mixed-methods designs is imperative to delineate optimal implementation strategies and elucidate how teachers might judiciously orchestrate Duolingo's affordances with complementary pedagogical interventions. Significant knowledge gaps persist, notably in our understanding of the differential impacts of Duolingo's myriad features, the extent of vocabulary transfer to authentic communicative scenarios, and the app's role in fostering self-regulated learning. The predominant focus on English as the target language further circumscribes the generalizability of findings.

In sum, while extant research corroborates Duolingo's potential in lexical development, it concurrently illuminates the imperative for more nuanced, theoretically grounded investigations. Future studies must transcend mere efficacy comparisons to explicate the complex interplay of learner variables, technological affordances, and pedagogical strategies that mediate vocabulary acquisition in this digital milieu. Only through such multifaceted inquiry can we construct a robust theoretical framework to inform evidence-based practices, thereby optimizing Duolingo's contribution to instructed second language acquisition.

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