A systematic review and meta-analysis of the evidence for mobile learning as developer of skills in a second language

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ABSTRACT: In our contemporary and multicultural society, the acquisition of a second language has evolved from being merely a practical means for employment to becoming an essential fundamental skill for personal development. This linguistic competence is a dynamic asset that not only unlocks professional opportunities but also significantly contributes to overall individual growth. Recognizing the inherent differences among language learners, innovative methodologies such as gamification and the flipped classroom have been proposed to diversify language teaching approaches. The integration of Information and Communication Technologies (ICT) in language education, specifically mobile learning (m-learning), has transformed the landscape of second language acquisition. Applications like Duolingo and Mobile-Assisted Language Learning (MALL) platforms are examples of this innovation.
This research aims to evaluate the influence of m-learning on second language education. Through a systematic review and meta-analysis of various studies, a convincing positive impact of m-learning on second language acquisition is revealed. Despite potential publication bias, the findings highlight the effectiveness of m-learning, especially in English learning contexts prevalent in Asian countries. The study acknowledges possible drawbacks and emphasizes the widespread influence of English as a second language. The limitations include the theoretical nature of the study and potential publication bias.
Keywords: Mobile Learning, Second Language Acquisition, Multicultural Education, Language Teaching Methodologies, Information and Communication Technologies in Education

Una revisión sistemática y metaanálisis de la evidencia para el aprendizaje móvil como desarrollador de habilidades en un segundo idioma

RESUMEN: En nuestra sociedad contemporánea y multicultural, la adquisición de un segundo idioma ha dejado de ser simplemente un medio práctico para el empleo y se ha convertido en una habilidad fundamental esencial para el desarrollo personal. Esta competencia lingüística es un activo dinámico que no solo abre oportunidades profesionales, sino que también contribuye significativamente al crecimiento individual en general. Reconociendo

las diferencias inherentes entre los estudiantes de idiomas, se han propuesto metodologías innovadoras como la gamificación y el aula invertida para diversificar los enfoques de enseñanza de idiomas. La integración de Tecnologías de la Información y la Comunicación (TIC) en la educación lingüística, específicamente el aprendizaje móvil (m-learning), ha transformado el panorama de la adquisición de segundas lenguas. Aplicaciones como Duolingo y plataformas de Aprendizaje de Idiomas Asistido por Móvil (MALL) son ejemplos de esta innovación.

Esta investigación se propone evaluar la influencia del m-learning en la educación de segundas lenguas. A través de una revisión sistemática y metaanálisis de diferentes estudios, se revela un impacto positivo convincente del m-learning en la adquisición de segundas lenguas. A pesar del posible sesgo de publicación, los hallazgos destacan la eficacia del m-learning, especialmente en contextos de aprendizaje del inglés en países asiáticos. El estudio reconoce posibles inconvenientes y enfatiza la influencia generalizada del inglés como segunda lengua. Las limitaciones incluyen la naturaleza teórica del estudio y un posible sesgo de publicación.

Palabras clave: Aprendizaje Móvil, Adquisición de Segundas Lenguas, Educación Multicultural, Metodologías de Enseñanza de Idiomas, Tecnologías de la Información y Comunicación en la Educación.

1. INTRODUCTION

Presently, our societal landscape reflects a multicultural paradigm, underscoring the imperative for the acquisition of a second language. This linguistic proficiency is not merely a utilitarian means to gain employment but stands as a pivotal and foundational skill integral to individual growth and personal development. In the contemporary context of diversity, the cultivation of a second language is positioned as a dynamic asset, enriching not only professional opportunities but also contributing substantially to the holistic development of an individual. The multifaceted nature of our interconnected world underscores the significance of linguistic versatility, transforming the mastery of a second language into a cornerstone for personal and societal advancement.

Within the development of a second language, individual differences contribute to variations in the progress of acquiring a second language (Kormos, 2020). This necessitates that language teaching incorporates diversification and adaptation of existing methodologies for language learning. Various proposals related to methodologies have been made, such as those by González and Álvarez (2022), who advocate for the implementation of gamification as a means of developing second languages, or Zhang (2019), who regards the flipped classroom as an essential methodology for the development of linguistic competencies in a second language.

Regardless of the methodology or approach applied to second language learning, two commonalities emerge across articles that incorporate such methodologies in second language acquisition. Firstly, learning creates opportunities not only in terms of employment but also in the social sphere, motivating the pursuit of a second language (Jiang and Wen, 2022). Secondly, there is a consistent reference to Information and Communication Technologies (ICT), which play a crucial role in the development of active methodologies and the teaching-learning process.

In particular, one technology has gained significant relevance in scientific literature due to various advantages. The widespread accessibility of smartphones to the general popula-

tion represents a significant advancement. This tool allows for the use of applications with various features, such as instant messaging apps, the ability to make video calls, or utilize augmented reality (Aznar-Díaz et al., 2018). Furthermore, this tool finds applications across all educational stages, with necessary adaptations for each, considering the specific needs of each stage. For instance, in Early Childhood Education, the use of tablets may be more suitable than smartphones (Romero-Rodríguez et al., 2020). Notably, ICT is highlighted as a literacy tool for individuals at risk of social exclusion, further justifying its widespread use (Trujillo-Torres et al., 2020).

Specifically, for mobile learning (m-learning), multiple proposals for applications and systems have been generated to meet the need for creating a space for language learning online or offline. Specifically, noteworthy applications include Duolingo, which proposes a simple system for learning a second language through these tools.

On the other hand, Mobile-assisted Language Learning (MALL) deserves attention. These tools are digital platforms where individuals learning a second language can receive both grammatical and pronunciation corrections for a phrase, simultaneously using it as a dictionary (Puebla et al., 2022).

This has sparked significant scientific interest and has resulted in other research reviews, such as that of Garzón et al. (2023), focused on mobile devices, understanding the potential for device mobility, which may include other types of devices like laptops. Additionally, the research by Persson and Nouri conducts a similar investigation to the present one but was published in 2018, rendering it outdated in the current context. In this manner, the aim of the current research is to ascertain the extent to which mobile learning influences the teaching-learning process of second languages. To achieve this, the following research inquiries are posited:

R.Q.1. In what context are the investigations being conducted (country in development, target population, sociocultural elements, and the second language being developed)?

R.Q.2 How are the m-learning interventions being carried out (specifying the tools, applications, and duration of the intervention)?

R.Q.3 What is the effect of working with mobile learning on the learning of second languages?

2. Methodology

Phase 1: Sources of information and Search strategies

For the present systematic review and meta-analysis, it is necessary to define a search equation that fits the characteristics of the study. Therefore, two key terms are proposed: "Mobile learning," from which the following keywords are generated: "mobile learning" OR "m-learning" OR "mobile assisted" OR "mobile assisted language learning" OR "MALL" OR "mobile technologies" OR "mobile devices," and the term "Second language learning," from which the following keywords are used: "second language" OR "second language learning" OR "second language acquisition." Additionally, the terms "Systematic Review" and "Meta-analysis" are excluded from any part of the text.

With the established search equation, the PRISMA protocol mentioned in the article by Page et al. (2021) is followed, adhering to the 27 points mentioned in it. The only point not emphasized is funding, as the present research does not have specific funding, making it unnecessary to include.

Phase 2: Eligibility criteria

Having specified the search equation and the protocol to be followed for the present meta-analysis, it is necessary to establish the criteria for article selection and filtering. For this article filtering, two stages can be distinguished. In the first stage, databases (WOS and Scopus) have specific filters to establish the year of the articles, setting the criterion from 2019 to 2023, and that they must be articles. In the second stage, all authors must read the title, abstract, and methodology of the articles to filter them according to the criteria in Table 1.

Table 1. *Criteria and Justification*

Criteria	Justification
Any language appart from Spanish/English	The authors of this article are proficient in both Spanish and English. However, both languages are of great scientific interest, and with few exceptions, articles are available in either of these languages.
Not Open Access	With the intention of creating a replicable study and ensuring data accessibility, all the research included in this study is available free of charge.
Not thoeretical works	The objective of this research is to establish a relationship between mobile learning and the learning of second languages. Therefore, the criterion has been set to exclude review articles, meta-analyses, critiques, etc., in order to respond appropriately to this objective.
Do not work Second Language	Despite the search equation delimiting this factor as a key aspect within the review, some articles do not address this aspect, so it is necessary to include this criteria
Do not include any mobile learning app	Despite the search equation delimiting this factor as a key aspect within the review, some articles do not address this aspect, so it is necessary to include this criteria
Do not have any control group	Due to the characteristics of the study, it is necessary to have a control group to observe the actual effect of using mobile learning.

Phase 3: Selection process

Once all the authors had independently selected the articles, they considered suitable for inclusion, a joint discussion was held, and articles were eliminated based on the previously established exclusion criteria. Finally, all the authors proceeded to a full reading of all the articles found to perform a final filtering and to answer the questions that had been posed earlier.
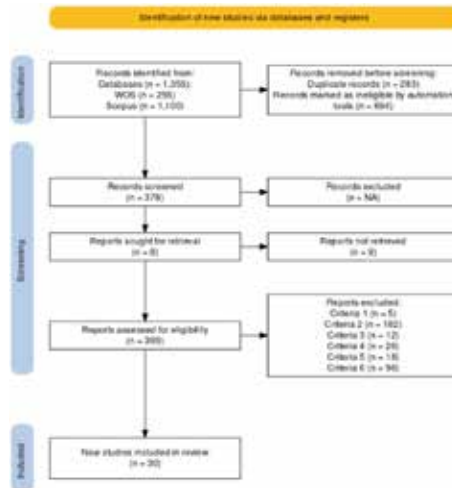
Figure 1. *Flowchart illustrating the review selection process conducted by PRISMA*

3. Results

3.1. In what context are the investigations being conducted (country in development, target population, sociocultural elements, and the second language being developed)?

To address question 1, an analysis of all characteristics will be conducted using Table 2, which includes essential information related to the posed question. In this way, the table provides the reference (sorted by year), the age of the students where the intervention takes place, the country, and the second language intended to be learned.

Table 2. *Relationship between reference, country, age and language*

Reference	Country	Age	Language
Keezhatta y Omar, 2019	Saudi Arabia	Secondary Schools	English
Liu et al., 2019	China	University Students	English
Chen et al., 2019	Taiwán	Students College of Liberal Arts at National Chengchi University (NCCU)	English
Imelda et al., 2019	Indonesia	Second Graders Of Vocational High School	English
Al-Hamad et al., 2019	Jordan	Yarmouk University Model Schoo	English
Rashtchi y Mazraehno, 2019	Iran	18-20	English
Haerazi et al., 2020	Indonesia	Pre-Service Teachers	English
Purgina et al., 2020	Japan	19-21 years old	English
Okumuş et al., 2020	Türkiye	Students at Cumhuriyet University	English
Sato et al., 2020	Japan	Undergraduate Students	English
Baek y Lee, 2021	Korea	University Students	English
Chen y Chew, 2021	China	19-21 years old	English

Tahounehchi, 2021	Iran	13-17 years old	English
Eltalhi et al., 2021	Libya	3-5	English
Karim et al., 2021	Malaysia	University Students	English
Cakmak et al., 2021	Türkiye	18-20	English
Mohsen y Mahdi, 2021	Saudi Arabia	Professors at University of Bisha	English
Aliakbari y Mardani, 2022	Iran	Learners In Kish Institute In Ilam	English
Alenezi y Bensalem, 2022	Saudi Arabia	Medical Students	English
He y Loewen, 2022	Japan	College EFL learners	English
Chrysafiadi et al., 2022	Greece	Second-Year Undergraduate Students	English
Li y Hafner, 2022	China	18-22 years old	English
Almawadeh y Al-Amad, 2023	Arab Emirates	Grade 9 students'	English
Janfeshan et al., 2023	Iran	16-19 years old	English
Hariyanto et al., 2023	Türkiye	Students Gazi University and Cumhuriyet University	English
Sun y Asmawi, 2023	China	Undergraduate Students	English
Rodriguez-Arce et al., 2023	Mexico	19,85 years old	German
Nguyen y Le, 2023	Vietnam	18-20 years old	English
Ye y Shi, 2023	China	19-24 years old	English
Xodabande y Boroughani, 2023	Iran	Adults	English

In this way, the context of the countries conducting research in this field is established, showing a predominance of Asian countries (Figures 2 and 3) over the rest. Additionally, it is essential to understand the supremacy that English establishes as the second language at the international level, as all studies except one focus on English language learning.
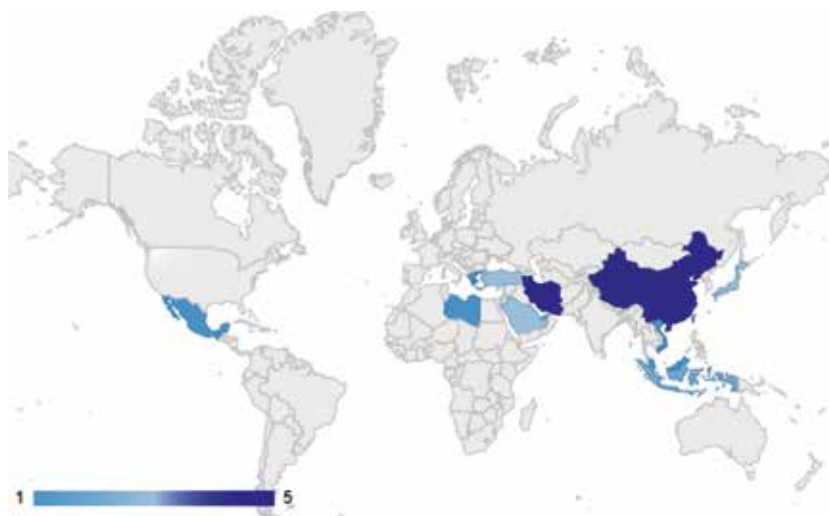

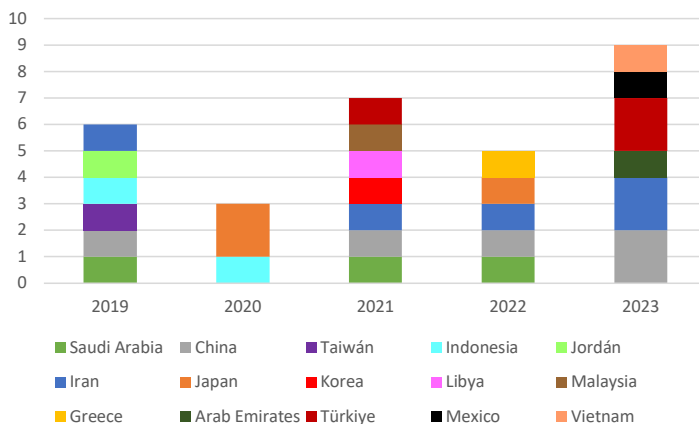**Figure 2:** *World map depicting the distribution of studies by countries.*

Figure 3: *Distribution of publications according to the year*

Regarding the sociodemographic and cultural section of the studies, it is important to mention the populations where the research is conducted. The majority of interventions are carried out in a university or pre-university context, with a population over 18 years old, all having access to a mobile phone through which they could access the platforms. It is also necessary to point out that in a large part of the studies, there is a significant incidence of English within the general population where the research is conducted. As a result, many participants already have a medium to advanced level in the language.

It is worth highlighting the aspect shown in figure 3, as during 2020, research related to this topic will decrease drastically. Despite the current global health situation, Asian countries in particular are investing heavily in the development of a second language. In particular English, as it is understood that this is the best-known language on an international level and is thus a fundamental tool for a process of globalisation.

3.2. How are the m-learning interventions being carried out (specifying the tools, applications, and duration of the intervention)?

Having analyzed the context in which the interventions are conducted, it is necessary to examine the intrinsic characteristics of the research to replicate such interventions.

In this regard, social networks are one of the most utilized tools. The ability to establish direct contact with people at a distance and engage in conversations and corrections are differentiating elements. Studies by Alenzi and Bensalem (2022), Almawadeh and Al-Amad (2023), Janfeshan et al. (2023), Sun and Asmawi (2023), Chen and Chew (2021), and Tahounehchi (2021) fall within this trend of using social networks. WhatsApp stands out as the most used social network within this group, providing good results. However, it is not the only one; other applications like WeChat or any that allow for these types of conversations, as well as video calls, are useful for grammatical or pronunciation error correction.

Moreover, the capabilities of mobile phones, along with the software and power they possess, have given rise to new tools, as mentioned earlier, known as MALL (Mobile-Assisted

Language Learning). This includes the works of Nguyen and Le (2023), Ye and Shi (2023), Xodabande and Boroughani (2023), Cakmak et al. (2021), Mohsen and Mahdi (2021), Sato et al. (2020), Liu et al. (2019), Keezhatta and Omar (2019), Hariyanto et al. (2023), Aliakbari and Mardani (2022), Baek and Lee (2021), Karim et al. (2021), Dağdeler et al. (2020), and Al-Hamad et al. (2019). These tools allow direct communication via mobile devices and like Word with automatic spelling correction, these tools guide the user to write and produce phrases and sentences adapted to the level of the learner.

The remaining studies fall within the category of mobile applications that cannot be classified into either of the two types mentioned. These applications are primarily focused on vocabulary development. An example is the study by Rodriguez-Arce et al. (2023), which utilizes an application with images and drawings through which students develop their vocabulary. All these applications serve a dictionary-like purpose, meaning that, in many cases, these digitalized applications could be replaced by non-digitalized elements. However, working with these tools implies simplification and an improvement in work efficiency.

Lastly, in reference to the duration of the intervention, significant differences are observed, although they all share some similarities. On one hand, there are interventions that focus on vocabulary acquisition, involving quick games that can make a difference in a single session. In this type of intervention, it is demonstrated that one hour of intervention can yield noticeable differences.

On the other hand, as mentioned, most studies do not fit into this classification. Instead, they are part of a longer-term planning that ultimately results in the development of various linguistic skills necessary for the acquisition of a second language. This second type of intervention typically has a maximum duration of 2 years, as it is understood that within that time, participants should have achieved a B1 level English language certification. However, shorter interventions with these characteristics typically last around 3 months, conducted over an academic quarter.

3.3. What is the effect of working with mobile learning on the learning of second languages?

Out of the 30 articles included in the systematic review, only 23 have been statistically analyzed to assess the influence of mobile learning technology. This is because two of them do not meet the requirements for statistical analysis: one due to the qualitative nature of the research and the other because the data is unavailable.

Furthermore, during the statistical analysis of the data, a significant influence is observed from 5 studies (Figure 4) whose research shows highly positive effects in favor of the experimental group. Specifically, these three studies are Keezhatta and Omar (2019), Chen et al. (2019), Haerazi et al. (2020), Cakmak et al. (2021), and Janfeshan et al. (2023). Therefore, as these studies present outliers, although they have been taken into account in the initial analysis, it is interpreted that there is a publication bias, and these studies may be attempting to magnify the effects of the intervention.
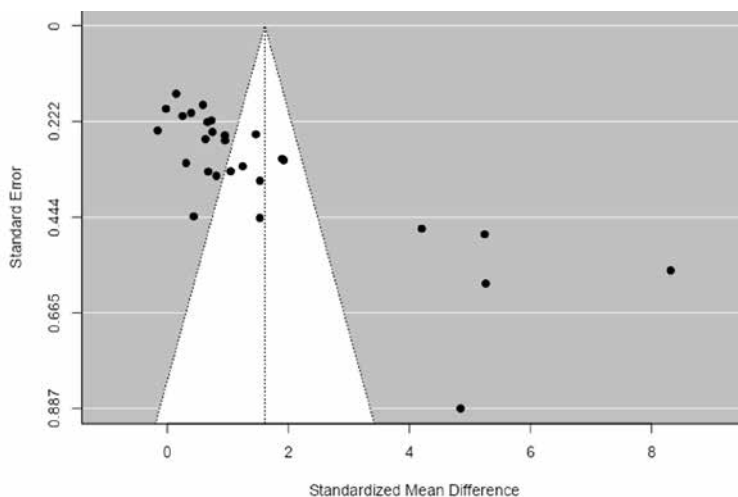
Figure 4. *Funnel Plot*

After removing those 7 articles, a significant impact of mobile learning on second language acquisition is evident, proving effective from various perspectives.

The analysis was carried out using the standardized mean difference as the outcome measure. A random-effects model was fitted to the data. The amount of heterogeneity (i.e., tau²), was estimated using the restricted maximum-likelihood estimator (Viechtbauer 2005). In addition to the estimate of tau², the Q-test for heterogeneity (Cochran 1954) and the I² statistic are reported. In case any amount of heterogeneity is detected (i.e., tau² > 0, regardless of the results of the Q-test), a prediction interval for the true outcomes is also provided. Studentized residuals and Cook's distances are used to examine whether studies may be outliers and/or influential in the context of the model. Studies with a studentized residual larger than the 100 x (1 - 0.05/(2 X k))th percentile of a standard normal distribution are considered potential outliers (i.e., using a Bonferroni correction with two-sided alpha = 0.05 for k studies included in the meta-analysis). Studies with a Cook's distance larger than the median plus six times the interquartile range of the Cook's distances are considered to be influential. The rank correlation test and the regression test, using the standard error of the observed outcomes as predictor, are used to check for funnel plot asymmetry (tables 3and 4).

Table 3. *Random-Effects Model*

Random-Effects Model (k = 23)

	Estimate	se	Z	p	CI Lower Bound	CI Upper Bound
Intercept	0.78	0.12	6.57	<.001	0.55	1.02
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Nota. Tau² Estimator: Restricted Maximum-Likelihood

Table 4. *Heterogeneity Statistics*

Heterogeneity Statistics

Tau	Tau²	I²	H²	R²	df	Q	p
0.50	0.247 (SE= 0.0975)	79.32%	4.84	.	22.00	101.43	<.001

A total of k=23 studies were included in the analysis. The observed standardized mean differences ranged from -0.1588 to 1.9217, with the majority of estimates being positive (91%). The estimated average standardized mean difference based on the random-effects model was \hat{\mu} = 0.7818 (95% CI: 0.5486 to 1.0150). Therefore, the average outcome differed significantly from zero (z = 6.5715, p < 0.0001). According to the Q-test, the true outcomes appear to be heterogeneous (Q (22) = 101.4288, p < 0.0001, tau² = 0.2470, I² = 79.3234%) (Figure 5). A 95% prediction interval for the true outcomes is given by -0.2197 to 1.7833. Hence, although the average outcome is estimated to be positive, in some studies the true outcome may in fact be negative. An examination of the studentized residuals revealed that none of the studies had a value larger than ± 3.0654 and hence there was no indication of outliers in the context of this model. According to the Cook's distances, none of the studies could be considered to be overly influential. Both the rank correlation and the regression test indicated potential funnel plot asymmetry (p = 0.0072 and p = 0.0039, respectively).

| Reference	Experimental Sample	Control Sample
Imelda et al., 2019	31	30
Al-Hamad et al., 2019	37	55
Rashtchi y Mazraehno, 2019	20	20
Purgina et al., 2020	10	11
Sato et al., 2020	40	54
Baek y Lee, 2021	69	56
Chen y Chew., 2021	20	20
Tahounehchi, 2021	13	13
Karim et al., 2021	23	22
Mohsen y Mahdi, 2021	19	18
Aliakbari y Mardani, 2022	30	30
Alenezi y Bensalem, 2022	53	55
He y Lowen, 2022	32	31
Chrysafiadi et al., 2022	50	50
Li y Hafner, 2022	46	39
Almawadeh y Al-Amad, 2023	31	30
Hariyanto et al., 2023	38	33
Sun y Asmawi, 2023	40	40
Rodriguez-Arce et al., 2023	20	20
Nguyen y Le, 2023	33	35
Ye y Shi, 2023	74	89
Xodabande y Boroughani, 2023	22	15
Okumus et al., 2020	33	36
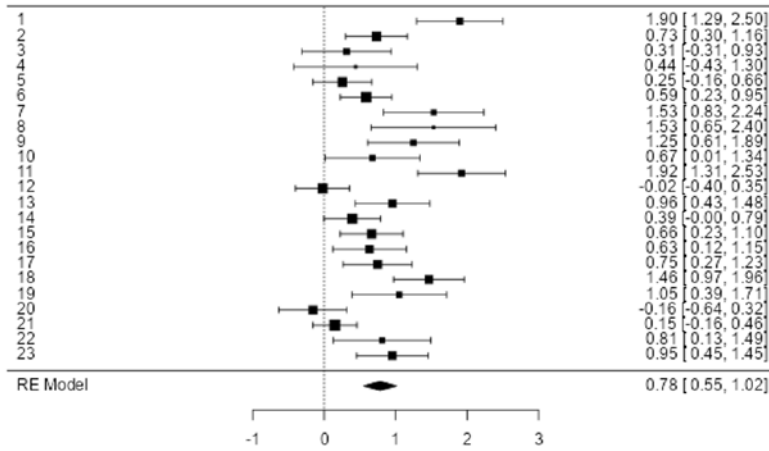
Figure 5. *Forest plot*
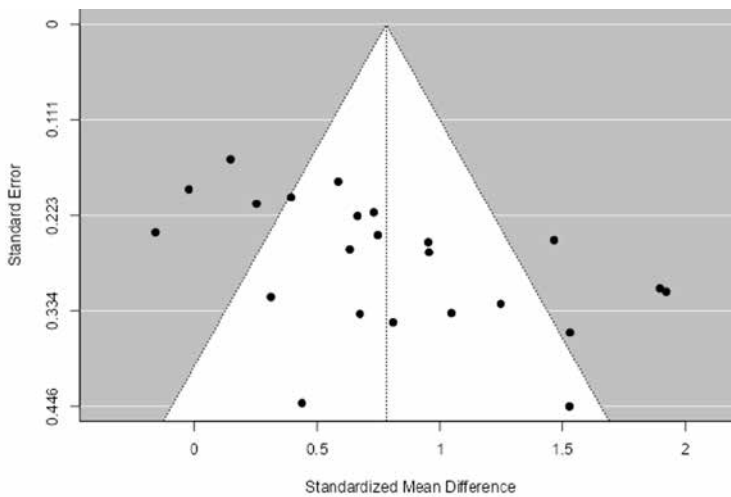
Figure 6. *Funnel Plot*

This, along with Egger's Regression, justifies that there is no selection bias in the choice of articles. Certainly, there is bias regarding their publication, as mentioned earlier, with some articles seemingly demonstrating much more influence than the rest highlighted here. Regarding the question of whether only articles with positive results are published, it can be argued that this is not the case, as we find 2 articles in favor of the control group. However, with the aforementioned justification, one could argue that there is a preference for a positive result in the experimental group, which may influence the overall results.

4. DISCUSSION

It can be emphasized that m-learning exerts a significant influence on second language acquisition, yielding results akin to those found in studies by Garzón et al. (2023) or Persson and Nouri (2018). It is crucial to comprehend the substantial strides that Asia is making towards multiculturalism and its interactions with other countries.

As can be seen from the answer to research question 1 regarding the thematic focus, the country with the highest number of investigations varies. For instance, in the realm of digital competencies, Spain emerges as one of the countries with the most publications (Fernández-Batanero et al., 2022). However, it is noteworthy that Europe, with the exception of articles from North Africa and the study conducted in Mexico, tends to dominate the literature on the subject, underscoring a significant emphasis on the theme in Asia.

Regarding how the interventions have been developed, it is worth noting, as highlighted by Puebla et al. (2022), that there is a greater disposition for learning a second language when utilizing Mobile-assisted Language Learning (MALL). Indeed, the majority of analyzed research indicates improvement. However, a substantial portion of the studies focuses on these types of tools, suggesting a positive effect on learning. This idea, although corroborated by the articles presented and the data provided, highlights an important consideration: the interventions do not appear to have a determined duration, which may influence the results reported in the studies. Additionally, it is necessary to establish how each application impacts different areas of second language development, as not all the applications reviewed address all language areas with the same intensity.

Finally, it is essential to acknowledge a negative aspect present during the research. As mentioned, there seems to be no publication bias, as some studies yield results favoring the control group. Nevertheless, the presence of articles by Keezhatta and Omar (2019), Chen et al. (2019), Haerazi et al. (2020), Cakmak et al. (2021), and Janfeshan et al. (2023), and their significant influence on the overall study average, might indicate a prioritization of publishing in favor of the experimental group.

Therefore, the conclusion is drawn that m-learning, as a tool for second language development, is quite effective. However, it is necessary to consider various aspects that may have negative effects. Additionally, it is essential to highlight the influence of Asian countries on scientific literature and the supremacy of English as a second language.

5. CONCLUSIONS

As a conclusion it can be determined that mobile learning has a positive effect on the different language areas, especially when it comes to developing a second language. However, it is necessary to reflect on the publications in the scientific literature because, as we have seen, there are no reliable data that allow us to identify the best intervention process in this area.

The present study has also shown that English is the most important international language and how the globalisation needs of Asian countries have established a line of work in education at different levels, although higher education is considered to be the time when most people are interested in developing a second language.

Finally, it is worth mentioning how mobile learning is very relevant in second language learning, although depending on the objective the applications may vary, but in general the interventions that are proposed in the short term have great results, but only for vocabulary. If, on the other hand, we want to propose a long-term intervention with the idea of developing the language in an integral way, it is necessary to make longer interventions, establishing 3 months as a standard in this type of research.

6. Limitations

As the main limitation of the research, it is important to mention the characteristics of the study itself. This study is confined to being a theoretical and literature analysis, so while it clearly demonstrates the current state of the issue, the research does not inherently explain the expected results of conducting an intervention in the context of the researchers. On the other hand, language limitation could be considered, although five articles have been excluded, so it is not deemed excessive.

The sample of the studies is not similar as there is a lot of difference in size as well as age within the studies making it a difficult point of comparison. It would be interesting to establish comparisons with common elements such as a sample of similar size and age, results with a standard deviation of less than 0.25 or studies longer than 3 months only. However, there are not enough publications related to the selected topic.

Finally, it is worth noting publication bias as articles with an outstanding influence over others have been identified.

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