



Unlocking the Power of Digital Games in Arabic Language Acquisition: A Meta-Analysis Across Educational Levels

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Abstract

This study examines the effect of digital game-based learning (DGBL) on Arabic language acquisition and the moderating role of school level. Although digital games are increasingly used in education, their impact across grade levels remains underexplored. The study aims to measure the effect size of digital games on Arabic learning outcomes at different school levels and to determine whether these levels shape the effectiveness of DGBL. A meta-analysis of 19 studies was conducted to assess the impact. The results show that digital games significantly improve Arabic language acquisition, with the strongest effects at the Junior High School level, followed by University and Junior High School. Primary School learners show a smaller but still positive effect. These findings indicate that older learners gain more from digital games, likely due to greater cognitive maturity and familiarity with digital tools. This study contributes to research on digital learning by demonstrating how age and educational context influence DGBL outcomes. However, the study is limited by the small number of included studies and its focus on Arabic. Future research should explore other subjects and evaluate long-term outcomes of digital game-based learning in diverse settings.

Keywords:

Digital Game Based Learning; Arabic Language Teaching; Meta-Analysis

A. INTRODUCTION

In the midst of the rapidly advancing technological revolution, the education sector is undergoing significant transformation (Chugh et al., 2023). One of the key innovations reshaping the learning paradigm is gamification, which involves integrating game elements into the learning process (Ojeda-Lara & Zaldívar-Acosta, 2023). In the context of Arabic language learning, a language known for its complexity, digital games offer an innovative solution that can enhance comprehension and mastery of the language (Daud et al., 2024). The application of digital games makes learning not only more enjoyable but also highly interactive, encouraging students to compete, collaborate, and develop language skills more effectively (Ghani et al., 2022).

Arabic, with its rich grammar and vocabulary, often presents unique challenges for learners (Vaknin-Nusbaum & Makhoul, 2025), therefore, adaptive and enjoyable approaches become essential to improve learning effectiveness (Sayed et al., 2023). Digital games provide a flexible learning experience, enabling students to master various linguistic skills through mechanisms such as challenges, levels, achievements, and rewards, which significantly motivate student engagement, boost curiosity, and provide instant feedback to accelerate the learning process (Krystalli & Arvanitis, 2024).

Although there is considerable research on the impact of digital games in foreign language learning, studies specifically focusing on Arabic remain limited. Research on languages such as English and Spanish has demonstrated the positive effects of digital games on student motivation, engagement, and learning outcomes (Rachels & Rockinson-Szapkiw, 2018; Xu et al., 2020). Furthermore, the effectiveness of digital game-based learning in language education is also influenced by the school level (Pitura & Terlecka-Pacut, 2018; Yu, 2024). Therefore, in addition to examining the effectiveness of digital game-based learning in Arabic language education, it is also essential to test the moderating variable of school level to make this study more comprehensive and meaningful.

Most existing studies have not fully explored the relationship between moderating variables, such as education level, and the effectiveness of digital games in Arabic language learning. Therefore, this study aims to fill this gap by measuring the effect size of digital games on Arabic language learning across different grade levels, as well as assessing the impact of moderating variables such as school level on the effectiveness of digital games. Using a meta-analytic approach, this research is expected to provide strong empirical evidence regarding the effectiveness of digital games in Arabic language learning, while also offering practical recommendations for educators and curriculum developers to design more effective, relevant, and engaging technology-based teaching strategies for students at all school levels.

B. METHODS

1. Summary of Included Studies

This study gathered 18 eligible studies, yielding 19 independent samples for meta-analysis. Table 2 presents essential details including the publication year, effect size (g), standard error (SE), and the population size of the experimental (Ne) and control (Nc) groups. Table 3 shows the results from the analysis of the moderating variables, including the number of school level.

Table 1. Inclusion and Exclusion Criteria

Criteria	Included	Excluded
Open Access	All open access	Gold, hybrid gold, bronze, green
Years	2014 - 2024	Others
Document Type	Article	Book Chapter, book, review, conference paper, conference reviews
Language	English and Arabic	Others
Research Design	Experimental Groups (Containing Control and Experimental Groups) N, M, SD, or a way of extracting equivalent	Others
Data Provided	Study conducted in formal school, e.g., primary school, junior high school, senior high school and university	Others
Quality	All	Ø

2. Data Analysis Procedure

The data identified for analysis will undergo examination through numerous statistical calculations facilitated by OpenMEE (<http://www.cebm.brown.edu/openmee/index.html>), specialized software designed for meta-analytic studies (Wallace et al., 2017). The continuous outcome data, which summarizes the mean values derived from the experimental groups (comparing controls versus treatment conditions), will be combined into a comma-separated values (CSV) file and then imported into the software platform. The effect size corresponding to each outcome variable will be derived using Hedges' g in a random effects model paradigm. This methodological framework is widely recognized for its effectiveness in representing data as the standardized mean difference (SMD) between experimental and control cohorts (Lin & Aloe, 2021).

Hedges' g is used to reduce potential bias caused by a decrease in sample size (Lin & Aloe, 2021). The calculation follows the formula $g \times d \times (1 - 3 / (4(n^1 + n_2) - 9))$, where n^1 and n_2 indicate the sample sizes associated with the treatment group and control group, respectively. A random effects model accompanied by a 95% confidence interval (CI) was used to generate the output, thus ensuring a comprehensive statistical evaluation. The use of Hedges' g was particularly beneficial in this study due to its increased effectiveness when dealing with issues related to small sample sizes, with the criterion that the sample size per group was greater than 10 and the sample size was not excessively small (Buck et al., 2022). The analysis produced a positive Hedges' g value ($P < 0.05$), indicating a significantly greater effect in the treatment group when compared to the control group (Posavac & Sinacore, 1984).

Next, moderator variables such school level will be examined, through subgroup meta-analysis in OpenMEE, using the Continuous Random Effects Model and Standard Mean Difference (SMD) metric. This methodological strategy aims to explain the impact of these variables on the magnitude of the intervention effect on outcome measures (Forrest et al., 2025). Subgroups consisting of fewer than two comparisons will be excluded from the meta-analysis, in accordance with established procedural guidelines (Ogbuwu & Mbajorgu, 2023).

To evaluate heterogeneity, the DerSimonian and Laird test (Q statistic) will be implemented, and the heterogeneity index (I^2) will be calculated, with a significance threshold set at $P < 0.05$ (Huedo-Medina et al., 2006; Langan et al., 2015). Heterogeneity will be classified into the following categories: no heterogeneity ($0 < I^2 \leq 25\%$), low heterogeneity ($25\% < I^2 \leq 50\%$), and moderate heterogeneity ($50\% < I^2 \leq 75\%$) and high ($I^2 > 75\%$) (White et al., 2024). To investigate publication bias, OpenMEE will use two analytical methodologies: the safe failure N method and forest plots. The investigation will combine the safe failure N method, which approximates the number of unpublished studies that produced insignificant results necessary to make the average effect size statistically insignificant (Rothstein, 2008).

Data were collected from various sources on different dates: on November 25, 2024, data was retrieved from Google Scholar using the keyword "game Arabic language" (66 documents); on December 17, 2024, using the keyword "game Arabic language experiment" (390 documents); on November 28, 2024, from the Scopus database using the keywords "game AND Arabic-language" (67 documents) and "gamification AND Arabic-language" (10 documents); and on December 8, 2024, using the keywords "game AND Arabic-language AND Experiment" (4 documents) and "gamification AND Arabic-language AND Experiment" (1 document). A total of 538 documents were retrieved, which were then filtered based on the publication year (2014 – 2024), document type (journal articles), language (English/Arabic), research design (experimental groups with N , Mean, and Standard Deviation), and educational level. Ultimately, 18 relevant studies were selected for analysis.

However, as shown in Table 3, from these 18 studies, 19 independent samples were identified for analysis. This discrepancy occurred because one study included multiple samples, as shown in (Al-Nawaisah, 2022). The remaining 18 studies each focused on a single language skill aspect.

C. RESULT & DISCUSSION

1. Summary of Included Studies

Table 1. Summary of Meta-Analysis Studies

No	Study	Ne	Nc	g	SE	School Level
1.	(Hamzah et al., 2019)	35	35	0,367893	0,239766	University
2.	(Ghani et al., 2022)	371	240	0,415839	0,083638	University
3.	(Eltahir et al., 2021)	54	53	2,007616	0,236831	University
4.	(Hejaili & Newbury, 2023)	25	25	0,700212	0,289352	Primary School
5.	(T. Alshammari, 2020)	28	30	0,233641	0,261908	Primary School
6.	(Aziz et al., 2018)	36	36	0,756415	0,242847	Junior High School
7.	(Bakry & Alsamadani, 2015)	12	12	5,363001	0,884038	University
8.	(Hakim, 2019)	22	22	4,272467	0,548181	University
9.	(Al-Mashaqbeh & Al Shurman, 2015)	42	42	1,074013	0,23262	Primary School
10.	(Al-Mashaqbeh & Neama, 2015)	60	60	1,778657	0,215377	Junior High School
11.	(Kadullah et al., 2023)	26	26	1,09195	0,295641	Junior High School
12.	(Ismail, 2018)	30	30	1,895915	0,310079	Junior High School
13.	(Hula et al., 2024)	20	20	1,427088	0,352117	Senior High School
14.	(Al-Nawaisah, 2022)1	19	20	0,088194	0,317236	Primary School
15.	(Al-Nawaisah, 2022)2	20	20	0,52817	0,318702	Primary School
16.	(Mutmainah et al., 2022)	20	19	-5726,84	655,1572	Junior High School
17.	(Nur et al., 2024)	14	14	0,779256	0,387124	Senior High School
18.	(Ubaidillah et al., 2024)	27	27	3,262052	0,415905	Junior High School
19.	(Mohammed et al., 2020)	15	15	-0,99394	0,382952	University

Table 1 presents the results of studies conducted across various school levels, including university, primary school, junior high school, and senior high school. Each entry records information about the number of participants in the experiment (Ne) and control group (Nc), the effect size (g), standard error (SE), and the school level where the research was conducted. Some studies show relatively high effect sizes, such as the one by (Bakry & Alsamadani, 2015) with a g value of 5.36, indicating a very large effect. On the other hand, there are studies with lower g values, such as (Al-Nawaisah, 2022), which reported a g of 0.088, indicating a smaller effect.

Most of the studies in table 1 were conducted at the university level, though several others were conducted in primary, junior high, and senior high schools. While some studies show significant and large effects, like the research by (Hejaili & Newbury, 2023) at the primary school level with a g of 0.70, there is also notable variability in the results. Some studies, such as (Mohammed et al., 2020; Mutmainah et al., 2022), report extremely negative g values, which may indicate anomalies or errors in data collection or analysis.

3. 2. Heterogeneity Test

Table 2. Heterogeneity Test

tau^2	Q(df=18)	Het. p-Value	I^2
1.073	301.282	<0.001	94.026

Table 2 presents the results of the heterogeneity test conducted in the meta-analysis. The tau-squared (τ^2) value is 1.073, indicating a significant degree of variability between the included studies. The Q-statistic with 41 degrees of freedom is 301.282, which is highly significant, as evidenced by the p-value (<0.001). This suggests that there is substantial heterogeneity across the studies, meaning that the effect sizes vary significantly from one study to another. The I^2 value of 94.026% further confirms the high level of heterogeneity, indicating that approximately 94% of the variability in the effect sizes is due to differences between the studies rather than sampling

error. These results highlight the need to consider study-specific factors when interpreting the overall effect in this meta-analysis.

3.3 Meta Analysis of Overall Included Studies

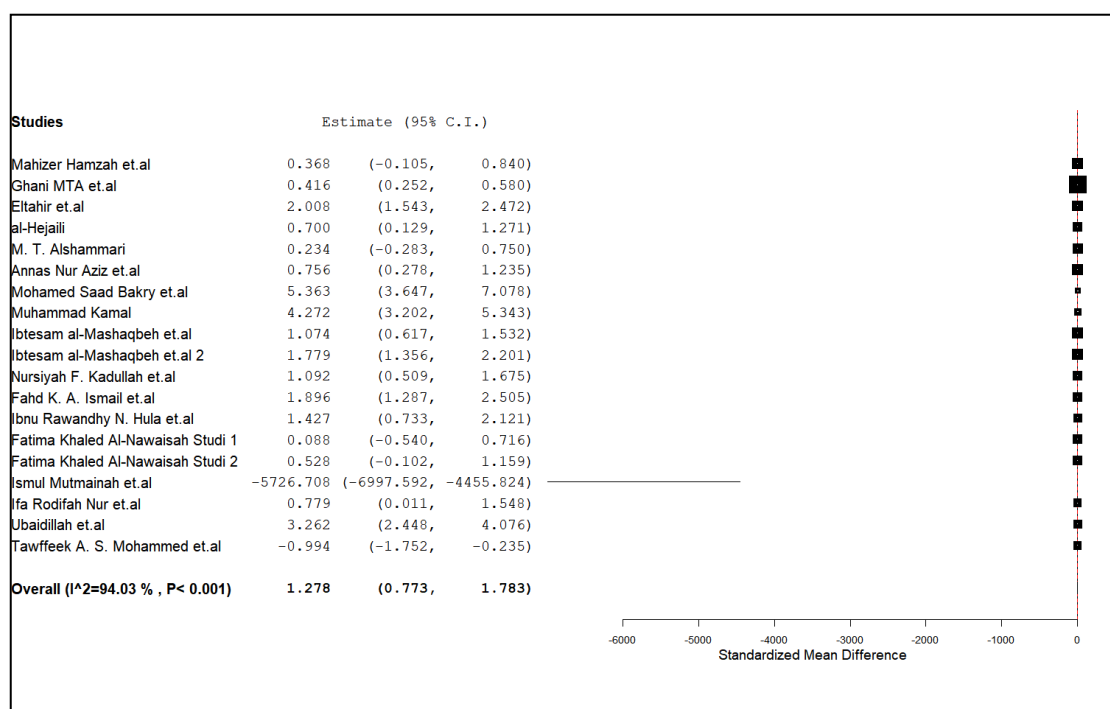


Figure 1. forest plot of overall included studies

Table 3. Meta-Analysis Result of Overall Included Study

Estimate	Lower Bound	Upper Bound	Std. Error	P-Value
1,278	0,773	1.783	0.258	< 0.001

The forest plot in figure 1 illustrates the standardized mean differences (SMD) and their 95% confidence intervals (C.I.) for various studies included in a meta-analysis. The studies are listed on the left, with their corresponding SMD estimates presented as point estimates along with the range of the confidence intervals. Most studies show positive SMD estimates, indicating a positive effect, though some studies, such as (Mutmainah et al., 2022), show a significantly negative SMD of -5726.84, which is an outlier in the data. The plot also includes an overall estimate of 1.278 (with a 95% C.I. ranging from 0.773 to 1.783), suggesting a moderate positive effect across all studies. The high I^2 value (94.03%) indicates substantial heterogeneity among the studies, with varying effect sizes, and the p-value (< 0.001) suggests the results are statistically significant.

Furthermore, table 3 presents the meta-analysis results for the overall studies included in the analysis. The estimate of the standardized mean difference (SMD) is 1.278, with a 95% confidence interval ranging from 0.773 to 1.783, indicating a moderate positive effect across all studies. The standard error of the estimate is 0.258, and the p-value is less than 0.001, suggesting that the overall effect is statistically significant. This result supports the conclusion that, on average, the intervention of digital games has a positive impact for arabic language acquisition across the included research.

3.4. The Analysis of Moderation Variables Based on School Level

Table 4. The Analysis of Moderation Variables Based on School Level

Studies	Estimate	Lower Bound	Upper Bound	Std. Error	p-Value
University	1.689	0.605	2.772	0.553	0.002

Primary School		0.549	0.182	0.916	0.187	0.003
Junior School	High	1.737	0.442	3.032	0.661	0.009
Senior School	High	1.125	0.492	1.758	0.323	<0.001
Overall		1.278	0.773	1.783	0.258	< 0.001

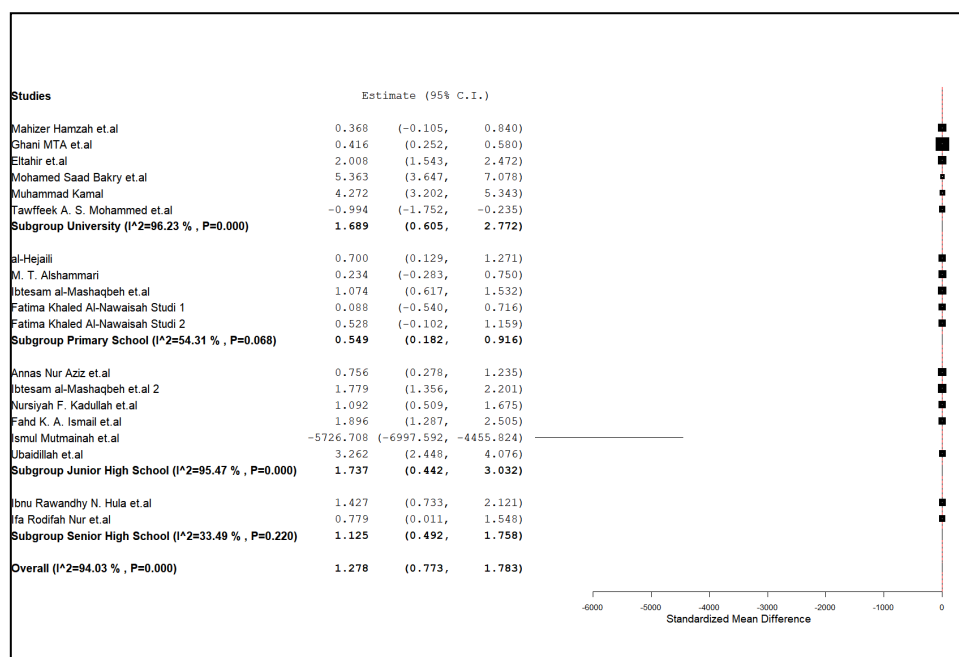


Figure 1. forest plot of the subgroup analysis based on school level

Table 4 presents the analysis of the moderating role based on educational level, exploring the impact of digital games on Arabic language acquisition at different educational stages, namely University, Primary School, Junior High School, and Senior High School. The moderation analysis based on school level was conducted to examine how the effectiveness of digital games in Arabic language learning differs across educational stages. The results indicate that digital games yield positive effects at all school levels, although the magnitude of these effects varies substantially.

At the junior high school level, the analysis reveals the highest effect size, with an estimate of 1.737 (CI 0.442–3.032; $p = 0.009$). Despite the considerable heterogeneity observed within this subgroup, these findings suggest that early adolescents benefit most from game-based learning. This may be attributed to their rapidly developing cognitive abilities and strong affinity for digital media, which enhances engagement and participation in learning activities.

The university subgroup also shows a notably large effect size of 1.689 (CI 0.605–2.772; $p = 0.002$). University students appear to respond positively to the integration of digital games, likely due to more advanced abstract reasoning skills and higher digital literacy. However, the substantial heterogeneity within this group indicates that contextual factors, such as instructional design, course format, and institutional environment, may differentially influence outcomes at the tertiary level.

For senior high school learners, the effect size is 1.125 (CI 0.492–1.758; $p < 0.001$), indicating a strong and statistically robust influence. The high level of significance in this subgroup suggests that students at this stage possess sufficient cognitive readiness to leverage game elements effectively for language comprehension and skill development. Furthermore, the relatively lower heterogeneity compared to other levels suggests greater consistency in how digital games are implemented in secondary education.

In contrast, the primary school subgroup demonstrates the smallest effect size at 0.549 (CI 0.182-

0.916; $p = 0.003$). While the results remain significant, the weaker effect suggests that younger learners require more structured guidance, simplified game mechanics, and additional teacher support when using digital games for Arabic language learning. Differences in early literacy skills, attention span, and technological familiarity may contribute to these more modest outcomes. Overall, the moderation analysis confirms that school level functions as a meaningful moderating variable, with the effectiveness of digital games increasing alongside learners' cognitive development and technological readiness. These findings highlight the importance of aligning game design, instructional strategies, and content complexity with the developmental characteristics of learners at each educational stage.

3.5. The Evaluation of Publication Bias

Table 5. The Evaluation of Publication Bias

Parameter	Value
Observed Significance Level	< 0.0001
Target Significance Level	0.05
Fail Safe-N	1416

Table 5 presents the evaluation of publication bias in the meta-analysis. The observed significance level is < 0.0001, which is significantly lower than the target significance level of 0.05, indicating a very low probability that the results are due to publication bias. This suggests that the findings are robust and not overly influenced by unpublished or missing studies. Additionally, the Fail-Safe N is 1416, meaning that 1416 studies with null results would need to be added to the analysis to nullify the overall effect, further supporting the reliability and strength of the observed results.

The results of this meta-analysis demonstrate a moderate and statistically significant overall effect of digital classrooms on Arabic language acquisition, as indicated by the pooled standardized mean difference (SMD) of 1.278. These findings are consistent with previous meta-analysis studies that highlight the positive impact of digital games environments on language acquisition, such as those conducted by (Chen et al., 2018; Dixon et al., 2022; Pasfield-Neofitou, 2014), which also found digital game based learning can enhance language learning outcomes. Furthermore, the high I^2 value (94.03%) suggests considerable heterogeneity across studies, emphasizing that while digital game based learning generally show a positive effect, the magnitude of the impact varies depending on factors such as the type of digital tools used, educational level, game type, gaming platform, and intervention duration (Wang et al., 2022). The statistically significant p-value (< 0.001) further confirms that the observed effects are not due to random chance, reinforcing the potential of digital classrooms to foster effective Arabic language learning across various educational contexts.

However, this study also highlights the variation in effectiveness across different educational levels. For instance, the most significant effect was found at the Senior High School level, with a highly significant effect size estimate of 1.125 ($p < 0.001$), indicating that older students benefit more from the use of digital games in language learning, as observed in the studies by (Amzalag et al., 2024; Tan, 2025). This finding aligns with previous research suggesting that high school students, due to their more advanced cognitive skills (Parr et al., 2024), may be better equipped to engage with and benefit from digital learning tools compared to younger learners, taking into account their environment and context (Katz et al., 2014).

These results also highlight the need to consider the diversity of educational levels when implementing digital classrooms. While the positive impact of digital games on language learning is evident, the variation in effects across educational stages suggests that strategies should be tailored to the developmental stages and cognitive abilities of learners, as emphasized by (Fajaruddin et al., 2024). For example, at the Senior High School level, where the impact is most pronounced, more advanced digital tools can be integrated into the curriculum. In contrast, for younger learners, the integration of digital games may need to be simplified and focused more on foundational language skills. This study contributes to the growing body of evidence supporting

digital classrooms in Arabic language acquisition and provides valuable insights into how educational context and age-related factors can influence the success of digital gamification interventions in Arabic language learning.

D. CONCLUSION

The results of this meta-analysis suggest that digital classrooms, particularly through the use of digital games, have a moderate and statistically significant positive effect on Arabic language acquisition across various educational levels. The forest plot analysis indicates that most studies show positive standardized mean differences (SMD), with an overall estimate of 1.278 ($p < 0.001$), confirming the effectiveness of digital tools in language learning. While there is substantial heterogeneity among the studies, the results reveal that digital classrooms have a notably strong impact, especially at the Junior High School level, where the effect size is 1.737 ($p = 0.009$). This suggests that older students benefit more from digital game-based learning, likely due to their advanced cognitive skills and familiarity with technology. The study also highlights the varying impacts across different school stages, reinforcing the need to tailor digital learning interventions to the developmental stage of the learners.

However, this study is not without limitations. The high level of heterogeneity ($I^2 = 94.03\%$) across the included studies suggests that the impact of digital classrooms on Arabic language acquisition is influenced by a variety of factors, including study design, digital tools used, and the specific context of each educational setting. Additionally, some included studies presented outlier data, which could have skewed the results. Despite these limitations, the findings contribute significantly to the understanding of digital classrooms' role in language acquisition. The study provides valuable insights into how educational level and context can influence the effectiveness of digital game-based learning, and offers recommendations for future research to explore these factors further.

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