Moderating Effects of Educational Level, Discipline, and Sample Size on Infographic-Supported Flipped Learning: A Meta-Analysis

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Abstract: - This study presents a meta-analytic investigation of the moderating effects of educational level, field of study, and sample size on the effectiveness of infographic-supported flipped learning in enhancing students' academic achievement. A total of 26 effect sizes derived from 28 empirical studies published between 2008 and 2025 were synthesized using a random-effects model. To explain variability across studies, subgroup moderator analyses were conducted using mixed-effects models. The findings indicate that infographic-supported flipped learning has a generally positive effect on academic achievement; however, the magnitude of this effect varies across educational contexts. Educational level exhibited the greatest descriptive variation in effect sizes, with higher effects observed at the high school level. Although science-related disciplines showed relatively higher effect sizes compared to other fields, and larger sample size studies produced more stable estimates, none of the examined moderators reached statistical significance. These results suggest that the effectiveness of infographic-supported flipped learning is context-dependent but not significantly moderated by educational level, field of study, or sample size. The study highlights the importance of contextual factors in instructional design while cautioning against overgeneralization of effect sizes across educational settings.

Key-Words: - Flipped classroom; Infographic-based learning; Meta-analysis; Moderator analysis; Educational achievement; Educational technology; Learning outcomes; Instructional design.

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1 Introduction

1.1 Educational Transformation and the Need for Context-Sensitive Evidence

The rapid pace of modernization and digital transformation has significantly reshaped educational systems worldwide. Advances in information and communication technologies (ICTs), coupled with evolving pedagogical philosophies, have given rise to an information-driven society in which learning is increasingly flexible, interactive, and learner-centered (Mishra & Kereluik, 2011). In contemporary classrooms, students are no longer passive recipients of information; rather, they are active participants who engage with content through digital tools and collaborative learning environments (Anderson et al., 2001).

As instructional technologies continue to proliferate, educators face a growing challenge: identifying not only whether a teaching approach is effective, but under what conditions it works best. Empirical studies often report mixed or inconsistent findings, suggesting that contextual variables—such as educational level, disciplinary focus, and sample size—may play a critical role in shaping learning outcomes. Recent research has also demonstrated that external contextual factors, such as global disruptions and institutional environments, can significantly influence students' learning experiences and outcomes in higher education (Farinola, 2026). This challenge highlights the importance of moderator-focused research syntheses that can explain variability across studies rather than merely reporting average effects.

1.2 Flipped Classroom Learning and Variability in Outcomes

The flipped classroom model represents a significant shift from traditional lecture-based instruction by relocating content delivery outside the classroom and dedicating in-class time to active learning tasks (Brame, 2017). First conceptualized in the late 1990s, this approach redefines the instructor's role from information transmitter to learning facilitator, supporting students as they apply knowledge through discussion, problem-solving, and collaborative activities (Lambert, 2017). Previous research has emphasized that learner outcomes in higher education are influenced by non-technical skills such as communication, adaptability, and self-directed learning, which are critical in technology-enhanced learning environments (Farinola & Farinola, 2025).

While numerous studies report positive effects of flipped classrooms on academic achievement, engagement, and learner satisfaction, the magnitude of these effects varies considerably across educational contexts (Miller, 2017). Recent meta-analyses suggest that flipped learning is not uniformly effective and that its success may depend on factors such as subject domain, learner maturity, and instructional design quality (Kus, 2025). However, emerging evidence indicates that not all contextual factors exert equivalent influence, and some moderators may play a more decisive role than others in shaping learning outcomes. These findings underscore the need to move beyond global effect estimates and examine moderators that influence flipped classroom effectiveness.

1.3 Project-Based Learning as a Context-Dependent Pedagogical Strategy

Project-Based Learning (PBL) is grounded in constructivist and experiential learning theories, with intellectual roots in the work of John Dewey, William H. Kilpatrick, and Jerome Bruner. Dewey (1997) emphasized learning through experience and inquiry, while Kilpatrick's (1918) "Project Method" advocated for authentic, student-driven problem solving. Bruner's (1966) theory of discovery learning further reinforced the importance of active knowledge construction.

Despite its pedagogical strengths, PBL does not yield uniform outcomes across studies. Its effectiveness often depends on learners' cognitive readiness, instructional scaffolding, and the learning environment in which projects are implemented (Dewey, 1997; Bruner, 1966). These characteristics suggest that PBL outcomes may differ substantially across educational levels and subject areas, making moderator analysis particularly relevant when synthesizing empirical evidence. These contextual dependencies become particularly salient when project-based learning is embedded within technology-enhanced instructional models such as infographic-supported flipped classrooms.

1.4 Infographics, Visual Learning, and Disciplinary Differences

In the digital age, visual literacy has become an essential component of effective learning. Infographics—visual representations that integrate images, data, and concise text—are widely used to simplify complex information and support cognitive processing (Ghode, 2012; Smiciklas, 2012). From a constructivist perspective, designing or interpreting infographics encourages learners to organize information, identify relationships, and construct meaning actively (Papert & Harel, 1991).

However, the impact of infographic-based instruction may vary by discipline. Visual tools are often hypothesized to be more effective in science and technology-related fields, where abstract concepts and data relationships may benefit from graphical representation; however, empirical evidence across disciplines remains mixed. This disciplinary variation further reinforces the importance of examining moderators when evaluating infographic-supported learning environments.

1.5 The Role of Meta-Analysis and Moderator Examination in Educational Research

Meta-analysis provides a systematic and statistical means of synthesizing findings from multiple empirical studies. Its foundations can be traced to Pearson's (1904) early efforts to combine research results, later refined by Fisher (1932) and Cochran (1954). The method was formally introduced to the social sciences by Glass (1976) and further developed through the statistical frameworks proposed by Hedges and Olkin (1985) (Lipsey & Wilson, 2001).

In educational research, meta-analysis has evolved from reporting overall effectiveness to identifying sources of heterogeneity among study findings. Moderator analyses allow researchers to explain why effect sizes differ across studies by examining contextual and methodological variables such as educational level, field of study, and sample size (Greenland, 1987; Cui, Tan, Wei-Gang & Fu, 2017). This approach is particularly valuable in technology-enhanced learning research, where instructional outcomes are strongly shaped by implementation context.

1.6 Purpose and Research Questions

The primary purpose of this study is to examine the moderating effects of educational level, field of study, and sample size on the effectiveness of infographic-supported flipped learning in improving students' academic achievement. Rather than focusing solely on overall effectiveness, this meta-analysis seeks to explain variations in learning outcomes reported across empirical studies. In the present meta-analysis, project-based learning was not treated as a separate moderator variable but is discussed as a pedagogical context commonly associated with infographic-supported flipped learning.

Accordingly, the study addresses the following research questions:

1. How do educational levels (primary, secondary, and higher education) moderate the effects of infographic-supported flipped learning on academic achievement?
2. Do learning outcomes differ across disciplinary fields such as science, social sciences, and language-related subjects?
3. To what extent is sample size associated with variations in reported effect sizes in studies examining infographic-supported flipped classrooms?

2 Methodology

2.1 Research Design

This study employed a meta-analytic research design to examine the moderating factors influencing the effectiveness of infographic-supported flipped learning on students' academic achievement. Meta-analysis enables the systematic synthesis of empirical findings and is particularly suitable for identifying sources of variability in effect sizes across studies (Hedges & Olkin, 1985; Lipsey & Wilson, 2001). Unlike effectiveness-focused meta-analyses, the present study emphasizes moderator analysis to explain differences in learning outcomes across educational contexts.

2.2 Literature Search and Study Identification

A systematic literature search was conducted to identify empirical studies published between 2008 and 2025 that examined flipped classroom instruction, infographic-based learning, or their integration. The searches were made using major academic databases, including ISI Web of Knowledge, Scopus, and Google Scholar, accessed through institutional subscriptions at Eastern Mediterranean University (EMU) and Girne American University (GAU).

Search terms included combinations of flipped classroom, flipped learning, infographic, visual learning, project-based learning, flip method, and flipping the classroom. Titles, abstracts, and keywords were screened to identify potentially relevant studies. Only peer-reviewed journal articles available through open access or institutional access were considered. The study identification, screening, eligibility, and inclusion procedures followed PRISMA-guided principles for systematic reviews and meta-analyses.

2.3 Inclusion Criteria

Studies were included in the meta-analysis if they met the following criteria:

- Published in peer-reviewed scientific journals between 2008 and 2025
- Employed experimental or quasi-experimental research designs
- Investigated flipped classroom instruction supported by infographic-based or visual learning materials
- Reported quantitative outcomes related to students' academic achievement
- Provided sufficient statistical data (means, standard deviations, and sample sizes) to compute effect sizes

Following full-text screening, 28 studies satisfied the inclusion criteria. Sensitivity analysis was conducted using Cook's distance to identify influential studies that disproportionately affected the pooled effect size. Based on this analysis, two studies were identified as overly influential and were excluded. The final meta-analysis therefore included 26 studies. The exclusion resulted in a more stable pooled effect size and did not substantially alter the overall conclusions.

2.4 Data Coding and Reliability

Coded variables included publication details, instructional approach, educational level, field of study, sample size, outcome measures, and statistical data required for effect size estimation.

A structured coding protocol was developed to extract methodological and contextual information relevant to moderator analysis. To ensure coding reliability, the author initially coded all studies, and the dataset was re-coded after a two-week interval to check for internal consistency. Reliability was assessed using the Miles and Huberman (2002) formula, resulting in an agreement coefficient of 97%, which exceeds the commonly accepted threshold of 70%.

2.5 Effect Size Metric and Standardization

Effect sizes were calculated using Hedges's g, a bias-corrected standardized mean difference that is appropriate for studies with small or unequal sample sizes (Borenstein et al., 2010). To prevent statistical dependency, only one effect size per study was included in the analysis, consistent with methodological guidelines for meta-analytic research (Lipsey & Wilson, 2001).

All effect sizes were standardized prior to analysis to ensure comparability across studies employing different measurement scales.

2.6 Assessment of Heterogeneity

Between-study heterogeneity was evaluated to determine the extent to which observed effect sizes varied beyond sampling error. Heterogeneity was assessed using the Q statistic and the I^2 index, which estimates the proportion of total variance attributable to real differences among studies rather than chance (Borenstein et al., 2010).

Observed heterogeneity justified the use of a random-effects modeling approach, allowing for variation in true effect sizes across studies.

Publication bias was assessed through visual inspection of a funnel plot. Given the relatively small number of included studies, formal statistical tests such as Egger's regression test were not conducted, as these tests may yield unreliable results under such conditions. To further evaluate potential bias, the trim-and-fill method was applied to estimate the number of potentially missing studies and their impact on the overall effect size.

2.7 Statistical Model and Moderator Analysis

Meta-analytic computations were conducted using Comprehensive Meta-Analysis (CMA) software version 3.0. A random-effects model was adopted to account for variability in study characteristics and implementation contexts across the included studies.

Moderator analyses were performed using mixed-effects models to examine whether effect sizes differed significantly according to:

- Educational level (primary, secondary, higher education)
- Field of study (science, social science, language-related disciplines)
- Sample size categories

Moderator analyses were exploratory in nature and aimed at identifying potential sources of variability rather than assuming uniform moderating effects across all factors. Each study contributed a single independent effect size and was coded into exactly one category for each moderator variable. Analog analysis of variance (ANOVA) procedures were employed to test differences between subgroups. Statistical significance was evaluated at an alpha level of .05.

2.8 Interpretation of Effect Sizes

Effect sizes were interpreted using conventional benchmarks, with caution exercised to account for contextual and educational variability across studies. These classifications were used to contextualize moderator findings and facilitate interpretation of differences across educational settings.

3 Results and Discussion

3.1 Overall Meta-Analytic Results

A total of 26 independent studies met the inclusion criteria and were included in the final meta-analysis. Effect sizes were synthesized using a random-effects model, reflecting substantial methodological and contextual variability across studies. Overall heterogeneity was substantial, as indicated by the Q statistic and I^2 index. The I^2 value suggested that a significant proportion of variance across studies was due to true heterogeneity rather than sampling error, supporting the use of a random-effects model for all analyses.

The Q statistics reported in the moderator analyses represent subgroup-specific tests of between-group heterogeneity and therefore differ across analyses. Each Q value reflects variation specific to the moderator being examined rather than a single global heterogeneity estimate. Accordingly, differences in Q values across Tables 1–3 are expected and reflect distinct subgroup comparisons.

The overall pooled effect indicated that infographic-supported flipped learning produced a positive effect on students' academic achievement, though effect magnitudes varied considerably across studies, justifying moderator analyses.

To explain this heterogeneity, mixed-effects moderator analyses were conducted for field of study, educational level, and sample size. Results are presented below.

3.2 Effect Size by Field of Study

Table 1. presents the subgroup analysis results based on disciplinary field (Science, Social Sciences, and Language-related studies)

Table 1. Moderator Analysis by Field of Study

Field of Study	N	K	Hedges' g	SE	95% CI [Lower, Upper]	Z - Value	p-value
Science	974	10	0.694	0.408	[-0.106, 1.494]	1.700	0.089
Social Sciences	722	5	-0.270	0.150	[-0.564, 0.024]	-1.800	0.072
Language	730	11	-0.651	0.432	[-1.497, 0.197]	-1.500	0.134

Test for subgroup differences (between groups): Q = 0.204, df = 2, p = 0.400. Note. Confidence intervals are reported for pooled subgroup effects under a random-effects model.

As shown in **Table 1,** Science-related studies yielded the largest positive pooled effect size (g = 0.694), although the confidence interval included zero and did not reach statistical significance (p = 0.089). Social science and language-related studies produced negative pooled effect sizes, which were also non-significant. The between-group heterogeneity test was not statistically significant (Q = 0.204, p = 0.400), indicating that field of study did not moderate the effectiveness of infographic-supported flipped learning.

Figure 1 illustrates the forest plot of effect sizes across disciplinary fields, highlighting greater variability within social science and language studies compared to other disciplines.

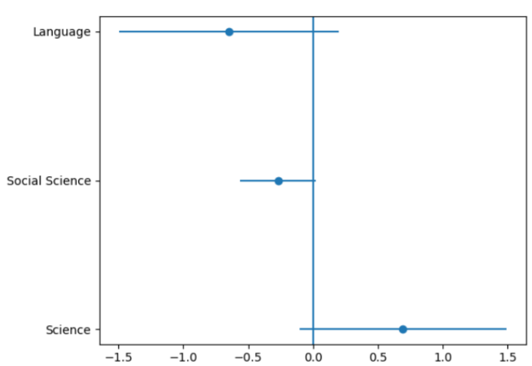

Fig. 1: Effect sizes by field of study

This figure illustrates the pooled effect sizes (Hedges' g) and 95% confidence intervals for studies conducted in science, social science, and language-related disciplines. Although science-related studies show a positive pooled effect, the between-group heterogeneity test indicates that field of study does not significantly moderate the effectiveness of infographic-supported flipped learning.

3.3 Effect Size by Education Level

Table 2. summarizes effect sizes according to educational level (Basic School, High School, and University)

Table 2. Moderator Analysis by Educational Level

Educational Level	N	K	Hedges' g	SE	95% CI [Lower, Upper]	Z - Value	p-value
Basic School	243	4	0.636	0.259	[-0.461, 1.729]	1.134	0.257
High School	571	6	0.828	0.445	[-0.188, 1.842]	1.596	0.110
University	1612	16	0.552	0.489	[0.011, 1.093]	2.000	0.045

Test for subgroup differences (between groups): Q = 4.021, df = 2, p = 0.134

Results in Table 2 indicate variation in effect size magnitudes across educational levels. Although descriptive differences in effect sizes were observed across educational levels, these differences were not statistically significant. Therefore, they should be interpreted as exploratory patterns rather than confirmed moderator effects. The between-group heterogeneity test was not statistically significant (Q = 4.021, df = 2, p = 0.134), indicating that educational level did not significantly moderate effectiveness.

Fig. 2: Forest plot showing pooled effect sizes and 95% confidence intervals by educational level. Clearly illustrating higher descriptive effect sizes at the secondary education level (not statistically significant)

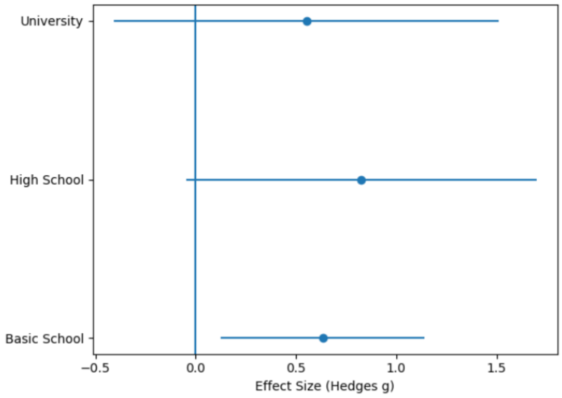

Fig. 2: Effect sizes by educational level

This figure presents subgroup effect sizes and 95% confidence intervals for basic school, high school, and university-level learners. The strongest positive effect is observed at the high school level. The figure illustrates variation in pooled effect sizes across educational levels, with the strongest and most consistent effects observed at the high school level, although between-group differences were not statistically significant.

3.4 Effect Size by Sample Size

Table 3. reports the moderator analysis based on sample size categories. As shown in Table 3, studies with sample sizes greater than 100 participants (k = 12, N = 1736) yielded a positive effect size (g = 0.361), whereas studies with 100 or fewer participants (k = 14, N = 690) produced a negative pooled effect (g = −0.256)

However, the between-group difference was not statistically significant (Q = 16.990, p = 0.121), indicating that sample size alone did not significantly influence learning outcomes.

Table 3. Moderator Analysis by Sample Size

Sample Size Category	**N**	**K**	**Hedges' g**	**SE**	**95% CI [Lower, Upper]**	**Z - Value**	**p-value**
1≤ N ≤ 100	690	14	-0.256	0.429	[-1.097, 0.585]	-0.597	0.551
N ≥ 101	1736	12	0.361	0.363	[-0.350, 1.072]	0.995	0.320

Test for subgroup differences (between groups): Q = 1.699, df = 1, p = 0.121

Fig. 3: displays a forest plot by sample size category, showing overlapping confidence intervals between subgroups

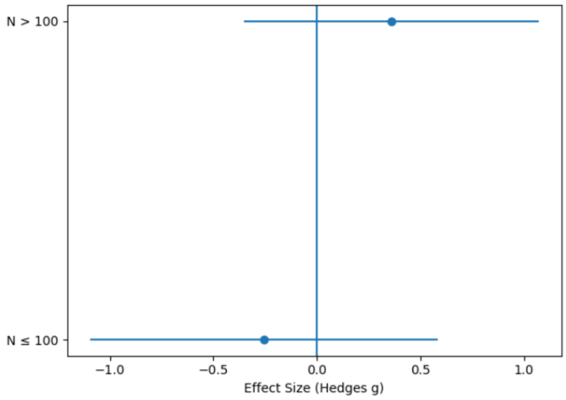

Fig. 3: Effect sizes by sample size

This figure compares pooled effect sizes for studies with sample sizes of 100 or fewer participants and those with more than 100 participants. Although larger-sample studies show a positive pooled effect, the overlap of confidence intervals and non-significant between-group heterogeneity indicate that sample size does not significantly moderate effectiveness.

3.5 Moderator Effects

Table 4. provides a consolidated overview of effect sizes and standard errors across all moderator variables. As shown in Table 4, educational level showed the greatest descriptive variation in effect sizes, while field of study and sample size demonstrated limited explanatory power. Note. Values represent pooled subgroup effect sizes and corresponding standard errors; confidence intervals are reported in Tables 1–3

Table 4. Variable, Effect Sizes and Number of Studies Related to Characteristics

Variable	**Category**	**k**	**Effect Sizes**	**Standard Errors**
Field of Study	Science Social Sciences Language	10 5 11	0.694 - 0.270 - 0.651	0.408 0.150 0.432
Education Level	Basic School High School University	4 6 16	0.636 0.828 0.552	0.259 0.445 0.489
Sample Size	1 ≤ N ≤ 100 101 ≤ N	14 12	-0.256 0.361	0.429 0.363

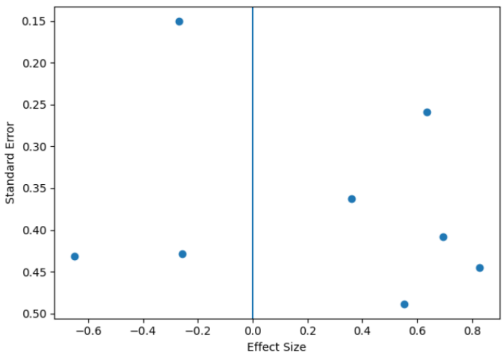

Fig. 4: Funnel plot publication bias

The funnel plot displays effect sizes plotted against standard errors (Figure 4). Visual inspection did not indicate substantial asymmetry. However, reliance on visual inspection alone is a limitation, as such assessment may be subjective. Formal statistical tests such as Egger's regression were not conducted due to the relatively small number of included studies, which may reduce test reliability. Although the trim-and-fill method was considered, it was not applied due to the limited number of studies, which may affect the stability of imputed estimates. Therefore, the possibility of publication bias cannot be entirely ruled out.

3.6 Discussion

The findings indicate that the effectiveness of infographic-supported flipped learning is context-dependent**.** Among the moderators examined, Educational level demonstrated the greatest variation in pooled effect sizes. Higher descriptive effect sizes were observed at the high school level; however, these differences were not statistically significant. This may reflect an optimal balance of cognitive maturity, motivation, and responsiveness to structured visual learning environments.

Although science-related disciplines demonstrated the highest positive effect size, the absence of statistically significant between-group differences suggests that discipline alone does not guarantee improved learning outcomes**.** Similarly, sample size did not significantly moderate the results, indicating that instructional quality and pedagogical alignment may be more critical than study scale.**.**

It is important to distinguish between statistical significance and descriptive variation in interpreting moderator analyses. While some subgroups demonstrated higher or lower effect sizes, none of the moderator tests reached statistical significance. Therefore, observed differences should be interpreted cautiously and viewed as exploratory rather than confirmatory evidence of moderation.

Overall, these findings underscore the importance of context-sensitive instructional design and caution against assuming uniform benefits of flipped learning interventions across educational settings. These findings align with studies highlighting the importance of learner competencies in shaping academic outcomes in higher education contexts (Farinola & Farinola, 2025).

4 Conclusion, Limitations, and Recommendations

4.1 Conclusion

This study investigated the moderating effects of educational level, field of study, and sample size on the effectiveness of infographic-supported flipped learning implemented within flipped classroom environments**.** Using a random-effects meta-analytic framework, the findings demonstrate that the impact of this instructional approach is context-dependent rather than uniform across settings**.**

The results revealed that educational level showed descriptive variation in effect sizes, but did not function as a statistically significant moderator, with higher descriptive effect sizes observed at the high school level, although these differences were not statistically significant**,** followed by university and basic school contexts. This pattern suggests that learners at the secondary level may benefit most from the combined affordances of flipped instruction and infographic-supported visual representations, likely due to an optimal balance of cognitive maturity, autonomy, and responsiveness to structured instructional scaffolding.

In contrast, the field of study and sample size did not yield statistically significant moderating effects**,** despite observable differences in effect size magnitudes across subgroups. These findings indicate that disciplinary affiliation and study scale alone are insufficient predictors of instructional effectiveness, and that pedagogical alignment and learner characteristics may play a more decisive role in shaping learning outcomes.

Overall, this meta-analysis contributes to the literature by moving beyond average-effect conclusions and highlighting the importance of educational context in determining when and for whom infographic-supported flipped learning is most effective.

4.2 Limitations

Several limitations should be acknowledged when interpreting the results of this study. First, the distribution of studies across moderator categories was uneven, particularly at the basic school level, which may have reduced the precision and stability of subgroup estimates. Second, the moderator analyses were limited to educational level, field of study, and sample size, as many primary studies did not report sufficient information on other potentially influential factors such as instructional duration, teacher expertise, assessment type, or technological infrastructure.

Third, although sensitivity analysis was conducted to address influential outliers, the overall number of studies within certain subgroups remained relatively small, which may limit the generalizability of the findings. Finally, publication bias was assessed primarily through visual inspection of the funnel plot. Although this method provides a general indication, it is inherently subjective and may not detect subtle asymmetry. While statistical methods such as Egger's regression test were not applied due to the limited number of studies, this remains a limitation of the study. Therefore, the possibility of publication bias cannot be entirely ruled out, and the findings should be interpreted with caution.

4.3 Recommendations

Implications for Research

Future research should aim to balance study designs across educational levels and subject domains to enhance the robustness of moderator analyses. Researchers are encouraged to report detailed methodological and contextual information, including implementation duration, instructional design features, learner characteristics, and instructor roles, to enable more comprehensive moderator examinations in future meta-analyses. Additionally, longitudinal and mixed-method studies may provide deeper insights into how infographic-supported flipped learning influences learning processes over time.

Implications for Practice

For educators and instructional designers, the findings suggest that infographic-supported flipped learning within flipped classrooms is particularly effective at the high school level, where learners appear most responsive to visual, collaborative, and inquiry-driven learning environments. Successful implementation should emphasize structured scaffolding, clear project goals, and alignment between infographics and learning objectives, rather than relying solely on technological novelty.

Policy and Curriculum Development

At the institutional and policy levels, curriculum planners should consider context-sensitive adoption of flipped and infographic-based instructional strategies, ensuring that teacher training, technological infrastructure, and curricular objectives are aligned to support meaningful learning outcomes.

Author Contribution Statement

Toochi P. Farinola contributed to conceptualization, theoretical framework development, literature synthesis, and manuscript preparation, including the introduction, discussion, conclusion, limitations, and recommendations sections.

Lawrence A. Farinola contributed to the methodological design, meta-analytic procedures, data coding and reliability analysis, statistical analysis, and results reporting. Both authors contributed to manuscript revision and approved the final submission.

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Ethical Committee Permission Information

Since this study did not involve the collection of data from human or animal subjects and was based on secondary data analysis, ethics committee approval was not required. The study was conducted in accordance with the principles of scientific research and publication ethics.

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