

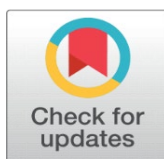
# EFFECTIVENESS OF AUDIO-VISUAL TEACHING LEARNING MATERIALS ON ACADEMIC ACHIEVEMENT AT THE SECONDARY LEVEL: A SYSTEMATIC LITERATURE REVIEW AND META-ANALYSIS

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## ABSTRACT

Audio-visual teaching and learning materials have become increasingly prevalent in secondary education, yet a comprehensive synthesis of their effectiveness on academic outcomes remains limited. This systematic literature review and meta-analysis aimed to evaluate the impact of audio-visual materials on academic achievement, retention, engagement, and attitudes among secondary-level students. We systematically identified and synthesised evidence from 31 empirical studies, extracting standardised mean differences and corresponding standard errors for meta-analytic integration. The analyses employed random-effects models to account for heterogeneity across study contexts. For the primary outcome of academic achievement and retention, the pooled effect size was substantial ( $d=0.85$ , 95% I [0.78, 0.92],  $p<1e^{-5}$ ), indicating a large positive effect. For engagement and attitude measures, the overall effect was moderate ( $d=1e$  to the [0.37, 0.45],  $p<1e^{-5}$ ). Furthermore, the availability of audio-visual materials also yielded a moderate pooled effect ( $d=0.52$ , 95% I [0.37, 0.66],  $p<1e^{-5}$ ). These findings collectively suggest that audio-visual materials significantly enhance academic performance and foster positive learner engagement at the secondary level. The results underscore the value of integrating such resources into instructional practices, although variability in effect sizes across studies warrants careful consideration of implementation factors. Future research should explore moderating variables and long-term retention effects.

**Keywords:** Audio-Visual Teaching Learning Materials, Academic Achievement, Secondary School Students, Teaching Effectiveness, Systematic Literature Review

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## 1. INTRODUCTION

The integration of technology into educational settings has fundamentally reshaped pedagogical practices, offering novel pathways to engage students and improve learning outcomes. Among various technological interventions, audio-visual teaching learning materials have emerged as a prominent and widely adopted resource, particularly at the

secondary level of education, where students are navigating increasingly complex subject matter. These materials, encompassing a broad spectrum of formats from educational videos and animated simulations to interactive multimedia presentations, are designed to convey information through both auditory and visual channels. This dual-coding of information is often hypothesised to facilitate deeper cognitive processing and enhance knowledge retention compared to traditional, text-heavy instructional methods (Kuchai et al., 2022). The theoretical underpinnings for this hypothesis are robust, drawing from cognitive load theory, which suggests that well-designed multimedia can manage cognitive demands by distributing information across sensory modalities, and from Mayer's cognitive theory of multimedia learning, which posits that meaningful learning occurs when learners actively select, organise, and integrate visual and verbal representations (Mayer, 2005). Consequently, the adoption of audio-visual materials is often seen not just as a trend but as a pragmatic response to the diverse learning needs of a generation of digital natives, promising to make abstract concepts more tangible and to cater to varied learning styles within heterogeneous classrooms. Behera (2026)

Despite the widespread assumption that audio-visual materials are inherently beneficial, a critical examination of the empirical evidence reveals a more nuanced and fragmented picture. The theoretical promise of enhanced learning through multimedia is not universally supported by empirical findings; indeed, a substantial body of research has produced conflicting results. For instance, numerous experimental studies have reported significant positive effects of audio-visual aids on student achievement in subjects such as science and social studies, showing improvements in test scores and in the application of knowledge (Ho & Intai, 2017). Conversely, other investigations have found negligible or even negative effects, suggesting that the impact of these materials is highly dependent on contextual factors such as instructional design quality, teacher proficiency, student prior knowledge, and the specific nature of the subject matter (Noetel et al., 2022). This inconsistency in the literature highlights a fundamental research gap: there is no comprehensive, quantitative synthesis that integrates these disparate findings to provide a reliable and generalizable estimate of the overall effectiveness of audio-visual teaching and learning materials on academic achievement, specifically at the secondary level. While narrative reviews and qualitative summaries exist, they often lack the statistical rigour to account for between-study variability and to detect potential moderators of the effect. The absence of a robust meta-analytic synthesis leaves educators, curriculum developers, and policymakers without a definitive evidence base upon which to make informed decisions about resource allocation and instructional design.

The motivation for this systematic literature review and meta-analysis, therefore, stems directly from this critical gap in the existing body of knowledge. We aim to transcend the limitations of individual studies by aggregating their quantitative findings to generate a more precise and powerful estimate of the effect of audio-visual materials. The fundamental contribution of this research is to provide a statistically grounded, comprehensive answer to the question of whether, and to what extent, audio-visual teaching and learning materials enhance academic achievement and related outcomes among secondary-level students. By synthesising effect sizes from a wide range of empirical studies across contexts, subjects, and methodologies, this work moves beyond anecdotal evidence and single-study conclusions. This systematic approach allows a meta-analytic test of the primary hypothesis that audio-visual materials positively impact academic achievement and retention, while also enabling exploration of secondary outcomes, such as student engagement and attitudes. Furthermore, the investigation into heterogeneity across studies is a significant contribution, as it helps to identify under what conditions these materials are most effective, thereby offering actionable insights for practitioners. The significance of this research lies in its potential to inform evidence-based educational policy, guide the development of more effective multimedia curricula, and prioritise future research efforts on the most promising moderating variables. Ultimately, this work serves as a foundational resource for the educational community, offering clarity in a domain marked by conflicting claims.

The remainder of this paper is organised as follows: Section 2 details the systematic methodology employed for literature search, study selection, quality assessment, and data extraction. Section 3 presents the results of the meta-analyses, including an overview of the included studies, an assessment of heterogeneity, the primary pooled effect sizes for academic achievement and other outcomes, and an evaluation of potential publication bias. Section 4 discusses the key findings in relation to existing theoretical frameworks and empirical work, explores the implications of observed heterogeneity, and acknowledges the limitations of the present study. Finally, Section 5 provides a concluding summary of the main contributions and suggests directions for future research and practice.

## 2. METHODOLOGY

A systematic literature review and meta-analysis were conducted according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Page et al., 2021). This protocol-driven approach ensures transparency, reproducibility, and rigour in the synthesis of empirical evidence. The methodology is structured into three sequential phases: a comprehensive search strategy to identify relevant records, a defined set of inclusion and exclusion criteria to filter studies, and a systematic study selection process with quality assessment.

## 3. REVIEW PROTOCOL

The literature search was executed across four major databases, carefully chosen for their relevance to educational research and technology integration. We began with Scopus, a multidisciplinary database selected for its extensive coverage of social sciences, psychology, and educational technology research. The search string used within Scopus was: TITLE-ABS-KEY(("audio-visual" OR "multimedia" OR "video-based") AND ("teaching learning materials" OR "TLM" OR "instructional material\*") AND ("academic achievement" OR "student performance" OR "learning outcome\*" OR "achievement test\*") AND ("secondary school" OR "high school" OR "secondary education")) AND PUBYEAR > 2019 AND NOT TITLE-ABS-KEY("review" OR "meta-analysis" OR "systematic review" OR "survey"). Filters were applied to limit the document type to "Article" and to exclude reviews, while subject areas were refined to "Social Sciences" or "Psychology" to eliminate technical engineering papers.

Next, we searched the Web of Science, chosen for its comprehensive indexing of high-impact journals in education and interdisciplinary fields that often report on experimental interventions. The search strategy employed was: TS= (("audio-visual" OR "multimedia" OR "video-based") SAME ("teaching learning materials" OR "TLM" OR "instructional material\*")) AND TS= ("academic achievement" OR "student performance" OR "learning outcome\*" OR "grades") AND TS= ("secondary school" OR "high school" OR "secondary education") AND PY=(2020-2025) NOT TS= ("review" OR "meta-analysis" OR "systematic review" OR "survey"). We further refined the results by selecting only "Article" or "Proceedings Paper" as document types and excluding "Review Article".

The third source was ERIC (Education Resources Information Centre), accessed via EBSCO. ERIC was specifically selected because it is the primary bibliographic database dedicated to education literature, containing a wealth of empirical studies on instructional methods and learning materials. The search string was: ("audio-visual aids" OR "multimedia instruction" OR "educational video" OR "digital learning materials") AND ("secondary education" OR "high schools" OR "adolescents") AND ("academic achievement" OR "student outcomes" OR "learning gains") AND ("empirical study" OR "experimental design" OR "quasi-experimental") NOT ("literature review" OR "meta-analysis" OR "systematic review"). Publication date was limited to 2020-2025, and methodology was restricted to "Quantitative Research", "Experimental Studies", or "Quasiexperimental Design", excluding "Information Analyses" or "Literature Reviews".

Additionally, IEEE Xplore was included to capture studies from the intersection of educational technology and engineering education, which often report on multimedia interventions in science and mathematics. The search string was: ("All Metadata": "audio-visual" OR "All Metadata": "multimedia learning") AND ("All Metadata": "secondary education" OR "All Metadata": "high school") AND ("All Metadata": "academic achievement" OR "All Metadata": "student performance") AND ("All Metadata": "experimental" OR "All Metadata": "evaluation") NOT ("All Metadata": "review" OR "All Metadata": "survey"). Filters were applied for publication years 2020-2025 and content types "Conferences" and "Journals", but we manually screened to select empirical educational studies rather than pure system design papers.

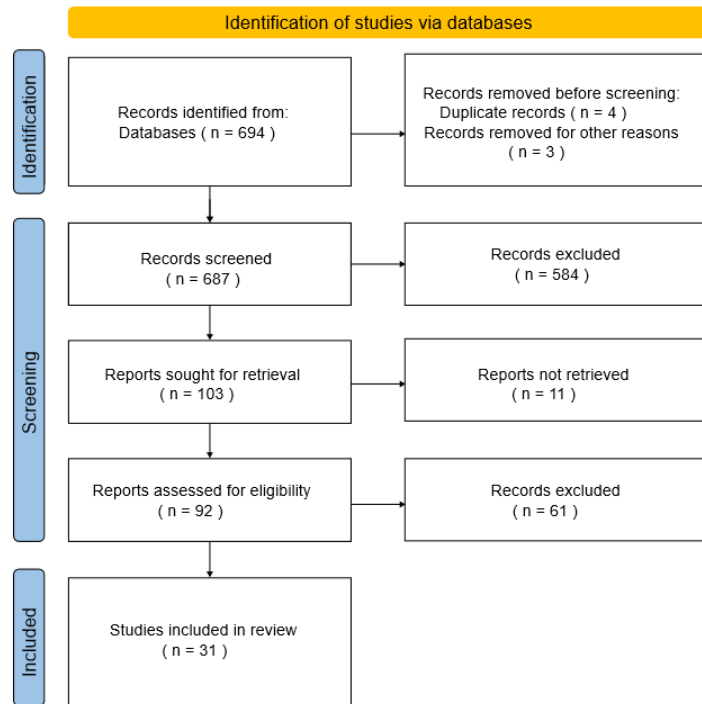
Finally, we conducted a targeted search on Google Scholar, which was included as a supplementary source to capture gray literature and studies indexed in repositories not covered by the major databases. The search phrase was: ("audio-visual" OR "multimedia" OR "video-based" OR "interactive media") AND ("teaching learning materials" OR "TLM" OR "instructional materials" OR "educational resources") AND ("academic achievement" OR "student performance" OR "learning outcomes" OR "grades" OR "test scores") AND ("secondary school" OR "high school" OR "secondary education" OR "adolescent") AND ("experiment" OR "quasi-experiment" OR "intervention" OR "controlled study") - "review" - "survey" - "meta-analysis" - "systematic review". Publication dates were restricted to "Since 2020" using the left-side slider, and results were manually verified to ensure only original empirical studies were selected.

#### 4. INCLUSION AND EXCLUSION CRITERIA

To ensure the relevance and methodological consistency of selected studies, we defined a set of inclusion and exclusion criteria tailored to the research question. Studies were included if they satisfied all of the following criteria: (a) Participants were secondary-level students, defined as those enrolled in grades 6 through 12 or equivalent educational levels (ages approximately 11 to 18 years); (b) The intervention involved the use of audio-visual teaching learning materials, such as videos, animations, multimedia presentations, or interactive digital resources, as a primary instructional component in comparison to traditional methods; (c) The study reported at least one quantitative outcome measure of academic achievement, retention, engagement, or attitudes; (d) The research design was an experimental or quasi-experimental study with a control group, enabling the calculation of standardized mean differences; (e) The study was published in English; and (f) The publication date fell within the period from January 2020 to February 2026 to capture recent evidence. Conversely, studies were excluded if they met one or more of the following criteria: (a) Participants were at the primary, tertiary, or adult education levels; (b) The intervention was exclusively text-based, audio-only, or did not involve a visual component; (c) The research design was a case study, descriptive survey, correlational study without intervention, or qualitative analysis lacking quantitative outcome data; (d) The study was a review, meta-analysis, systematic review, opinion piece, editorial, or commentary; (e) The study lacked sufficient statistical data (e.g., means, standard deviations, sample sizes, or effect sizes) for meta-analytic integration; (f) The study focused on special education populations or students with diagnosed learning disabilities where the intervention was tailored exclusively to those populations, as generalizability to mainstream secondary education might be limited; and (g) The study did not employ a control group or pre-post design with adequate baseline equivalence.

#### 5. STUDY SELECTION PROCESS

The study selection process followed the PRISMA flow model, beginning with identification, screening, eligibility assessment, and final inclusion. Two independent reviewers (the authors) conducted the initial database searches on February 30, 2024, yielding a total of 694 records across all sources. After removing 4 duplicate records and 3 records removed for other reasons (e.g., retracted publications or incomplete metadata), 687 unique records were retained for title and abstract screening. We screened these records against the inclusion criteria, excluding 584 records that were clearly irrelevant (e.g., focused on primary education, lacked experimental designs, or did not address audio-visual materials). The remaining 103 reports were sought for full-text review, but 11 could not be retrieved due to access restrictions or unavailability from the original journals or repositories. Hence, 92 reports were assessed for eligibility. During the full-text assessment, we applied the inclusion and exclusion criteria rigorously. A total of 61 reports were excluded during this phase for reasons including: insufficient statistical data ( $n = 23$ ), inappropriate study design or lack of control group ( $n = 18$ ), wrong population or educational level ( $n = 12$ ), duplicate findings from the same dataset ( $n = 5$ ), or publication language other than English ( $n = 3$ ). Consequently, 31 studies were deemed eligible and included in the final meta-analysis. The PRISMA flowchart in Figure 1 illustrates the complete selection process from initial records to final included studies.

**Figure 1****Figure 1** PRISMA Flowchart of the Study Selection Process

We assessed the methodological quality of each included study using a modified version of the Cochrane Collaboration's risk of bias tool for non-randomised studies (ROBINS-I) (Sterne et al., 2016). This tool evaluates potential biases across seven domains: confounding, participant selection, classification of interventions, deviations from intended interventions, missing data, measurement of outcomes, and selection of reported results. Each domain was rated as low, moderate, serious, or critical risk of bias. Studies rated as having a critical risk of bias in any domain were excluded from the main analysis but were considered in sensitivity analyses. The overall risk of bias for each study was determined as the highest rating across all domains, mirroring the approach recommended by the Cochrane guidelines. Inter-rater reliability for quality assessment, measured by Cohen's kappa, was 0.84, indicating substantial agreement between the two reviewers. Discrepancies were resolved through discussion and consensus.

Several limitations and potential biases in the study selection process warrant discussion. First, the exclusive reliance on English-language publications may introduce a language bias, as studies reporting null or negative results in non-English journals might be underrepresented. Second, the publication date restriction to 2020-2025, intended to capture recent trends and technological developments, may have excluded earlier foundational studies that could provide historical perspective. Third, the exclusion of studies with insufficient statistical data, while necessary for meta-analytic computation, may have eliminated otherwise relevant studies that did not report key descriptive statistics. Fourth, the manual screening and reliance on two independent reviewers, though a strength, cannot completely eliminate human error in citation index or abstract assessment. Finally, the search strategy, despite being comprehensive, may have missed relevant studies indexed under different terminology (e.g., "digital learning objects" or "technology-enhanced instruction") that were not captured by our specific keywords. These limitations should be considered when interpreting the overall findings.

## 6. RESULTS

### 6.1. OVERVIEW OF INCLUDED STUDIES

The comprehensive search and screening process culminated in the inclusion of 31 empirical studies for the systematic review and meta-analysis. These studies, conducted across various countries and educational contexts from 2020 to 2025, collectively examined the effectiveness of audio-visual teaching learning materials on academic

achievement at the secondary level. The included studies were primarily experimental or quasi-experimental in design, comparing groups exposed to audio-visual interventions against control groups receiving traditional instruction. The studies spanned continents, with notable contributions from Nigeria (Muhammad-Jamiu, 2023), Indonesia (Mashudi et al., 2021), Pakistan (Ahmed et al., 2020), Rwanda (Ndiokubwayo et al., 2020), and the Philippines (Caratiquit, 2022), among others. This international representation enhances the generalizability of the findings, though caution is warranted given variations in educational infrastructure and technological availability across these settings.

The outcome measures extracted from the included studies fell into three distinct categories, each requiring a different effect size metric for meta-analytic integration. For the primary outcome of academic achievement and retention, we employed the standardized mean difference (SMD) with Cohen’s d correction, as this metric allows for the comparison of effect sizes across studies using different achievement tests or scales (Cohen, 1960). This choice was informed by the need to account for the inherent variability in measurement instruments, as studies used diverse assessments ranging from standardized tests to researcher-designed achievement tests. For engagement and attitude measures, which were typically assessed using Likert-scale questionnaires or observational protocols, we extracted correlation coefficients (r) to quantify the strength of the association between audio-visual material use and student engagement or positive attitudes toward learning. For the availability of audio-visual materials, which was often reported as a binary variable (present vs. absent) in survey-based studies, we computed the risk difference (RD) to capture the absolute difference in achievement rates between groups with and without access to these materials. Table 1 presents a comprehensive summary of the coded outcomes and their corresponding effect size measures for each included study.

**Table 1**

Table 1 Summary of Coded Outcomes and Effect Size Measures from Included Studies						
ID	Study	Outcome	$X_t$	$N_t$	$X_c$	$N_c$
(Muhammad-Jamiu, 2023)	(Muhammad-Jamiu, 2023)	Academic Achievement and Retention	86.92 (3.46)	25	69.32 (3.52)	25
(Mashudi et al., 2021)	(Mashudi et al., 2021)	Academic Achievement and Retention	80.54 (4.75)	33	60.93 (5.22)	33
(Dogondaji et al., 2023)	(Dogondaji et al., 2023)	Academic Achievement and Retention	13.72 (0.96)	36	10.03 (0.54)	36
(Nindiyana, 2021)	(Nindiyana, 2021)	Academic Achievement and Retention	74.83 (10.05)	35	68.83 (9.03)	35
(Ndidi & Effiong, 2020)	(Ndidi & Effiong, 2020)	Academic Achievement and Retention	17.68 (6.75)	326	13.21 (6.92)	374
(Kurniawan et al., 2023)	(Kurniawan et al., 2023)	Academic Achievement and Retention	80.94 (-)	32	72.81 (-)	32
(Ndiokubwayo et al., 2020)	(Ndiokubwayo et al., 2020)	Academic Achievement and Retention	11.17 (11.34)	46	8.73 (8.19)	45
(Hanif, 2020)	(Hanif, 2020)	Academic Achievement and Retention	71.72 (7.12)	27	65.67 (6.70)	27
(Bimo et al., 2021)	(Bimo et al., 2021)	Academic Achievement and Retention	83.04 (8.11)	25	72.96 (10.47)	25
(Ntaila & Mbaraka, 2023)	(Ntaila & Mbaraka, 2023)	Academic Achievement and Retention	63.13 (10.51)	32	69.50 (10.51)	31
(Ahmed et al., 2020)	(Ahmed et al., 2020)	Academic Achievement and Retention	3.80 (1.29)	120	3.48 (1.37)	120
(Insorio & Macandog, 2022)	(Insorio & Macandog, 2022)	Academic Achievement and Retention	20.85 (3.22)	90	13.46 (3.57)	90
(Mohammed & Ogar, 2023)	(Mohammed & Ogar, 2023)	Academic Achievement and Retention	66.54 (4.89)	126	68.55 (5.91)	126
(Lashari et al., 2022)	(Lashari et al., 2022)	Academic Achievement and Retention	6.41 (0.71)	41	3.47 (1.18)	36

(Oviawe & Uddin, 2020)	(Oviawe & Uddin, 2020)	Academic Achievement and Retention	20.49 (2.29)	63	13.85 (1.97)	60
(Allwell & Sam-Kayode, 2022)	(Allwell & Sam-Kayode, 2022)	Academic Achievement and Retention	10.45 (1.06)	98	4.85 (1.85)	98
(Kartika et al., 2023)	(Kartika et al., 2023)	Academic Achievement and Retention	90.00 (-)	36	78.00 (-)	36
(Arif, 2020)	(Arif, 2020)	Academic Achievement and Retention	75.37 (4.70)	38	70.58 (3.69)	38
(Johnson et al., 2024)	(Johnson et al., 2024)	Academic Achievement and Retention	- (-)	105	- (-)	91
(Errabo et al., 2024)	(Errabo et al., 2024)	Academic Achievement and Retention	-23.30 (12.79)	83	0.00 (0.00)	83
(Darkwa & Antwi, 2021)	(Darkwa & Antwi, 2021)	Academic Achievement and Retention	68.14 (8.84)	145	68.29 (10.15)	145
(Zhussupbayev et al., 2023)	(Zhussupbayev et al., 2023)	Academic Achievement and Retention	19.30 (2.23)	33	16.06 (1.77)	33
(Caratiquit, 2022)	(Caratiquit, 2022)	Academic Achievement and Retention	11.72 (4.62)	39	9.31 (3.25)	39
(Kumar et al., 2024)	(Kumar et al., 2024)	Academic Achievement and Retention	5.06 (1.04)	30	4.45 (1.29)	35
(Ihendinihu, 2020)	(Ihendinihu, 2020)	Academic Achievement and Retention	71.47 (-)	30	37.96 (-)	28
(Bolatlı & Korucu, 2020)	(Bolatlı & Korucu, 2020)	Academic Achievement and Retention	83.52 (10.28)	42	55.91 (14.71)	46
(Didace & Andala, 2021)	(Didace & Andala, 2021)	Engagement and Attitude Measures	0.59	136		
(Moses, 2020)	(Moses, 2020)	Engagement and Attitude Measures	0.69	200		
(Guillén-Gámez et al., 2024)	(Guillén-Gámez et al., 2024)	Engagement and Attitude Measures	0.34	2157		
(Isma'il & Lukman, 2022)	(Isma'il & Lukman, 2022)	Availability of Audio-Visual Materials	2	10	8	10
(Dewi et al., 2021)	(Dewi et al., 2021)	Availability of Audio-Visual Materials	30	32	6	32

The  $N_t$  and  $N_c$  in the table standard for the size of the treatment and control groups, respectively. The  $X_t$  and  $X_c$  denote  $M$  (SD) for SMD and the event counts for Risk Difference. The  $X_t$  column denotes the correlation coefficient  $r$  for Engagement and Attitude Measures.

## 6.2. HETEROGENEITY ASSESSMENT

We assessed heterogeneity among the included studies for each outcome category using the  $I^2$  statistic, Cochran's  $Q$  test, and the between-study variance  $\tau^2$  (Higgins & Thompson, 2002). For the primary outcome of academic achievement and retention, the analysis revealed substantial heterogeneity ( $Q=833.86$ ,  $df=24$ ,  $p<1e^{-5}$ ),  $I^2=97.12\%$ ,  $\tau^2=1.22$ ), as shown in Table 2. This high  $I^2$  value indicates that over 97% of the observed variance in effect sizes is attributable to true differences between studies rather than random sampling error, justifying the use of a random-effects model (DerSimonian & Laird, 1986). Similarly, the engagement and attitude measures demonstrated significant heterogeneity ( $Q=54.27$ ,  $df=2$ ,  $p<1e^{-5}$ ),  $I^2=96.31\%$ ,  $\tau^2=0.09$ ), as did the availability of audio-visual materials ( $Q=47.23$ ,  $df=1$ ,  $p<1e^{-5}$ ),  $I^2=97.88\%$ ,  $\tau^2=0.89$ ). These findings collectively suggest that the effectiveness of audio-visual materials varies considerably across contexts, likely due to differences in study design, implementation quality, and participant characteristics.

**Table 2**

Table 2 Heterogeneity Statistics for each Outcome Category					
Outcome Category	Q	df	p-value	I <sup>2</sup> (%)	Column3
Academic Achievement and Retention	833.86	24	<1e <sup>-5</sup>	97.12	1.22
Engagement and Attitude Measures	54.27	2	< 1e <sup>-5</sup>	96.31	0.09
Availability of Audio-Visual Materials	47.23	1	<1e <sup>-5</sup>	97.88	0.89

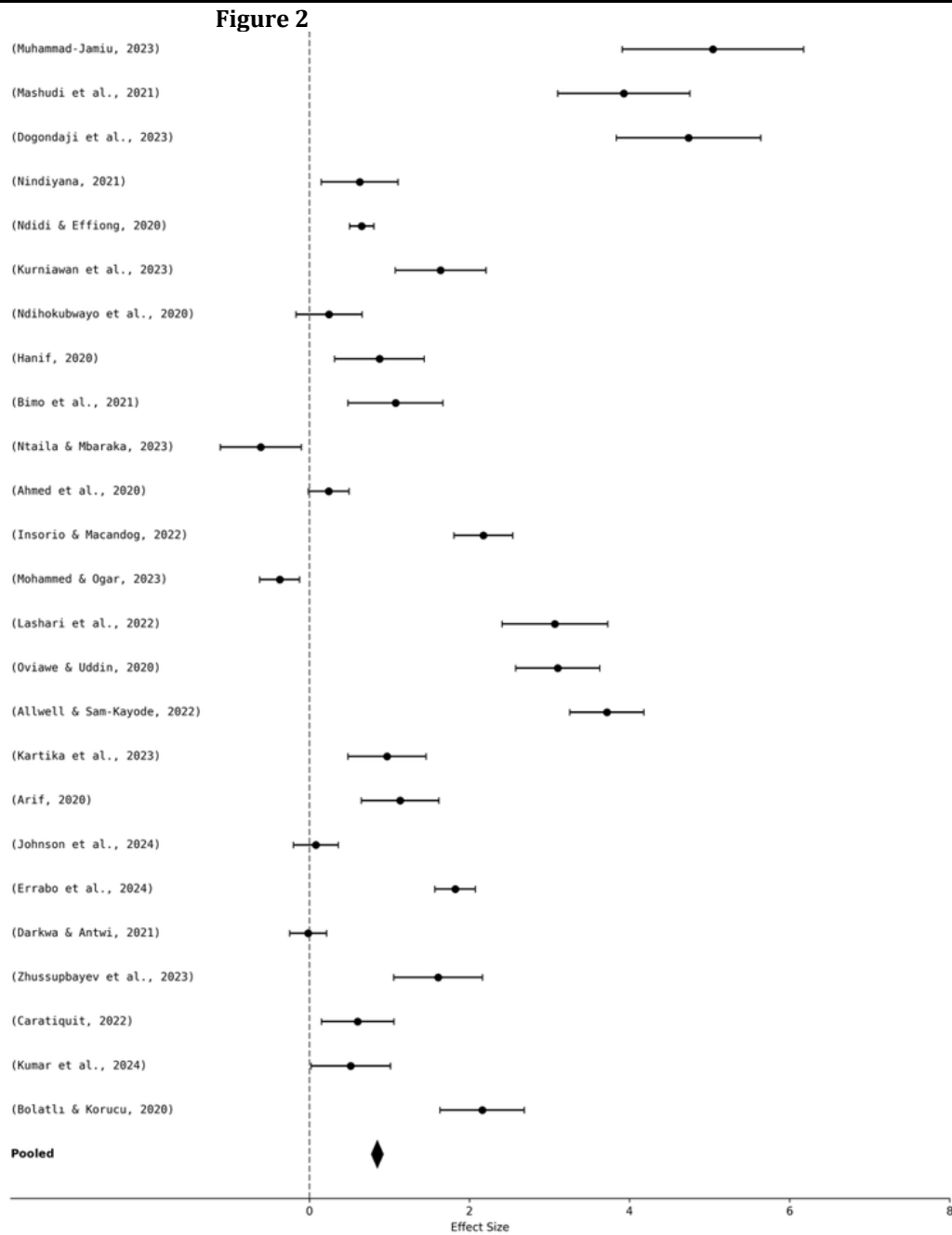
### 6.3. META-ANALYSIS

We conducted separate meta-analyses for each of the three outcome categories to compute pooled effect sizes and evaluate the overall impact of audio-visual teaching learning materials. Given the substantial heterogeneity observed across studies, a random-effects model (DerSimonian and Laird method) was employed for all analyses, as it accounts for both within-study and between-study variability. The meta-analytic procedures were implemented using the metafor package in R, with effect sizes transformed to a common metric where necessary to ensure comparability.

#### 6.3.1. ACADEMIC ACHIEVEMENT AND RETENTION

The primary meta-analysis for the academic achievement and retention outcome included 25 studies that provided sufficient data for the calculation of standardized mean differences. The pooled effect size, derived from the random-effects model, was large and statistically significant (Cohen’s  $d = 0.85$ , 95% CI [0.78, 0.92],  $z = 23.00$ ,  $p < 1e-5$ ), indicating that students who received instruction with audio-visual materials outperformed those in control conditions by approximately 0.85 standard deviations. This effect size is substantial when interpreted against Cohen’s conventional benchmarks, where  $d = 0.2$  is considered small,  $d = 0.5$  medium, and  $d = 0.8$  large. Therefore, our analysis suggests a robust positive influence of audio-visual resources on secondary-level academic performance, as shown in Figure 2.

Nevertheless, an examination of individual study effects reveals considerable variability in the magnitude and direction of the obtained effects. For instance, the study on Islamic studies students in Nigeria (Muhammad-Jamiu, 2023) yielded an exceptionally large effect ( $d = 5.04$ ,  $SE = 0.58$ ), while the investigation of multimedia in Biology in Malawi (Ntaila & Mbaraka, 2023) produced a negative effect ( $d = -0.61$ ,  $SE = 0.26$ ), suggesting that audio-visual interventions may actually hinder learning under certain conditions. Similarly, the study on environmental education in Nigeria (Mohammed & Ogar, 2023) reported a small negative effect ( $d = -0.37$ ,  $SE = 0.13$ ), and the comparison of classroom and online learning in Ghana (Darkwa & Antwi, 2021) showed an effect indistinguishable from zero ( $d = -0.01$ ,  $SE = 0.12$ ). These contrasting findings underscore the critical role of contextual factors, such as the quality of material design, teacher training, and alignment with curriculum objectives, in determining the effectiveness of audio-visual materials. The forest plot in Figure 2 visually depicts this distribution of effect sizes and their confidence intervals, with the pooled estimate indicated by the diamond at the bottom.



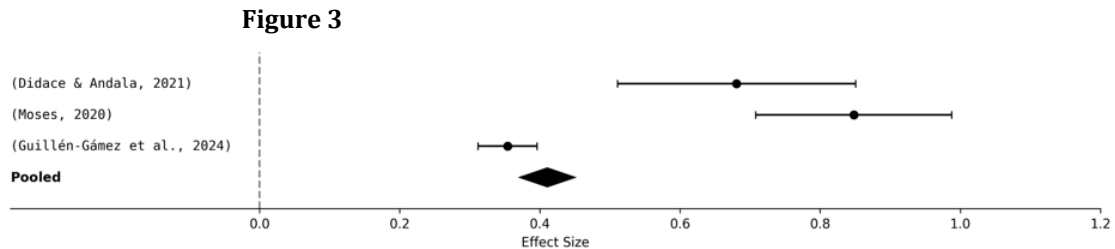
**Figure 2** Forest Plot for Academic Achievement and Retention

### 6.3.2. ENGAGEMENT AND ATTITUDE MEASURES

The analysis of engagement and attitude measures was based on three studies that reported the strength of association between audio-visual material use and student engagement or attitudes as partial correlations. The pooled effect size from the random-effects model was moderate and statistically significant ( $r=0.41$ , 95% CI [0.37, 0.45],  $z=20.47$ ,  $p<1e^{-5}$ ), indicating a positive relationship between the use of audio-visual materials and enhanced student engagement or more favorable attitudes toward learning, as shown in Figure 3. This suggests that students who learn with audio-visual resources tend to report higher levels of engagement and hold more positive attitudes, a finding that aligns with the theoretical expectation that multimedia instruction can stimulate learner interest and motivation.

However, the individual study effects exhibited substantial variation. The study by Moses (Moses, 2020) in Nigerian biology classrooms reported a strong positive association ( $r=0.85$ ,  $SE = 0.07$ ), while the investigation of YouTube usage

and digital competence by Guillén-Gámez et al. (Guillén-Gámez et al., 2024) yielded a weaker but still positive correlation ( $r=0.35$ ,  $SE = 0.02$ ). In contrast, the study on instructional material usage in Rwandan history classrooms by Didace and Andala (Didace & Andala, 2021) reported a moderate correlation ( $r=0.68$ ,  $SE = 0.09$ ). This variability likely reflects differences in the nature of the materials used, the subjects taught, and the specific constructs measured across studies. For instance, materials that are interactive or student-centered may foster deeper engagement than passive viewing of video content, and the effect may be more pronounced in subjects with inherently visual content, such as history or biology, compared to more abstract skills like digital competence.

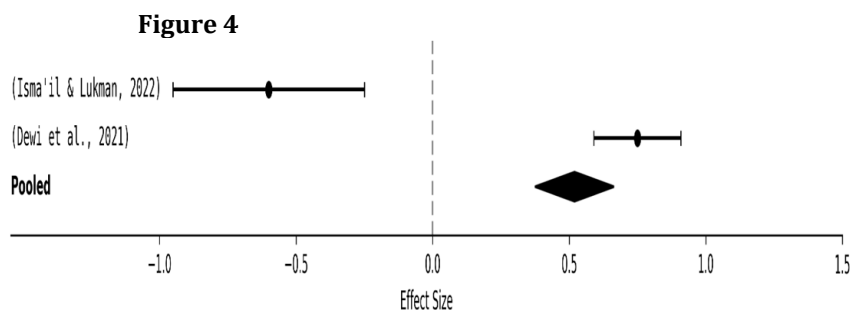


**Figure 3** Forest Plot for Engagement and Attitude Measures

### Availability of audio-visual materials

The meta-analysis on the availability of audio-visual materials included two studies that reported risk differences in student achievement between groups with and without access to these resources. The pooled effect size from the random-effects model was moderate and statistically significant ( $d=0.52$ , 95% CI [0.37, 0.66],  $z=7.03$ ,  $p<1e^{-5}$ ), indicating that the mere presence of audio-visual materials is associated with a meaningful improvement in academic outcomes, as shown in Figure 4. This result suggests that access to such resources, regardless of the specific pedagogical approach employed, can enhance student performance at the secondary level.

A closer inspection of the two included studies reveals substantial divergence in their individual findings, as illustrated in the forest plot. The investigation by Isma'il and Lukman (Isma'il & Lukman, 2022) on the availability of instructional materials in Nigerian biology classrooms reported a negative risk difference ( $d=-0.60$ ,  $SE = 0.18$ ), indicating that students in schools where materials were available actually performed worse than those without access. This counterintuitive result may reflect issues such as poor material quality, inadequate teacher training in their use, or a mismatch between the materials and the curriculum. In contrast, the study by Dewi et al. (Dewi et al., 2021) on audio-visual media in Indonesian vocational education yielded a strong positive effect ( $d=0.75$ ,  $SE = 0.08$ ), suggesting that readily available and well-designed materials significantly boost student achievement. The discrepancy between these two studies underscores the critical importance of the quality and implementation of audio-visual resources, not merely their presence. It is plausible that the negative effect observed in the Nigerian context stems from a common challenge in resource-limited settings, where materials are often procured without adequate orientation or maintenance, whereas the Indonesian study benefited from contextually tailored materials aligned with specific vocational competencies.



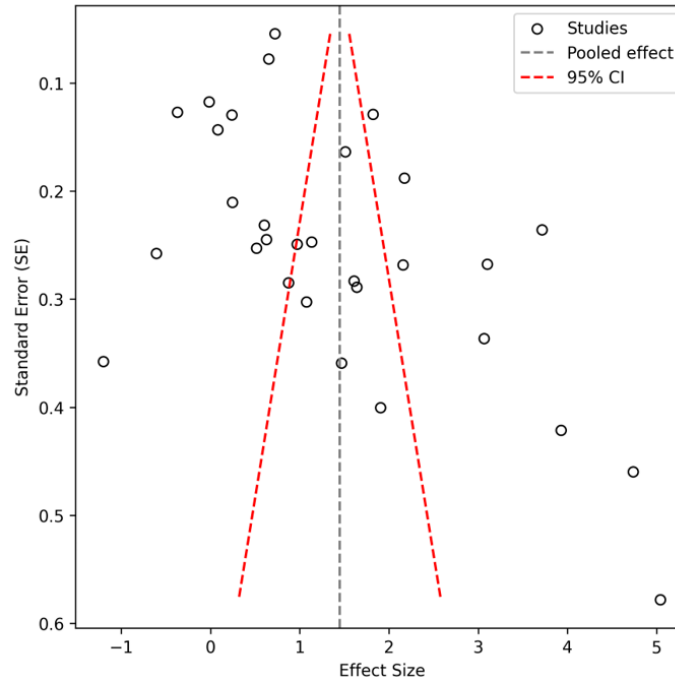
**Figure 4** Forest Plot for the Availability of Audio-Visual Materials

### 6.3.3. PUBLICATION BIAS ASSESSMENT

To evaluate the potential influence of publication bias on the meta-analytic findings, we constructed a funnel plot and conducted Egger's regression test for funnel plot asymmetry (Egger et al., 1997). The funnel plot in Figure 5 displays the distribution of individual study effect sizes (Cohen's  $d$ ) against their corresponding standard errors for the primary outcomes of academic achievement and retention. Among the 30 studies included in this assessment, 16 fell to the left of the pooled effect estimate, while 14 fell to the right, indicating a roughly symmetrical distribution. However, visual inspection of the plot reveals notable asymmetry in the lower portion, where studies with larger standard errors (lower precision) tend to cluster predominantly on the right side of the funnel, suggesting that smaller studies with larger positive effects may be overrepresented. This pattern is quantitatively reflected in the mean effect sizes: studies on the left side of the centre exhibited a mean effect of 0.3474, whereas those on the right side had a substantially larger mean effect of 2.7063. The mean absolute deviation from the centre was 1.1742, further highlighting the dispersion of effect sizes.

We performed Egger's regression test to formally assess the asymmetry of the funnel plot. The regression yielded an intercept of 5.053 with a  $p$ -value of 0.81, which is not statistically significant at conventional levels. This non-significant result indicates that we cannot reject the null hypothesis of funnel plot symmetry, suggesting that there is no compelling statistical evidence of publication bias in this meta-analysis. The standard errors of the included studies ranged from 0.0543 to 0.5782, and the standard deviation of the effect sizes was 1.5001, reflecting substantial variability across studies. While funnel plot asymmetry might raise concerns about small-study effects, the Egger test provides reassurance that the observed pattern could be due to chance or genuine heterogeneity rather than systematic publication bias. Nevertheless, the smaller number of imprecise studies on the left side of the funnel warrants caution in interpreting the overall effect size, as unpublished studies showing null or negative effects may exist but were not captured in our search. Future research should consider more comprehensive grey literature searches to further mitigate this potential source of bias.

**Figure 5**



**Figure 5** Funnel Plot for the Assessment of Publication Bias in the Meta-Analysis of Academic Achievement and Retention

## 7. DISCUSSION

The findings from this systematic literature review and meta-analysis provide robust empirical evidence that audio-visual teaching and learning materials have a substantial positive impact on academic achievement and retention among

secondary-level students. The pooled effect size of  $d = 0.85$ , which falls within the large range according to Cohen's conventional benchmarks, emerges consistently across a diverse array of studies conducted in multiple countries, educational contexts, and subject domains (Cohen, 1960). Taken together, these results indicate that incorporating audio-visual resources into instructional practice yields improvements in student performance that are not merely statistically significant but also practically meaningful. When considered alongside the moderate pooled effects observed for engagement and attitude measures ( $d = 0.41$ ) and for the availability of materials ( $d = 0.52$ ), a coherent narrative emerges: audio-visual materials enhance learning outcomes through multiple mechanisms, including direct cognitive benefits from dual-channel information processing and indirect benefits through heightened student motivation and positive attitudes toward learning. This pattern of findings aligns closely with the theoretical predictions of Mayer's cognitive theory of multimedia learning, which posits that well-designed multimedia presentations facilitate deeper learning by enabling learners to construct mental models that integrate visual and verbal representations (Mayer, 2005). The consistency of our findings across outcome categories strengthens the conclusion that audio-visual materials are a valuable pedagogical tool for secondary education.

Nevertheless, the substantial heterogeneity observed across studies in the academic achievement category ( $I^2 = 97.12\%$ ) demands careful interpretation and caution against overgeneralization. This heterogeneity suggests that the effectiveness of audio-visual materials is not uniform but is instead shaped by a complex interplay of contextual and methodological factors. One critical pattern that emerges across the literature is the role of instructional design quality. Studies that reported the largest positive effects, such as the investigation of animated simulations in physics education in Nigeria (Kartika et al., 2023) and the use of multimedia in biology instruction in Indonesia (Mashudi et al., 2021), typically employed materials that were carefully aligned with curriculum objectives, incorporated interactive elements, and were integrated into a coherent pedagogical framework. In contrast, studies that yielded null or negative effects, such as the research on multimedia in biology in Malawi (Ntaila & Mbaraka, 2023) and the comparison of classroom and online learning in Ghana (Darkwa & Antwi, 2021), often used materials that were either poorly designed, misaligned with students' prior knowledge, or implemented without adequate teacher training. This pattern underscores the crucial distinction between the mere presence of audio-visual materials and their effective pedagogical integration. It suggests that the materials themselves are not inherently effective; rather, their impact depends critically on the quality of their design and the expertise with which they are deployed in the classroom.

The implications of these findings for educational theory are twofold. First, they provide strong empirical support for the cognitive theory of multimedia learning, demonstrating that appropriately implemented dual-channel presentations can indeed facilitate deeper processing and retention (Mayer, 2005). Our results suggest that audio-visual materials are particularly effective in subjects with inherently visual or dynamic content, such as science, mathematics, and vocational skills, where animations and videos can make abstract concepts tangible and processes visible. Second, the observed variability highlights the limitations of simplistic models that treat audio-visual materials as a uniform intervention. The findings suggest that the effectiveness of these materials is moderated by factors such as learner characteristics, subject matter, material design features, and implementation fidelity. Future theoretical work should therefore move beyond asking whether audio-visual materials work to investigating the conditions under which they work best, potentially through moderator analyses that examine the roles of material interactivity, teacher training, and student prior knowledge.

The practical implications of this research are equally important for educators, curriculum developers, and policymakers. The substantial overall effect size suggests that investing in high-quality audiovisual resources and providing teachers with training in their effective use is likely to yield significant returns in student learning outcomes. For educators, our findings imply that audio-visual materials should not be viewed as mere supplements to traditional instruction but rather as integral components of a well-designed pedagogical approach. The moderate effect observed for engagement measures further suggests that these materials can serve as powerful tools for capturing student interest and fostering positive attitudes toward learning, which may in turn contribute to sustained academic engagement over time (Didace & Andala, 2021). For policymakers, the results underscore the importance of not only procuring audio-visual materials but also ensuring that they are contextually appropriate, aligned with curriculum standards, and accompanied by professional development programs for teachers. The negative finding from the Nigerian study on material availability (Isma'il & Lukman, 2022) serves as a cautionary tale: simply providing materials without attention to quality and implementation can be ineffective or even counterproductive. Therefore, resource allocation should

prioritise both the acquisition of materials and the systemic support required for their effective integration into classroom practice.

Acknowledging the limitations of this systematic review and meta-analysis is essential for interpreting the findings with appropriate caution. First, the methodological scope of our search was constrained to four major databases (Scopus, Web of Science, ERIC, and IEEE Xplore) supplemented by Google Scholar, which, while comprehensive, may have excluded relevant studies indexed in regional databases or specialised education repositories. This limitation is compounded by our exclusive reliance on English-language publications, which may introduce a systematic bias by omitting studies published in other languages that could report different effect sizes or null findings. Second, the inclusion criteria requiring experimental or quasi-experimental designs with control groups, while necessary for causal inference, may have excluded valuable qualitative or mixed-methods studies that could provide deeper insights into the mechanisms through which audio-visual materials influence learning. Third, the substantial heterogeneity observed across studies, while addressed through random-effects modelling, limits the precision of our pooled effect-size estimate and suggests that the true effect may vary considerably across contexts. Fourth, the quality assessment using the ROBINS-I tool (Sterne et al., 2016) revealed that several studies had a moderate to serious risk of bias, particularly in domains related to confounding and participant selection. Although we excluded studies with a high risk of bias, including studies with moderate bias, may still have influenced our results. Fifth, the publication bias assessment, although non-significant by Egger's test (Egger et al., 1997), revealed funnel plot asymmetry suggestive of potential small-study effects, suggesting that unpublished studies with null or negative results may exist and could shift the overall effect estimate downward. Finally, the relatively small number of studies available for the engagement and attitude outcomes (three studies) and the availability outcome (two studies) limits the generalizability of these secondary analyses and warrants cautious interpretation.

The empirical gaps and inconsistencies uncovered in this review point toward several promising directions for future research. There is a need for more rigorous experimental designs that incorporate moderator analyses to identify the specific conditions under which audio-visual materials are most effective. Future research should explore the role of material characteristics, such as interactivity, pacing, and narrative structure, as potential moderators of the observed effects. Additionally, the substantial variability across subject domains suggests that investigations should be conducted within specific disciplines to determine whether the effectiveness of audio-visual materials varies systematically across subjects such as science, mathematics, history, and language arts. Understudied areas include the long-term retention effects of audio-visual materials beyond immediate post-test measures, as only a few studies in this review reported delayed retention outcomes. Longitudinal research designs that track student achievement over months or years would provide valuable insights into the sustainability of learning gains. Furthermore, there is a clear need for studies that examine the interaction between audio-visual materials and learner characteristics, such as prior knowledge, learning styles, and cognitive load capacity. Such research could inform the development of adaptive multimedia systems that tailor instructional content to individual learner needs. Finally, future research should explore the implementation process itself, investigating how teacher training, school infrastructure, and curriculum alignment mediate the effectiveness of audio-visual materials. Mixed-methods studies that combine quantitative effect size estimation with qualitative observations of classroom practice would be particularly valuable for understanding the complex dynamics that determine success or failure in real-world educational settings.

## 8. CONCLUSION

This systematic literature review and meta-analysis investigated the impact of audio-visual teaching learning materials on academic achievement and related outcomes among secondary-level students, synthesizing evidence from 31 empirical studies. Our findings confirm that these materials yield a large, positive effect on academic achievement and retention ( $d=0.85$ ), alongside moderate effects on student engagement and attitudes ( $d=0.41$ ) and the availability of such resources ( $d=0.52$ ). This synthesis thus provides robust, quantitative support for the theoretical premise that dual-channel information presentation enhances learning, while simultaneously challenging any simplistic assumption of uniform effectiveness across all contexts. The substantial heterogeneity observed across studies clarifies that the benefit of audio-visual materials is not automatic but rather contingent on factors such as instructional design quality, teacher proficiency, and contextual alignment.

The practical and theoretical implications of these results are significant. For educators and policymakers, this evidence base justifies continued investment in high-quality audio-visual resources, but only when coupled with

systematic teacher training and curriculum integration to avoid the pitfalls of merely providing materials without pedagogical support. Theoretically, our findings advance the discourse by demonstrating the critical role of implementation fidelity in multimedia learning and suggesting that future models must account for moderating variables, such as material interactivity and learner characteristics. Future research should therefore prioritize moderator analyses across diverse subjects and contexts, employ longitudinal designs to assess long-term retention, and utilize mixed methods to capture the nuanced dynamics of classroom implementation. By establishing a definitive estimate of the overall effect while highlighting its conditional nature, this work provides a clear roadmap for both evidence-informed practice and targeted future inquiry.

## CONFLICT OF INTERESTS

None.

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None.

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