**Journal of Basic Education Research**
Vol. 6, No. 2, May 2025, pp. 79~89
ISSN: 2716-3725, DOI: 10.37251/jber.v6i2.1420


# Effectiveness of Strategic Intervention Material (SIM) in Improving Filipino Student's Performance in Science and Mathematics: A Meta-analysis

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**Article Info**

***Article history:***

Received Jan 12, 2025
Revised Marc 5, 2025
Accepted Apr 5, 2025
OnlineFirst May 11, 2025

***Keywords:***

Filipino Student's Performance
Meta-analysis
Science and Mathematics
Strategic Intervention Material

**ABSTRACT**

**Purpose of the study: T**his meta-analysis aimed to determine the effectiveness of Strategic Intervention Materials (SIM) in improving Filipino students' science and mathematics performance.

**Methodology:** Fifteen eligible studies from three databases: Google Scholar, Crossref, and Semantic Scholar were chosen using Harzing's Publish and Perish tool. The studies underwent meta-analysis using the Jamovi Tool.

**Main Findings:** Using Strategic Intervention Material has a large average effect size (ES = 1.60) with most of the studies obtaining positive effect sizes (87%). In connection, the moderator analysis showed paper-based SIM has a relatively larger effect size than digital SIM, elementary level obtained a larger effect size than Junior and Senior High and science has larger effect size than mathematics. Nevertheless, all moderators obtained large effect sizes which means SIM is an effective classroom intervention across the different types, grade levels and content areas.

**Novelty/Originality of this study:** This research introduces new insights into classroom intervention by exploring the use of Strategic Intervention Material (SIM) which was conceptualized and commonly used in the Philippines. The study opens discourse on the use of SIM to improve the learners' science and mathematics achievement for possible adoption on a global scale.



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## 1. INTRODUCTION

Science and Mathematics are fundamental subjects that learners must develop skills to be able to solve complex problems and explain and understand different phenomena that happen in everyday living. These interdisciplinary subjects are very important for the holistic development of the students. However, when transitioning from one grade level to another, students have difficulty coping with the increasing competency requirements in the science and mathematics curriculum [1]. Performance in these two subjects is also affected by intrinsic factors such as students' learning strategies, self-motivation and self-belief as these are the two subjects that most of the students deemed as difficult subjects [1]–[3]. Aside from students' attitude toward the subject, teachers' behavior, teaching approaches and learning atmosphere are the key factors that affect the performance of learners in both science and mathematics [4]. Hence, both teachers and learners factors directly influence science and mathematics achievements.

The Programme for International Students Assessment (PISA) 2022 result of the student's ranking in mathematics and science achievements was somehow similar to the 2018 assessment. The result is disappointing for Filipinos because of the very low performance of students. Notably, the Philippines ranked sixth from the bottom in numeracy with an average score of 355 much lower than the average OECD. Though there is a slight improvement in rank from the 2018 result, it is not statistically significant. Likewise, Filipino students ranked third lowest in science with a declined score of 355 from 356 scores in 2018 [5]. Poor performance alike was observed in reading comprehension which is the sixth lowest and creative thinking which is the second lowest. Because of these underwhelming results in the succeeding PISA, the Department of Education implemented programs for the recovery of the educational system of the county called the National Learning Recovery Plan(NLRP). Its purpose is to address the learning loss brought about by the pandemic and learning gaps in literacy and numeracy [6]. In connection, DepEd encourages teachers to implement strategies to help learners recover from poor academic performance in science and mathematics as well as in reading.

Various remedial programs and classroom-based interventions were implemented by teachers to help improve the performance of learners in science and mathematics. Remedial programs target students who are lagging behind by teaching in their current skill levels [7]. It encompasses approaches that modify the classroom environment, teaching methodologies, and teacher-student interactions to improve student behavior or performance [8]. It may be in the form of one-on-one with the teacher, peer tutorial, small group discussion, specialized learning materials and technology-integrated instruction [9],[10]. Strategic Intervention Material (SIM) is one of the specialized remedial tools that science and mathematics teachers employ to improve students' academic performance in the Philippines. SIM is made specifically for students who are having difficulty in mastering a certain topic or skill [11]. It is applied in remedial lessons to help students master the least-learned competencies or skills [12]. It is comprised of five main parts including a guide card, activity card, enrichment card, assessment card, and answer card. It can be printed or digital. SIM makes learning enjoyable because of its visually appealing content that uses animated pictures and illustrations [13]. Furthermore, SIM promotes autonomous learning and concept retention among learners [14].

The concept of Strategic Intervention Material can be aligned to the Strategic Instructional Model which is an instructional framework conceptualized by the University of Kansas Center for Research on Learning that promotes self-directed and explicit instructional approaches for students with learning difficulties to easily learn [15]. Using instructional materials with self-discovery and cognitive conflict approaches addresses misconceptions among students [16]. Furthermore, applying self-regulated learning intervention to students significantly improves their academic performance [17]. It was discovered that one-on-one, small group and large group interventions had a favorable impact on students' performance but the intervention that showed much growth in the performance of the students was the individual intervention [18]. Additionally, the development and use of SIM followed the Response to Intervention (RTI) model as it requires diagnostic of least-learned skills to provide intensive intervention for specific target competencies. RTI is an instructional model that provides early intensive intervention by identifying students with learning difficulties [19], [20].

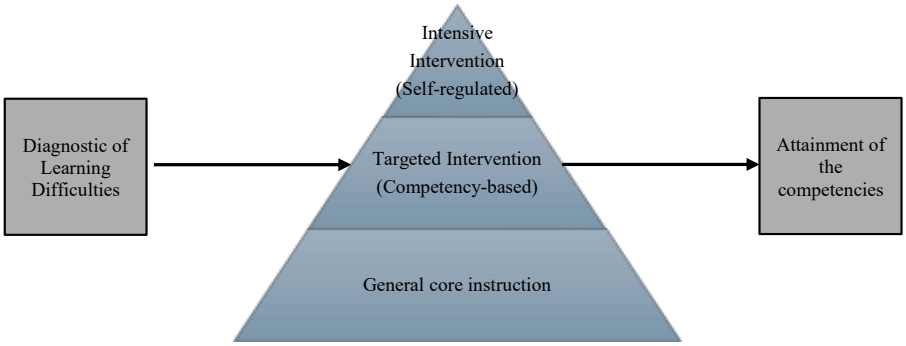


Figure 1. Conceptual Paradigm

SIM was first introduced by the Department of Education through DepEd Memorandum 117 s. 2005 where teachers underwent training workshops on how to craft the intervention material. Today, it is one of the interventions employed in the classroom in the Philippines. As science and mathematics teachers, the researchers wanted to uplift the quality of science and mathematics education in the country so exploring the effectiveness of Strategic Intervention Material can give insights on how effectively implement classroom interventions. Moreover, this study paves the way to introduce the SIM on a global scale for possible adoption. In connection, many studies delved into the effectiveness of different instructional strategies and some focus on learning interventions. However, few studies focus on the effectiveness of strategic intervention material in science and mathematics.

Almost none conducted a meta-analysis of different empirical studies on strategic intervention material in science and mathematics. This study bridged these gaps.

**Objectives**

The study aimed to determine the effectiveness of SIM in improving Filipino student's performance in Science and Mathematics through meta-analysis. Specifically, it answered the questions below:

1. What is the frequency and percentage of studies in terms of the type of SIM, Grade Level, and Content Area?
2. How effective are the strategic intervention materials in improving Filipino student's performance in Science and Mathematics?
3. How does the effectiveness of strategic intervention materials vary in terms of the:
   a. Type of SIM
   b. Educational Level
   c. Content Area
4. What is the state of publication bias of the included studies on the effectiveness of SIM in improving Filipino student's performance in Science and Mathematics?

## 2. RESEARCH METHOD

This systematic review incorporates meta-analysis to explore the effectiveness of SIM in enhancing Filipino students' achievement in Science and Mathematics. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 was employed as a guide in the conduct and presentation of this systematic review. PRISMA 2020 contains updated reporting procedures that explicitly show the techniques for finding, choosing, evaluating, and synthesizing studies for meta-analysis [21]. Thus, the researchers followed the methodical ways to search, identify, and analyze existing studies about the effectiveness of strategic intervention materials (SIM).

### 2.1 Eligibility Criteria

The researchers established eligibility criteria to select which of the searched studies would be included for analysis. To be included in the study the intervention must be the strategic intervention material. The study focused on either science or mathematics. The study was published from 2018 to 2024. Lastly, the research design utilized by the study is either experimental or quasi-experimental. The inclusion and exclusion criteria are explicitly shown in Table 1.

Table 1. Inclusion and exclusion criteria

| Eligibility Criteria | Inclusion | Exclusion |
|---|---|---|
| Intervention | Strategic Intervention Material (SIM) | Other interventions |
| Subject Area | Mathematics and Science | Other subjects |
| Sample Population | Elementary and Secondary Students | Tertiary and Graduate Students |
| Year Published | 2018-2024 | Earlier than 2018 |
| Research Design | Experimental and Quasi-experimental | Qualitative Research and Pre-experimental |

### 2.2 Search Strategies

To search for the potential articles to be considered in the systematic review about the effectiveness of Strategic Intervention Material (SIM) in increasing Filipino student's achievement in Science and Mathematics, Harzing's publish or perish tool was utilized. It is a software that retrieves and analyzes the impact of academic researches [22]. It was used in the study to search and sort studies from the following research databases: Google Classroom, Crossref and Semantic Scholar. Articles were also searched and sorted manually from other registers to complement the collected articles from Harzing's publish or perish tool. The following keywords were used in searching, "Strategic Intervention Material Science AND Mathematics", "Strategic Intervention Material Science OR Mathematics", "PISA intervention" and "SIM intervention".

### 2.3 Identification of Studies

Through the screening process shown in the PRISMA flowchart below, the researchers trimmed down 1651 studies to arrive at the final fifteen studies. Using the eligibility criteria as the basis, the researchers independently checked the title and abstract of the studies to ensure the inter-reliability of the selection process. Any difference in judgment on the identification of the included studies was thoroughly discussed by the two authors to arrive at an agreement. To ensure high-quality evidence from the studies, the researchers conducted a risk of bias assessment utilizing the ROBINS-I tool. It is an appropriate tool to be used in non-randomized studies included in a systematic review to assess their strength and weaknesses to eliminate biases in the selection process [23]. After deliberation, only fifteen studies were left for inclusion.

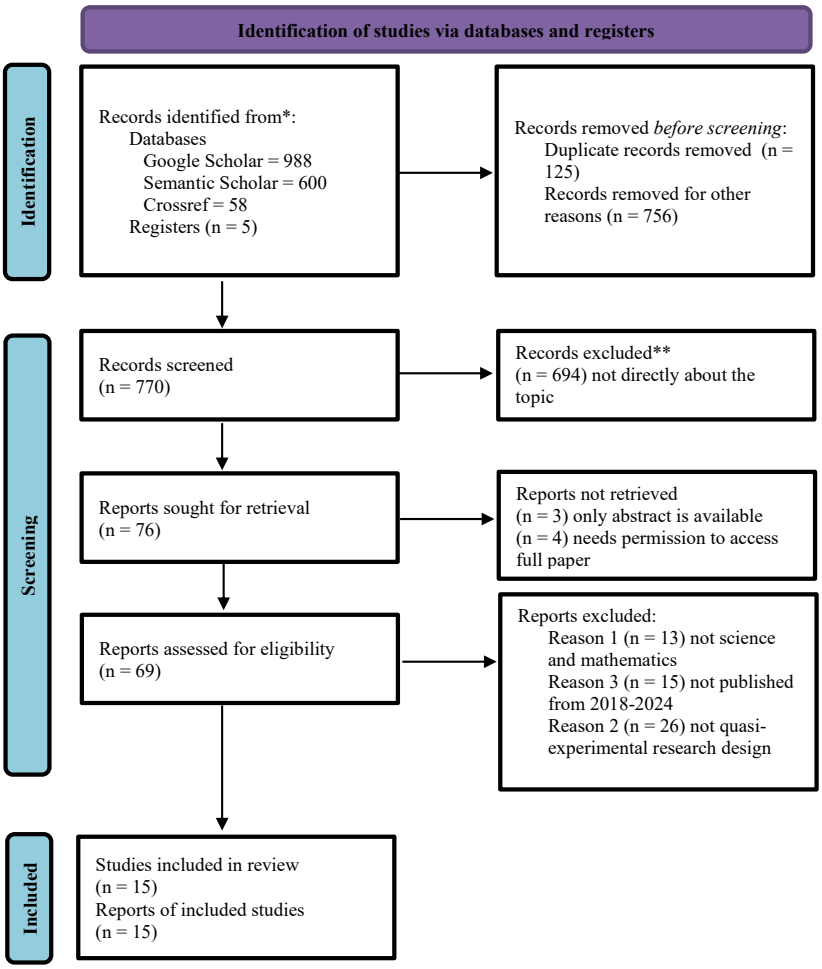


Figure 2. PRISMA flowchart diagram of screening strategies [21].

### 2.4 Data Analysis

The researchers reviewed each included study to obtain the number of participants, mean and standard deviation of each study. Then, the data were recorded in a spreadsheet in preparation for the analysis phase. The collected data were subjected to data analysis using the Jamovi tool. Appropriate statistical tools were used to answer each question. The frequency count and percentage were used to determine the number of studies in terms of the kind of SIM, grade level, and content area. On the other hand, the effectiveness of SIM was determined using Hedge's g to compute the standardized effect size of the studies. Hedge's g is a statistical tool to calculate the standard mean difference of two sets of data or groups [24]. Furthermore, the heterogeneity among studies involved was determined by employing Cochran's Q test and I2 index. The Q test is a traditional test to know the differences between studies involved in the meta-analysis, while the I2 index is a more recent approach to calculate the real differences in the meta-analyses [25]. Lastly, the potential publication bias in the study was detected utilizing the Begg and Mazumdar Correlation and Egger's Regression test.

## 3. RESULTS AND DISCUSSION

The researchers gathered fifteen empirical studies with a total respondents of 1067 students involved in the meta-analysis. The table below depicts the characteristics of the studies.

Table 2. Characteristics of the studies based on the eligibility criteria

| Authors | Year Published | Locale (Province/City) | Educational Level | Content Area | Research Design |
|---|---|---|---|---|---|
| Abuda [26] | 2019 | Eastern, Samar | Senior High | Mathematics | Quasi-experimental |
| Aranda et al. [27] | 2019 | Capiz | Junio High | Science | Quasi-experimental |
| Arpilleda [28] | 2021 | Surigao City | Junior High | Mathematics | Descriptive & Experimental |

| | | | | | |
|---|---|---|---|---|---|
| Balazo [29] | 2021 | Eastern, Samar | Senior High | Mathematics | Solomon Four-group Quasi-experimental |
| Contreras [30] | 2018 | Manila | Junior High | Science | Experimental |
| De Leon and Justo [31] | 2023 | Antipolo City | Junior High | Science | Quasi-experimental |
| Dumdumaya et al. [32] | 2024 | Camiguin | Elementary | Science | Quasi-experimental |
| Dumigsi and Cabrella [33] | 2019 | Digos City | Junior High | Mathematics | Quasi-experimental |
| Gabucan and Sanchez [34] | 2020 | Cebu City | Junior High | Science | Quasi-experimental |
| Halcon [35] | 2019 | Manila | Elementary | Science | Experimental |
| Mercado and Tandog [36] | 2018 | Cagayan De Oro City | Junior High | Mathematics | Quasi-experimental |
| Pantilon [37] | 2024 | Zambales | Junior High | Science | Quasi-experimental |
| Quilloy [38] | 2023 | Laguna | Junior High | Mathematics | Quasi-experimental |
| Segarino et al. [39] | 2022 | Dumaguete City | Elementary | Mathematics | Quasi-experimental |
| Zabala [11] | 2023 | Davao City | Senior High | Mathematics | Quasi-experimental |

The data above shows that the included studies were published from 2018-2024 (1 study each from 2020 & 2022, 4 studies from 2019, 2 studies each from 2018, 2021 & 2024, and 3 studies from 2023). All studies were conducted in the time frame when the Philippines joined the PISA. In addition, all the studies were conducted in the Philippines (1 study each from Capiz, Antipolo City, Camiguin, Digos City, Cebu City, Surigao City, Cagayan De Oro City, Zambales, Laguna, Dumaguete City & Davao City and 2 studies from Eastern Samar & Manila). Furthermore, the included studies utilized experimental research (12 studies utilized the Quasi-experimental design with one that used Solomon's four-group, and 3 studies employed experimental design with one that integrated other research design). The strategic intervention material (SIM) was used in different educational levels of the basic education curriculum namely elementary, junior high and senior high school. Likewise, it was used in two major subjects in basic education namely Science and Mathematics.

### 3.1 Studies in terms of type of SIM, Educational Level, and Content Area

Different types of strategic intervention material (SIM) were utilized across the various educational levels and content areas to determine their effectiveness. Table 3 reveals the number and percentage of studies in terms of the type of Strategic Intervention Material (SIM), Educational Level, and Content Area.

Table 3 Frequency count of studies in terms of type of SIM, educational level and content area

| Groupings | Frequency | Percentage (%) |
|---|---|---|
| Type of Strategic Intervention Material | | |
| Paper-based | 12 | 80.00 |
| Digital | 3 | 20.00 |
| Educational Level | | |
| Elementary | 3 | 20.00 |
| Junior high school | 9 | 60.00 |
| Senior high school | 3 | 20.00 |
| Content Area | | |
| Science | 7 | 46.67 |
| Mathematics | 8 | 53.33 |

The table above revealed that the studies developed and utilized several types of strategic intervention materials (SIMs). The paper-based (printed) strategic intervention materials were widely used with twelve studies (80%) employing it as their intervention material meanwhile three studies (20.00%) utilized digital strategic intervention materials. In terms of the educational level, the majority of the studies are conducted in junior high schools with nine studies (60.00%). Moreover, there were three studies (20.00%) conducted in elementary and senior high schools respectively. As for the content area, the data revealed that SIM was used in both science and mathematics with seven (46.67%) studies in science and eight (53.33%) in mathematics.

The data above implies that many teachers still opt to develop and utilize printed strategic intervention material compared to digital type. It might be attributed to the ease of making and using printed strategic intervention material. Printed materials are relatively inexpensive to produce, more accessible and flexible to use and do not require gadgets to work [40]. Strategic Intervention Materials are more commonly utilized in Junior high school than in elementary and senior high school. The junior high students as the focus of most interventions are logical because the sample population of the PISA was 15-year-old Filipino students who are under the age range of Junior high school students [5]. Strategic intervention materials (SIM) are utilized alike in mathematics and science subjects. These findings revealed the intense effort of the teachers to augment the student's performance in both science and mathematics. This is connected to the result of the PISA where the Philippines performed poorly in both subjects. The 2022 PISA focuses on mathematics with science and reading comprehension as minor areas and creative thinking as an innovative area [5].

### 3.2 Effect Size of the Study

The fifteen research articles underwent Hedge's g test to determine the standardized mean difference. The table below shows the results.

Table 4. The average effect size

| | ES | se | Z | p | 95 % CI | | Heterogeneity | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Lower | Upper | Q | df | p | I2 |
| Random Effect | 1.60 | 0.428 | 3.74 | <.001 | 0.764 | 2.442 | 359.15 | 14.00 | <.001 | 96.97 |

The amount of heterogeneity was reported using the Q-test and the I2. The results of the Q-test (Q = 359.15) and I2 (I2=96.97) suggested significant heterogeneity among studies. Even though the average outcome estimate is positive, in several studies the result appears to be negative. In connection, the result of heterogeneity revealed that the random-effect model was the appropriate model to be used. The estimated average standardized mean difference was 1.60 which differed significantly from zero which depicts a large overall effect size. The forest plot below was presented to give a glance at the individual effect size of the studies.

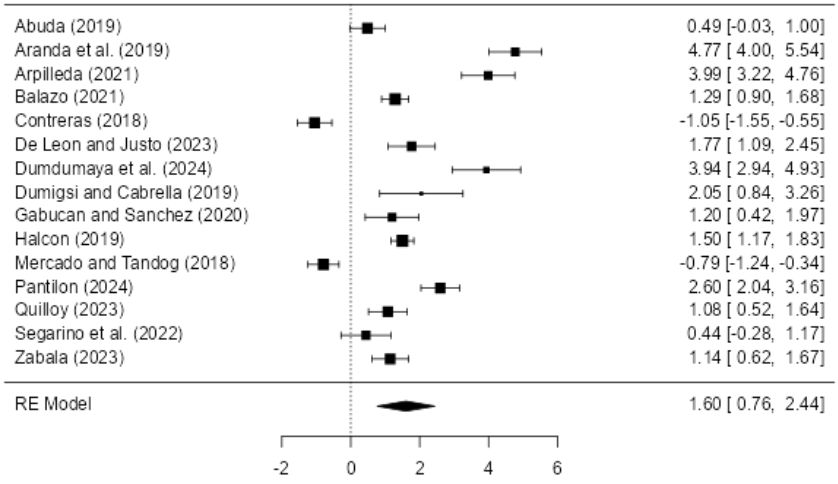


Figure 3. Forest Plot

Based on the forest plot, the standardized mean difference of the studies ranges from -1.05 to 4.77 where most of the study's estimate was positive (87%). The majority of studies exhibit positive effect sizes on the effectiveness of SIM in boosting performance in science and mathematics. Aranda et al. scored the highest effect size of 4.77 which shows significantly relevant results. It was noticeable though that there were two studies with different results from the others having a negative effect size. Contreras and Mercado & Tandog obtained -1.05 and -0.79 effect sizes respectively. Though there are some unfavorable effect sizes on the effectiveness of SIM, the overall effect size remains positive.

It implies that the use of SIM helps in improving Filipino learner's achievement in science and mathematics. Developing and using intervention materials and tools greatly improves academic performance. A developed computer-assisted remedial tool was successful in improving learners' knowledge and hands-on skill performance in STEM courses [41]. Likewise, a package of interventions that includes workbooks was provided to students through extra-curricular remedial activities showed a large positive impact on low-performing students in mathematics [42].

The positive results of educational intervention were also seen in other kinds of science and mathematics intervention programs. Two designed interventions on reteaching foundational mathematics and extended time of core mathematics subjects resulted in better mathematics achievement [43]. Furthermore, A science intervention through a 5-week enhancement program for middle-grade students resulted in positive change in the performance and attitude towards science [44]. It is imperative that for slow learners to cope with the lessons in science and mathematics intervention is deemed necessary. Employing remedial strategies is vital to address various needs and raise a supportive learning environment for students [45] Based on the result, using SIM exhibits great potential as a science and mathematics intervention.

### 3.3 Moderator's Effect Sizes

The researchers sought to know if the effectiveness of strategic intervention material varies across types of SIM, educational levels and content areas. Thus, the moderator analysis was performed to identify the standard

mean difference of the studies in terms of the type of SIM, educational level, and content area. The moderator analysis is shown in the table below.

Table 5. Moderator analysis in terms of type of SIM, educational level, and content area

| Groupings | k | ES | se | Z | P | 95% CI | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower | Upper |
| Type of SIM | | | | | | | |
| Paper-based | 12 | 1.67 | 0.538 | 3.10 | 0.002 | 0.613 | 2.721 |
| Digital | 3 | 1.34 | 0.197 | 6.78 | 0.001 | 0.950 | 1.722 |
| Educational Level | | | | | | | |
| Elementary | 3 | 1.93 | 1.03 | 1.87 | 0.062 | -0.098 | 3.957 |
| Junior High | 9 | 1.72 | 0.646 | 2.66 | 0.008 | 0.452 | 2.983 |
| Senior High | 3 | 0.989 | 0.246 | 4.01 | < 0.001 | 0.506 | 1.472 |
| Content Area | | | | | | | |
| Science | 7 | 2.08 | 0.723 | 2.88 | 0.004 | 0.666 | 3.501 |
| Mathematics | 8 | 1.18 | 0.492 | 2.40 | 0.016 | 0.216 | 2.144 |

Table 5 reveals that the paper-based SIM and digital SIM obtained large effect sizes with a value of 1.67 and 1.34 respectively. However, paper-based SIM has a relatively larger effect size than digital SIM. It implies that both standard and digital SIM were effective in enhancing science and mathematics performance. In a similar result, paper-based learning on vocabulary produced superior test results than digital learning when the test was administered on paper in which the same effect was not observed when the test was administered digitally [46]. On the contrary, digital is more effective than printed in teaching literacy among elementary pupils [47].

All educational levels recorded large effect sizes. The largest effect size was obtained in the elementary level (ES = 2.91) which means that SIMs are more effective in elementary than in junior and senior high school which obtained 1.72 and 0.989 respectively. In terms of the content area, the use of SIM in both science and mathematics recorded large effect sizes with 2.08 and 1.18 respectively with science having a greater effect size than mathematics.

The above results were valid as elementary students are mostly visual learners, and SIM is composed of visuals in the form of pictures and illustrations in every activity. Elementary students learned best through pictures, colors and symbols because they preferred learning what they see rather than what they hear [48]. In connection, interventions in mathematics and science intended for early childhood resulted in long-lasting positive outcomes among children's skills development. [49], [50]. Moreover, the application of STEM interventions is effective in improving students' achievement [51], [52].

### 3.4. Publication Bias

The funnel plot below reveals the assessment of publication bias of the study. The standard error and the standardized difference of fifteen empirical studies were plotted below to determine possible publication bias in the study.

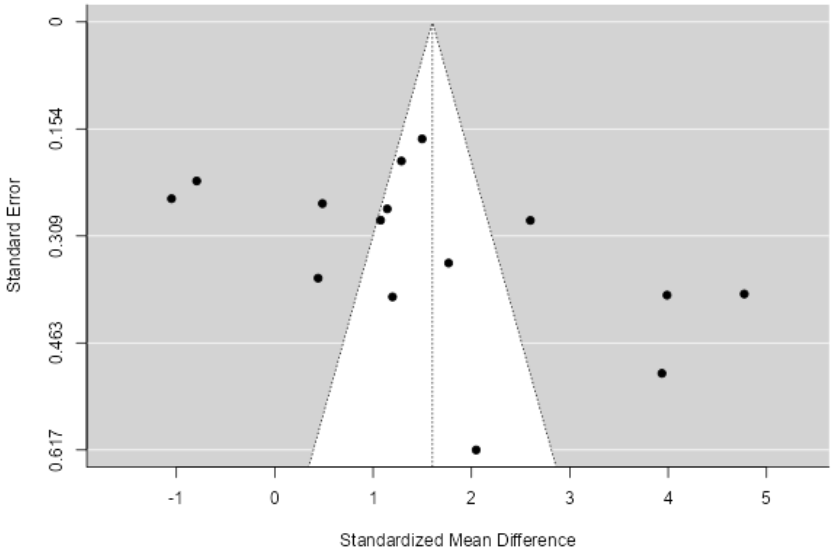


Figure 4. Funnel Plot

The funnel plot above shows asymmetry which may indicate publication bias. However, it may also be a sign of clinical or methodological heterogeneity between studies [53]. The included studies have a small sample size (n = 15) which means that the funnel plot may not be reliable in determining publication bias. The asymmetrical funnel plots may not signify publication bias specifically if there were only a few studies involved in meta-analysis [54]. In connection, other tests were performed to determine the publication bias. The table below presents the status of publication bias.

Table 6. Publication bias status

| Test Name | Value | p |
|---|---|---|
| Fail-Safe N | 1763.000 | <.001 |
| Begg and Mazumdar Rank Correlation | 0.341 | 0.114 |
| Egger's Regression | 2.123 | 0.034 |
| Trim and Fill Number of Studies | 0.000 | |

The researcher conducted the Begg and Mazumdar Rank Correlation test which is the appropriate statistical tool to indicate publication bias in meta-analysis with a small sample size. Egger's regression test & Fail-Safe N test were also performed. Though Egger's regression reveals potential asymmetry with p = 0.34 lower than the alpha, the Begg and Mazumdar Rank Correlation test resulted in a p-value higher than the alpha with a p-value of 0.114 which means the acceptance of the null hypothesis. Thus, no publication bias was identified in the meta-analysis. Based on the studentized residuals and Cook's distance, there are no potential outliers because none of the studies had a value greater than ± 2.9352. The Fail-Safe result agreed with the validity and resistance to publication bias of the sample studies. Hence, 1763 studies were required to invalidate the result of the meta-analysis.

There are very few studies that have conducted a meta-analysis on the effectiveness of the strategic intervention material in science and mathematics because of the limited empirical studies on Strategic Intervention Materials which are only confined to the Philippines. This meta-analysis is only limited to certain geographic locations; hence, further studies on SIM on a global scale are needed to validate the results. On the other hand, there are several meta-analyses conducted about learning interventions with a variety of focus and results that show similarities or contrasts in the present research. In the meta-analysis conducted on the effectiveness of interventions on learning burnout, contrary to the result of the present study, the funnel plot together with the Egger's test resulted in asymmetry, which resulted in the trim-and-fill of seven studies [55]. Though there was detected publication bias, the result shows the effectiveness of the learning burnout intervention. Furthermore, the meta-analysis conducted on the effects of problem-based learning intervention on critical thinking has no evident publication bias based on the result of Eagger's bias test . The PBL intervention promoted the development of critical thinking skills among students; however, additional studies were needed to explore the other influencing factors.

## 4. CONCLUSION

Based on the results of the research that has been conducted, it can be concluded that the meta-analysis of these fifteen empirical studies revealed that standard strategic intervention is the type of MIS that is widely used by teachers and students. Furthermore, MIS is used in Science and Mathematics as an intervention. MIS is more widely used in junior high schools than in elementary and high schools. The meta-analysis revealed a large average effect size of 1.60 which means that MIS is effective in improving the academic achievement of Filipino students in Science and Mathematics. Although most of the studies involved obtained a positive effect size (87%), there were some studies with negative effect sizes. Moderator analysis revealed that paper-based MIS has a relatively larger effect size than digital MIS. The effect size of elementary level is larger than junior and high school. In addition, science has a larger effect size than mathematics. It was revealed that all moderators obtained a large effect size which means that MIS is an effective classroom intervention across types, grade levels, and disciplines. Therefore, every school should intensify the use of MIS as an intervention to improve the performance of students who have difficulty in science and mathematics. In addition, the Department of Education can provide more training to equip teachers on how to develop effective MIS. Further research on other classroom interventions can be conducted to help improve student performance in science and mathematics. The recommendations of this study are that each school should intensify the use of MIS as an intervention strategy to support students who struggle with Science and Mathematics. School administrators should encourage the integration of paper-based MIS whenever possible, especially in the early grades, to maximize its effectiveness. In addition, the Department of Education is encouraged to design and implement regular training programs to equip teachers with the skills to design, adapt, and implement paper-based and digital MIS effectively.

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