



www.ijemst.net

## Effectiveness of Worksheets in Science Students' Learning Outcomes: A Meta-Analysis

Mark Justine N. Revano<sup>1\*</sup>, Jarine A. Tanda<sup>2</sup>, Fhebie A. Walles<sup>3</sup>

<sup>1</sup> University of Southeastern Philippines, Obrero, Davao City, Philippines,  0009-0003-4573-4569

<sup>2</sup> University of Southeastern Philippines, Obrero, Davao City, Philippines,  0009-0005-2988-6970

<sup>3</sup> University of Southeastern Philippines, Obrero, Davao City, Philippines,  0009-0002-4693-3810

\* Corresponding author: Mark Justine N. Revano (mjnrevano01527@usep.edu.ph)

### Article Info

### Abstract

#### Article History

Received:  
4 August 2025

Revised:  
8 December 2025

Accepted:  
11 January 2026

Published:  
1 March 2026

#### Keywords

Worksheets  
Learning outcome  
Science education  
Meta-analysis

Improving students' learning outcomes remains a central goal of science education, as students are expected to engage critically, reason scientifically, and apply knowledge in diverse contexts. Worksheets have long been used in science classrooms to achieve this goal. But despite their widespread use, existing meta-analyses have been limited in scope, often focusing on single disciplines or lacking the influence of moderating variables. This study conducted a meta-analysis, analyzing 38 effect sizes drawn from 33 studies involving 2,465 students. Results revealed a large and statistically significant overall effect (Hedges  $g = 1.600$ ), confirming that worksheets substantially improve students' learning outcomes in science. Moderator analysis indicated a significant effect based on country, education level, scientific discipline, learning domain, and worksheet variation. The most notable effects were observed in the secondary level, in the field of physics, and in ethnoscience and representation-rich worksheets. This study provides evidence-based insights on the effectiveness of worksheets and the importance of thoughtfully designing them as tools that extend beyond routine practice to support meaningful learning in science education.

**Citation:** Revano, M. J. N., Tanda, J. A., & Walles, F. A. (2026). Effectiveness of worksheets in science students' learning outcomes: A meta-analysis. *International Journal of Education in Mathematics, Science and Technology (IJEMST)*, 14(2), 603-624. <https://doi.org/10.46328/ijemst.5408>



ISSN: 2147-611X / © International Journal of Education in Mathematics, Science and Technology (IJEMST). This is an open access article under the CC BY-NC-SA license (<http://creativecommons.org/licenses/by-nc-sa/4.0/>).



## Introduction

In response to global challenges and issues, science education promises to equip the children of today with the necessary knowledge, skills, and dispositions to navigate and contribute to the increasingly volatile, uncertain, complex, and ambiguous (VUCA) world they will be inheriting (Stein, 2021). However, realizing this also depends on the capacity of science teachers to adopt instructional strategies and interventions grounded in research-backed pedagogy. Among the many tools available in today's classrooms are worksheets, a widely used and enduring tool due to their flexibility and cost-effectiveness (Chutami & Suhartini, 2021). Worksheets are teacher-designed learning sheets with a set of tasks, exercises, and visual aids that are intended to support students' independent practice or to serve as a guide in completing learning activities (Bartoňová & Kričfaluš, 2021). Well-designed worksheets offer valuable opportunities for students to engage in retrieval practice (Burkholder et al., 2021) and apply what they know through structured tasks and guided questioning (Mahyuna et al., 2018).

Despite their widespread use, the evidence supporting their effect has been mixed. Several reviews have looked at how science worksheets are developed and used in the classroom (Putri et al., 2021; Chutami & Suhartini, 2021; Syahdi et al., 2021), but these studies only focused on one scientific discipline and lacked the methodological rigor needed to draw firm conclusions. A meta-analysis conducted by Chutami and Suhartini (2021) attempted to synthesize the effects of worksheets. It did not, however, follow the PRISMA guidelines for a rigorous quantitative synthesis. These studies did not explore how moderators might influence students' learning outcomes. Such gaps point to a clear need for further and comprehensive analysis that can offer science teachers practical and research-based insights on how to create worksheets that are effective for enhancing students' cognitive, affective, and psychomotor learning outcomes in science education.

This study addresses this by quantitatively synthesizing existing research on worksheets in science education in adherence to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines in order to provide a more rigorous and comprehensive understanding of their effectiveness (Moher et al., 2015). This study synthesizes the impact of worksheets on students' learning outcomes, investigates the role of country, educational level, scientific discipline, and learning domain moderators, and examines which variations of worksheets are most effective. Insofar as previous literature has fallen short in identifying what makes worksheets effective in improving science students' learning outcomes, this study also contributes to the discussion by clarifying the variations under which they work best.

## Literature Review

Worksheets in science education have evolved beyond traditional roles as repetitive practice tools. Today, they are recognized as instructional materials that enhance critical thinking skills and promote a scientific attitude (Burkholder et al., 2021). Grounded in the constructivist learning principle, worksheets are designed to actively engage students in constructing knowledge through exploration, reflection, and inquiry-driven tasks (Tuerah, 2019). These worksheets often accompany activities that require students to investigate real-world problems, analyze data, and draw evidence-based conclusions through hands-on engagement (Senisum et al., 2022). When

used intentionally, guided-inquiry worksheets help develop students' conceptual understanding, quantitative reasoning, and metacognitive skills by prompting sense-making and deeper thinking across scientific contexts (Koretsky et al., 2018). Scaffolding-based worksheets provide structured support at the beginning of learning, which gradually encourages independent learning and improved overall learning outcomes (Maysara et al., 2024).

In literature, worksheets have been referred to by various names, commonly as student worksheets or scientific worksheets. Student worksheets emphasize more on the process of finding concepts and often include varied stimuli through multiple media and student-centered activities, making learning more meaningful, effective, and enjoyable. Hence, when these worksheets are designed with hands-on experimentation in mind, they help stimulate students' abilities to predict, measure, and communicate effectively (Haerani et al., 2023). Mahyuna et al. (2018) emphasized that scientific worksheets grounded in guided inquiry significantly improved students' science process skills. Guided inquiry worksheets are effective as they are easy to understand, contextual, and motivate the students to do a science investigation. When they become embedded in Problem-Based Learning (PBL) or STEM-integrated instruction, they become even more effective in promoting student engagement and higher-order learning. Yalyn et al. (2022) demonstrated that PBL-oriented worksheets significantly improved students' science process skills with high gains in steps like hypothesis formulation, variable identification, data interpretation, and communication.

Worksheets have long served as essential instructional tools in science due to their structured, student-centered approach, which facilitates knowledge construction and independent learning. As their classroom use continues to grow, several studies have evaluated their effect on students' learning, prompting a meta-analysis to synthesize emerging findings. Chutami and Suhartini (2021) conducted a meta-analysis of ten relevant articles in related national journals and reported medium to very high effect sizes and concluded that using student worksheets in science learning has an effect on students' learning outcomes. Similarly, Putri et al. (2022) focused on the effect of worksheets on students' learning outcomes in physics, analyzing 30 articles and showing positive outcomes. Their analysis found that worksheets had a high to very high effect on students' learning outcomes at the junior high school educational level using the Contextual Teaching and Learning (CTL) model. In a separate review, Syahdi et al. (2021) synthesized 20 studies and demonstrated that worksheets indeed have a positive effect on improving the critical and creative thinking skills in natural science. Anjani et al. (2023) extended the scope across physics, chemistry, and biology from 25 studies. This study revealed that worksheets have a very good influence on students' higher-order thinking abilities.

While previous meta-analyses have reported positive effects of worksheets in science education, several limitations remain unaddressed. Most notably, earlier reviews did not focus on the effect of worksheets on students' overall learning outcomes across science disciplines (Putri et al., 2021; Chutami & Suhartini, 2021). Worksheets integrated into inquiry-based learning have been shown to promote students' critical, creative, higher-order thinking skills, and problem-solving (Syahdi et al., 2021; Anjani et al., 2023; Widodo et al., 2023). However, these reviews largely concentrated on thinking skills and did not include foundational learning outcomes. Moreover, some attempts have been made to examine the moderating variable. These include subject areas, instructional models, and grade levels (Putri et al., 2021; Anjani et al., 2023). Despite this, they did not account

for other key moderators such as worksheet variation, geographic location, and learning domain. Some also lacked the methodological rigor emphasized in the PRISMA guidelines. Therefore, our study aims to examine the overall effectiveness of worksheets in improving students' science learning outcomes. A moderator analysis was conducted to assess how the impact of worksheets varies across countries, educational level, scientific discipline, and worksheet variation. The lifelong pursuit of science teachers to strengthen their technological, pedagogical, and content knowledge (TPACK) means that there is a need for evidence-based insights into this area of research. In doing so, this study contributes empirically grounded recommendations to inform worksheet instructional materials development and advance research-based practices in science education.

## Research Questions

This study used a meta-analysis to examine the effectiveness of worksheets on science students' learning outcomes. Specifically, this study aimed to answer the following questions:

1. What is the effect of worksheets on science students' learning outcomes?
2. Does the effect of worksheets on students' learning outcomes vary when the included studies are grouped into:
  - a. learning domain;
  - b. country
  - c. educational level;
  - d. scientific discipline; and
  - e. worksheet variation
3. What specific types of worksheets did the included studies employ and how were they used?

## Methodology

### Research Design

We utilized a meta-analysis to investigate the effectiveness of worksheets in improving science students' learning outcomes. This study adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2015). Meta-analysis involves the synthesis of data from individual studies into a single effect estimate to answer a focused research question (Xia & Guzzo, 2025). Combining data from various studies allows us to examine how differences in study design, implementation, analysis, and results affect the overall treatment effects (Jones et al., 2008). To better understand the differences in effect sizes, moderator analyses were carried out to investigate underlying sources of variation across studies (Paul & Barari, 2022). The moderators included in this study were learning domain, country, educational level, scientific discipline, and worksheet variation.

### Literature Search Procedures

An extensive literature search targeted empirical studies published between January 1, 2015, and June 1, 2025. Using the Publish or Perish (PoP) tool (Harzing, 2007), studies were retrieved from Google Scholar, Crossref,

OpenAlex, and Scopus using the search terms “worksheets,” “science education,” “learning outcomes,” and “quasi-experimental.” Manual searches via Elicit and Scispace also supplemented the database results. In total, 3,069 records were identified, including 3,001 from databases and 68 from manual searching. Duplicate removal, using both an online tool and manual checks, excluded 276 studies, leaving 2,793 for screening. Title screening eliminated 2,446 irrelevant records, and abstract screening further narrowed the pool to 130 studies for full-text review. After thorough evaluation, 38 studies met the inclusion criteria and were included in the final meta-analysis.

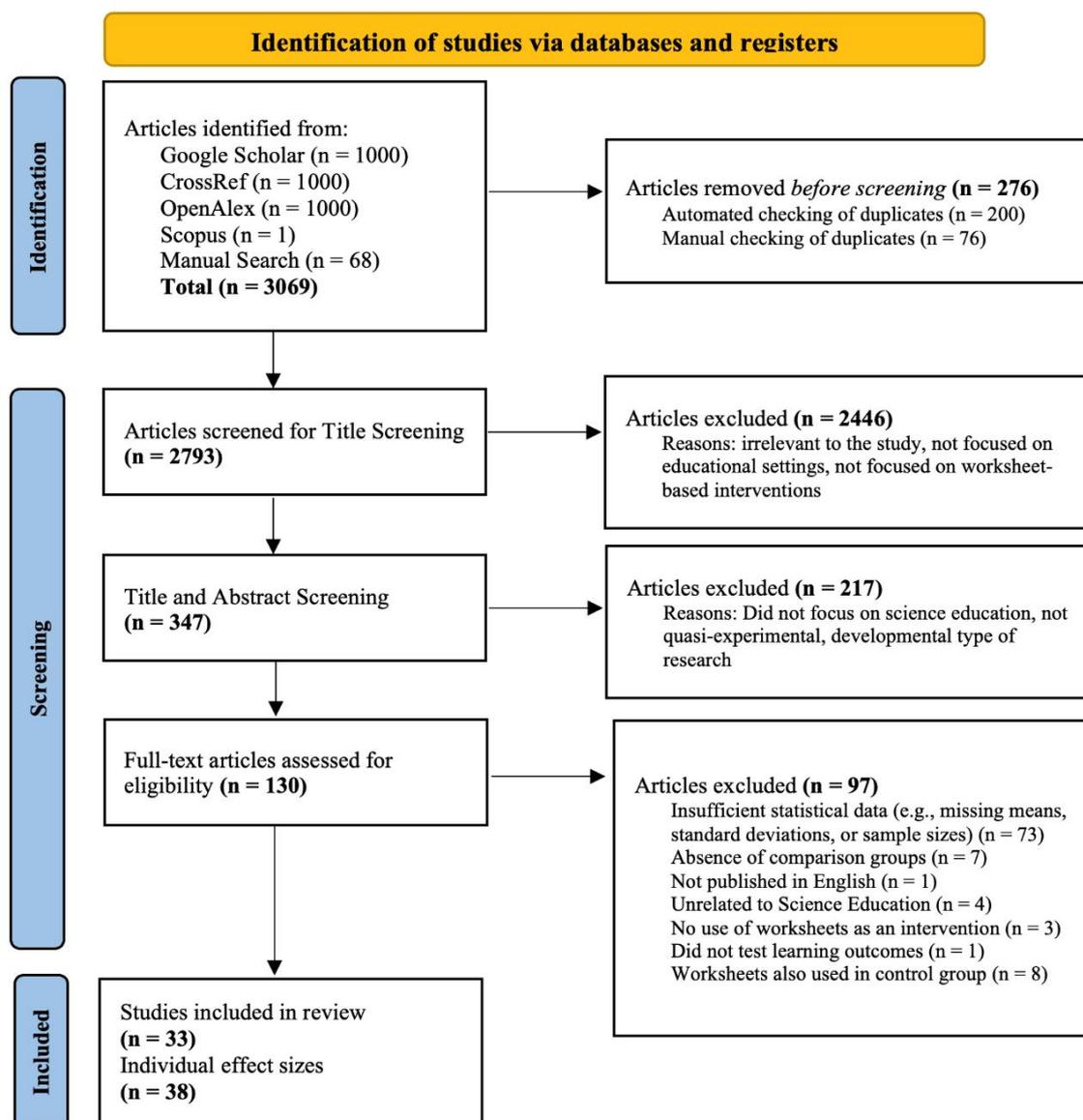


Figure 1. Flow Diagram Using the PRISMA Protocol

### Eligibility Criteria

To ensure that only relevant articles were included in the review, the selection process was guided by a set of criteria formulated by the researchers. Namely, included articles must be:

- a. Available in full-text online
- b. Published between 2015 and 2025
- c. Written in English
- d. Conducted in an elementary, secondary, or tertiary educational setting
- e. Employed a quasi-experimental design with a control group using conventional instruction
- f. Focused on science education
- g. Must report sufficient quantitative data, including post-test mean scores, standard deviations, and sample sizes.

Out of the 130 full-text articles reviewed, 97 were excluded due to reasons such as lack of worksheet use ( $n = 3$ ), absence of conventional instruction in the control group ( $n = 8$ ), no group comparison ( $n = 7$ ), missing quantitative data ( $n = 73$ ), not focused in science education ( $n = 4$ ), study did not test learning outcomes ( $n = 1$ ), and non-English language ( $n = 1$ ). This left 33 studies eligible for inclusion, from which 38 effect sizes were extracted, as some studies reported multiple learning outcomes aligned with the scope of this study.

### **Coding Features and Procedures**

Data from 33 eligible studies yielding 38 independent effect sizes were extracted and coded based on our established eligibility criteria. The three researchers independently coded and extracted data using a shared Google Sheet. After the initial coding, another researcher cross-checked each study, and discrepancies or errors were resolved through discussion. We initially wanted to include the intervention duration, but later decided not to because most eligible studies did not report this. We could also not contact the original authors due to time constraints. Therefore, all data in this meta-analysis were derived from the information available only in the full-text manuscripts.

Because many included studies described a range of worksheet designs, we grouped them based on recurring instructional features and their alignment with established educational theories. Studies were categorized based on the dominant instructional design features described in the manuscript. The categories are: conventional, technology-enhanced, constructivist, inquiry-based, representation-rich, differentiated, and ethnoscience. Conventional worksheets did not have pedagogical or technological modifications, while technology-enhanced worksheets integrated digital tools and simulations. Constructivist worksheets are based on the Constructivist theory which posits that learners build knowledge through interaction with tasks and contexts (Jonassen, 1991).

Inquiry-based worksheets were treated as a separate category because enough studies have employed this approach to create a meaningful moderator analysis. Representation-rich worksheets incorporated visual and symbolic aids grounded in cognitive load and dual coding theories (Sweller, 1994; Mayer, 2014). Differentiated worksheets used strategies like scaffolding and guided notes to support diverse learners (Tomlinson, 2005). Lastly, ethnoscience worksheets incorporated indigenous knowledge, aligning with culturally responsive pedagogy (Banks, 2021). The table below shows the categories alongside their specific worksheet variations and the number of corresponding studies:

Table 1. Worksheet Variation Categories

Category	Specific Variation	Number of Studies Included (k)
<b>Constructivist</b>	Problem-based Learning	4
	Discovery Learning	2
	Problem-solving based	2
	Project Argumentative Learning	1
	Project-Based Learning	1
<b>Representation-rich</b>	Process Image-Based	4
	HOTS-oriented	2
	Cartoon-enriched	1
	Multiple-Intelligences Based	1
	Multiple Representations	1
<b>Inquiry-based</b>	Inquiry-based	3
	Guided-inquiry	2
	Process-oriented guided inquiry	1
<b>Technology-enhanced</b>	Electronic	4
	Augmented Reality	2
<b>Differentiated</b>	Blended Learning	1
	Guided Note Taking	1
	Learning-style oriented	1
	Scaffolding-based	1
<b>Conventional</b>	-	2
<b>Ethnoscience</b>	-	1
<b>Total</b>		<b>38</b>

### Effect Size Calculation

Effect sizes for the 33 studies were calculated using Comprehensive Meta-Analysis (CMA) Version 4 (Borenstein et al., 2022). We chose Hedges  $g$  over Cohen's  $d$  as the standardized measure of effect size due to its correction for bias in small sample sizes (Borenstein et al. 2010). We applied a random effects model as it was appropriate for heterogeneous studies (Borenstein et al., 2010). The effect sizes were interpreted as small (0.2), medium (0.5), or large (0.8) based on Cohen (1992). Positive values indicated favor toward worksheets, while negative values favored conventional instruction. Moderator analyses employed a mixed-effects model to examine differences by country, education level, discipline, learning domain, and worksheet type. Publication bias was assessed using the Classic fail-safe  $N$ , Begg-Mazumdar test, and funnel plot inspection. All analyses used 95% confidence intervals

and a significance level of  $p < 0.05$ .

### Results

This meta-analysis synthesized 38 effect sizes from 33 studies involving 2,465 students to assess the impact of worksheets on science learning outcomes. Significant heterogeneity was found ( $Q(37) = 512.047, p < 0.001; I^2 = 92.77%$ ), warranting the use of a random-effects model. The overall effect was large and significant (Hedges  $g = 1.600, SE = 0.175, 95\% CI [1.257, 1.942], z = 9.151, p < 0.001$ ), which means that worksheets substantially improve science learning outcomes.

Table 1. Overall Intervention Effect Size and Heterogeneity Analysis

Model	Effect size at 95% confidence interval						Test of null (2-Tailed)		Heterogeneity statistics			
	Number of effect sizes	Hedges $g$	Std. error	Variance	Lower Limit	Upper Limit	$z$ -value	$p$ -value	$Q$ -value	$df$	$p$ -value	$I^2$
<b>Fixed</b>	38	1.223	0.046	0.002	1.142	1.324	26.545	0.000	.047	37	0.000*	92.774
<b>Random</b>	38	1.600	0.175	0.031	1.257	1.942	9.151	0.000				

Note: Std=standard error ;  $Q$ =Homogeneity value;  $df$ =degrees of freedom ; \*A  $p$ -value  $< 0.05$  shows significance

Table 2. Forest Plot and Distribution of Effect Sizes

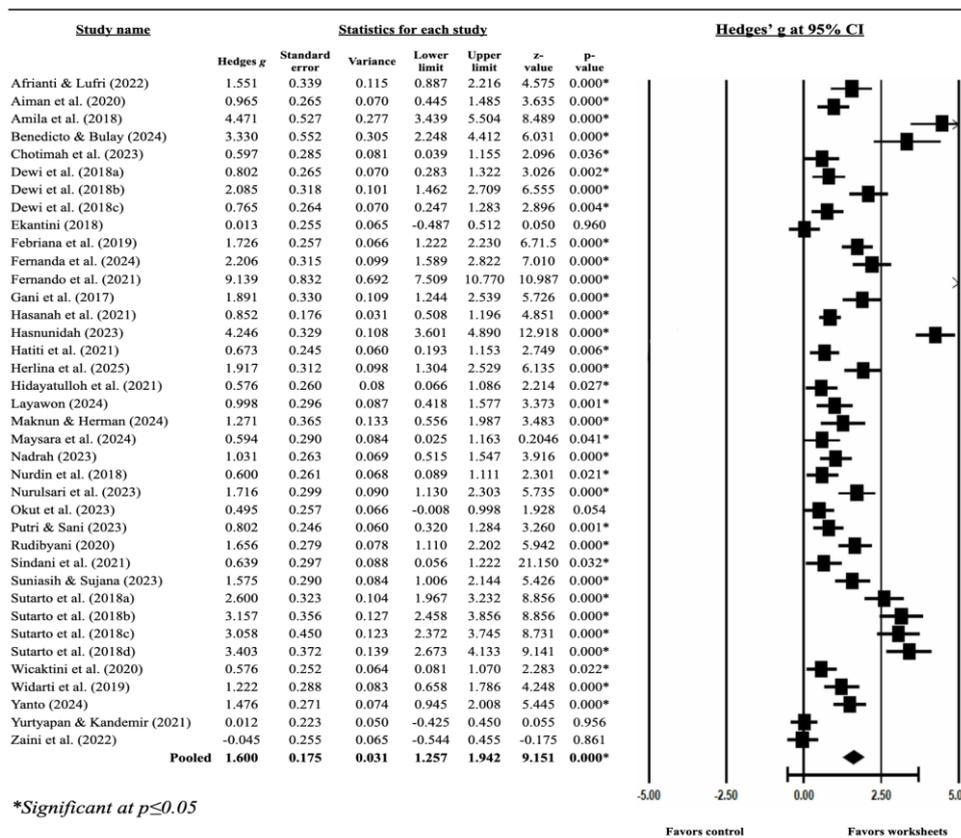


Table 2 shows the forest plot presenting the individual effect sizes, standard errors, variances, z-values, and p-values for each of the 38 studies. The effect sizes range widely, from -0.045 to 9.139, with most falling within the positive range. Of the 38 studies, 35 yielded statistically significant results ( $p < 0.05$ ), while three were not statistically significant ( $p > 0.05$ ). The forest plot visually represents each study's effect size (square) and its 95% confidence interval (horizontal line), with the overall pooled effect size indicated by the diamond at the bottom. This figure highlights the consistency of positive effects and the variation in magnitudes across studies, reinforcing the robustness of the overall finding favoring the use of worksheets.

### Moderator Analysis

Due to significant heterogeneity, moderator analysis was conducted across five variables: country, educational level, scientific discipline, learning domain, and worksheet variation. Results showed significant differences. The largest effects were found in Indonesia ( $g = 1.657$ ), secondary education ( $g = 1.777$ ), and Physics ( $g = 2.069$ ). All learning domains showed strong effects, with the cognitive domain highest ( $g = 1.660$ ). Among the worksheet variations, ethnoscience ( $g = 4.471$ ) and representation-rich ( $g = 2.772$ ) had the largest effect sizes, while conventional worksheets had the smallest ( $g = 0.520$ ).

Table 3. Moderator Analysis of Included Studies

Variable	Category	k	Effect size	95% CI		Heterogeneity Test	
				LL	UL	Q-value	p-value
Country	Indonesia	34	1.657	1.294	2.019	32.798	0.000*
	Philippines	3	1.509	0.233	2.786		
	Turkey	1	0.012	-0.425	0.450		
Educational Level	Secondary	31	1.777	1.373	2.180	6.737	0.034*
	Tertiary	3	0.892	0.209	1.538		
	Elementary	4	0.874	-0.055	1.839		
Scientific Discipline	Physics	19	2.069	1.530	2.608	31.816	0.000*
	Biology	10	1.426	0.724	2.129		
	Chemistry	3	1.161	0.557	1.766		
	Earth Science	2	0.980	0.592	1.367		
	Elementary Science	3	0.847	-0.089	1.782		
	Environmental Science	1	0.013	-0.487	0.512		
Learning Domain	Cognitive	35	1.660	1.281	2.039	13.222	0.001*
	Psychomotor	1	1.476	0.945	2.008		
	Affective	1	0.825	0.539	1.112		
Worksheet Variation	Ethnoscience	1	4.471	3.439	5.504	51.827	0.000*
	Representation-rich	9	2.772	1.701	3.844		
	Constructivist	10	1.632	0.978	2.285		

Technology-enhanced	6	1.090	0.394	1.786
Differentiated	4	0.952	0.440	1.464
Inquiry-based	6	0.950	0.546	1.354
Conventional	2	0.520	-0.478	1.517

\*A *p*-value <0.05 shows significance

### Worksheet Variations

Figure 2 shows how frequently various categories were employed by the studies. This figure shows the distribution of studies employing different types of worksheets. Constructivist ( $k = 10$ , 26.3%) and representation-rich worksheets ( $k = 9$ , 23.7%) were the most common, followed by inquiry-based and technology-enhanced types ( $k = 6$ , 15.8% each). Differentiated ( $k = 4$ ), Conventional ( $k = 2$ ), and Ethnoscience worksheets ( $k = 1$ ) appeared less frequently.

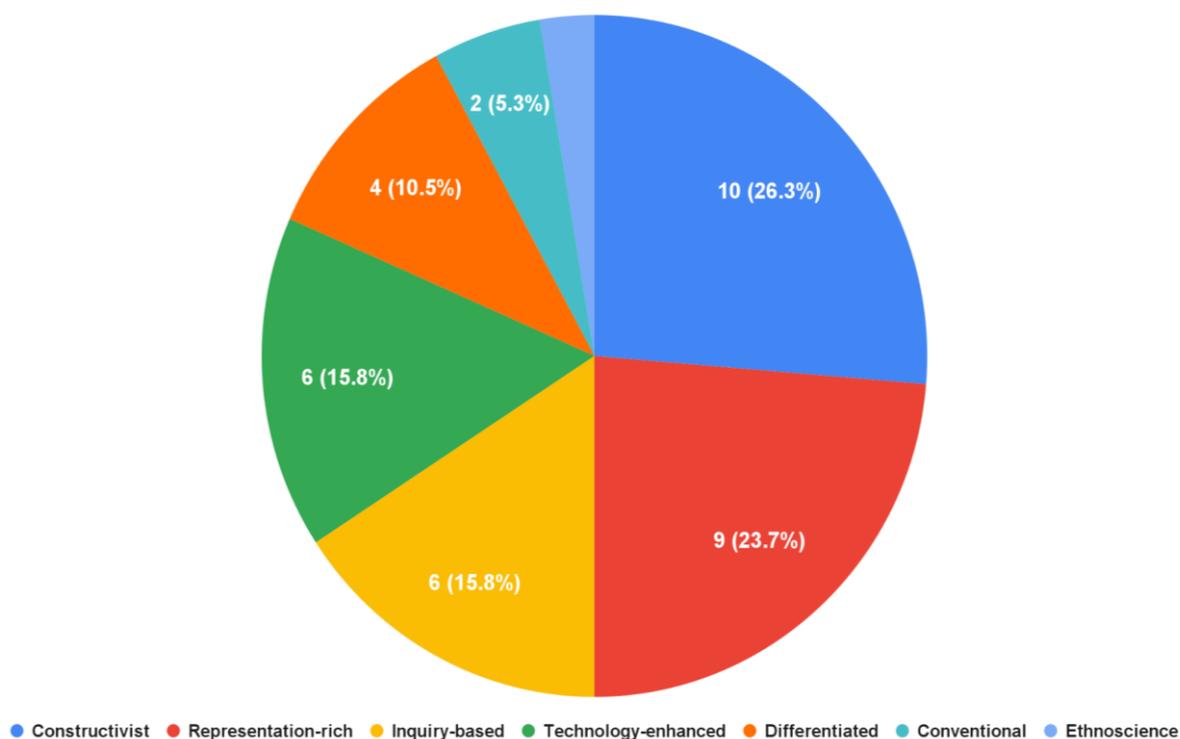


Figure 2. Distribution of Worksheet Variations

Table 4 presents example studies for each worksheet variation. Ethnoscience worksheets incorporated cultural elements like dance and architecture (Amila et al., 2018), while representation-rich worksheets used multiple models to aid understanding (Widarti et al., 2019). Constructivist worksheets facilitated inquiry and argumentation (Hasnunidah et al., 2023), and technology-enhanced worksheets offered self-paced digital learning (Okut et al., 2023). Differentiated worksheets used guided note-taking to reinforce lessons (Febriana et al., 2019). Inquiry-based worksheets encouraged discussion and experimentation (Chotimah et al., 2018), and conventional worksheets focused on post-lecture practice (Nadrah, 2023).

Table 4. Study Exemplars of Worksheet Variations in Science Instruction

Worksheet Variation	k	Hedges g	Study Exemplar
Ethnoscience	1	4.471 (Large)	Amila et al. (2018) showed images of local traditional dances and architecture in their ethnoscience worksheets to teach rigid body equilibrium, combining visuals with discussion and experimentation to connect indigenous knowledge to science.
Representation-rich	9	2.772 (Large)	Widarti et al. (2019) used worksheets with macroscopic, sub-microscopic, and symbolic representations to teach intermolecular forces and improve students' conceptual understanding.
Constructivist	10	1.632 (Large)	Hasnunidah et al. (2023) used project-argumentative worksheets on environmental pollution to guide group-based inquiry, evidence gathering, and argument building with the worksheets scaffolding each step of the inquiry and argumentative process.
Technology-enhanced	6	1.090 (Large)	Okut et al. (2023) electronic worksheets in order to provide self-paced learning in Grade 10 science to improve academic performance toward the systems of the body.
Differentiated	4	0.952 (Large)	Febriana et al. (2019) used guided note-taking worksheets with partially completed content, allowing students to fill in key concepts on the excretory system during lectures.
Inquiry-based	6	0.950 (Large)	Chotimah et al. (2018) used a guided inquiry worksheet in kinetic gas theory consisting of sequential tasks. Students had to work in groups, actively discussing and responding to each section as they progressed through an experiment.
Conventional	2	0.520 (Medium)	Nadrah (2023) used conventional worksheets containing practice questions and short-answer tasks. Students then had to complete the worksheets after the teacher's explanation.

Note: k = number of effect sizes

### Publication Bias

We assessed publication bias through multiple tests. The funnel plot showed slight asymmetry, suggesting possible missing studies with small or negative effects. Egger's test (Intercept = 12.98,  $p < 0.001$ ) and Begg-Mazumdar's rank correlation ( $\tau = 0.66$ ,  $p < 0.001$ ) supported this. However, the Classic fail-safe N test showed that 8,666 additional null-effect studies would be required to reduce the p-value above the .05 threshold. The

overall pattern of results and robust fail-safe N estimates suggests that while some degree of publication bias is present, it does not pose a serious threat to the validity or robustness of the findings in this meta-analysis.

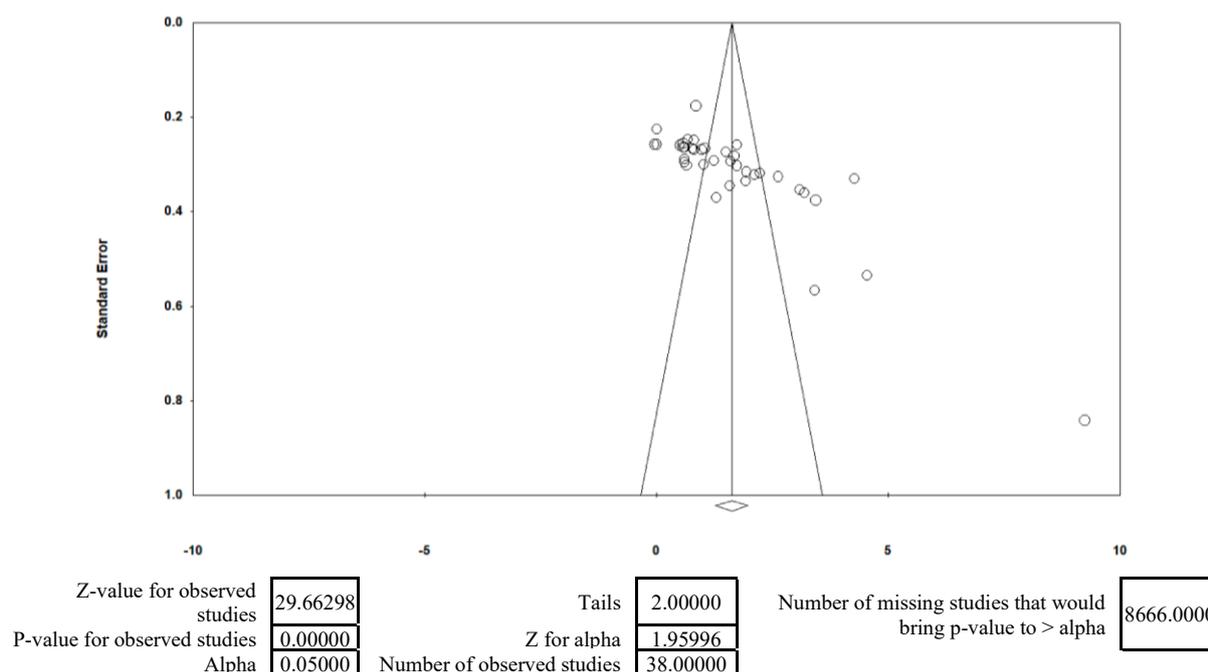


Figure 3. Funnel Plot of Standard Error by Hedges  $g$

## Discussion

Our findings provide strong empirical support for the effectiveness of worksheets in science education. The overall effect size ( $g = 1.600$ ) is considered large, confirming that worksheets significantly enhance students' learning outcomes. The forest plot supports the quantitative findings of this meta-analysis by visually demonstrating the beneficial impact of worksheets on student learning. These findings are consistent with prior meta-analyses (Chutami & Suhartini, 2021; Putri et al., 2022), which reported medium to very high effects when worksheets were embedded within student-centered learning activities. Our study extends this by using a larger and more diverse sample, adhering to the PRISMA framework, and examining a wider range of moderators. The  $Q$ -value of 512.047 and an  $I^2$  value of 92.774% suggest substantial heterogeneity exists among the 38 effect sizes examined. Higgins et al. (2003) indicate that an  $I^2$  exceeding 75% implies considerable variation beyond what would be expected by random chance. This reinforces the importance of analyzing moderating factors that may influence the impact of worksheets on learning. Variability in instructional context, worksheet design, subject matter, and learner characteristics likely accounts for these differences (Higgins & Thompson, 2002).

Learning domain also revealed a large and significant effect size, with the most pronounced outcomes observed in the cognitive domain. These findings imply that worksheets make learning more meaningful and, in turn, increase students' cognitive skills (Widodo et al., 2023). Next are the affective and psychomotor domains with effect sizes of ( $g = 1.476$ ) and ( $g = 0.825$ ), respectively. The learning process mostly centers on the student's

cognitive development, while the student's affective and psychomotor development is underexplored. However, studies showed that worksheets, especially when using the guided inquiry model, effectively develop students' scientific attitude. And to facilitate the integration of the worksheet in the scientific attitude, discovery and critical thinking should be purposefully embedded within the scientific process (Misbah et al., 2018). Similarly, Lufri et al. (2021) found that student worksheet-based PBL can significantly enhance their affective competence by encouraging them to take responsibility and think critically when formulating and responding to questions. Meanwhile, worksheets also help students develop their psychomotor skills through active involvement in the scientific process (Septyowaty et al., 2023). Future research should explore how worksheets influence affective and psychomotor development, particularly in practical and values-oriented science topics.

All studies were conducted in Asia, with Indonesia ( $k=34$ ) having a high overall effect size ( $g = 1.657$ ). Second is the Philippines ( $k = 3$ ), still reporting a large effect size ( $g = 1.509$ ). Meanwhile, Turkey was represented by a single study ( $k = 1$ ), with a negligible effect size ( $g = 0.012$ ). The large effects seen in Indonesia and the Philippines could be attributed to educational policies that emphasize student-centered strategies, integration of 21st-century skills, and the use of active learning tools (Amiruddin et al., 2023; Patresia et al., 2020). These findings corroborate the study by Lee (2014), which showed that although worksheets are a globally common instructional tool, worksheet use in Asia is more often a formal part of the curriculum, not just supplementary materials. This geographical limitation also indicates a need for more global research in diverse educational systems.

Moderator analysis also showed that educational level significantly influenced worksheet effectiveness ( $p = 0.034$ ). The strongest effect appeared at the secondary level ( $g = 1.777$ ,  $k = 31$ ), while smaller effects were observed at the tertiary ( $g = 0.892$ ,  $k = 3$ ) and elementary levels ( $g = 0.874$ ,  $k = 4$ ). Differences may influence these findings in students' cognitive development and learning readiness. Cognitive differences affect how learners grasp scientific concepts, while socio-economic and cultural backgrounds can influence readiness. As a result, children of the same age are not always at the same level of preparation to receive wider outside influences (Wahyuni et al., 2021). Hence, the observed variation in the effectiveness of worksheets across elementary, secondary, and tertiary levels may be attributed to students' differing levels of cognitive maturity and readiness to process structured learning materials.

Scientific discipline was found to have significant effects ( $p = 0.000$ ), indicating that the impact of worksheets varies depending on the specific branch of science. Physics yielded the highest effect size ( $g = 2.069$ ,  $k = 19$ ), likely because the subject's abstract concepts benefit from visualizations and multiple representations commonly found in representation-rich worksheets. Orulebaja et al. (2021) emphasized that effective Physics learning takes many forms such as equations, diagrams, graphs and words and constructing meaning across these forms can enhance conceptual understanding and problem-solving skills. Following Physics were Biology ( $g = 1.426$ ), Chemistry ( $g = 1.161$ ), Earth Science ( $g = 0.980$ ) and Elementary Science ( $g = 0.847$ ), all showing large effects. A commonality identified across these disciplines is that they were designed to actively engage students in constructing knowledge (Tuerah, 2019) in disciplines that require understanding of complex systems and processes (Kokkonen & Schalk, 2020). In contrast, Environmental Science ( $g = 0.013$ ) showed a very small, non-significant effect. However, this result but should be interpreted cautiously due to having only one study.

Our analysis also revealed diverse variations in how worksheets are designed and implemented, all showing significant differences. Among these, the sole ethnoscience worksheet of Amila et al. (2018) had the largest positive effect ( $g = 4.4471$ ,  $k = 1$ ). The large effect can likely be attributed to the culturally responsive approach, connecting new scientific concepts with students' prior cultural knowledge (Banks, 2021). Similarly, Gay (2018) argued that contextualization through familiar narratives enhances both understanding and relevance for the students. However, it should be noted that we only had one study for this worksheet, so while the results are promising, we should interpret them cautiously. Still, our findings point to the potential of teaching science by connecting it to local culture. Representation-rich worksheets also yielded consistently large effects ( $g = 2.772$ ,  $k = 9$ ). It can be observed that these worksheets were frequently used in chemistry and physics, where abstract concepts are very prevalent. Widarti et al. (2019), for instance, reported improved understanding of intermolecular forces through the use of multiple representations. Gates (2017) argues that different visuals are an effective way to help students understand challenging concepts by giving them multiple ways to "see" the information presented to them. However, the success of these worksheets depends on thoughtful design. As Rasch and Schnotz (2009) caution, poorly integrated visuals may create redundancy or increase cognitive load. Therefore, the effectiveness of representation-rich worksheets likely comes from their ability to enhance, not distract from, the core learning by minimizing unnecessary repetition and ensuring that the visuals are used efficiently to enhance learning.

Constructivist worksheets were the most frequently used type and consistently demonstrated strong effects ( $g = 1.632$ ,  $k = 10$ ). Hasnunidah (2023) used a project-argumentative learning worksheet on environmental pollution. Prior research supports how these worksheets promote deeper understanding and metacognitive development (Koretsky et al., 2018; Mahyuna et al., 2018; Tuerah, 2019). However, without clear structure, these tasks can overwhelm students who are still building their critical thinking skills (Kirschner & Merriënboer, 2013). Thus, while the evidence shows the strong potential of constructivist worksheets, their effectiveness still relies on teachers gradually guiding students from dependence to independence. The large effect of technology-enhanced worksheets ( $g = 1.090$ ), reflects the growing value and evolution of digital interventions in science education. As emphasized in the literature, well-designed digital worksheets can improve student attitudes and motivation and promote independent learning (Haerani et al., 2023). For example, Okut et al. (2023) implemented electronic worksheets to support self-paced learning on body systems. But this shift also brings up important questions about students' access to devices, the internet, and the skills needed to use these devices. As classrooms go digital, future studies should explore students' perceptions with the technology and what kind of support they need. When technology is used not as an add-on but as a tool that supports inquiry, visualization, and feedback, technology-enhanced worksheets become highly effective for deepening science learning in both our traditional and digital classrooms.

Inquiry-based worksheets also showed a consistently large effect in science students' learning outcomes ( $g = 0.950$ ,  $k = 6$ ). Chotimah et al. (2018) developed guided inquiry worksheets for the Kinetic Gas Theory, enabling students to participate in scientific sense-making actively. Prior studies have shown that inquiry-based worksheets effectively strengthen science process skills such as analyzing data and constructing explanations based on evidence (Mahyuna et al., 2018; Yalyn et al., 2022). The strong effect seen in our analysis supports these earlier findings. This means that the impact of these worksheets may be most visible in learning environments that have

placed more emphasis on hands-on learning and problem-solving. In which case, inquiry-based worksheets provide students with both the structure and the opportunity to explore ideas more deeply. Differentiated worksheets also produced a large effect similar to the Inquiry-based worksheets ( $g = 0.952$ ,  $k = 4$ ). Febriana et al. (2019) used guided note-taking worksheets on the excretory system, where key concepts were partially provided and students filled in during lectures. Studies have shown that differentiated worksheets, whether through scaffolding or blended learning models, supports comprehension (Maysara et al., 2024; Putri & Sani, 2023). These are especially useful in diverse classrooms where students may progress at different paces.

Conventional worksheets showed the least, albeit still moderate, effect size ( $g = 0.520$ ,  $k = 2$ ) relative to the other variations. They appear to still be in use in the classroom due to their simplicity and promotion of active learning (Burkholder et al., 2021). Nevertheless, their often-low cognitive demand may limit their ability to cultivate deeper learning outcomes, a concern echoed in Mayer's (2004) critique of rote-based approaches. While conventional worksheets can serve a useful foundational purpose, our findings show that their educational value increases when combined with other pedagogical approaches or technological enhancements, leading to larger effects. Thus, the challenge for teachers is not to outright abandon their use, but to evolve their design through inquiry prompts, technological enhancements, contextualization, learner-centered approaches, multiple representations, or differentiation to provide students more meaningful learning experiences.

## Conclusion

This meta-analysis examined 38 individual effect sizes from 33 total studies to determine the effectiveness of using worksheets in enhancing science learning outcomes among students. The overall effect size was found to be large and positive, indicating that the use of worksheets significantly improves science students' learning outcomes. However, the analysis also revealed a significant level of heterogeneity, implying variations in this effectiveness across different contexts. This study conducted a moderator analysis on five key variables: learning domain, country, educational level, scientific discipline, and worksheet variation. All of these moderators yielded a statistically significant influence on the effect sizes. In the context of country implementation, worksheets proved to be most beneficial in research carried out in Indonesia and the Philippines. At the same time, at the education level and scientific discipline, the most significant and largest effect was found at the secondary level, and in the field of Physics, respectively. Meanwhile, worksheets focused on the cognitive domain and those rich in representations or grounded in ethnoscience demonstrated the largest and significant effect on learning outcomes. These findings accentuate the need to thoroughly take into account the educational contexts, subject matter, and learner needs when making worksheets to maximize their effectiveness.

## Recommendations

Our study provides practical guidance for science educators and curriculum developers. Teachers are encouraged to use engaging worksheet formats such as constructivist, representation-rich, inquiry-based, culturally relevant, and technology-integrated designs. For curriculum developers, it is important to create differentiated worksheets that target cognitive, affective, and psychomotor learning outcomes, particularly in subjects like physics and

chemistry, where visual supports are shown to be effective. Teacher Education Institutions (TEIs) should equip future teachers to create research-informed, multimedia-supported, and culturally responsive materials. As digital worksheets become more common, schools should ensure equitable access and support students' digital literacy. Future research should broaden geographical coverage and explore factors like intervention duration. Notably, the lack of worksheets evaluating affective and psychomotor outcomes highlights a critical research gap that future researchers could explore. Improving science instruction at the classroom level is foundational to addressing global challenges. This means transforming worksheets from fill-in-the-blank papers into tools that nurture students' skills, values, and scientific ways of thinking.

## Acknowledgements

We would like to express our sincerest gratitude to the University of Southeastern Philippines, Department of Science and Technology - Science Education Institute, Alliance of Agham Scholars, and the Gokongwei Brothers Foundation for their support. The researchers would like to further thank Reynaldo M. Nogodula for extending his help in the writing of this study.

## References

*Studies included in the meta-analysis are marked with an asterisk (\*).*

- \*Afrianti, E & Lufri (2022). Development of Student Worksheets (LKPD) based on discovery Learning to improve students' critical thinking ability on movement system and digestive system materials in Class XI SMA/MA. (2022). *International Journal of Multidisciplinary Research and Analysis*, 05(06). <https://doi.org/10.47191/ijmra/v5-i6-40>
- \*Aiman, U. (2020, October). The Improvement of Science Learning Outcomes of Primary School Students Through the Model of POGIL-Supplemented With the Student Worksheet. In *The 5th Progressive and Fun Education International Conference (PFEIC 2020)* (pp. 181-188). Atlantis Press. <https://doi.org/10.2991/assehr.k.201015.028>
- \*Amila, A., Syatna, A., & Herlina, K. (2018). Practicality and effectiveness of student'worksheets based on ethno science to improve conceptual understanding in rigid body. *International Journal of Advanced Engineering, Management and Science (IJAEMS)*, 4(5), 400-407. <https://dx.doi.org/10.22161/ijaems.4.5.11>
- Amiruddin, N., Baharuddin, F. R., Takbir, N., & Setialaksana, W. (2023). May student-centered principles affect active learning and its counterpart? An empirical study of Indonesian curriculum implementation. *SAGE Open*, 13(4). <https://doi.org/10.1177/21582440231214375>
- Anjani, H. R., Syahdi, N., & Dewi, U. P. (2023). Meta-analysis of the effect of using integrated student worksheets innovative natural science learning models to improve high order thinking skills of high school students. *Jurnal Penelitian Pendidikan IPA*, 9(8), 5806-5815. <https://doi.org/10.29303/jppipa.v9i8.2700>
- Banks, J. A. (Ed.). (2021). Transforming multicultural education policy and practice: Expanding educational opportunity. *Teachers College Press*.

- Bartoňová, M., & Kričfaluši, D. (2021, September). The Methodology for Creating Worksheets for Integrated Science. In Proceedings of the 4th International Baltic Symposium on Science and Technology Education (BalticSTE2021) (pp. 7-15). <https://doi.org/10.33225/BalticSTE/2021.07>
- \*Benedicto, S., & Bulay, M. (2024). Effectiveness of Laboratory Worksheet with Problem-Based Learning Approach for Enriching the Least-Learned Competencies in Life Science. *Journal of Interdisciplinary Perspectives*, 2(12), 268-275. <https://doi.org/10.69569/jip.2024.0475>
- Borenstein, M., Hedges, L. V., Higgins, J. P., & Rothstein, H. R. (2010). A basic introduction to fixed-effect and random-effects models for meta-analysis. *Research synthesis methods*, 1(2), 97-111. <https://doi.org/10.1002/jrsm.12>
- Borenstein, M. (2022). Comprehensive meta-analysis software. *Systematic reviews in health research: meta-analysis in context*, 535-548. <https://doi.org/10.1002/9781119099369.ch27>
- Burkholder, E., Mohamed-Hinds, N., & Wieman, C. (2021). Evidence-based principles for worksheet design. *The Physics Teacher*, 59(6), 402-403. <https://doi.org/10.1119/5.0020091>
- \*Candra, O. (2024). E-Worksheets with Augmented Reality Technology in Laboratory Learning: Examining Their Effectiveness on Students' Learning Performance. *International Journal of Information and Education Technology*, 14(11), 1544-1553. <https://doi.org/10.18178/ijiet.2024.14.11.2185>
- Chotimah, C. (2020, March). A meta-analysis of the effects of using PhET interactive simulations on student's worksheets toward senior high school students learning result of physics. In *Journal of Physics: Conference Series (Vol. 1481, No. 1, p. 012093)*. IOP Publishing. <https://doi.org/10.1088/1742-6596/1481/1/012093>
- \*Chotimah, A. N., Setyawarno, D., & Rosana, D. (2023). Effect of guided inquiry model by PhET Simulations worksheet on science process skills and mastery of concepts. *Journal of Science Education Research*, 7(2), 100-105.
- Chutami, F., & Suhartini, S. (2021). The Effectiveness of Using Student Worksheets in Science Learning on Student Learning Outcomes. *Jurnal Penelitian Pendidikan IPA*, 7(4), 587-592.
- Cohen, J. (1992). Statistical power analysis. *Current directions in psychological science*, 1(3), 98-101. <https://doi.org/10.1111/1467-8721.ep10768783>
- \*Dewi, N. R., Akhlis, I., Aini, F. N., & Taufiq, M. (2018). The Effect of Inquiry-Based Independent Worksheet Using ICT Towards Science Learning to Embody the Student's Creativity and Characters. *International Journal of Engineering & Technology*, 7(2), 574-580.
- \*Ekantini, A., & Wilujeng, I. (2018). The Development of Science Student Worksheet Based on Education for Environmental Sustainable Development to Enhance Scientific Literacy. *Universal Journal of Educational Research*, 6(6), 1339-1347. <https://doi.org/10.13189/ujer.2018.060625>
- \*Febriana, E., Huda, I., & Sarong, M. A. (2020, February). Guided note taking based on students worksheet effect towards students learning outcome. In *Journal of Physics: Conference Series (Vol. 1460, No. 1, p. 012073)*. IOP Publishing. <https://doi.org/10.1088/1742-6596/1460/1/012073>
- \*Fenanda, H. E., Herlina, K., & Abdurrahman, A. (2024). Practicality and effectiveness of e-worksheet based on ExPRession learning model activities to train critical thinking skills. *Asian Journal of Science Education*, 6(1), 118-128. <https://doi.org/10.24815/ajse.v6i1.37353>
- \*Fernando, T. J., Darvina, Y., Sari, S. Y., Dwiridal, L., & Rahim, F. R. (2021). The Effect of Hots-Oriented

- Worksheets with Barcode Assistance in Online Learning on Critical Thinking and Creatives of Students of Class XI SMAN 1 HARAU. *Pillar of Physics Education*, 14(1), 15.
- \*Gani, A., Safitri, R., & Mahyana, M. (2017). Improving the Visual-Spatial Intelligence and Results of Learning of Junior High School Students' with Multiple Intelligences-Based Students Worksheet Learning on Lens Materials. *Jurnal Pendidikan IPA Indonesia*, 6(1). <https://doi.org/10.15294/jpii.v6i1.9594>
- Gates, P. (2017). The importance of diagrams, graphics and other visual representations in STEM teaching. In *STEM education in the junior secondary: The state of play* (pp. 169-196). Singapore: Springer Singapore. [https://doi.org/10.1007/978-981-10-5448-8\\_9](https://doi.org/10.1007/978-981-10-5448-8_9)
- Gay, G. (2018). *Culturally responsive teaching: Theory, research, and practice*. teachers college press.
- Haerani, H., Arsyad, M., & Khaeruddin, K. (2023). Development of Experiment-Based Physics worksheets in science in developing students' science process skills. *Jurnal Penelitian Pendidikan IPA*, 9(1), 292–298. <https://doi.org/10.29303/jppipa.v9i1.2609>
- Harzing, A.W. (2007) Publish or Perish, available from <https://harzing.com/resources/publish-or-perish>
- \*Hasanah, Z., Ritonga, S., Ikhsan, Z., & Suarni, S. (2021). The implementation of problem based learning integrated with STEM-based worksheets to improve learning motivation. *Asian Journal of Science Education*, 3(2), 102-112. <https://doi.org/10.24815/ajse.v3i2.19745>
- \*Hasnunidah, N., Rosidin, U., Maulina, D., & Ismi, R. (2023). Students' Argumentation Skills towards Using Biology e-Worksheet based on Project-Argumentative Learning Model. *Eurasian Journal of Educational Research*, 103(2), 341-361.10.
- \*Hatiti, A., Distrik, I. W., & Rosidin, U. (2021). The Effect of HOTS-Oriented Blended Learning Student Worksheets on Students' Cognitive Learning Outcomes on Work and Energy Materials. *Berkala Ilmiah Pendidikan Fisika*, 9(3), 381. <https://doi.org/10.20527/bipf.v9i3.11176>
- \*Herlina, K., Abdurrahman, A., Umam, A. N., Nurjanah, A., Rabbani, G. F., & Pratiwi, F. A. I. (2025). Expression-Based E-Worksheet (EBEW): An Effort to Enhance Students' Computational Thinking Skills. *Journal of Technology and Science Education*, 15(1), 50-63. <https://doi.org/10.3926/jotse.2210>
- \*Hidayatulloh, W., Herliandry, L. D., & Kuswanto, H. (2021, March). Graphical Representation Skills in Online Learning During COVID-19 Pandemic Through Augmented Reality Assisted Student Worksheets. In *6th International Seminar on Science Education (ISSE 2020)* (pp. 453-460). Atlantis Press. <https://doi.org/10.2991/assehr.k.210326.065>
- \*Jalmo, T., & Ertikanto, C. (2018). Effectiveness of guided inquiry model student worksheet to improve critical thinking skill on heat material. *International Journal of Advanced Engineering, Management and Science (IJAEMS)*, 4(7), 564-573. <https://dx.doi.org/10.22161/ijaems.4.7.10>
- Jonassen, D.H. Objectivism versus constructivism: Do we need a new philosophical paradigm?. *ETR&D* 39, 5–14 (1991). <https://doi.org/10.1007/BF02296434>
- Jones, J., Blecker, S., & Shah, N. R. (2008). Meta-Analysis 101: What You Want to Know in the Era of Comparative Effectiveness. *American Health & Drug Benefits*, 1(3), 38. <https://pmc.ncbi.nlm.nih.gov/articles/PMC4115319/>
- Kokkonen, T., & Schalk, L. (2020). One Instructional Sequence Fits all? A Conceptual Analysis of the Applicability of Concreteness Fading in Mathematics, Physics, Chemistry, and Biology Education. *Educational Psychology Review*. <https://doi.org/10.1007/s10648-020-09581-7>

- Kirschner, P. A., & Van Merriënboer, J. J. (2013). Do learners really know best? Urban legends in education. *Educational psychologist*, 48(3), 169-183. <https://doi.org/10.1080/00461520.2013.804395>
- Koretsky, M., Keeler, J., Ivanovitch, J., & Cao, Y. (2018). The role of pedagogical tools in active learning: a case for sense-making. *International Journal of STEM Education*, 5(1). <https://doi.org/10.1186/s40594-018-0116-5>
- \*Layawon, D. M. F. (2024). Integrating Problem-Based Learning Worksheets as Supplemental Materials with Modular instruction: Its Effect on Learners' Critical Thinking Skills on Earthquakes in Grade 8 Earth and Space. *International Journal of Research and Innovation in Social Science*, 8(3s), 2806-2832. <https://dx.doi.org/10.47772/IJRISS.2024.803205S>
- Lee, C. (2014). Worksheet usage, reading achievement, classes' lack of readiness, and science achievement: A Cross-Country comparison. *International Journal of Education in Mathematics Science and Technology*, 2(2). <https://doi.org/10.18404/ijemst.38331>
- Lufri, L., Laili, F., & Anhar, A. (2021). Effect Scientific Approach with Assistance of Student Worksheets based PBL towards Students' Biology Affective Competence in Bacterial Learning Material. *Journal of Physics Conference Series*, 1940(1), 012119. <https://doi.org/10.1088/1742-6596/1940/1/012119>
- \*Maknun, J., & Herman, N. D. (2024). Developing critical thinking skills in vocational high school students through the application of physics project team learning model integrated with vocational-based worksheets. *Revista de Gestão Social e Ambiental*, 18(7), 1-15. <https://doi.org/10.24857/rgsa.v18n7-042>
- Mayer, R. E. (2014). Cognitive theory of multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (2nd ed., pp. 43-71). Cambridge University Press. <https://doi.org/10.1017/CBO9781139547369.005>
- Maysara, N., Wahyuni, W. O. A., Marhadi, M. A., Dahlan, N., Haetami, A., & Esnawi, N. (2024). Application of the discovery learning model using student worksheets based on scaffolding on stoichiometric materials to improve learning outcomes. *International Journal of Educational Technology and Learning*, 16(1), 1-7.
- Mahyuna, M., Adlim, M., & Saminan, I. (2018, September). Developing guided-inquiry-student worksheets to improve the science process skills of high school students on the heat concept. In *Journal of Physics: Conference Series (Vol. 1088, No. 1, p. 012114)*. IOP Publishing. <https://doi.org/10.1088/1742-6596/1088/1/012114>
- Misbah, M., Dewantara, D., Hasan, S. M., & Annur, S. (2018). The Development of Student Worksheet by Using Guided Inquiry Learning Model to Train Student's Scientific Attitude. *Unnes Science Education Journal*, 7(1).
- Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., ... & Prisma-P Group. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Systematic reviews*, 4(1), 1. <https://doi.org/10.1186/2046-4053-4-1>
- \*Nadrah, N. (2023). The Effectiveness of Providing Student Worksheets in an Effort to Improve Science Learning Outcomes for Class V Elementary School Students. *International Journal of Multidisciplinary: Applied Business and Education Research*, 4(2), 413-420.
- \*Nurulsari, N., Viyanti, V., & Yassine, B. (2023). HOTS-Oriented student worksheets with blended learning: Improving students' science process skills. *Online Learning in Educational Research*, 3(1), 47-58.

<https://doi.org/10.58524/oler.v3i1.228>

- \*Okita, J. L., Miñoza, J., & Bentuan, J. L. F. (2023). Electronic learning activity sheets (e-LAS): Its effect on the academic performance and attitude of grade 10 science students. *Psychology and Education: A Multidisciplinary Journal*, 14(9), 1-1.
- Orulebaja, Y. T., Owolabi, O. L., & Akintoye, H. (2021). Effects of Multiple representations and Problem-solving learning strategies on Physics students' problem-solving abilities. *International Journal for Innovation Education and Research*, 9(4), 350–365. <https://doi.org/10.31686/ijer.vol9.iss4.3045>
- Patresia, I., Silitonga, M., & Ginting, A. (2020). Developing biology students' worksheet based on STEAM to empower science process skills. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, 6(1), 147–156. <https://doi.org/10.22219/jpbi.v6i1.10225>
- Paul, J., & Barari, M. (2022). Meta-analysis and traditional systematic literature reviews—What, why, when, where, and how? *Psychology & Marketing*, 39(6), 1099–1115. <https://doi.org/10.1002/mar.21657>
- Putri, I. Y., Desnita, D., Putra, A., & Murtiani, M. (2022). Meta Analysis of the Effect of Student Worksheet Use on Student Learning Outcomes. *DOAJ (DOAJ: Directory of Open Access Journals)*.
- \*Putri, N. A., & Sani, R. A. (2023). The Impact of Student-Oriented Worksheets for Differentiated Learning (LKPD) on Students' Physics Learning Outcomes at MAN Binjai. *Jurnal Pendidikan Fisika dan Teknologi*, 9(2), 315-324. <https://dx.doi.org/10.29303/jpft.v9i2.5302>
- Rasch, T., & Schnotz, W. (2009). Interactive and non-interactive pictures in multimedia learning environments: Effects on learning outcomes and learning efficiency. *Learning and Instruction*, 19(5), 411-422. <https://doi.org/10.1016/j.learninstruc.2009.02.008>
- \*Rudibyani, R. B. R. (2020). The Effectiveness of Problem Solving-Based Student Worksheet to Improve Students' Critical Thinking Skills. *Jurnal Pendidikan Progresif*, 10(2), 279-291. <http://dx.doi.org/10.23960/jpp.v10.i2.202012>
- Senisum, M., Susilo, H., Suwono, H., & Ibrohim, N. (2022). GIRESIMCO: A learning model to scaffold students' science process skills and Biology cognitive learning Outcomes. *Education Sciences*, 12(4), 228. <https://doi.org/10.3390/educsci12040228>
- Septyowaty, R., Azizahwati, N., & Syafii, M. (2023). Application of the guided inquiry model to improve psychomotor skills and interest in learning physics. *Jurnal Penelitian Pendidikan IPA*, 9(10), 8106–8113. <https://doi.org/10.29303/jppipa.v9i10.4434>
- \*Sindani, Vanessa & Darvina, Yenni & Ramli, Ramli & Satria Dewi, Wahyuni. (2021). The Effect of The Implementation of Worksheet Based-Problem Solving on Students' Critical Thinking Skills in Rotational Dynamics and Elasticity. *Pillar of Physics Education*. <http://dx.doi.org/10.24036/10144171074>
- Stein, S. (2021). Reimagining global citizenship education for a volatile, uncertain, complex, and ambiguous (VUCA) world. *Globalisation, Societies and Education*, 19(4), 482–495.
- \*Suniasih, N. W., & Sujana, I. W. (2023). Interactive LKPD Based on Guided Discovery in Improving Science Learning Outcomes of Grade V Elementary School Students. *Journal of Education Research and Evaluation*, 7(1), 121-128. <https://doi.org/10.23887/jere.v7i1.59627>
- \*Sutarto, S., Indrawati, I., Prihatin, J., & Dwi, P. A. (2018). Geometrical optics process image-based worksheets for enhancing students' higher-order thinking skills and self-regulated learning. *Jurnal Pendidikan IPA Indonesia*, 7(4), 376-382.

- Sweller, J. (1994). Cognitive load theory, learning difficulty, and instructional design. *Learning and instruction*, 4(4), 295-312. [https://doi.org/10.1016/0959-4752\(94\)90003-5](https://doi.org/10.1016/0959-4752(94)90003-5)
- Syahdi, N., Desnita, Murtiani, & Dewi, W. S. (2021). Meta-analysis of the effect of use worksheets on students critical thinking skills in learning natural science in junior high school and physics in senior high school. *Pillar of Physics Education*, 14(3), 235. <https://doi.org/10.24036/11887171074>
- Tomlinson, C. A. (2005). How to differentiate instruction in mixed-ability classrooms. Pearson/Merrill Prentice Hall.
- Tuerah, R. M. S. (2019). Constructivism approach in science learning. *Proceedings of the 5th International Conference on Education and Technology (ICET 2019)*. <https://doi.org/10.2991/icet-19.2019.59>
- \*Wahyuni, W. O. A., Marhadi, M. A., & Haetami, A. (2024). Application of the discovery learning model using student worksheets based on scaffolding on stoichiometric materials to improve learning outcomes. *International Journal of Educational Technology and Learning*, 16(1), 1-7. <https://doi.org/10.55217/101.v16i1.744>
- \*Wicaktini, A., Juanengsih, N., & Noor, M. F. (2020, January). Problem Based Learning Models With Student Worksheets: Effect on Higher Order Thinking Skills in Digestive System Concept. In *ICEMS 2019: Proceedings of the 5th International Conference on Education in Muslim Society, ICEMS 2019, 30 September-01 October 2019, Jakarta, Indonesia* (p. 279). European Alliance for Innovation.
- Widodo, S. A., Wijayanti, A., Irfan, M., Pusporini, W., Mariah, S., & Rochmiyati, S. (2023). Effects of worksheets on Problem-Solving Skills: Meta-Analytic studies. *International Journal of Educational Methodology*, 9(1), 151–167. <https://doi.org/10.12973/ijem.9.1.151>
- \*Widarti, H. R., & Marfu'ah, S. (2019, June). The Effects of Using Multiple Representations on Prospective Teachers' Conceptual Understanding of Intermolecular Forces. In *Journal of Physics: Conference Series* (Vol. 1227, No. 1, p. 012006). IOP Publishing. <https://doi.org/10.1088/1742-6596/1227/1/012006>
- Xia, L., & Guzzo, T. (2025). Meta-analysis: Design, measures, and classic examples. *Translational Urology*, 171-176. <https://doi.org/10.1016/B978-0-323-90186-4.00056-0>
- Yalyn, D., Sari, D. a. P., & Widodo, W. (2022). The implementation of student worksheets based on problem-based learning to improve students science process skill. *JURNAL PIJAR MIPA*, 17(5), 569–576. <https://doi.org/10.29303/jpm.v17i5.3710>
- \*Yurtyapan, E., & Kandemir, N. (2021). The effectiveness of teaching with worksheets enriched with concept cartoons in science teaching laboratory applications. *Participatory Educational Research*, 8(3), 62-87. <https://doi.org/10.17275/per.21.54.8.3>
- \*Zainil, M., & Kenedi, A. K. (2022). Advancement of STEM-based e-student worksheet to enhance the HOTS of elementary school students. *Journal of Education Technology*, 6(3), 478-488. <https://doi.org/10.23887/jet.v6i3.46202>

## Appendix. Characteristics of the Included Studies

Author(s) and Year Published	Country	Education Level	Scientific Discipline	Learning Outcome	Specific Worksheet Variation	Experimental			Control		
						Mean	SD	n	Mean	SD	n
1. Afrianti & Lufri (2022)	Indonesia	Secondary	Biology	Cognitive	Discovery Learning	78	10.6	22	60.36	11.704	22
2. Aiman et al. (2020)	Indonesia	Primary	Earth Science	Cognitive	Process-Oriented guided inquiry	76.17	13.752	30	64.8	9.224	32
3. Amila et al. (2018)	Indonesia	Secondary	Physics	Cognitive	Ethnoscience	82.52	9.67	25	41.44	8.37	25
4. Benedicto & Bulay (2024)	Philippines	Secondary	Biology	Cognitive	Problem-based learning	20.91	4.68	21	7.46	1.64	11
5. Chotimah et al. (2023)	Indonesia	Secondary	Physics	Cognitive	Guided-inquiry	76.48	13.254	25	69.6	9.046	25
6. Dewi et al. (2018a)	Indonesia	Secondary	Biology	Cognitive	Inquiry-based	89	2.46	30	87	2.46	30
7. Dewi et al. (2018b)	Indonesia	Secondary	Biology	Cognitive	Inquiry-based	84	2.84	30	78	2.84	30
8. Dewi et al. (2018c)	Indonesia	Secondary	Biology	Affective	Inquiry-based	94	2.58	30	92	2.58	30
9. Ekantini (2018)	Indonesia	Secondary	Environmental Science	Cognitive	Conventional	0.48	12.2	30	0.32	12.42	30
10. Febriana et al. (2019)	Indonesia	Secondary	Physics	Cognitive	Guided note taking	84.93	3.672	42	77.48	4.83	40
11. Fernanda et al. (2024)	Indonesia	Secondary	Physics	Cognitive	Electronic	79.3	7.72	32	62.34	7.47	32
12. Fernando et al. (2021)	Indonesia	Secondary	Physics	Cognitive	HOTS-Oriented	83.1	4.2	33	36.8	5.7	33
13. Gani et al. (2017)	Indonesia	Secondary	Physics	Cognitive	Multiple-Intelligences Based	80.04	8.32	27	63.67	8.74	25
14. Hasanah et al. (2021)	Indonesia	Secondary	Biology	Affective	Problem-based Learning	73.6	8.36	71	66.97	7.04	69
15. Hasnunidah (2023)	Indonesia	Secondary	Biology	Cognitive	Project Argumentative Learning	61.294	8.656	60	22.96	9.56	60
16. Hatifi et al. (2021)	Indonesia	Secondary	Physics	Cognitive	Blended Learning	70.43	9.73	35	63.68	10.099	34
17. Herlina et al. (2025)	Indonesia	Secondary	Physics	Cognitive	Electronic	81.46	7.52	32	66.79	7.59	27
18. Hidayatulloh et al. (2021)	Indonesia	Secondary	Physics	Cognitive	Augmented Reality	79.33	8.872	30	74.77	6.585	30
19. Layawon (2024)	Philippines	Secondary	Earth Science	Cognitive	Problem-based Learning	21.1	6.37	25	15.6	4.28	25
20. Maknun & Herman (2024)	Indonesia	Secondary	Physics	Cognitive	Project-based Learning	44.9	6.4	40	35.4	10.42	40
21. Maysara et al. (2024)	Indonesia	Secondary	Chemistry	Cognitive	Scaffolding-based	77.5	7.661	24	72.92	7.506	24
22. Nadrah (2023)	Indonesia	Elementary	Elementary Science	Cognitive	Conventional	16.1563	3.244	32	12.5313	3.689	32
23. Nurdin et al. (2018)	Indonesia	Secondary	Physics	Cognitive	Guided-inquiry	70.83	6.86	30	67.18	5.01	30
24. Nurulsari et al. (2023)	Indonesia	Secondary	Physics	Cognitive	HOTS-oriented	53.6221	14.3413	29	31.6994	10.74039	31
25. Okut et al. (2023)	Philippines	Secondary	Biology	Cognitive	Electronic	25.47	4.67	30	23.42	2.94	31
26. Putri & Sani (2023)	Indonesia	Secondary	Physics	Cognitive	Learning-style oriented	73.71	9.96	35	65.33	10.7	35
27. Rudibyani (2020)	Indonesia	Secondary	Chemistry	Cognitive	Problem Solving-Based	78.8629	12.18868	34	57.6288	13.15014	34
28. Sindani et al. (2021)	Indonesia	Secondary	Physics	Cognitive	Problem Solving-Based	78.83	6.52	23	74.39	7.12	23
29. Suniasih & Sujana (2023)	Indonesia	Elementary	Elementary Science	Cognitive	Discovery Learning	0.43	0.2	31	0.16	0.13	30
30. Sutarto et al. (2018a)	Indonesia	Secondary	Physics	Cognitive	Process Image-Based	80.1	2.6	35	70.6	4.4	35
31. Sutarto et al. (2018b)	Indonesia	Secondary	Physics	Cognitive	Process Image-Based	80.6	2.1	35	70	4.2	35
32. Sutarto et al. (2018c)	Indonesia	Secondary	Physics	Cognitive	Process Image-Based	80.48	1.9	35	70	4.4	35
33. Sutarto et al. (2018d)	Indonesia	Secondary	Physics	Cognitive	Process Image-Based	81.51	1.9	35	69.4	4.6	35
34. Wicaktini et al. (2020)	Indonesia	Secondary	Biology	Cognitive	Problem-Based Learning	74.02	12.63	32	66.79	12.18	32
35. Widarti et al. (2019)	Indonesia	Tertiary	Chemistry	Cognitive	Multiple Representations	55.93	16.8	28	36.93	13.7	28
36. Yanto (2024)	Indonesia	Tertiary	Physics	Psychomotor	Augmented Reality	80	7.588	34	67.06	9.623	34
37. Yurtyapan & Kandemir (2021)	Turkey	Tertiary	Biology	Cognitive	Cartoon-enriched	16.59	3.51	37	16.55	2.97	42
38. Zaini et al. (2022)	Indonesia	Elementary	Elementary Science	Cognitive	Electronic	50	10.56	30	50.5	11.56	30