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The importance of creating mathematical worksheets and their impact on critical and creative thinking skills.

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ABSTRACT

This research is motivated by low critical and creative thinking skills. Apart from that, many previous studies have looked at the effect of worksheets on critical and creative thinking skills. It is worth evaluating whether the statistical results of these studies can be trusted and reported. For this reason, this research aims to compile and statistically evaluate the results of an independent study that examines worksheets on critical and creative thinking skills. The research method used is meta-analysis. A study search was conducted from 2014 to 2023 in Google Scholar. The search results provided 47 studies that met the inclusion requirements for extraction. This research produced 1.960, an excellent category for the entire study, and the mean population correlation coefficient was 0.498. This shows that the effect of the worksheet on critical and creative thinking skills is very high. Limitations of this research include the fact that the discussion of this research is only used as a basic idea for further research, and only analyses the results of studies over the last ten years. Developing worksheets is recommended to improve critical and creative thinking skills.

Keywords: evidence-based practice, STEM teaching, education research, teacher development, teacher perceptions

INTRODUCTION

Critical thinking skills are students' ability to understand a complex problem, connect one piece of information with another so that various perspectives emerge, and find solutions to a problem. Critical reasoning or thinking ability is thinking logically and systematically when deciding or solving a particular problem (Butterworth & Thwaites, 2013; Chukwuyenum, 2013; Stupple et al., 2017). Critical thinking can also be interpreted as the ability to reason, understand and make complex choices; understand the interconnections between systems, organize, express, analyze, and solve problems (Paul & Elder, 2019; ŽivkoviĿ, 2016; Tunçer & Sapancı, 2021). During the rapid flow of information in the digital era, this soft skill is vital for students to distinguish truth from lies, facts from opinions, or fiction from non-fiction. This is one of the capitals for students to make wiser decisions throughout their lives (Papadopoulou et al., 2025; Setiana et al., 2021; Kutluca, 2018). Critical thinking skills are also crucial for students to become good learners.

Several studies that have been conducted previously and have been conducted by several other researchers show that critical thinking skills still need to be improved.

This statement can be seen from research conducted on 24 grade VIII junior high school students in Indonesia which was taken purposively and found that students' critical thinking skills were still in the low category (Basri et al., 2019). The results of the previous research explained that only interpretation skills had a percentage of 63%, Meanwhile, for the skills of Analysis, Evaluation, Inference, Explanation and Self-regulation, the percentage is less than 46%. In addition, previous research results show that 70% of high school graduates do not have competencies involving critical thinking skills and over 4 years students only have 28% of critical thinking skills (Wartono et al., 2018). This means that students can only complete calculations mathematically, but need help connecting the concept of these calculations with the actual situation in the environment around the students. The same results were also obtained in other research results that in the analysis of critical thinking skills in vocational school students, it was found that only the ability to explain was in the excellent category, while others such as interpretation, analysis, self-regulation, evaluation, and inference were in the less good category (Punto Aji & Nugraheni, 2023; Suarniati et al., 2018).

Many studies have been conducted on developing critical thinking abilities. For example, studies that employ problem-based, project-based, flipped classrooms, guided inquiry, and STEM to enhance critical thinking abilities (Aini et al., 2019; Mercy et al., 2020; Murnaka et al., 2019; Priatna et al., 2020; Rejeki et al., 2021; Sasson et al., 2018; Yaki, 2022; Toupin & Lévesque, 2025). Likewise, with worksheets, according to various research, using STEM-based worksheets is one way to help develop critical thinking skills (Priatna et al., 2020), e-worksheet ethnoscience in problem-based learning (Astuti & Kurniawati, 2025; Kusuma & Sumarni, 2024), worksheet-based comics (Ningrum et al., 2022), and worksheets used in Team Accelerated Instruction (Cahyono, 2019). However, it cannot be denied that the critical thinking skills of students in Indonesia are not at have better abilities to date.

In addition to critical thinking skills, one of the skills that is the focus of this study is creative thinking skills. Creative thinking skills are the ability to break away from the dominant patterns stored in the brain to think of unusual solutions (Ibrahim & Widodo, 2020; Krisdiana et al., 2019; Mkpae & Obowu-Adutchay, 2017). Creative thinking can emerge when students are stimulated or faced with questions or problems that are curious and challenging, so that the answer to the question or issue can be more than one alternative answer (Kartikasari et al., 2022). Thinking with creativity means trying to come up with original concepts. The steps involved in creative thinking are as follows: comprehending the issue, speculating and estimating it, looking for solutions, putting up supporting data, and summarizing the findings (Fabian, 2018).

One of the learning challenges students currently face is their lack of proficiency in the creative thinking skills necessary to answer mathematical problems, preventing them from solving problems that take the shape of non-routine inquiries (Evans et al., 2021; Ozrecberoglu et al., 2022; Shawan et al., 2021). In comparison, critical thinking refers to the skills used to explore new ideas or generate solutions when solving problems (Birgili, 2015; Hidayat et al., 2025). Therefore, the creative thinking skills possessed by students are expected to develop their understanding of mathematical concepts, not just get the correct answers to solve math problems (Yayuk et al., 2020).

Students' understanding of mathematical creative thinking skills is still considered low. The study results show that most people do not yet understand that mathematical creative thinking is a cognitive and affective factor (Akgül & Kahveci, 2016). The results of exploratory research conducted by several other researchers also support this opinion, namely that creative thinking is included in the less satisfactory category. Like research that was conducted on primary school students in Malang, Indonesia, it was found that students with low and medium abilities still experienced difficulties in dealing with mathematical problems using non-routine questions, so that they become less creative in solving mathematical problems (Yayuk et al., 2020). Even their research found that high-ability students did not reach the level of novelty in the creative thinking aspect. Likewise, early research by other researchers revealed that pupils' poor creative thinking skills were still a result of their frequent errors when addressing mathematical tasks (Puspitasari et al., 2018; Umam et al., 2025). In addition, the low level of students' creative thinking skills is also caused by the lack of teacher training regarding students' creative thinking skills. This is reinforced by students' responses, which tend to memorize rather than understand concepts because the language given tends to be the same as in books (Astuti et al., 2022; Birgili, 2015). In fact, if teachers do not make an effort to improve students' knowledge and understanding of creative thinking, they can be blamed by many parties (Lucas & Spencer, 2017; Manalo & Kapur, 2018).

Much research has been done on developing one's capacity for creative thought. For example, studies that use an ethnomathematics approach to scientific learning, problem-posing learning, and problem-solving contextual learning (Bicer et al., 2020; Purnami et al., 2022; Suherman & Vidákovich, 2025; Toheri et al., 2020). Likewise, the use of worksheets, such as the use of worksheets in learning Means-Ends Analysis (Citroresmi et al., 2022; Rosulawati & Caswita, 2020), worksheets based on Problem-based learning (Adillah Adnan, 2021; Sitorus et al., 2019; Umriani et al., 2020), worksheets based on multiple representations (Mutia & Prasetyo, 2018), and

worksheets based on scientific creativity and critical thinking (Wulansari et al., 2019), the use of learning using STEM to Improve Creative Thinking (Pramasdyahsari et al., 2025; Stylianidou et al., 2018; Winarto et al., 2025; Sultan et al., 2025). However, problems related to low creative thinking skills do not seem to have improved.

From various studies regarding worksheets on critical and creative thinking skills that have been reviewed previously, researchers attempted to identify the effect of worksheets on critical and creative thinking abilities. For this reason, this research aims to determine the impact or influence of worksheets on critical and creative thinking abilities. By knowing the impact of worksheets on students' cognitive abilities, it is expected to provide a clearer picture of the effectiveness of a worksheet in improving students' cognitive abilities, especially in the realm of high-level abilities such as creative and critical thinking skills. In addition, a deep understanding of the influence of worksheets on critical and creative thinking skills can be used as a basis for developing more innovative and contextual worksheets, so that the mathematics learning process can develop students' mathematical thinking skills holistically.

One way to find out the influence of worksheets on critical and creative thinking skills is by examining a variety of worksheets from earlier research and assessing critical and creative thinking skills as one of the characteristics seen in those earlier studies, which used different tools and methods, this research uses a meta-approach in the analysis technique in this research. This is what distinguishes this study from other studies that focus on the influence or effect of worksheets on critical and creative thinking skills, so that the novelty of this study can be seen in the methods and data analysis techniques used. There are not many meta-analysis studies that link students' worksheets with mathematical critical thinking skills and mathematical creative thinking skills. The results of an online search with the keywords: meta-analysis, mathematical critical thinking skills and creative thinking skills, obtained the results of a meta-analysis study that tested the effect of implementing a cooperative learning model on students' mathematical critical and creative thinking skills and received a joint effect size of 0.696 (Siagian et al., 2023).

Meta-analysis studies conducted partially, such as Mathematical Critical Thinking skills alone or Mathematical Creative Thinking skills alone or mathematical worksheets on mathematical abilities, have been widely performed. Meta-analysis studies that have been conducted partially that are in line with the variables of this study include studies on the effects of problem-based learning on students' creative thinking in mathematics (Yunita et al., 2020), constructivism-based learning models against students' mathematical creative thinking abilities (Tamur & Juandi, 2020), effects of worksheets on problem-solving skills (Widodo et al., 2023), effect of problem-based learning on mathematical critical thinking skills (Juandi & Tamur, 2021; Yohannes et al., 2021; Chi, 2022). Due to the author's limitations in exploring the research results that previous researchers have conducted, the results of the studies used in this study are in the range of 2014-2023. In addition, the research results are part of a limited synthesis, with the keywords: worksheets, critical thinking, and creative thinking skills. This is important to ensure the overall impact of worksheets on critical and creative thinking skills.

Research Questions

To achieve the objectives of this research, several research questions that support the objectives of this research include (1) how big is the effect of worksheet size on students' creative and critical thinking skills? and (2) does the worksheet have a positive effect on students' creative and critical thinking skills?

METHOD

Research Design

This study aims to statistically assess the findings of a separate investigation on worksheets designed to foster critical and creative thinking in Indonesian pupils. For this reason, meta-analysis research is used to achieve the objectives of this research. A meta-analysis is a study that synthesizes the findings from several studies on a particular research question. Its goal is to present a comprehensive overview of all the available data on a specific subject so that conclusions drawn from the combined data can be more reliable and accurate than those drawn from independent studies (Borenstein et al., 2021; Suurmond et al., 2017). Meta-analysis provides a thorough evaluation by statistically analyzing quantitative data from various studies on specific subjects. This evaluation will, of course, affect the general research conclusions obtained so far. The results of this evaluation can strengthen, but can also weaken, existing research conclusions. Researchers can (1) produce more precise estimates of effect size—the intensity of the association between variables—in meta-analysis studies than with any one study. Providing plausible explanations for variations in analysis-based results is another purpose for meta-analysis. This is to determine whether or not the findings of distinct investigations are inconsistent or generally consistent. Furthermore, finding out what could affect the outcomes, such as variations in study design, sample characteristics, or analysis techniques, can be aided by meta-analysis research.

Effect size is typically used in meta-analysis studies to quantify differences between two groups. This effect calculation has many advantages compared to other statistical significance tests. These advantages include the results being more representative, making it possible to combine various previous research results, and being able to answer gaps in results from multiple similar studies. The steps that can be used for meta-analysis studies are (1) identify problems that will be included in meta-analysis research, (2) Search for literature related to the problem being studied, (3) select literature that meets the specified requirements, (4) statistical analysis of research is carried out to see the size of the effect and the error rate, and (5) interpreting the results of meta-analysis calculations.

Literature Search

A study using worksheets on critical or creative thinking skills served as the article criterion for this investigation. The result of the research serves as the article criterion in this study and involves critical or creative thinking skills obtained from worksheets. The effect of this research can be seen in increasing critical or creative thinking skills or in differences in critical and creative thinking abilities between the control group and the experimental group. The study findings have been released in conferences, journals, and repositories. You can use Google Scholar to find the research findings using the keywords worksheet, critical thinking skills, and creative thinking skills.

The stages of literature search in meta-analysis research refer to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) stages, namely determining eligibility criteria, determining information sources, selecting data, collecting data, and taking data (Aravantinos et al., 2024; Erden et al., 2023; Tülübaş et al., 2023). The Prisma stages used in this study can be seen in **Figure 1** for more details. After the data is selected, the next step is to conduct a statistical analysis by determining the predetermined effect size and then concluding the data obtained (Borenstein et al., 2021; Cooper et al., 2019; Gurevitch et al., 2018; Pigott & Moon, 2016).

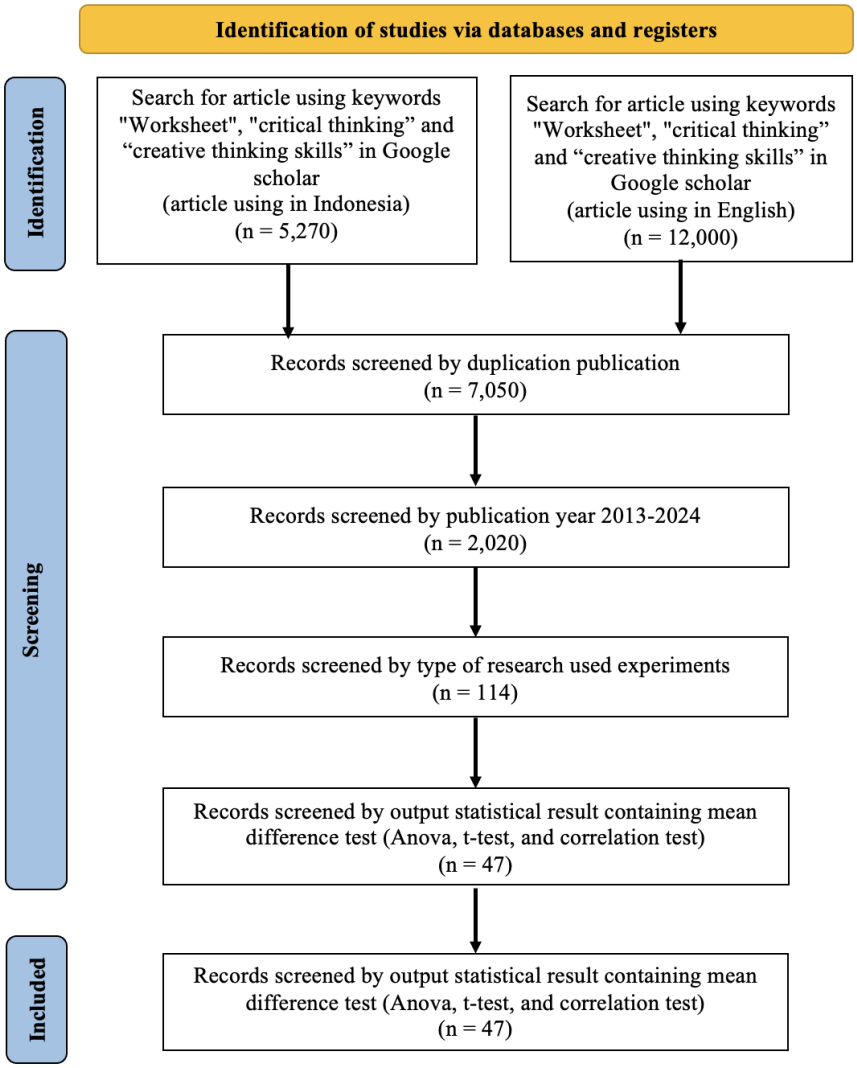

Figure 1. PRISMA diagram to illustrate the process of screening papers on the influence of Worksheets on critical and creative thinking skills

Inclusion criteria

The development and experimental research results were analyzed in this study. The restricted synthesis study was conducted over the last ten years, specifically from 2014 to 2023. The synthesis's source papers must display the outcomes of statistical analyses, such as the z, t, F, and r tests and the research sample size. Based on these inclusion criteria, 47 studies were included in this study (see Appendix A). The results of the selected research consisted of 29 studies that looked at the effect of worksheets on creative thinking abilities, with 29 comparisons and 18 studies that looked at the impact of worksheets on creative thinking abilities, with 18 comparisons.

Data coding

The instruments in this meta-analysis were carried out using a coding category sheet. The coding form is made according to predetermined characteristics, such as the number of studies researched, the author, the title, and the skills that are the focus of the research. Based on Table 1, it can be seen that the results of previous research used as research subjects are in the form of worksheets and the skills that were the focus of their research. This type of coding was created to improve research appropriateness and reliability. In addition, this coding was used to avoid conflicts that could occur in the future between us and previous researchers. See Table 1for details on study findings that satisfy the inclusion requirements.

Table 1. Number of study characteristics obtained.

Characteristics		f
Research at the level	Elementary School	8
	Junior High School	17
	Senior High School	21
	Higher School	1
Year of Research	2014-2016	4
	2017-2020	19
	2021-2023	24
Type of publication	proceeding	37
	Journal	5
	Thesis	5
The kind of skill observed	Creative thinking skills	18
	Critical thinking skills	29

Data Analysis

Meta-analysis research analyses the data by determining the effect size, changing the F values to t and r, and assessing the sample impact. A derivative formula is used to determine the effect size value (Widodo et al., 2023), as shown in **Table 2.**

Table 2. The formula for determining the effect size for the z, t, r and F-test

Type of test	The formula for effect size
Z Test	$ES = Z\sqrt{\frac{1}{n_e}+\frac{1}{n_c}}$
t-test	$ES = t\sqrt{\frac{1}{n_e}+\frac{1}{n_c}}$
r	$ES = \frac{2r}{\sqrt{1-r}}$
F test	$ES = F\sqrt{\frac{2}{n}}$

The effect size computation's outcomes are as in Table 3, then compared with the predetermined criteria in **Table 3** (Glass, 1977; Widodo et al., 2023, 2025).

Table 3. Criteria of effect size

Range	Criteria
$-0.15 \leq ES < 0.15$	No level
$0.15 \leq ES < 0.40$	Low level
$0.40 \leq ES < 0.75$	Moderate level
$0.75 \leq ES < 1.10$	High level
$1.10 \leq ES < 1.45$	Very high level
$ES \geq 1.45$	Excellent level

To convert F's value into a t value and a r value, this can be done using a formula $t = \sqrt{F}$ and $r_{xy} = \frac{t}{\sqrt{t^2+(N-2)}}$.

Bare-bones meta-analysis methods were used to determine the impact of sampling (Hu & Yang, 2021; Quan & Shang, 2021; Widodo et al., 2025).

RESULT

Based on 46 research articles that were used as research subjects, these 46 articles, 47 pairs of comparisons were carried out in meta-analysis, consisting of 29 comparison data that were studied to see the influence of worksheets on creative thinking skills and 18 data comparison data to see the impact of worksheets on creative thinking skills. **Table 4** displays the outcome of computing the impact size coefficients F, t, and r.

Table 4. The effect size for worksheets on creative and critical thinking skills

Number	N	F	t	r	Effect size	$N \times r$	$(r - \check{r})^2$
1	51	–	3.452	0.442	0.967	22.557	0.006
2	72	–	3.156	0.353	0.744	25.412	0.028
3	44	8.555	2.925	0.411	1.824	18.100	0.012
4	57	–	4.043	0.479	1.071	27.283	0.002
5	71	–	2.549	0.293	0.605	20.829	0.052
6	56	–	19.026	0.933	5.085	52.239	0.169
7	64	–	2.950	0.351	0.739	22.454	0.029
8	44	1.010	1.005	0.153	0.215	6.743	0.136
9	51	–	2.904	0.383	0.732	19.545	0.019
10	44	–	2.522	0.363	0.761	15.959	0.025
11	63	–	3.538	0.413	0.892	25.996	0.012
12	78	0.727	0.853	0.097	0.116	7.593	0.180
13	60	–	–	0.500	1.414	30.000	0.000
14	72	–	1.760	0.206	0.415	14.822	0.100
15	62	–	10.053	0.792	2.566	49.112	0.073
16	65	2.996	1.731	0.213	0.526	13.849	0.095
17	87	–	9.681	0.724	2.076	63.002	0.041
18	40	–	10.293	0.858	3.255	34.316	0.113
19	74	–	2.336	0.265	0.543	19.641	0.066
20	66	1.830	1.353	0.167	0.319	11.004	0.126
21	40	–	9.930	0.850	3.140	33.984	0.108
22	69	–	3.311	0.375	0.798	25.874	0.021
23	52	2.644	1.626	0.224	0.519	11.654	0.088
24	68	–	15.728	0.888	3.815	60.416	0.135
25	56	–	23.580	0.955	6.302	53.464	0.188
26	76	–	9.256	0.733	2.010	55.671	0.045
27	70	0.164	0.405	0.049	0.028	3.434	0.223
28	49	–	3.810	0.486	1.089	23.803	0.001
29	64	–	14.776	0.883	3.694	56.481	0.130
30	24	–	8.890	0.884	3.629	21.227	0.132
31	64	–	10.466	0.799	2.616	51.142	0.077
32	68	–	6.972	0.651	1.691	44.285	0.017
33	66	–	19.400	0.924	4.776	61.016	0.162
34	60	–	2.270	0.286	0.586	17.139	0.056
35	66	1.830	1.353	0.167	0.319	11.004	0.126
36	68	–	41.120	0.981	9.973	66.710	0.211
37	68	–	4.754	0.505	1.153	34.344	0.000
38	22	–	12.860	0.945	5.484	20.779	0.179
39	66	–	5.894	0.593	1.451	39.148	0.005
40	60	10.423	3.228	0.390	1.903	23.418	0.017
41	70	–	4.763	0.500	1.139	35.011	0.000
42	69	–	4.065	0.445	0.979	30.690	0.006
43	100	–	3.096	0.298	0.619	29.849	0.050
44	57	–	2.533	0.323	0.671	18.420	0.039
45	76	2.398	1.549	0.177	0.389	13.465	0.119
46	54	–	18.565	0.932	5.053	50.336	0.169
47	30	–	9.442	0.872	3.448	26.170	0.123
Total	2853	--	--	24.512	92.136	1419.389	3.712
Average	--	--	--	--	1.960	--	--

From **Table 4,** the average effect size is 1.960. This shows that the effect of the worksheet on creative and critical thinking skills is in the Excellent level category. This shows a positive influence of worksheets on creative and critical thinking skills. **Figure 2** shows the distribution of effect sizes from 47 comparisons conducted in a meta-analysis of 46 research articles, examining the impact of worksheets on creative thinking and problem-solving

skills. The varying bar lengths indicate differences in effect sizes, with some comparisons showing more substantial effects than others. The concentration of bars in the middle suggests that most studies reported moderate effect sizes, while a few outliers exhibit significant effects. This variation may be attributed to differences in study design, sample characteristics, or worksheet implementation. The presence of substantial effect sizes in specific comparisons highlights the potential effectiveness of worksheets, though variability suggests that their impact may depend on contextual factors.

Figure 2. Effect size distribution

Apart from that, the findings of the investigations that served as examples for this meta-analysis study were grouped into two groups based on the worksheet effect, namely creative thinking abilities and critical thinking abilities. In the effect of the worksheet on these two abilities, it is found that the results of the transformation of the F and t values to the population correlation mean $\check{r} = \frac{1419.389}{2853} = 0.498$, so that the population correlation variance $\sigma^2 r$ is

$$\sigma^2 r = \frac{\sum(r-\check{r})^2}{2} = \frac{3.712}{2} = 1.856.$$

Assess the effect of the sampling, which can be done by (1) converting the values of F and t into r, (2) finding the average population correlation $(\check{r})$, (3) finding the variance $(\sigma^2 r)$, (4) finding the error variance sampling $(\sigma^2 e)$, (5) estimating the population correlation variance $(\sigma^2 \varrho)$, and (6) determining the confidence interval. Based on Table 5, the results of calculating the mean population correlation is $\check{r} = 0.498$, and the population correlation variance $\sigma^2 r$ is 1.856. For that, the sampling error variance is

$$\sigma^2 e = \frac{\left(1-\check{r}^2\right)^2}{N-1} = \frac{\left(1-(0.498)^2\right)^2}{2853-1} = 0.000199.$$

So, the impact of sampling error is

$$\frac{\sigma^2 e}{\sigma^2 r} \times 100\% = \frac{0.000199}{1,856} \times 100\% = 0.01\%.$$

The lower percentage of sample error suggests a lower likelihood of error bias due to sampling errors. The computation's findings indicate that the sampling error as a percentage is 0.01%. This suggests that there is little to no error bias resulting from sample problems in studies on the impact of worksheets on critical and creative thinking skills.

Furthermore, the confidence interval in the meta-analysis study needs to be computed to ascertain whether the mean correlation that results from the effect size calculation is within an acceptable range. Estimate the correlation variance $\sigma^2 \varrho$, then the confidence interval. Meanwhile, to determine the correlation variance using a formula

$$\sigma^2 \varrho = \sigma^2 r - \sigma^2 e = 1.856 - 0.0001999 = 1.85584.$$

After obtaining the correlation variance $\sigma^2 \varrho = 1.85584$. Then the confidence interval is done using the formula $\check{r} \pm 1.96 \sqrt{\sigma^2 r}$, so

$\check{r} \pm 1.96 \sqrt{\sigma^2 r} = 0.498 \pm 1.96 \sqrt{1.858} = 0.498 \pm 2.670$.

Therefore, the confidence interval is $-2.173 < \check{r} < 3.168$.

The computation's outcomes demonstrate that the average population correlation is $\check{r} = 0.498$, and this value is in the interval $-2.173 < \check{r} < 3.168$, so it can be concluded that worksheets positively influence students' creative and critical thinking abilities.

DISCUSSION

Worksheets are a type of learning aid containing tasks that students must carry out, accompanied by essential competencies or learning objectives that students must achieve (Lee, 2014; Mortensen & Smart, 2007). The worksheet aims to (1) serve as a guide for students in carrying out the process of teaching and learning activities (Arends & Kilcher, 2010; Mihardi et al., 2013), (2) help students obtain notes from the material studied (Siregar et al., 2022), (3) help students develop learning concepts (Anggraini & Susilowati, 2022; Yaden, 2017), and (4) train students to discover and develop process skills (Divia et al., 2022; Rahayu et al., 2018).

Because worksheets are a learning aid, they are a source of learning (Chomal, 2022; Choo et al., 2011). Teachers can develop worksheets as facilitators in learning activities. Worksheets can be created based on the circumstances and scenarios encountered during learning activities. Apart from being a learning resource, judging from its function, worksheets can be seen as a learning medium (Rahayu et al., 2018; Yaden, 2017). This is so because educational media is a tool that contains learning objectives or is used to transmit messages or information, and this is one of the functions and purposes of worksheets. With this condition, worksheets become a learning resource based on teacher-designed learning activities.

Using worksheets in learning is one of the teachers' efforts to achieve learning goals well (Ratnasari & Budiyanto, 2020; Sun & Lee, 2016). Worksheets are materials prepared and utilized by teachers to help carry out classroom teaching and learning activities (Lee, 2014; Töman et al., 2013). Worksheets can be arranged in sheets containing material, summaries, and tasks students must complete (Yaden, 2017) in learning can act as teaching materials that can minimize the role of educators but activate students more (Davies et al., 2013; Tate, 2015).

Meta-analysis research aims to analyze data originating from primary sources or sources arising from research results. Research findings from meta-analyses can be utilized to validate or refute the theories put out by earlier scholars. The present study hypothesizes that "the worksheets used positively affect creative and critical thinking abilities". When referring to development research for research products in the form of worksheets, preparatory research using meta-analysis techniques might be conducted to determine the urgency of creating spreadsheets. For this reason, meta-analysis in development research can be used to provide specific guidance for further research. It can be used as a basis for determining whether or not it is necessary to develop worksheets for learning so that students' creative and critical thinking skills improve.

Based on the findings of the meta-analysis, it is discovered that the average effect size is 1.960 with the excellent level category, with a mean population correlation coefficient of $\check{r} = 0.498$, which is in the range $-2.173 < \check{r} < 3.168$, so it can be concluded that worksheets positively influence students' creative and critical thinking abilities. In addition, the analysis's findings indicate that the sampling error percentage is 0.01%. This shows that there is less possibility of conclusion bias caused by sampling error. This suggests that prior studies can be justified scientifically and applied to a larger population. Based on these results, it can be concluded that worksheets can improve students' creative and critical thinking abilities.

The results of this meta-analysis research align with the results of other preliminary research that uses meta-analysis and states that using worksheets can improve problem-solving abilities (Widodo et al., 2023). The study reported that the effect size was 1.281, obtained from a comparison of 40 studies from 2014 to 2022. This research is included in a preliminary survey of the urgency of developing worksheets for students' cognitive skills. The differences between the research conducted by Widodo et al. and the current research include the cognitive abilities observed in these two studies. Previous research used problem-solving abilities, while recent research uses students' critical and creative thinking abilities (Widodo et al., 2023).

In line with the Merdeka curriculum that has been implemented in most schools in Indonesia, the focus of this curriculum includes learning achievements that are adapted to student development (level) and developing student character by the Pancasila student profile (Rizaldi & Fatimah, 2023; Simarmata & Mayuni, 2023). The Pancasila Student Profile has several character traits and competencies that students are expected to achieve, which are based on the noble values of Pancasila (Amanda et al., 2023; Pratikno et al., 2022). The skills of thinking creatively and reasoning critically are two of the six elements in the Pancasila student profile (Pusporini et al., 2023). In critical reasoning skills, students must objectively process qualitative and quantitative information, build relationships

between various information, analyze data, evaluate, and conclude (Eales-Reynolds et al., 2013; Osborne, 2013; Jones, 2023). Meanwhile, in creative thinking skills, students are expected to be able to modify and produce something original, meaningful, valuable, and impactful (Alghafri & Ismail, 2014; Daly et al., 2014).

Much research has been related to improving students' critical and creative abilities. Research conducted at Thot Not High School in Can Tho City, Vietnam, found that students in classes using the problem-solving approach performed better in proving inequalities than students in control classes, and they also presented more solutions to inequality-proving problems (Tong et al., 2020). Apart of that, the meta-research conducted to test the effectiveness of Collaborative Learning on Critical Thinking and Creative Thinking Skills in Biology Learning, it was found that these two abilities can be improved with collaborative learning (Ramdani et al., 2022). This study involved 36 critical thinking and 18 creative thinking that were searched online between 2000 and 2021. Based on the results of the meta-analysis showing variations in the effectiveness of using Student Worksheets in improving creative thinking and problem-solving skills, there are several specific recommendations for teachers and curriculum developers in designing and implementing Student Worksheets in mathematics learning. These recommendations aim to ensure that Student Worksheets are not only a tool for practising questions but can also stimulate high-level thinking skills in students(Papadakis, 2020; Parissi et al., 2023).

Teachers have an essential role in ensuring the effectiveness of using Student Worksheets in the classroom. One strategy that can be applied is to use problem-based Student Worksheets, such as in the Problem-Based Learning (PBL) or Discovery Learning approach. Student Worksheets designed with this model allow students to explore concepts and find solutions from various perspectives. In addition, contextual, culture-based Student Worksheets can improve students' understanding by connecting mathematical concepts with local cultures, such as batik patterns in geometry or calculations in traditional trading systems.

In addition, teachers need to adjust the cognitive level of student worksheets to fit students' abilities. Practical Student Worksheets should have scaffolding stages, from questions with low cognitive demands to the level of analysis and synthesis. Thus, students get challenges appropriate to their level of understanding, so the learning process becomes more optimal. Using technology in student worksheets, such as Augmented Reality (AR) or interactive applications, can also help visualize abstract concepts and increase student engagement in mathematics learning (Aravantinos et al., 2024).

In curriculum development, student worksheets should be used as a practice tool and a differentiated learning tool. Student worksheets that are designed with high flexibility can help students with various levels of ability so that they still get appropriate challenges. Using formative assessment in student worksheets also needs to be strengthened by providing a reflection section or assessment rubric to help students evaluate their understanding and develop solutions more creatively.

In addition, it is essential to build collaboration between teachers and curriculum developers in designing student worksheets. Teachers can provide input based on classroom experiences, while curriculum developers can optimize the structure and content of student worksheets based on practical learning principles. Training for teachers in using innovative student worksheets is also needed so that their implementation in the classroom runs optimally. We hoped that using student worksheets in mathematics learning would help students understand concepts procedurally and improve their creative thinking and problem-solving skills. This will support the achievement of 21st-century competencies and create a more meaningful learning experience for students.

CONCLUSIONS

Forty-seven studies spanning 2014 to 2023 were examined in this study. An effect size of 1.960 was obtained from the meta-analysis results. These results indicate that the population mean correlation coefficient is in the excellent level category, namely$\check{r} = 0.498$. These findings suggest that worksheets significantly impact critical and creative thinking skills, so teachers can use worksheets to improve students' critical and creative thinking abilities.

Aside from that, more study is required to create worksheets to help students develop critical and creative thinking skills. Other suggestions for researchers include the need for more study since, as time goes on, a lot of fresh writing about the impact of worksheets on students' critical and creative thinking skills will surface. This circumstance may lead to a more significant number of studies from earlier meta-analyses being examined. The more studies are analyzed, the more likely the effects will change. Apart from that, it is hoped that researchers can develop a worksheet to improve students' critical and creative thinking abilities.

This study has several limitations that need to be considered. First, the focus is on the characteristics and instructional potential of the worksheet itself, not on the characteristics of individual students as research subjects. Therefore, this study does not limit itself to a particular level of education, but rather discusses the design and use of worksheets in general, which conceptually can be applied from Elementary School to Higher Education. Although this approach provides flexibility in the application of the results, this generality is also a limitation, because it does not consider the differences in cognitive, affective, and pedagogical characteristics that are specific

to each level of education. There was variation in the study designs, including differences in experimental methods, measurement instruments, and data analysis techniques. Second, this could affect the effect size estimates obtained, so the results should be generalised with caution. Third, this meta-analysis did not specifically stratify the effectiveness of worksheets by educational level, student learning style, or learning context (such as online vs. face-to-face classes). However, these factors may influence the impact of worksheets on students' critical and creative thinking skills.

Furthermore, publication bias must also be considered, where the reported research tends to come from studies that show significant results. In contrast, studies that do not find a strong relationship may be less published. Finally, the lack of uniformity in defining and measuring critical and creative thinking skills across studies makes comparing results more complex.

Based on these limitations, several recommendations can be made for further research. Future research should conduct subgroup analyses based on factors such as educational level, type of subject, and teaching method used to understand the effectiveness of worksheets in various learning contexts. In addition, exploring the use of digital and interactive worksheets, such as Augmented Reality (AR) worksheets or those integrated with online learning platforms, may provide new insights into the effectiveness of technology in improving students' critical and creative thinking skills. As research in this area grows, future meta-analyses need to include more recent studies to see if there is a change in the effects of worksheets on students' thinking skills, especially considering innovations in learning design. In addition, more rigorously controlled experimental studies, such as using different approaches, may provide more accurate results in isolating the effects of worksheets from other factors that influence learning. Finally, further research is needed to determine the most optimal worksheet design for improving critical and creative thinking skills, including exploring the effects of open vs. closed tasks, problem difficulty levels, and integration with active learning methods. By addressing existing limitations and continuing research in more specific and innovative directions, it is hoped that the use of worksheets in learning can be increasingly practical and relevant to the development of modern education.

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Appendix A. study results used in this research.

No.	Code of study	Form of the Worksheet	Skills
1	Indriani et al. (2014)	Learning Strategies to Improve Thinking Abilities	Creative Thinking
2	Lestari et al. (2014)	Means-Ends Analysis	Creative Thinking
3	Tinedi et al. (2015)	problem-based learning	Creative Thinking
4	Firanti & Paidi (2016)	problem solving	Creative Thinking
5	Aripin & Purwasih (2017)	Alternative Solutions	Creative Thinking
6	Lathifah & Fitrayati (2017)	Treffinger	Creative Thinking
7	Mutia & Prasetyo (2018)	multiple representations	Creative Thinking
8	Nurisalfah et al. (2018)	Project	Creative Thinking
9	Budiono et al. (2019)	guided inquiry	Creative Thinking
10	Kartika et al. (2019)	Scientific creativity and critical worksheet	Creative Thinking
11	Maisaroh (2019)	RME	Creative Thinking
12	Masitoh & Prasetyawan (2019)	Open-ended Problem	Creative Thinking
13	Pratiwi et al. (2019)	strategy REACT	Creative Thinking
14	Putri et al., 2019)	PSL	Creative Thinking
15	Sarwinda & Meilana, 2019)	Science based on HOTS	Creative Thinking
16	Wulansari et al. (2019)	Scientific creativity and critical thinking	Creative and critical Thinking
17	Muazaroh & Abadi (2020)	open-ended	Creative Thinking
18	Tohiroh et al. (2020)	Ecopreneurship	Creative Thinking
19	Anjani et al. (2021)	Heat and Kinetic Theory	Creative Thinking
20	Fernando et al., 2021)	barcode Assistance	Creative Thinking
21	Purwaningsih et al., 2021)	STEM	Creative Thinking
22	Aulia et al. (2022)	Inquiry learning	Creative Thinking
23	Fitriani et al. (2022)	problem-solving	Creative Thinking
24	Khasanah 92022)	RME	Creative Thinking
25	Latifah (2022)	Project-Based learning	Creative Thinking
26	Mahendrawan et al. (2022)	problem-based learning	Creative Thinking
27	Desmarani (2023)	Inquiry-Flipped classroom	Creative Thinking
28	Islamiyati et al. (2023)	Alternative Solutions	Creative Thinking
29	Muhiddin et al. (2023)	Guided Inquiry	Creative Thinking
30	Nurliana et al. (2007)	Guided Inquiry	Critical Thinking
31	Firdaus & Wilujeng (2018)	Guided Inquiry	Critical Thinking
32	Listiani (2018)	critical thinking	Critical Thinking
33	Elfina & Sylvia (2020)	Problem-based learning	Critical Thinking
34	Zulmi & Akhlis (2020)	Epub Extention	Critical Thinking
35	Fernando et al. (2021)	Barcode Assistance	Critical Thinking
36	Puspita & Dewi (2021)	Investigation	Critical Thinking
37	Silaban et al. (2021)	Problem-based learning	Critical Thinking
38	Habsyi et al. (2022)	Guided Discovery Learning	Critical Thinking
39	Ningrum et al. (2022)	Comic	Critical Thinking
40	Novitasari et al. (2022)	Etnomatematika	Critical Thinking
41	Rahmadansah et al.(2022)	Team Accelerated Instruction	Critical Thinking
42	Rosyidah (2022)	Number Head Together	Critical Thinking
43	Subariyanto et al. (2022)	Discovery Learning	Critical Thinking
44	Suhadi (2022)	Investigation	Critical Thinking
45	Sya'bani & Fawaida (2022)	Education for Sustainable Development	Critical Thinking
46	Budiyanti et al. (2023)	Number Head Together	Critical Thinking
47	Wahyuningtyas et al. (2023)	Etnoscience based on Problem-Based Learning	Critical Thinking