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

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Abstract: Many studies have been conducted on the effect of student worksheets on student High Order Thinking Skills abilities. However, this research is still limited to aspects of research variables, especially moderator variables. The solution to this problem is to do a meta-analysis of the effect of worksheets on student High Order Thinking Skills abilities. The research objective was to determine the effect of worksheets on student High Order Thinking Skills abilities based on class levels, subjects, and learning models. The method used in this study is the method of meta-analysis, examining several articles in national and international journals. The number of samples taken used 25 articles related to scicence worksheets with 11 Physics articles, 7 Biology articles, 7 Chemistry articles. Articles reviewed from 2018-2022. The results of the analysis show that the use of worksheets has a significant effect on student High Order Thinking Skills abilities both in terms of class level, subjects, and learning model. Thus, the use of worksheets is effective for increasing student High Order Thinking Skills abilities at various grade levels, subjects, and learning models. Based on the research results using worksheets in physics learning is a good solution to improve student High Order Thinking Skills abilities.

Keywords: High order thinking skills; Learning models; Meta-analysis

Introduction

Technological developments in the 21st century are very rapid in various fields of life. The digital era as a result of technological advances has had a tremendous impact on the entire fabric of human life (Khaeruddin et al., 2022). This development also had an impact on the world of education. Education is in the knowledge age which is very closely related to information and communication technology which is currently developing rapidly (Budiman, 2017; Harahap, 2019).

In the era of globalization, rapid technological developments cannot be avoided because they have an impact on educational life. According to Hidayatullah et al. (2021), the 21st century is marked by globalization which causes changes in all aspects of life. The demands

of globalization demand that the world of education always and continues to change, developing technology to improve the quality of education, especially by adjusting the use of information and communication technology with the world of education, especially learning in the educational environment. Education as a fundamental aspect of life is not spared from these changes, so education is directed at learning that equips students with 21st century skills (Putri et al., 2023).

Innovative learning is learning that is student centered. Learning that allows students to be able to learn independently, either with the teaching materials used or peers. Innovations learning can improve students' high-order thinking and communication skills and create other variables such as collaborative skills, critical thinking skills, creativity, and student motivation

(Afikah et al., 2022). Innovative learning is usually based on student constructive paradigms that help students to reproduce knowledge or understanding of concepts from the students themselves. This is consistent with Nunung (2023) that transformation occurs through the creation of new understanding resulting from the emergence of new cognitive structures. Specifically, the teacher's role is as a facilitator or mediator who can carry out learning by creating and understanding innovative learning models to achieve learning goals.

In Indonesia, the level of education is still low. This is evident from a survey conducted by the Association for Monetary Co-activity and Improvement (OECD) regarding the quality of education, and Indonesia is ranked 69 out of 76 OECD member countries. This is certainly a strong blow for Bangka Indonesia, where with various natural resources available but not supported by qualified human resources. This can be seen from the low high-order thinking ability of physics teacher candidates which are still not as expected. This is in line with research Anggraeni et al. (2020), the most frequently cited reason that also hinders teachers is that they do not understand HOTS and the technique of constructing instruments with verbs that measure HOTS.

The results of the analysis of student answers conducted by Nurhayati et al. (2017) show that students who complete the final semester exam questions on optics are still low on HOTS criteria questions. Only 20% of students can solve problems at a high level, such as analyzing, evaluating and creating. Erfan et al. (2018) found that most physics teacher candidates were able to solve questions in the low order thinking skills (LTS) category but were still dominant in the low category in high order thinking skills (HOTS). This is in line with research Nurhayati et al. (2022) which says that it is necessary to change the learning process to improve the abilities of high-level students to make it easier for students to understand an abstract optical subject.

Besides that Based on the information obtained that teaching materials so far have only been based on textbooks, but the use of student worksheets does not apply the steps of an interesting learning model, so there are still some students who do not think critically, creatively, and lack independence in learning (Rizki et al., 2021). Student Worksheets are a means to assist in facilitating teaching and learning activities so that effective interactions are formed between students and teachers (Nurhaisa et al., 2023). In the worksheets there are instructions and directions that will make it easier for students to learn which in the end will increase the competence that exists in students if the worksheets given is of good quality. Teaching and learning can be more effective and efficient bu using worksheets

(Chutami et al., 2021; Kosim et al., 2023). Worksheets also helps students in solving a problem and this can directly or indirectly help students improve their own competence, especially High Order Thinking Skills competence.

Research on the effect of science teaching materials on learning outcomes has already been carried out, therefore we want to look specifically at observing the effect of using science worksheets to improve High Order Thinking Skills competence. In order to find out how much influence the High Order Thinking Skills Worksheets Science Science has on students, it is necessary to analyze the results of previous studies using the journal review method by means of effect size analysis. The purpose of conducting this research is to: 1) Determine the effect sizes of the effect of using worksheets on high order thinking skills. 2) To determine the effect size of the effect of using worksheet on high order thinking skills based on class level. 3) To find out the effect sizes of the effect of using worksheet on high order thinking skills based on subjects. 4) To determine the effect sizes of the influence of the use of worksheets on high order thinking skills based on the learning model.

Method

This study uses the method of meta-analysis, examining several articles in national and international journals. Research that is undertaken through the summarization, review, and analysis of data from numerous previous studies is known as meta-analysis (Pangesti et al., 2017). The number of samples taken used 25 articles related to worksheets science with 11 Physics articles, 7 Biology articles, 7 Chemistry articles. Articles reviewed from 2018-2022.

The analysis technique used is a quantitative approach by calculating the data analysis already in the article. The steps for tabulating the data were: 1) identifying the variables found, 2) determine the mean and standard deviation of the two groups, 3) calculating the effect size using the Glass, McGaw & Smith equation, can be summarized in Table 1.

Table 1. Determination of Effect Size

Statistics Data	Formulas
Effect size formula for comparison test	$ES = \dfrac{x_{post} - x_{pre}}{SD_{pre}}$
The effect size formula for a comparison test of two independent samples	$ES = \dfrac{x_E - x_C}{SD_C}$
With the t test	$ES = t\sqrt{\dfrac{1}{n_E} + \dfrac{1}{n_C}}$

Furthermore, the effect size according to Cohen is categorized at the following levels:

Table 2. Effect Size Criteria

Effect Size	Criteria
0 – 0.20	Weak
0.21 – 0.50	Enough
0.51 – 1.00	Moderate
> 1.00	Strong

Result and Discussion

The data examined in this study were 25 articles, both national and international articles. From the articles that have been analyzed, the results of this study are grouped into 4, namely the influence of worksheets integrated into innovative learning models on High Order Thinking Skills, based on class level, based on subjects, and based on models learning used. The following are the data from the research results:

The Effect of worksheets Student High Order Thinking Skills Ability

The summary effect size of the influence of student worksheets on student High Order Thinking Skills abilities first uses hypothesis testing. This test produces a Q which is used to determine which model to use. Heterogeneous test of the effect of student worksheets on student High Order thinking skills is shown in Table 3.

Table 3. Testing the Heterogeneity of the Effect of Worksheets Innovative Natural Science Learning Models on Student High Order Thinking Skills Ability

Article Code	Y_i	V_{yi}	W_i	W_i^2	W_iY_i	$W_i.Y_i^2$
A1	1.32	0.06	17.12	292.92	22.61	29.86
A2	0.69	0.07	13.67	186.84	9.44	6.52
A3	3.05	0.10	10.33	106.64	31.51	96.15
A4	0.95	0.09	11.22	125.85	10.71	10.23
A5	4.40	0.07	14.52	210.74	63.92	281.41
A6	0.47	0.06	16.18	261.89	7.68	3.65
A7	0.69	0.03	31.08	965.81	21.32	14.63
A8	0.51	0.06	16.60	275.60	8.54	4.39
A9	1.13	0.07	13.98	195.41	15.74	17.72
A10	0.20	0.07	15.01	225.17	2.96	0.59
A11	0.88	0.07	15.29	233.91	13.46	11.84
A12	0.97	0.07	13.88	192.67	13.43	13.00
A13	0.52	0.07	13.84	191.52	7.24	3.79
A14	0.92	0.07	13.69	187.52	12.57	11.54
A15	0.82	0.06	16.92	286.21	13.90	11.42
A16	1.18	0.10	10.20	104.10	12.03	14.19
A17	0.70	0.07	14.79	218.80	10.30	7.18
A18	1.48	0.08	13.09	171.45	19.39	28.70
A19	1.13	0.07	15.08	227.54	17.00	19.16
A20	1.07	0.07	14.25	203.02	15.18	16.16
A21	0.68	0.07	13.68	187.17	9.27	6.29
A22	0.65	0.06	15.60	243.43	10.17	6.62
A23	0.69	0.10	10.05	100.99	6.91	4.75
A24	1.05	0.06	15.81	249.95	16.58	17.38
A25	0.97	0.07	15.21	231.39	14.80	14.39
		Amount	371.09	5876.54	386.65	651.55
Q						248.69
C						355.26
Df						24
T^2						0.63
I^2						90.35

The test results show that Q > df, with an article data heterogeneity value of 90.35%, indicating a population difference between articles of 90.35% and heterogeneous Calculation of the summary effect size of the influence of student worksheets on student High Order Thinking Skills abilities by testing the hypothesis, the results of the hypothesis testing can be seen in Table 4.

The results of testing the first hypothesis show that there is an effect of the use of integrated worksheets learning models on student High Order Thinking Skills abilities, there is a positive and significant effect. Judging from the value of the effect size, the influence of

worksheets has a high effect. Worksheets integrated learning models have an impact on increasing student High Order Thinking Skills, because through the use of worksheets integrated learning models make students actively involved in the learning process, and students are able to analyze with their abilities through worksheets learning resources both individually and in groups.

The results of this test agree with Destie et al. (2018) agree that the form of assignments using an inquiry-

based learning model can significantly improve student High Order Thinking Skills. Mahfuzah et al. (2018) in her research also stated that higher order thinking skills can be improved in several ways, one of which is by implementing learning strategies that are able to foster high-order and deep thinking skills. Similar results were also reported by Segara et al. (2018) in improving the skills of advanced students by using an integrated learning model of student worksheets.

Table 4. Hypothesis Testing of the Effect of Worksheets Innovative Natural Science Learning Models on Student High Order Thinking Skills Ability

Article Code	Yi	Vyi	T^2	Vyi + T^2	Wi*	Wi*Yi*
A1	1.32	0.06	0.63	0.69	1.45	1.91
A2	0.69	0.07	0.63	0.71	1.42	0.98
A3	3.05	0.10	0.63	0.73	1.37	4.19
A4	0.95	0.09	0.63	0.72	1.39	1.32
A5	4.40	0.07	0.63	0.70	1.43	6.28
A6	0.47	0.06	0.63	0.69	1.44	0.68
A7	0.69	0.03	0.63	0.66	1.51	1.03
A8	0.51	0.06	0.63	0.69	1.44	0.74
A9	1.13	0.07	0.63	0.70	1.42	1.60
A10	0.20	0.07	0.63	0.70	1.43	0.28
A11	0.88	0.07	0.63	0.70	1.43	1.26
A12	0.97	0.07	0.63	0.70	1.42	1.37
A13	0.52	0.07	0.63	0.70	1.42	0.74
A14	0.92	0.07	0.63	0.71	1.42	1.30
A15	0.82	0.06	0.63	0.69	1.45	1.19
A16	1.18	0.10	0.63	0.73	1.37	1.62
A17	0.70	0.07	0.63	0.70	1.43	1.00
A18	1.48	0.08	0.63	0.71	1.41	2.09
A19	1.13	0.07	0.63	0.70	1.43	1.61
A20	1.07	0.07	0.63	0.70	1.42	1.52
A21	0.68	0.07	0.63	0.71	1.42	0.96
A22	0.65	0.06	0.63	0.70	1.44	0.94
A23	0.69	0.10	0.63	0.73	1.37	0.94
A24	1.05	0.06	0.63	0.70	1.44	1.51
A25	0.97	0.07	0.63	0.70	1.43	1.39
				Total	35.60	38.47
M*						1.08
VM*						0.03
SEM*						0.17
LLM*						0.75
ULM*						1.41
Z*				6.45		
p-value one-tailed test				0.00		
p-value two-tailed test				0.00		

The Effect of Worksheets on High Order Thinking Skills based on Class Level

Furthermore, the influence of student worksheet media on students' High Order Thinking Skills abilities based on class level. The summary effect size value of the effect of worksheets media on student High Order Thinking Skills abilities based on class level was obtained through the initial stage, namely testing

heterogeneity at each grade level. Testing the heterogeneity of the effect of worksheets media on student High Order Thinking Skills abilities based on student class levels can be seen in Table 5.

Based on the results of the heterogeneity test, it can be seen that at 3 grade levels it shows Q > df, so the estimation of the variance between articles is quite large and heterogeneous. The model that is suitable for use at

these 3 class levels is the random effects model. The data obtained were heterogeneity values in class X of 93.69%, class XI 84.03%, and class XII of 83.78%. This heterogeneity value indicates a difference at each grade level. The next stage is testing the hypothesis of the effect of worksheets media on the High Order Thinking Skills abilities of grade-level students. Hypothesis calculation based on class level can be seen in Table 5.

Based on the test results of the second hypothesis, it shows that at all grade levels, starting from class X, class XI and class XII, there is a positive and significant influence on the use of worksheets on student High Order Thinking Skills abilities. The summary effect size of the three grade levels shows that class X has a greater effect on student higher order thinking skills.

Table 5. Testing the Heterogeneity of the Effect of Worksheets Innovative Natural Science Learning Models on Student High Order Thinking Skills by Class Level

Class	Article Code	Q	Df	I^2
	A1			
	A2			
	A5			
	A6			
	A11			
X	A12	174.28	11	93.69%
	A14			
	A17			
	A20			
	A22			
	A24			
	A25			
	A3			
	A4			
	A7			
	A8			
	A9			
XI	A10	62.61	10	84.03%
	A15			
	A16			
	A19			
	A21			
	A23			
XII	A13	6.17	1	83.78%
	A18			

The class X effect size shows that the use of worksheets integrated with innovative learning models is very good. This shows that the worksheets is an appropriate alternative learning tool for students, because worksheets helps students to add information about the concepts learned through systematic learning

activities. Some specific advantages of using worksheets in learning are that it can foster student independence, can foster activity, creativity, and student learning motivation, saves time, and provides more opportunities for teachers to carry out individual or group guidance.

Table 6. Testing the Hypothesis of the Effect of Worksheets Innovative Natural Science Learning Models on Student High Order Thinking Skills Ability by Class Level

Class	Article Code	ES	SE_M	LL_M	UL_M	P
	A1					
	A2					
	A5					
	A6					
	A11					
X	A12	1.174	0.24	0.70	1.65	0.00
	A14					
	A17					
	A20					
	A22					

Class	Article Code	ES	SE_M	LL_M	UL_M	P
	A24					
	A25					
	A3					
	A4					
	A7					
	A8					
	A9					
XI	A10	1.002	0.25	0.50	3.92	0.00
	A15					
	A16					
	A19					
	A21					
	A23					
XII	A13	1.002	0.59	-0.16	2.17	0.07
	A18					

The Effect of Worksheets on High Order Thinking Skills Based on Subjects

The third result is in the study of the effect of worksheets media on student High Order Thinking Skills abilities based on moderator variables, namely based on subjects. Articles that discuss the effect of worksheets media on High Order Thinking Skills abilities in terms of science subjects can be seen in table 7.

Table 7. Testing the Heterogeneity of the Effect of Worksheets Innovative Natural Science Learning Models on Student High Order Thinking Skills Based on Subjects

Subjects	Article Code	Q	Df	I^2
	A15			
	A16			
	A17			
	A18			
	A19			
Physics	A20	9.36	10	-6.88%
	A21			
	A22			
	A23			
	A24			
	A25			
	A8			
	A9			
	A10			
Chemistry	A11	9.42	6	36.28%
	A12			
	A13			
	A14			
	A1			
	A2			
	A3			
Biology	A4	197.47	6	96.96%
	A5			
	A6			
	A7			

Based on the results of heterogeneity testing in the 3 learning subjects, it was found that the Physics, Chemistry and Biology material showed a value of Q> df, so the estimation of the variance between articles was quite large and the existing data was heterogeneous. The suitable model is the random effects model.

The next stage is testing the hypothesis of the effect of worksheets media on student High Order Thinking Skills abilities towards subjects. Hypothesis calculation based on class level can be seen in Table 8.

Based on the test results of the third hypothesis, it shows that the use of worksheets integrated with

innovative learning models has a positive and significant impact on student High Order Thinking Skills abilities based on subjects. The summary effect size shows that the use of worksheets applied to Biology material has a more significant impact on student higher

order thinking skills. This is in line with the results of research (Mufida, 2018) which states that the use of worksheets can train high school student thinking skills in biology learning.

Table 8. Testing the Hypothesis of the Effect of Worksheets Innovative Natural Science Learning Models on Student High Order Thinking Skills Based on Subjects

Subjects	Article Code	ES	SE_M	LL_M	UL_M	P
	A15					
	A16					
	A17					
Phyics	A18	0.946	0.25	0.45	1.44	0.00
	A19					
	A20					
	A21					
	A22					
	A23					
	A24					
	A25					
	A8					
	A9					
	A10					
	A11					
Chemistry	A12	0.732	0.32	0.11	1.35	0.01
	A13					
	A14					
	A1					
	A2					
	A3					
	A4					
Biology	A5	1.654	0.32	1.02	2.26	0.00
	A6					
	A7					

The Effect of Worksheets on High Order Thinking Skills Based on the Learning Model

The final result of the study is related to the effect of worksheets media on student High Order Thinking Skills abilities based on the learning model. Testing the

hypothesis on the effect of worksheets media on student High Order Thinking Skills abilities can be known by first testing the heterogeneity of the learning model media used. Heterogeneity testing based on the learning model can be seen in Table 9.

Table 9. Testing the Heterogeneity of the Effect of Worksheets Innovative Natural Science Learning Models on Student High Order Thinking Skills Based on the Learning Model

Learning Model	Article Code	Q	*Df*	I²
Auditory Intellectually	A1	-	-	-
	A6			
	A7			
Problem Based Learning	A16	3.37	5	-48.07%
	A19			
	A23			
	A25			
Guided Discovery Learning	A8	-	-	-
	A9			
	A10			
Problem Solving	A11	3.33	5	-50.08%
	A12			
	A13			
Inquiry	A2	28.48	6	78.88%

Learning Model	Article Code	Q	Df	I²
	A4			
	A5			
	A15			
	A17			
	A20			
	A22			

Based on the results obtained in Table 8, we can see that only three learning models were tested for heterogeneity. This is because only three learning models had different populations. The 3 learning models tested for heterogeneity are the Problem Based Learning, Problem Solving and Inquiry models. Meanwhile, the other 2 learning models were not tested for heterogeneity because the populations were the same.

The results of the heterogeneity test of the three learning models showed values of Q > df for the problem-based learning, problem-solving, and survey models, so the estimates of the between-item variance were very large and the data were It was foreign. The model that is suitable for calculating summary effect sizes is the Problem Based Learning, Problem Solving and Inquiry models, namely the random effects model.

Next is testing the hypothesis of the influence of worksheets media on student High Order Thinking Skills abilities based on the learning model. Calculation of the hypothesis based on the learning model can be seen in Table 10. The results of testing the fourth hypothesis show that of all the learning models used in worksheets, they have a positive and significant impact on student knowledge. Based on the results of the summary effect size, it shows that the inquiry learning model has a significant effect on student higher order thinking skills. The effect size of the inquiry learning model shows a very high effect.

This shows that with the worksheets integrated innovative learning models students become more active in the learning process and produce higher knowledge than when using other learning models. The results of this test are consistent with those reported by Destien et al. (2018) found that worksheets using survey-based learning models can significantly improve high-level thinking skills in students. Aulia et al. (2018) in her research also stated that higher order thinking skills can be improved in several ways, one of which is by implementing learning strategies that are able to foster high-order and deep-thinking skills.

Table 10. Testing the Hypothesis of the Effect of Worksheets Innovative Natural Science Learning Models on Student High Order Thinking Skills Based on the Learning Model

Learning model	Article Code	ES	SE_M	LL_M	UL_M	P
Auditory Intellectually	A1	-	-	-	-	-
	A6					
	A7					
Problem Based Learning	A16	0.854	0.34	0.18	1.52	0.01
	A19					
	A23					
	A25					
Guided Discovery Learning	A8	-	-	-	-	-
	A9					
	A10					
Problem Solving	A11	0.678	0.34	0.09	0.43	0.01
	A12					
	A13					
	A2					
	A4					
	A5					
Inquiry	A15	1.236	0.48	1.07	2.79	0.00
	A17					
	A20					
	A22					

Conclusion

The results of the meta-analysis study concluded that the first Worksheets integrated learning models had a very good influence on student High Order Thinking Skills abilities. Second, Worksheets integrated learning model has a very good influence on student High Order Thinking Skills abilities at all three grade levels, namely class X, XI, and XII especially for class X students. Third, Worksheets integrated learning model has a very good influence on student High Order Thinking Skills abilities for subjects IPA, and the highest in Biology. Fourth, Worksheets integrated with learning models have a good effect on increasing student High Order Thinking Skills for several learning models, and have a very good effect on increasing student High Order Thinking Skills in the use of the inquiry model.

Author Contributions
The author's contributions include Hilmi Rizki Anjani, Nadya Syahdi and Utari Prisma Dewi collecting data, analyzing data, writing original drafts, and so on; Asrizal and Festiyed: focus onmethodology, and review of writing.

Conflicts of Interest
The authors declare no conflict of interest.

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