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Meta-analysis Of Cooperative Learning To Improve Learning Outcomes In Biology Subject

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ABSTRACT

This research aims to re-analyze the cooperative learning model in improving learning outcomes in Biology subject. The cooperative learning model is an active approach that emphasizes group work, positive relationships, cooperation, and mutual motivation, thus creating promotive interactions to build a learning community. This research used meta-analysis method as the main approach. The research stages included problem formulation, exploration of existing relevant research, and data analysis. Data collection was conducted using non-test techniques through electronic journal searches such as Google Scholar and ResearchGate, as well as documentation studies in the library. A total of 48 journal articles and 2 thesis collections were found for further analysis. The results showed that the cooperative learning model was able to improve students' learning outcomes in Biology subject. Interaction in learning groups encourages students to support each other and take responsibility together. This approach also provides space for students to develop communication and critical thinking skills. In general, learning that involves students actively is able to form effective individual understanding in Biology.

Introduction

Education is an effort to create a learning atmosphere to help students develop their potential. Education plays a very important role in shaping the good or bad of the human person based on normative standards and creating human resources who have high competence, quality and dedication so that a country excels in global competition (Kurnianti and Saleh, 2023; Mansur et al. 2023; Nababan, Pratiwi, and Nugraha, 2023; Sari, Yamin, and Khairuddin, 2023). The quality of education can be seen from the quality of the learning process. If the learning process is good, then the quality of education is also good.

Learning is the interaction between teachers and students in the process of transferring knowledge from teachers to students to support active learning and achieve learning goals (Hannifa, Susanti, and, Sari 2022; Lestari, Oetomo, and Karyanto, 2023). Good learning should be preceded by learning planning. Planning in learning is carried out by making a learning plan (RPP) where the teacher must plan the learning process by paying attention to strategies, approaches, methods, techniques and tactics. To realize these hopes, learning is needed that accommodates all students' needs by choosing the appropriate learning model.

Batubara et al. (2022); Ridwan, Hadi, and Jailani (2022); Wullur, Pendong, and Yalindua (2023); Aulia and Lena (2023) stated that the application of learning models must be adapted to student characteristics, materials, student needs, learning environment, availability of learning support tools, relevant subjects and curriculum. So, by implementing an appropriate learning model, it is hoped that it can create maximum learning in the classroom (Ichsan et al. 2023). Appropriate and diverse learning models enable students to gain knowledge effectively and have a positive impact on student learning outcomes and increase students' desire (motivation) to learn more actively (Lestari, Ekanara, and Purwaningsih, 2021; Nursal, Syamsurizal, and Alberida, 2023; Laia and Waruwu, 2023). One learning model is the cooperative learning model.

The cooperative learning model is learning that focuses on grouping students based on different levels of academic ability in small groups in which group collaboration and teamwork occurs among students to understand the learning material (Togatorop, 2021; Widhihastuti and Supardi, 2023; Nababan et al., 2023; Ghaemi, Ebrahimi, and Ocak, 2023). The first element of the cooperative learning model is positive interdependence, in practice it really depends on the conditions and main problems being solved, placing individual and group responsibility, so that students grow and develop attitudes and behavior of positive interdependence (Lestari et al. 2021). The second element is student interaction, students must have a high level of digital literacy and be motivated to participate in the learning process in order to engage in successful interactions (Castro and Tumibay 2021).

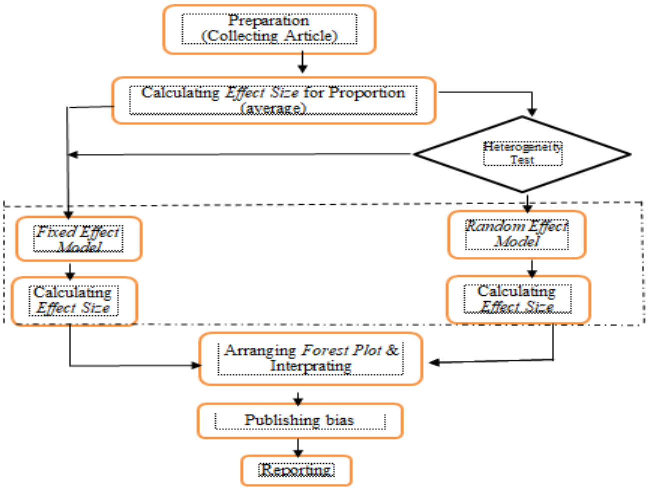
Interaction between students is also very important, this is because through discussion and collaboration, students can learn from each other and exchange understanding (Patulak, Syamsiah, and Kandek 2023). Apart from that, all group members must feel responsible for contributing in completing their tasks towards obtaining grades for their group by providing understanding or providing the best answers (Zb, Ananda, and Mensah, 2022; Ibrahim, Marwan, and Firmansyah, 2023). The third element is individual accountability, according to Segundo-marcos, Carrillo, and Fernandez (2022) individual accountability in the cooperative learning model is clearly defined and there is a balance of performance between individuals and groups and learning objectives are achieved through group collaboration. This is in accordance with the statement of Noviyanto, Susanti, and Khairunnisa (2022); Nurhalijah et al. (2023); Samosir (2023) states that the cooperative learning model is different from other learning models in that this learning model places more emphasis on the process of working together in groups to solve problems. The fourth element is interpersonal and social, referring to the skills needed to interact and collaborate with peers. The skills in question include actively asking questions, sharing tasks, respecting other people's opinions, expressing ideas or opinions, working in groups (Simanungkalit 2020). Achievement and success are the result of teamwork and group efforts rather than individualistic effort (Tadesse, Gillies, and Manathunga 2020).

Learning outcomes are an output obtained by students in mastering a subject after following a series of learning in terms of cognitive, affective, psychomotor and mixed abilities during a certain period (Lestari et al., 2021; Rezeki and Haryanti, 2022; Kurnianti and Saleh, 2023; Aghel, 2023). Biology learning outcomes at the cognitive level (students' understanding and knowledge regarding the values of biology learning) can be measured based on predetermined standards. Meanwhile, learning outcomes are viewed from affective and psychomotor aspects, seen from changes in attitudes and behavior while at school and under teacher supervision after biology learning. Therefore, researchers want to prove whether the application of the cooperative learning model can improve biology learning outcomes.

Method

This research is quantitative using a meta-analysis research approach . Metaanalysis is a research methodology for quantitatively analyzing or the process of categorizing subjects, themes, or areas of research findings by integrating the results of a series of empirical studies on a particular topic and evaluating the results quantitatively (Sabaryati et al., 2022; Batubara et al., 2022; Aghel, 2023). Collecting data from research results for the analysis process is called secondary data. Research data was collected by searching for articles in online journals using Google Scholar, Researchgate and theses were obtained from library collections over the last 5 years.

In meta-analysis research, 3 steps to do to get the accumulation of research, namely: First, formulating meta-analysis research questions. Second, gathering studies as material for meta-analysis. Third, calculating the effect size and compile the report. In the third step, conducting a meta-analysis is by calculating the standard error of the effect size, the weight, the average of effect size, the significance of the effect size, the lower limit and the upper limit of the effect size, the magnitude of the effect size, then describe the plot forests. After that, interpretation performed on the magnitude and direction of the effect size to illustrate the results of the aggregation. Furthermore, the analysis of the publication carried out by using the JASP 0.8.4.0 program. The steps of the meta-analysis are as follows. Meta analysis steps according to Retnawati et al. (2018) is as follows.



Result and Discussion

A. Journal Article and Thesis Data

Collecting research data in the form of articles obtained from *Google Scholar, Researchgate* and a collection of theses related to the application of cooperative learning models in improving biology learning outcomes totaling 50 articles consisting of 48 journal articles and 2 thesis collections in the library. Next, carry out a meta-analysis of the article. obtained from library collections over the last 5 years which contain of calculate the average effect size(ES), standard error of the effect size (SE), calculate the weight (w), calculate the average effect size considering the weight (w.ES), test the significance of the effect size, calculate the lower (LB) and upper limits of the effect size (UB), calculate the magnitude of the effect size (w.ES^Z) following are the research results in Table 1:

Table 1. Secondary Data: Tabulation of Article Search Results

Author	N	ES	SE	w	w.ES	LB	UB	w.ES^Z
Kurniasari and Ngatiman (2023)	34	0,941176	0,04	614,12	578,00	0,86	1,02	544,00
Nurjanah and Sasinggala (2021)	30	0,866667	0,06	259,62	225,00	0,75	0,99	195,00
Pertiwi, Samsuri, and Muliadi (2019)	13	0,769231	0,12	73,23	56,33	0,54	1,00	43,33
Kalsum, Faisal, and Kurniawan (2023)	34	0,882353	0,06	327,53	289,00	0,77	0,99	255,00
Yani and Kusmana (2020)	35	0,828571	0,06	246,41	204,17	0,70	0,95	169,17
Laia and Waruwu (2023)	35	0,885714	0,05	345,77	306,25	0,78	0,99	271,25
Wullur et al. (2023)	28	0,857143	0,07	228,67	196,00	0,73	0,99	168,00
Andrani (2019)	32	0,875	0,06	292,57	256,00	0,76	0,99	224,00
Erlina (2019)	31	0,83871	0,07	229,16	192,20	0,71	0,97	161,20
Sari, Tanjung, and Khairuna (2022)	29	0,896552	0,06	312,68	280,33	0,79	1,01	251,33
Pursetianingsih (2019)	30	0,833333	0,07	216,00	180,00	0,70	0,97	150,00
Saputra and Loli (2019)	21	0,857143	0,08	171,50	147,00	0,71	1,01	126,00
Minarti (2022)	42	0,761905	0,07	231,53	176,40	0,63	0,89	134,40
Lahamma (2021)	26	0,846154	0,07	199,73	169,00	0,71	0,98	143,00
Triningsih (2022)	32	0,9375	0,04	546,13	512,00	0,85	1,02	480,00
Puradin, Hasan, and Tolangara (2019)	22	0,954545	0,04	507,04	484,00	0,87	1,04	462,00
Habibi (2022)	14	0,928571	0,07	211,08	196,00	0,79	1,06	182,00
Subudi (2021)	32	0,71875	0,08	158,30	113,78	0,56	0,87	81,78
Goba (2020)	32	0,90625	0,05	376,64	341,33	0,81	1,01	309,33
Nurkomalasari, Suhendar, and Ramdhan (2020)	36	0,916667	0,05	471,27	432,00	0,83	1,01	396,00
Gunawan, Ismail, and Alwi (2023)	20	0,75	0,10	106,67	80,00	0,56	0,94	60,00
Artanti and Mukhtar (2024)	36	0,861111	0,06	301,01	259,20	0,75	0,97	223,20
Khairani (2022)	30	0,9	0,05	333,33	300,00	0,79	1,01	270,00
Rosidha (2020)	21	0,809524	0,09	136,19	110,25	0,64	0,98	89,25
Ettin (2022)	25	0,92	0,05	339,67	312,50	0,81	1,03	287,50
Muhaeming, Syamsiah, and Murniati (2023)	36	0,916667	0,05	471,27	432,00	0,83	1,01	396,00
Mansur, Setiono, and Ramdan	29	0,862069	0,06	243,89	210,25	0,74	0,99	181,25

Author	N	ES	SE	w	w.ES	LB	UB	w.ES^Z
(2019)								
Rismadimeng et al. 2023)	19	0,894737	0,07	201,74	180,50	0,76	1,03	161,50
Pamiaryani (2020)	32	0,90625	0,05	376,64	341,33	0,81	1,01	309,33
Nurhayati, Sa'adah, and Wibowo (2022)	36	0,805556	0,07	229,83	185,14	0,68	0,93	149,14
Reflina 2020)	40	0,95	0,03	842,11	800,00	0,88	1,02	760,00
Nuraida, Risnita, and Rohmansyah (2023)	13	0,846154	0,10	99,86	84,50	0,65	1,04	71,50
Mulyani 2021)	32	0,9375	0,04	546,13	512,00	0,85	1,02	480,00
Kalsum (2022)	30	0,8	0,07	187,50	150,00	0,66	0,94	120,00
Sujiati (2020)	26	0,846154	0,07	199,73	169,00	0,71	0,98	143,00
Nuraeni (2022)	25	0,84	0,07	186,01	156,25	0,70	0,98	131,25
Telaumbanua et al. (2023)	24	0,875	0,07	219,43	192,00	0,74	1,01	168,00
Martini (2023)	36	0,805556	0,07	229,83	185,14	0,68	0,93	149,14
Givari, Patongai, and Asia (2023)	30	0,866667	0,06	259,62	225,00	0,75	0,99	195,00
Jasriyanto (2023)	39	0,923077	0,04	549,25	507,00	0,84	1,01	468,00
Tantu et al. 2023)	18	0,888889	0,07	182,25	162,00	0,74	1,03	144,00
Najoan, Lawalata, and Rengkuan (2024)	30	0,866667	0,06	259,62	225,00	0,75	0,99	195,00
Sholihah, Arsal, and Fatmawati (2023)	36	0,916667	0,05	471,27	432,00	0,83	1,01	396,00
Satar, Arafah, and Wahyuni (2023)	18	0,944444	0,05	343,06	324,00	0,84	1,05	306,00
Arifuddin, Arsal, and Resova (2023)	36	0,888889	0,05	364,50	324,00	0,79	0,99	288,00
Sembiring, Wurarah, and Sumakul (2023)	15	0,866667	0,09	129,81	112,50	0,69	1,04	97,50
Hebindatu, Tanor, and Tumbel (2023)	24	0,875	0,07	219,43	192,00	0,74	1,01	168,00
Rizal, Faisal, and Anna (2023)	31	0,83871	0,07	229,16	192,20	0,71	0,97	161,20
Rahmawati, Faradita, and Sudjani (2023)	25	0,92	0,05	339,67	312,50	0,81	1,03	287,50
Udju, Bano, and Enda (2023)	32	0,875	0,06	292,57	256,00	0,76	0,99	224,00
Total				14910,04	13259,06			11827,06

Based on data calculations, the mean effect size (Aggregate (ES)) is 0.8893, the standard error of the SEES effect size is 1.060432, with an upper limit (ESLB) of -1.189177 and a lower limit (ESUB) of 2.967718. Next, the effect size inequality hypothesis was tested, with 0.75. Criteria obtained from learning are said to be complete if it reaches the Minimum Master Criterion (KKM) ≥ 75%. The z value of 0.096501 (0.096501 <1.96), so that Ho is rejected, Ha is accepted, which means the implementation of cooperative learning models affects the value of the Minimum Master Criterion (KKM). While Q was obtained at 11790.92 with I^2 of 11.8627. Furthermore, the forest plot can be presented as follows.

B. Forest plot

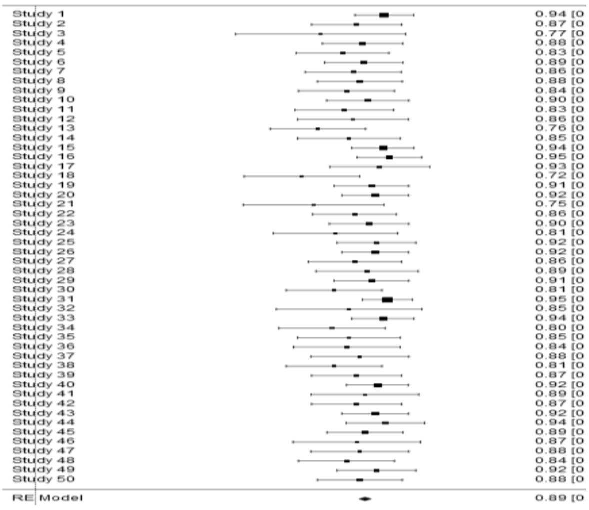


Figure 1. Forest plot, source: JASP 0.8.4.0 program

Based on Figure 1, it shows that the average student learning outcomes completed after implementing the cooperative model is 89%. This means that 89% of students were declared to have completed the completion criteria score of 75. Of the 50 articles used for meta analysis, the upper limit of the effect size was 0.86 and the lower limit of the effect size was 1.02.

C. Hypothesis Test

After obtained *effect size* (ES) and *standard error* (SE), the next step is data analysis using the JASP application version 0.8.4.0. Data is input in format *txt* then select the menu *meta-analysis* and *classical.* The output of the analysis results is then copied and pasted into Ms. word and ready to be interpreted. Hypothesis testing is used to find out the appropriate model to use to analyze data. The hypothesis is as follows.

H_0: The cooperative learning model has no effect on improving Biology learning outcomes.
H_1: The cooperative learning model has an effect on improving Biology learning outcomes.
The results of the hypothesis test can be seen as in Table 2 and Table 3.

Table 2. Results of JASP analysis of fixed effects and random effects

	Q	df	p
Omnibus test of Model Coefficients	11790.92	1	< .001
Test of Residual Heterogeneity	36.17	49	0.913

Note. *p* -values are approximate.

Table 3. JASP analysis results z coefficient value

	Estimate	Standard Error	z	p	Lower Bound	Upper Bound
intrcpt	0.8893	0.0082	108.59	0	0.8732	0.9095

Note. Wald test.

Based on Table 2 and Table 3, it can be seen that the z value is 108.59 and the value*p-value* is 0.001 less than 0.05, until H_0 rejected. This means that the cooperative learning model has an effect on improving Biology learning outcomes. The random effects model shows a positive and significant influence between the cooperative learning model with a p-value of 0.001 and a z-value of 108.59.

D. Heterogeneity Test

According to Ridwan et al. (2022) the heterogeneity test was carried out using statistical parameter values *Q*, τ^2, and I^2 as in Table 4.

Tabel 4. Heterogeneity Test

Dependent Variable	Heterogeneity Test Parameter				
	Q-Statistic				
	Value	df	*p-value*	τ^2	I^2
Biology Learning Outcomes	36.17	49	0.913	0.0005	11.8627

Based on Table 4, it can be seen that the heterogeneity test measurement using Q-statistics obtained a value of 36.17so that value>df and*p-value* of 0.913which is greater than 0.05 so it can be concluded that the meta analysis sample data is heterogeneous. This can also be proven by parameter values I^2 of 11.8627 and the value of τ^2 namely 0.01 which is a value more than 0.

E. Bias Publication

The Publication bias test is used to determine whether the selected sample is representative of the population (Negara and Kurniawati 2023). The results of the Publication bias test analysis can be seen in Table 5 and Table 6.

Table 6. Analysis results *Rank Correlation*

Rank correlation test for Funnel plot asymmetry		
	Kendall's τ	**p**
Rank test	-0.6003	< .001

Table 7. Analysis results *Regression Method*

Regression test for Funnel plot asymmetry ("Egger's test")		
	z	**p**
sei	-4.8455	< .001

Analysis results *Rank Correlation* and *Regression Method* the funnel plot aims to see studies that fall into the category of biased and non-biased Publications based on the Kendall value and regression correlation coefficient with variance. Decision making with the criterion that if the p-value < α (0.05), then the research includes Publication bias. Meanwhile, if the p value ≥ α (0.05), then the research is an unbiased Publication. After carrying out the analysis, the rank correlation method value was -0.6003 with p-value (0.001) < α (0.05), while the regression method was -4.8455with p-value (0.001) < α (0.05), meaning evidence of Publication found The results of Publication bias can also be seen in the funnel plot output as in Figure 2.

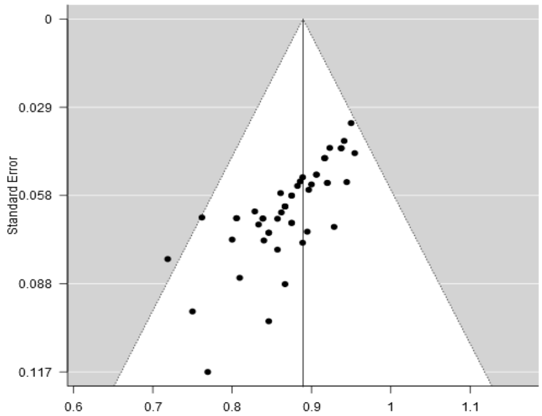


Figure 2. Funnel plot, source: JASP 0.8.4.0

Based on the Funnel Plot image above, it can be seen that the effect size is distributed around a vertical line even though there is research outside the funnel with a closed circle so that no bias is found. This is in accordance with the statement of Ridwan et al. (2022) that if there is research with closed circles located outside the funnel at the bottom and middle, then the data does not show Stateation bias. This means that conclusions based on the relationship between learning models and learning outcomes in biology subjects are valid.

F. Discussion

Based on the results of the analysis, applying the cooperative learning model to biology subjects can improve student learning outcomes. This was obtained from statistical calculations of an average Effect Size of 0.89, which means 89% of students passed the Minimum Completeness Criteria (KKM). The z value is 0.096501 (0.096501<1.96), so Ho is rejected, Ha is accepted, which means that the application of the cooperative learning model has an effect on the Minimum Completeness Criteria (KKM) value. Meanwhile, Q is 87.6019, meaning that the effect size between studies is heterogeneous. This shows that the random effects model is the recommended model for analysis. The random effects model is used when the research population being analyzed is functionally different due to different observed sample/participant characteristics (Retnawati et al. 2018). Based on the forest plot, the results showed that the aggregate proportion of students who completed their studies was around 89%, meaning that 89% of students had 75% completeness.

Based on the results of the analysis, applying the cooperative learning model to biology subjects can improve student learning outcomes. This was obtained from statistical calculations of an average Effect Size of 0.89, which means 89% of students passed the Minimum Completeness Criteria (KKM). The z value is 108.59 and the value*p-value* is 0.001 less than 0.05, until H_0 rejected. This means that the cooperative learning model has an effect on improving Biology learning outcomes. The random effects model shows a positive and significant influence between the cooperative learning model with a p-value of 0.001 and a z-value of 108.59.

Meanwhile, Q is 36.17, meaning that the effect size between studies is heterogeneous. This shows that the random effects model is the recommended model for analysis. The random effects model is used when the research population being analyzed is functionally different because the observed sample/participant characteristics are different (Retnawati et al. 2018). For the effect size I deviation index value^2 amounting to 11.8627%. These results indicate that the index deviation is in the low category. Based on the forest plot, the results showed that the aggregate proportion of students who completed their studies was around 89%, meaning that 89% of students were declared to have completed the KKM score of 75.

Based on these findings, the application of the positive cooperative learning model can help students to improve Biology learning outcomes. Several research results reveal that cooperative learning models can improve student learning outcomes (Rabgay, 2018; Han and Son, 2020; Hikmawati, Munir, and Parakassi, 2020; Costouros, 2020; Wyman and Watson, 2020; Supena, Darmuki, and Hariyadi, 2021). The learning model or method applied by the teacher in each learning process will have a big influence on student learning outcomes so that the factors that influence learning outcomes are not only internal (learning motivation) (Kurnianti and Saleh 2023).

Application of learning models that involve students actively and socially in learning plays an important role in mastering biological concepts (Bizimana, Mutangana, and Mwesigye 2022). Factors that determine the success of learning objectives include the teacher factor in carrying out the teaching and learning process, because teachers can directly influence, develop and improve students' intelligence and skills (Mansur et al. 2023).. In line with Mansur's statement, apart from delivering teaching material, teachers also act as facilitators, mediators and guides to students in solving problems (Saefuddin, Setiono, and Nuranti 2023).

The cooperative learning model has a positive impact on teachers and students, for teachers the benefit is to gain direct experience in implementing learning, as motivation to improve skills in choosing varied learning strategies so that they can provide the best service for student (Denis, Lena, and Erkka 2023). Meanwhile, for students, it is improving their ability to work together and socialize. The application of the cooperative learning model not only has an impact on student learning outcomes but also prospective teachers. The positive impacts include fostering prolonged interactions, developing a strong sense of togetherness, providing a safe space, facilitating discussions, and increasing self-confidence (Kopparla and Goldsby 2019).

Conclusion

Good learning can create a positive environment for students. Through the application of the cooperative learning model, students can work together, have positive interdependence, help each other, and motivate each other. So, there is promotive interaction to create a learning community that develops knowledge by applying effective learning models, strategies, approaches and methods. In general, a learning model that actively involves students can form an effective individual understanding of biology subject.

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