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Meta-Analysis: Effect of Using Inquiry Based Learning (IBL) Model on Students' Competence

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Abstract *–The development of science and technology has led to a process of change in all aspects of education which includes students' competencies such as attitudes, knowledge, and skills. However, in reality schools students tend to be disinterested when conventional learning like lecture method is carried out, the level of curiosity or research on students is still low, and students are not accustomed to learning independently or exploring new information about a theory. This study aims to determine the effect of Inquiry Based Learning on the students' competence. This type of research is meta-analysis conducted by summarizing, reviewing and analyzing data from several previous studies. The research sample consisted of 22 articles taken from journals that already had an ISSN. The data analysis technique used in this study is calculating the effect size of each article. Based on the research results, two conclusions were drawn. First, viewed from educational level, Inquiry Based Learning is more effectively applied at the high school level particularly to enhance students' attitudes and knowledge competencies with an effect size of 2.47 and 1.45, respectively; when concerning skill competency, IBL is more effective to be used at the tertiary level with an effect size of 2.19. Second, the Inquiry Based Learning is more suitable to be used in physics subjects, especially to develop attitude and knowledge competencies, with an effect size of 2.47 and 1.30, respectively; while skill competency is more effectively implemented to teach biochemistry subjects with an effect size of 2.19.*

Keywords: *effect size; inquiry based learning; student competence*

I. INTRODUCTION

The development of technological know-how and generation has brought approximately a process of alternate in all areas of lifestyles, including the world of education. Academic reforms need to therefore be applied in a timely way to maximize students' competence (Syahrial et al., 2019). Science is considered a pioneer of the advancement of modern technology (Oladejo et al., 2011). This is because science learning students are trained to think actively, logically and structurally so that meaningful concepts are formed to develop knowledge. Thus, the increasingly advanced development

of science and technology will also take a role in developing the students' competence.

Competence is a mastery of abilities possessed by students which include attitude competencies, knowledge competencies and skill competencies (Rohida et al., 2018). Permendikbud (2013) defines that competency is a set of attitudes, knowledge and skills that students must possess, internalize and master in order to complete the level of education they are currently pursuing. Attitude competence relates to attitudes, values, interests, appreciation and adjustment of social feelings. Permendikbud (2016) states that knowledge competence consists of several levels of understanding, namely knowing, understanding, applying, analyzing, evaluating and creating. And finally, skill competence related to skills both manual and motor in nature.

As one of the factors supporting its success learning process, educators need to help students to improve learning outcomes and critical thinking skills through models learning that can support students to study actively. One of the learning models that can be used is an inquiry model (Amijaya et al., 2018; Nurazmi et al., 2021). The use of the inquiry model will create more fun learning activities and ultimately affect the understanding of the concept. In principle, the purpose of inquiry teaching is to help students to formulate questions, looking for answers or solutions to satisfy his curiosity and to help his theories and ideas about the world. Furthermore it is said that inquiry learning aims to develop the level of thinking and also critical thinking skills (Juniati & Widiana, 2017). One way to develop scientific attitude is to treat students like young scientists as children participate in science learning activities. Active involvement of students both physically and mentally in laboratory activities will have an impact on the formation of patterns of student action that always based on scientific matters (Maretasari et al., 2012).

The real conditions found in the field were not in accordance with the expected ideal conditions. There have been many learning models implemented in schools, but their application is still not optimal. Based on the results of observations, several causes were found for the unsuccessful application of the learning model, namely: 1) the teacher did not really understand the syntax for applying the learning model in schools, 2) students tended to be unenthusiastic when conventional learning such as the lecture method was carried out, 3) the level of curiosity or research students are still low, 4) students are not used to learning independently or exploring new information about a theory. This is in line with several previous studies namely: 1) the models used tend to be monotonous and there are still some who use conventional learning models (Mursid, 2017). 2) learning does not go two ways, and learning is teacher-centered (Jayawardana, 2017; Rivalina & Siahan 2020;

Emaliana, 2017). 3) on certain materials that enable experiments, the teacher only conveys material without conducting experiments (Fatmawati et al., 2019). Thus there are still deficiencies in applying the learning model in the classroom.

Learning that applies the inquiry model can influence a person's attitude during learning because with this model students are directed to be independent. Activities such as formulating hypotheses, designing experiments, analyzing experiments, collecting data trained students to become independent. This is in line with the opinion (Cetin et al., 2019) that the inquiry model can improve students' attitude skills.

There are plenty of research about the application of inquiry-based learning to students' competence. The inquiry-based learning model is used to overcome some of the above problems. However, the inquiry-based learning model also has drawbacks including: a. It is difficult to control the activities and success of students, b. It is difficult to plan lessons because they are out of sync with students' study habits, c. In implementing it, it takes a long time so it is often difficult for the teacher to adjust it to a more specified time, d. The success criteria are determined by the ability of students to master the subject matter, so the inquiry learning model will be difficult for every teacher to implement, e. If this learning model is used, that managing activities and the achievement of students must be correct. Students have brilliant ideas so they can become active people, f) Usually through application, it definitely takes a long time, so the teacher feels complicated conditioning at the scheduled time. Students must have intelligence in order to think critically (Nurdini et al., 2022; Prasetiyo & Rozy, 2021; Sugianto et al., 2020).

However, there are some shortcomings from previous studies such as only examining one subject, one grade level and one student competency variable so that the effect of inquiry-based learning on the students' competence does not look significant. The novelty of this research is to examine the effect of the application of inquiry-based learning on the students' competence including attitudes, knowledge, and skills based on two variables at once, namely education level and subjects. As many as 22 articles have been obtained regarding the application of inquiry-based learning to students' competence. Articles were obtained from various sources which were then analyzed for effect sizes; then, we determined the effect on the competence of students.

The formulation of the research is whether the inquiry-based learning model has an influence on the students' competence? The research objective was to determine the effect of Inquiry Based learning on the students' competence.

II. METHODS

This study uses the method of meta-analysis. A meta-analysis is a study conducted by summarizing, reviewing, and analyzing data from multiple studies that have been conducted. The stages of meta-analysis can be explained as follows:

1. Stages of preparation
   a. Data management, namely collecting data from various sources such as Google Scholar, International Journal of Instruction, Journal of Educational Science and Technology (EST), International Journal of Elementary Education, Atlantis Press, International Journal of Scientific and Research Publications (IJSRP), and Scientific Journals Science Education
   b. The research variables are the dependent variable, namely Inquiry based learning, knowledge competence, attitude competence, skills competence and moderator variables, namely education level and subjects.
2. Implementation stage
   a. Collecting data through literature sources from 3 October -20 November 2022
   b. Resuming research article data in the form of research variables, research objectives, level of education, material and statistical data that can be used
   c. Research coding to facilitate analysis
   d. Analyzing ES from the results of the collection of research articles
   e. Summarize the results of data analysis

Table 1. How to determine the magnitude of the Effect Size

No	Statistics	Formula		Formula Kode
1	Statistical mean in one group	$ES = \frac{\bar{X}_{post} - \bar{X}_{pre}}{SD_{pre}}$	(1)	Fr-1
2	Statistical mean in each group *(two groups posttest only)*	$ES = \frac{\bar{X}_{E} - \bar{X}_{C}}{SD_{C}}$	(2)	Fr-2
3	Statistical mean in each group *(two groups pre-post tests)*	$ES = \frac{(\bar{X}_{post} - \bar{X}_{pre})E - (\bar{X}_{post} - \bar{X}_{pre})C}{\frac{SD_{preC} + SD_{preE} + SD_{postC}}{3}}$	(3)	Fr-3
4	Chi-Square Statistics	$ES = \frac{2r}{\sqrt{1-r^2}}$; $\sqrt{\frac{x^2}{n}}$	(4)	Fr-4
5	Statistics t count	$ES = t\sqrt{\frac{1}{n_E} + \frac{1}{n_c}}$	(5)	Fr-5
6	P value statistic	CMA (Comprehensive Meta Analisis Software)		Fr-6

(Becker & Park, 2011)

Table 2. Category Effect Size (Becker & Park, 2011)

Effect Size	Category
$0 \leq ES \leq 0,2$	Low
$0,2 \leq ES \leq 0,8$	currently
$ES \geq 0,8$	High

III. RESULTS AND DISCUSSION

This meta-analysis was conducted to see the effect of the application of Inquiry Based Learning from two moderator variables, namely education level and subjects on students' competence. The collected articles are 26 articles which have been analyzed based on two variables to find the effect size. The effect sizes of the two moderator variables have varied results.

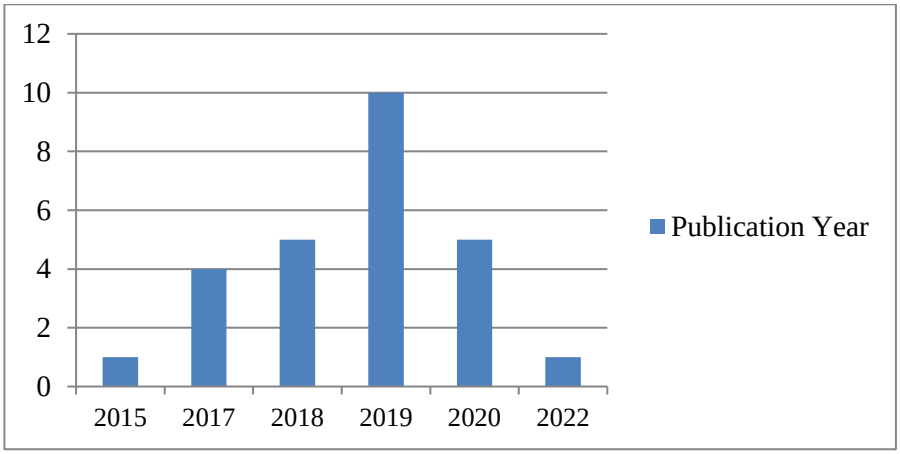

Figure 1. Article Publication Year

The articles reviewed are collected from 2015-2022. Of the 26 articles, there was only 1 article published in 2015; most of the articles were published in 2019, namely 10 articles as shown in Figure 1. The year of publication shows the update of the research results. The interest in Inquiry Based Learning research from year to year has increased which shows that the importance of the competency and Inquiry Based Learning is to increase students' competence in physics learning.

Table 3. Article Grouping in General

No	Identity	Identity Level of Education	Scale	Competency	N	Subjects	ES	Fr
				Attitude				
1.	(Husni, 2020)	Senior High School	International	Liveliness	40	Physics	2,47	Fr-3
2.	(Mbari et al., 2018)	Elementary School	National	Motivation	40	Natural Science	1,33	Fr-2
3.	(Sari & Lahade, 2022)	Elementary School	National	Scientific Attitude	15	Natural Science	1,60	Fr-5
4.	(Silm et al., 2017)	Elementary School	International	Attitude	228	Natural Science	0,35	-
5.	(Wildan et al., 2019)	College	International	Scientific Attitude	41	Biochemistry	1,72	Fr-2
6.	(Pamuji et al., 2019)	Elementary School	National	Scientific Attitude	80	Natural Science	0,94	Fr-5
7.	(Suryantari et al., 2019)	Elementary School	National	Scientific Attitude	43	Natural Science	1,38	Fr-2
8.	(Syahrial et al., 2019)	Elementary School	International	Attitudes towards cultural values	86	Natural Science	1,25	Fr-5
				Knowledge				
1.	(Olaoluwa & Olufunke, 2015)	Senior High School	International	Learning Outcomes	103	Physics	2,31	Fr-1
2.	(Hayati et al., 2017)	Senior High School	National	Learning Outcomes	49	Physics	1,47	Fr-5
3.	(Maharani et al., 2020)	Senior High School	National	Learning Outcomes	35	Physics	0,86	Fr-5
4.	(Mbari et al., 2018)	Elementary School	National	Learning Outcomes	40	Natural Science	1,20	Fr-5
5.	(Anggraini et al., 2020)	Junior High School	National	Learning Outcomes	80	Natural Science	0,87	Fr-5
6.	(Purwanita et al., 2019)	Elementary School	International	Learning Outcomes	50	Natural Science	1,16	Fr-5
7.	(Af'idayani et al., 2018)	Junior High School	International	Learning Outcomes	50	Natural Science	2,14	Fr-5
8.	(Nasir et al., 2020)	Senior High School	National	Thinking Level	66	Biology	1,61	Fr-5
9.	(Aryanti et al., 2017)	Senior High School	National	Learning Outcomes	15	Elektronics	0,99	Fr-5
10.	(Barus & Sani, 2017)	Senior High School	National	Learning Outcomes	74	Physics	0,23	Fr-1
11.	(Sukariasih et al., 2019)	Junior High School	International	Learning Outcomes	26	Natural Science	0,85	Fr-1
12.	(Fatmawati et al., 2019)	Senior High School	International	Learning Outcomes	25	Physics	1,62	Fr-3
13.	(Suryantari et al., 2019)	Elementary School	National	Learning Outcomes	43	Natural Science	1,12	Fr-2
14.	(Safitri & Budhi, 2017)	Junior High School	National	Learning Outcomes	60	Natural Science	1,31	Fr-4
				Skills				

No	Identity	Identity Level of Education	Scale	Competency	N	Subjects	ES	Fr
1.	(Purwanita et al., 2019)	Elementary School	International	Critical Thinking	50	Natural Science	2,20	Fr-1
2.	(Hidayati & Suryanti, 2018)	Elementary School	National	Critical Thinking	30	Natural Science	0,59	-
3.	(Rambe et al., 2020)	Senior High School	International	Critical Thinking	68	Physics	0,52	Fr-1
4.	(Wildan et al., 2019)	College	International	Communication	41	Biochemistry	2,19	Fr-2

The data in table 3 are generally grouped based on education level, subject matter, article scale, namely national and international scale, competency measured, effect size value, number of samples and the formula used to calculate the effect size of each article. Based on the research that has been done, it has found 26 articles on the application of inquiry based learning that affect the competence of students.

Table 4. The Effect of Inquiry Based Learning on Student Competence based on educational level

	Attitude			Knowledge			Skills		
Identity Level of Education	Attitude Type	Article Code	Effect Size	Type of Knowledge	Article Code	Effect Size	Type of Skill	Article Code	Effect Size
Elementary School	Attitudes towards cultural values	J1	1,25	Learning Outcomes	J6	1,20	Critical Thinking	J8	2,20
	Motivation	J6	1,33	Learning Outcomes	J8	1,16	Critical Thinking	J15	0,59
	Scientific Attitude	J10	1,60	Learning Outcomes	J21	1,12			
	Attitude	J18	0,35						
	Scientific Attitude	J20	0,94						
	Scientific Attitude	J21	1,38						
Average	1,14 (High)			1,16 (High)			1,39 (High)		
Junior High School	-			Learning Outcomes	J7	0,87	-		
				Learning Outcomes	J22	1,31			
				Learning Outcomes	J9	2,14			

Attitude				Knowledge			Skills		
Identity Level of Education	**Attitude Type**	**Article Code**	**Effect Size**	**Type of Knowledge**	**Article Code**	**Effect Size**	**Type of Skill**	**Article Code**	**Effect Size**
Average	-			1,44 (High)			-		
Senior High School	Liveness	J5	2,47	Learning Outcomes Learning Outcomes Learning Outcomes Learning Outcomes Learning Outcomes	J2 J3 J4 J12 J16	2,31 1,47 0,86 0,99 1,62	Critical Thinking	J17	0,52
Average	2,47 (High)			1,45 (High)			0,52 (High)		
College	Scientific Attitude	J19	1,72	-			Communication	J19	2,19
Average	1,72 (High)			-			2,19 (High)		

The data in table 4 consists of a collection of articles on the impact of IBL on the students' competence based on their educational level. At the elementary level, six articles were found to have an average effect size of 1.14. Then, at the junior high school level, there were no articles that discussed about improving attitudes through the inquiry-based online learning model. Then at the high school level one article was found to have an effect size of 2.47. And finally, at the tertiary level, one article had an effect size value of 1.72. From this level of education, the highest effect size is obtained at the high school level with an effect size value of 2.47 which is in the very high category. Attitude competencies found based on educational level consist of scientific attitude, motivation, attitude towards cultural values and activeness. These outcomes are consistent with the study conducted by Husni & Bisri (2020) which states that mastering the usage of the inquiry based learning model has several benefits in its application. First, it can balance the cognitive, affective and psycho-motor factors so that mastery of learning is more significant. Second, students are given the freedom to study based on their own style. Third, this model adheres to the precept that experience causes changes in behavior because of the getting to know technique and this idea is included within the idea of contemporary psychology. Fourth, this IBL can facilitate college students who have extraordinary competencies. Fifth, learning becomes more alive by using the inquiry based model. Sixth, IBL can build and expand the basic standards of students. Seventh, IBL help students to transfer a concept to a new idea. Eighth, it can provide enough time for college kids to new technique and accommodate the data they obtain.

Ninth, IBL can encourage students to think openly and honestly, have initiative, and be objective. Tenth, IBL can create a two-way learning atmosphere, meaning that the teacher is not the only source of information. Eleventh, it allows students to take advantage of various learning resources. Finally, it trains students to learn positively and be able to develop the information they have.

Furthermore, there were eleven articles on the effect of IBL on students' competence. At the elementary level, three articles were found with an average effect size of 1.16. At the junior high school level, three articles have an average effect size of 1.44. At the high school level, five articles have an average effect size of 1.45. For tertiary institutions, there has not been an article on the effect of inquiry based learning on the knowledge competence of students. Based on the data, it can be seen that the high school level has the highest effect size, that is 1.45 in the use of inquiry based learning on students' knowledge competencies. Knowledge competency assessed in the collection of articles is the learning outcome.

Putra (2013) also found that the inquiry based learning is more effectively applied in

the senior high school level because students are more independent due to their age. In addition, the application of IBL with age maturity can take place in an orderly and regular basis and can create learning that describes the environment in which students live and learn. Then the results of research conducted by Abdi (2014) revealed that learning using the inquiry based learning model can get higher learning outcomes compared to using traditional learning methods. This happens because with the inquiry based learning model, students are given the freedom to develop their own learning style so that students become more relaxed in learning and their knowledge can develop properly.

Finally, there were four articles concerning the effect of inquiry based learning on students' skills. At the elementary level, two articles were found with an average effect size of 1.39. Moreover, there was one article with an effect size of 0.52 in the high school level, and an effect size of 2.19 at the tertiary level. Thus the level of tertiary education has the highest effect size in terms of increasing skill competence by inquiry based learning model, which is 2.19. The skill competencies measured in the collection of articles consist of critical thinking skills and communication skills.

This is in line with research King et al. (2018) that the inquiry based learning model can improve students' skills because this learning model has a gradual process, so that students can understand each stage of the implementation of this model well. Thus, students can also plan their next investigation better and more mature (Jolley et al., 2016).

Table 5. The Effect of Inquiry Based Learning on Student Competencies based on subjects

	Attitude			Knowledge			Skills		
Identity Level of Education	**Attitude Type**	**Article Code**	**Effect Size**	**Type of Knowledge**	**Article Code**	**Effect Size**	**Type of Skill**	**Article Code**	**Effect Size**
Nature Science	Motivation	J6	1,33	Learning Outcomes	J6	1,20	Critical Thinking	J8	2,20
	Scientific Attitude	J10	1,60	Learning Outcomes	J7	0,87			
	Attitude	J18	0,35	Learning Outcomes	J8	1,16			
	Scientific Attitude	J20	0,94	Learning Outcomes	J9	2,14	Critical Thinking	J15	0,59
	Scientific Attitude	J21	1,38	Learning Outcomes	J14	0,85			
	Attitudes towards cultural values	J1	1,25	Learning Outcomes	J21	1,12			
				Learning Outcomes	J22	1,31			
Average	1,14 (High)			1,23 (High)			1,39 (High)		
Physics	Liveliness	J5	2,47	Learning Outcomes	J2	2,31	Critical Thinking	J17	0,52
				Learning Outcomes	J3	1,47			
				Learning Outcomes	J4	0,88			
				Learning Outcomes	J13	0,23			
				Learning Outcomes	J16	1,62			
Average	2,47 (High)			1,30 (High)			0,52 (Medium)		
Biochemistry	Scientific Attitude	J19	1,72	-			Communication	J19	2,19
Average	1,72 (High)			-			2,19 (High)		
Electronics	-			Learning Outcomes	J12	0,99	-		
Average	-			0,99 (High)			-		

The data in table 5 consists of a collection of articles about the influence of inquiry based learning on student competence viewed from different subjects. Science subjects consist of six articles that affect the attitude competence of students with an average effect size of 1.44 which consists of scientific attitude, motivation, activeness, and attitude towards cultural values. In the physics subject, one article was found with an effect size of 2.47, while in the biochemistry subject, there was also one article with an effect size of 1.72. Based on a collection of articles grouped into subjects, the physics subject has the greatest influence on the attitude competence of students when applied to the inquiry based learning model, which is 2.47 or a very high effect size category. This is in accordance with (Budiyono & Hartini, 2016) who state that the inquiry learning model research is learning that requires students to be able to plan and conduct experiments, collect and analyze data as well as draw oriented conclusion to solve the problem. By using inquiry process, students were actively involved in solving a problem given by the teacher. Scientific attitude of students that use inquiry based learning is better that those who use conventional learning (Apriliani et al., 2019).

In addition, there were fourteen articles concerning the knowledge competence viewed from subjects. In science subjects, there were seven articles found with an average effect size value of 1.23, while in the physics subject, there were five articles found with an average effect size value of 1.30. Finally, in the electronics subject, one article was found with an effect size value of 0.99. From these collection of articles, the physics subject has the most significant influence on the knowledge competence of students when the inquiry-based online learning model is applied, with the average effect size value of 1.30 which is in the very high category. The knowledge competency measured in this collection of articles is in the form of learning outcomes.

This is in line with the research by Olaoluwa & Olufunke (2015) which states that physics is a science that involves universal studies, namely behavior and relationships between various physical phenomena. Through learning physics, students will gain procedural and conceptual knowledge that is relevant to their lives. Hence, the students become better in the knowledge competence mastery.

The final data in table 5 show that there were four articles found regarding the effect of inquiry based learning on students' competency skills. In science subjects, two articles were found with an average effect size value of 1.39, in the physics subject, there was one article found with an effect size value of 0.52, while in the biochemistry subject, one article was found with an effect size value of 2.19. Thus it can be concluded that the inquiry based learning model has the most significant influence on the skill

competence of students in the biochemistry subject. Skill competencies that are measured are critical thinking competence and communication competence. Inquiry learning in the form of a learning process and learning that facilitates students to be able to search and investigate systematically, critically, logically, and analytically, so they can formulate and find themselves through question guide (Budiyono & Hartini, 2016). Individual success in learning using this inquiry method is the success in developing the students' self-skills; one of them is critical thinking skills (Sochibin et al., 2009). In order that learning can maximize the process and results of learning mathematics, teachers need to encourage students to be actively involved in discussions, ask and answer questions, think critically, explain each answer given, and provide reasons for each answer given filed (Purwasih, 2015).

Based on the conclusions from some of the research results above, the inquiry based learning model is a learning model that can increase the competence of students. The advantages of this model are: 1) it can balance the cognitive, affective and psycho-motor factors so that mastery of learning is more significant. 2) students are given the freedom to study based on their own style. 3) this model adheres to the precept that experience causes changes in behavior because of the getting to know technique and this idea is included within the idea of contemporary psychology. 4) IBL can facilitate college students who have extraordinary competencies. 5) Learning becomes more alive by using the inquiry based model. 6) IBL can build and expand the basic standards of students. 7) IBL help students to transfer a concept to a new idea. 8) it can provide enough time for college kids to new technique and accommodate the data they obtain. 9) IBL can encourage students to think openly and honestly, have initiative, and be objective. 10) IBL can create a two-way learning atmosphere, meaning that the teacher is not the only source of information. 12) it allows students to take advantage of various learning resources. 13) it trains students to learn positively and be able to develop the information they have (Husni, 2020).

IV. CONCLUSION AND SUGGESTION

From the data analysis carried out, it can be stated that there are two research results. Firstly, the application of Inquiry Based Learning is more effectively applied at the high school level for attitude and knowledge competencies with an effect size of 2.47 and 1.45, respectively, while for skill competencies it is more effectively applied at the tertiary level with an effect size of 2.19. Secondly, the application of inquiry based learning is more effectively applied to physics subjects for attitude and knowledge competencies, while for skill competencies, it is more effectively applied to biochemistry subjects. It is recommended for future researchers to look for more data reference

sources and articles so that the results obtained are more valid.

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