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META-ANALYSIS OF GUIDED INQUIRY MODEL ON PHYSICS LEARNING

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Abstract
Guided Inquiry is one of the learning models that often used in research into the application of learning models in physics learning. This study aims to analyse the learning process with the Guided Inquiry model and its effect on increasing the students' competence and skills from previous studies. This research method uses meta-analysis with stages: data collection, data reduction, data display, and drawing conclusions or verification. The secondary data used, that is, data collected indirectly on the object studied in the form of 20 national and international journal articles. The first step in this research is to collects journals, selection 20 journals with the same research design, creates a visualisation in VOSviewer software, and calculates the effect size of the research results. The meta-analysis topic discusses in the research is about to improve students' science skills, school level, subject matter and then the media used. The results of the study state that learning physics using Guided Inquiry model can improve the scientific literacy competencies, critical-thinking skills, and students learning outcomes that measured separately (moderate effect) and simultaneously (modest effect). Another results show that Guided Inquiry model recommended for students that have higher-order-thinking skills, apply with real learning-media, and used for the investigated characteristic content-material.

Keywords: *Guided Inquiry, physics learning, meta-analysis*

Abstrak
Inkuiri terbimbing merupakan salah satu model pembelajaran yang kerap digunakan dalam penelitian penerapan model pembelajaran dalam pembelajaran fisika. Penelitian ini bertujuan untuk menganalisis proses pembelajaran dengan model inkuiri terbimbing dan pengaruhnya terhadap peningkatan kompetensi dan keterampilan siswa dari penelitian-penelitian yang pernah dilakukan. Metode penelitian ini menggunakan meta-analisis dengan tahapan: koleksi data, reduksi data, display data, dan penarikan kesimpulan atau verifikasi. Teknik pengumpulan data yang digunakan adalah data sekunder, yaitu data yang dikumpulkan secara tidak langsung terhadap objek yang sedang diteliti berupa 20 artikel jurnal nasional dan internasional. Langkah pertama dalam penelitian ini adalah mengumpulkan jurnal, lalu memilih 20 jurnal yang memiliki desain penelitian yang sama, membuat visualisasi dalam *software* VOSviewer, dan menghitung *effect size* dari hasil-hasil penelitian tersebut. Topik diskusi meta-analisis dalam penelitian ini adalah tentang meningkatkan keterampilan sains siswa, tingkat sekolah, materi pelajaran dan kemudian media yang digunakan. Hasil penelitian menyatakan bahwa pembelajaran fisika menggunakan model Guided Inquiry dapat meningkatkan kompetensi literasi sains, keterampilan berpikir kritis, dan hasil belajar yang diukur secara terpisah (efek sedang) dan secara bersamaan (efek lemah). Hasil lain menunjukkan bahwa model Guided Inquiry direkomendasikan untuk siswa yang memiliki keterampilan berpikir tingkat tinggi, mengaplikasikan media pembelajaran yang riil, dan digunakan untuk konten materi dengan karakteristik investigasi.

Kata kunci: Inkuiri Terbimbing, pembelajaran fisika, meta-analisis

INTRODUCTION

In the 21st century, the development of knowledge in the field of science and technology accelerate, so that the challenge in education world the more severe, one of the problems such as education must be able to generate the individual who readies in overcoming the problem in life (Yuliati, 2017). In the 21st century, resources humans began to replace with technology, so the skills that humans have now can no longer follow the standards of ancient times. On the current era of globalisation, all can be more easy and practical. It indicated by many applications in the form of sophisticated technology application that provides the need to simplify human survival (Pratiwi et al., 2019). RAND Corporation (2012) were making nine criteria of

science learning in 21-century skills. There are: curriculum relevant to everyday life, students learning that involves interdisciplinary, develop lower and higher-order thinking skills, applying the knowledge gained to other areas or other disciplines together with daily activities, students how to learn, students learning that counteracting misconception, learning the cooperation, use technology to support learning, and encourage students' creativity.

The 21st century makes education demands the teaching process using various models or strategies developed to achieve the purpose of learning. Some classroom with the approach rendering is the invention of the kind of class, based sort of classroom project, a model learning problems, and models learning design (Redhana, 2019). Some researchers develop learning models to enhance the 21st-century skills, such as Creative Responsibility Based Teaching model (Suyidno et al., 2017). Another science learning models developed are Collaborative Problem Based Physics Learning model (Prahani et al., 2018), Group Science Learning model (Fuad et al., 2019), Local Wisdom Integrated Learning Model (Dewi et al., 2019), Collaborative Creativity Learning model (Astutik et al., 2019), etc. Another researcher integrated the learning model with an approach or strategy to increase the students' thinking skills based on the 21st-century skills framework. Such as integration the Means-End Analysis strategy on Problem-Based Learning model (Permatasari and Jauhariyah, 2020), integration of scientific literacy with Case-Based Learning model (Rohmah and Jauhariyah, 2020), etc. Some other applying constructivist learning models such Problem-Based Learning (Mukhayyarotin et al., 2014 and Jauhariyah, 2017), Guided Inquiry Laboratory (Madlazim et al., 2015), Inquiry Labs (Febriyanti and Jauhariyah, 2019), Inquiry (Alfazriyah and Supardi, 2018), Inquiry Discovery Learning (Komariah et al., 2017), Guided Inquiry (Agustin et al., 2020; Agustina et al., 2020; Ma'ruf and Novianti, 2020; Safitri et al., 2020; Harjilah et al., 2019; Istiqomah and Hariyono, 2019; Wahyuni et al., 2019; Aulia et al., 2018; Dewi and Sunarti, 2018; Nisa et al., 2018; Putri and Sunarti, 2018; Sarwi et al., 2018; Shellawati and Sunarti, 2018; Suprianto et al., 2018; Arifin and Sunarti, 2017; Syahrial et al., 2017; Tamara and Sunarti, 2017; Almunthaseri et al., 2016; Sarwi et al., 2016; Wahyuni et al., 2016; Deta et al., 2013), etc.

Among the many learning models, there is a learning model believed to be active and can be used to support a variety of complexity the skills will need in this century, the Guided Inquiry learning model. Guided Inquiry is an instructional learning model with the students work for answers to matter that has been dictated by the teacher, and students were trying to solve the problem under intensive. Teacher guidance job is to increase the motivation to do something. Teachers brought issues addressed; students then will find the best way to solve problems. Besides, having the characteristics of, Guided Inquiry, asserted guide investigation to facilitate effectively to develop skills to think critically and logically (Sarwi et al., 2016). Characteristic of Guided Inquiry can be used as the basis of the application in learning physics, having the characteristics of physics as knowledge acquired through understanding. Physics properties in nature, understanding the properties of physics was through the investigation and used creative and logical thinking skills (Nehru and Syarkowi, 2017). All main target of learning activities is the involvement of student all at maximum in focus the action in a logical and systematic on the objective of learning and develops attitudes believe in them about what found in the process of Inquiry (Wahyuni et al., 2016).

The application of Guided Inquiry model also has been researched by scientists in the field of social science. The education sector physics is no exception. To know how far to scatter research on Guided Inquiry, able to be seen through the search for keywords Guided Inquiry use VOSviewer software. The results of the investigation VOSviewer looked in Figure 1.

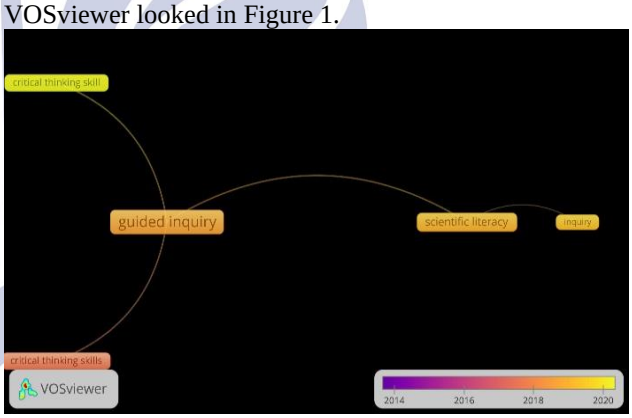

Figure 1. Visualize the area of Guided Inquiry use overlay visualisation

The journal article that we use for research on the average around the years 2014 until 2020 informed that there was a very tightly between Guided Inquiry with critical thinking. Furthermore, scientific literacy sees how the learning physics by Guided Inquiry enhanced literacy science and think critically in learning physics. Needs further analysis of education level, content material, media used, and conducted a meta-analysis of the to some research that has been done by researchers before.

If explored further about learning research using Guided Inquiry with VOSviewer, we can see with density visualisation for the keywords Guided Inquiry (Figure 2). It can see that researchers who conducted research using Guided Inquiry in the results of the index journal that having gradations getting dark. This show that the implementation of Guided Inquiry learning is more

researched than scientific literacy, Inquiry, Inquiry labs, or others.

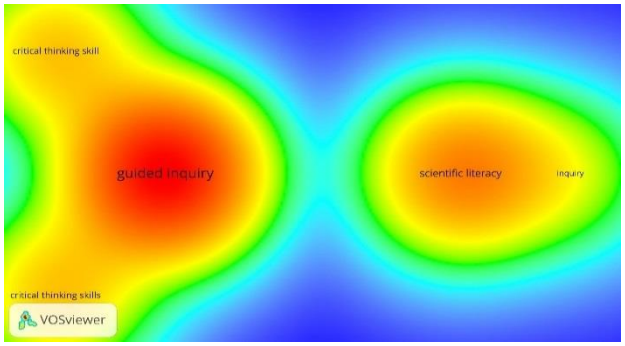

Figure 2. Visualize the Guided Inquiry topic use density visualisation.

During this time, the learning research using Guided Inquiry with various research design applied to learn physics on various material topics. However, it has never investigated in detail Guided Inquiry has a more powerful impact on what content material, on what media, at what level of the school, even the most appropriate to improve the physics skills of what part. Therefore, an analysis of the results of previous studies of the Guided Inquiry is needed. Report of the review referred to as a required meta-analysis. Hopefully, the results of the meta-analysis of this study can provide recommendations to teachers or prospective teachers regarding the use of Guided Inquiry model in physics learning, i.e. in choosing appropriate physics content material, in choosing learning media used, and in measuring skills.

METHOD

The research conducted to analyse the kind of Guided Inquiry classroom benefits as an implementation of scientific students—meta-analysis used in the study. The meta-analysis, in straightforward terms, can be defined as the analysis of analysis—assesses. Also, a meta-analysis of this research conducted by researchers with summarises of data, reviewing and analysing the research data of some studies that had previously existed (Yanto, 2018). This method using meta-analysis with examining some articles of scientific articles. The qualitative approach used to describe the result of meta-analysis—a descriptive-qualitative analysis.

The data collected indirectly to the object investigated. The secondary data used in this research from 20 articles from 2014 to 2020 with the same researches design, namely one-group pretest-posttest design. The articles research topic relating to benefit Guided Inquiry to improve students' skills in physics. After collecting some journals about Guided Inquiry related benefits to improve skills students, data analysed using a meta-analysis.

The coding data distribution of 20 journals used in this study can see in Table 1—it categories on school-level, subject, and media. The methods of reduces the data from the journals see in the Chart 1.

Tabel 1. Meta-analysis Topics

Information	School-level	Subject	Media
Junior high school	2		
Senior high school	17		
Higher education	1		
Optic		1	
Density		1	
Elasticity		2	
Dynamic Fluid		3	
Static Fluid		3	
Impulse and Momentum		2	
Harmonic Vibration		1	
Newton's Law		1	
Dynamic electricity		3	
Work and energy		2	
Matter		1	
PPT Slide			7
Worksheet			3
Mind Map			5
Non Media			5
Total Articles	20	20	20

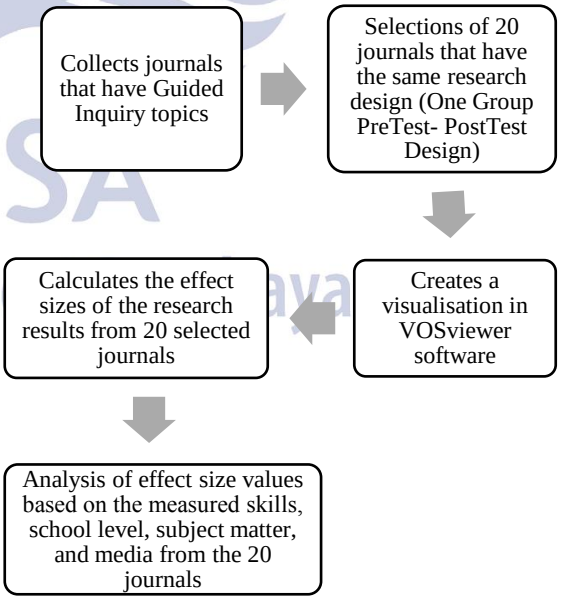

Chart 1. Methods of reduces the data

We also analyse the impact of Guided Inquiry learning on the physics competencies or thinking skills for all of the source in this review study. So we need steps to

analyse data from the previous research. The steps for tabulation data:

1. Identification of research variables
2. Identification of mean and deviation standard of the posttest and pretest result
3. Calculate effect size by using a formula based on Cohen (2007), find the effect size is to subtract the average value of the posttest (x-posttest) with the average of the pretest (x-pretest) result and then divide by the standard deviation (SD) of the data (Eq. 1)

$$\Delta = \frac{x_{posttest} - x_{pretest}}{SD} \quad (1)$$

The results of the calculation of effect size can refer to the criteria presented in Table 2.

Table 2. The criteria of effect size interpretation (Cohen, 2007)

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

RESULTS AND DISCUSSIONS

The result of each article effect size explained in Table 3. Table 3 shows that there are different response variable measured on the research articles, such as critical thinking, literacy, science process, learning outcome, soft skill and hard skill.

Most articles show that the researchers apply Guided Inquiry to improve scientific literacy with the moderated category. Only 2 (two) results show the modest effect of using Guided Inquiry to enhance critical-thinking skills/ability and 1 (one) article has the small impact on improving science process skills, science literacy and learning outcomes that measured together. Two other research shows a moderate effect of Guided Inquiry implementation to enhance critical-thinking skills. The study of Siregar and Motlan (2015) shows the strong impact of Guided Inquiry learning to improve the students' learning outcomes.

Although the effect size data indicate that Siregar and Motlan research shows a substantial effect on learning outcomes, Ma'ruf and Novianti (2020) study shows a moderate impact on learning outcomes. This result indicates that in general, the application of Guided Inquiry learning can have a collective effect on improving students' thinking skills in the 21st century such as critical-thinking skills, scientific literacy competencies, scientific process skills, and even students' learning outcomes. Based on this analysis, Guided Inquiry often used to train or improve scientific literacy skills.

Table 3. The results of the effect size analysis

The Measured Skills	Source	Effect Size (ES)	Criteria
critical-thinking skills	(Nisa et al., 2018)	0.27	modest effect
critical-thinking ability	(Safitri et al.,2020)	0.67	Moderate effect
critical-thinking skills	(Harjilah et al., 2019)	0.68	moderate effect
critical-thinking ability	(Agustin et al., 2020)	0.45	modest effect
literacy ability	(Tamara and Sunarti, 2017)	0.80	moderate effect
literacy ability	(Shellawati and Sunarti, 2018)	0.61	moderate effect
scientific literacy	(Nurfadhilah and Admoko, 2016)	0.54	moderate effect
scientific literacy ability	(Agustina et al., 2020)	0.78	moderate effect
Science literacy abilities	(Dewi and Sunarti, 2018)	0.76	moderate effect
scientific literacy	(Arifin and Sunarti, 2017)	0.78	moderate effect
scientific literacy	(Istiqomah and Hariyono, 2019)	0.69	moderate effect
scientific literacy ability	(Almunthaseri et al., 2016)	0.66	moderate effect
scientific literacy skills and confidence	(Gormally et al., 2014)	0.82	moderate effect
scientific process skills	(Putri and Sunarti, 2018)	0.71	moderate effect
scientific process skills	(Komariah et al., 2017)	0.83	moderate effect
scientific process skills	(Alfazriyah and Supardi., 2018)	0.79	moderate effect
scientific process skills, science literacy and learning outcomes	(Syahrial et al., 2017)	0.34	modest effect
learning outcomes	(Siregar and Motlan, 2015)	1.74	Strong
learning outcomes	(Ma'ruf and Novianti, 2020)	0.57	moderate effect
hard skills and soft skills	(Suprianto et al., 2018)	0.77	moderate effect

Guided Inquiry model in physics learning usually applies to enhance the students' ability of science at some level of education. To identify the effects of Guided Inquiry model on a school-level, we analyse it using the

effect size. The source grouped into a category based on the level of junior high school, senior high school, and higher education. This category determined based on the article search results obtained. Based on that category, the mean of pretest and posttest analyses with the effect size formula (Cohen, 2007). The results can see in Table 4.

Tabel 4. The influence of a Guided Inquiry model against the level of education.

No.	School-level	Effect Size	Criteria
1.	Junior High School	0.56	Moderate effect
2.	Senior High School	0.67	Moderate effect
3.	Higher education	0.69	Moderate effect

The meta-analysis results based on the level of school found that a Guided Inquiry model gives the effect of being moderate. But in Junior high school have an impact that is lower than the level of Senior high school and higher education. From the results of the calculation of the effect size, it indicated if the thinking-level in higher education is better. So that the test values given using the Guided Inquiry model are more can be accepted by higher education students this has implications for the benefit of the effect size obtained. It is fascinating to explore further related to the effect size received. We will discuss the level of cognitive development according to age or level of education.

According to Asih (2018), the stage of cognitive development of junior-high-school students, stages of cognitive development middle-school-age learners First (12-15 years), referred to Piaget's theory of formal operating stages. Where they develop new tools for manipulating information, can think abstract, deductive, and inductive can consider the possibility of time ahead, look for answers, handle problems with flexible, testing hypotheses, and draw conclusions—further elaboration at a higher level of thinking. The cognitive level of senior-high-school students is about logical operations. Most understood by students is the compensation part, then doubling logic, proportionality, classification, relationships, opportunities, and which most challenging is this patterning line which confirms Piaget's theory of cognitive development which states that of senior high school age (around 15 - 19 years) (Santosa, 2013). Whereas in higher education, students must demand more than senior-high-school students, namely the application of science literacy and critical thinking, and even high-order thinking skills commonly used in the academic world of higher education. According to Hikmawati et al. (2014), Students on higher education are not only required to have thinking skills only low level but also the ability to think high level. How to plan and implement learning have been trained by students.

The analysis undertaken is looking at big the influence of model Guided Inquiry for each subject matter physics observed during the Guided Inquiry. According to the articles analysed, there are eleven different physics material learning. The results of the meta-analysis shown in Table 5.

Tabel 5. The model Guided Inquiry on the subject matter.

No.	Subject matter	Effect Size	Category
1.	Elasticity	0.37	Modest effect
2.	Matter	0.38	Modest effect
3.	Density	0.42	Modest effect
4.	Dynamic electricity	0.44	Modest effect
5.	Harmonic Vibration	0.45	Modest effect
6.	Optic	0.53	Moderate effect
7.	Work and energy	0.60	Moderate effect
8.	Dynamic Fluid	0.68	Moderate effect
9.	Static Fluid	0.76	Moderate effect
10.	Momentum Impuls	0.84	Moderate effect
11.	Newton’s Law	0.86	Moderate effect

Based on the subject matter, the Guided Inquiry model has a sufficient excellent of 11 kinds of subject matter examined. Only four has the impact of affecting was modest more the moderate rest effect of this outcome of a topic. We can see that we have the meticulous percentage Guided Inquiry model adorable to be applied to much matter to say ability students in science both in the think critically, even the literacy students to learn science.

Next, we will discuss the dimensions of student thinking for each material we examine from the journal. Level of student thinking. Analysis of material characteristics for mastery the concept follows the cognitive realm which according to Bloom's revised taxonomy Anderson, namely from the cognitive domain of C1 (remembering), C2 (understanding), C3 (applying), C4 (analysing), C5 (assess), and C6 (create) (Yulianci et al., 2017). We can observe from the table that elasticity has a modest effect. In contrast, the cognitive domain is only

seeing and understanding (C2) directly rather than abstractly. At the same time, in impulse-momentum, a subject matter which must use abstraction and analysis (C4) has a moderate effect. It relates to the characteristics and compatibility of the learning model with the subject matter studied. But in general, the results of the effect sizes obtained already illustrate the suitability of the subject matter that matches the Guided Inquiry learning model. Guided Inquiry model is more suitable for material discovery, so it must have basic knowledge related to the content to learn so that it can elaborate to find or create new concepts or skills (Yanti and Prahmana, 2017). So that teachers only become facilitators who facilitate students on things new things discovered and not known by students. On these materials, Optic, Work and energy, Dynamic Fluid, Static Fluid, Momentum-Impulse, Newton's Law are suitable to be developed using discovery learning, so obtain moderate effect size.

While in Elasticity, Matter, Density, Dynamic electricity, and Harmonic Vibration subject matter, we have a modest effect. We can understand that the Guided Inquiry model might be suitable to improve students' scientific abilities or student learning outcomes in the subject matter that need real experiments. Still, there are other factors that we have not been able to examine. It is in line with Astra (2015), to improve students' abilities, it is not enough to use quality and appropriate learning models. Assignments given to students depend on each school. The teacher must know the ability of students to provide them with suitable tasks. The level of difficulty depends on the strength of each student. It is a unique condition. Therefore, teachers must pay attention to students overall.

After we know the effect size of that done research of every piece of material, the last step is to identify the effects of Guided Inquiry model on media used in learning physics. The learning-media used grouped into two media that is real or real and virtual media. The results of the analysis of the data can see in Table 6.

Tabel 6. The Guided Inquiry model on the media used

No.	Media	Effect Size	Category
1.	Real	0.66	Moderate effect
2.	Virtual	0.54	Moderate effect

The meta-analysis of the Guided Inquiry on the medium used to have a learning-media are being right media or real or virtual over s.d 0.54-0.66 effect. However, the impact of media used on Guided Inquiry learning model gives real effect. It is because the students directly invented the concept of knowledge or build new lab work or scientific research he did significantly.

Learning Guided Inquiry model enhancement effect on the ability to think critically and the strength of students literacy science students this is in line with some studies already performed. Beforehand though this kind of classroom students can find the physics with go directly. Practice, based on the results of the research, it can be concluded that research has developed from Guided Inquiry-based useful learning material to use in teaching and learning in improving students' knowledge and skills (Aulia et al., 2018) As well as statements, Wahyuni et al. (2019) state that a Guided Inquiry model clad of experiments on learning physics can help students became more creative. Other than that, according to Deta (2013), the Guided Inquiry also invited students researched by teacher guidance creativity have played a role in the solution of a problem faced by students.

Review articles journal study through a meta-analysis of the formerly subjects of constraint in previous studies was limited. There are observe the increasing of n-gain from any variable used without seeking the value of effect size that kind of classroom inflicted when Guided Inquiry applied. This research more focused is about effect size that discusses the links between the results of a prior and after Guided Inquiry kind of classroom involved and variable that exert influence against it.

An essential component in analysing the influence of Guided Inquiry on the ability of students is about effect size. The effect size shows the effect of a treatment relationship between two variables. Effect size can present information from the results of the journal summary analysed. By determining the effect size of each study, the average overall effect size determined. Researchers calculate the effect size using a formula derived from Cohen.

The data collected from 20 journals, most of the journals used to inform the relation between variables in this study related to between the impact of the Guided Inquiry model with an increase in the student ability, then the effect of the Guided Inquiry model on the level of education and the Guided Inquiry model with physics subject matter and the contact of the Guided Inquiry model with the media used. So in this study, it was found that the Guided Inquiry model can improve critical thinking skills and students' scientific literacy abilities, even student learning outcomes in the moderate effect category.

CONCLUSION

Based on the results of this meta-analysis study, noted that in general, the application of the Guided Inquiry learning model has a moderate impact on increasing

scientific literacy competencies, critical-thinking skills, and student learning outcomes measured separately. Measurement of 3 thinking skills simultaneously provides sufficient effect (modest effect). Further analysis can provide recommendations to teachers or prospective teachers in using the Guided Inquiry learning model. Guided Inquiry gives a better impact on the level of Higher or senior high school. The learning-media used should be real. The content-material found in the learning process Guided Inquiry is better that has the characteristics to be investigated the method or steps of research or discovery.

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