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Meta analysis of learning models in improving Higher Order Thinking Skills (HOTS) in junior highs school mathematics learning

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Abstract

The Industrial Revolution 4.0 requires students to have Higher Order Thinking Skills (HOTS). To achieve this aim, an effective learning models is needed with various cosiderations. Many studies have been conductes and provide different conclusions, so that new problems arise regarding which learning models is considered more influential in improving students' HOTS. This study aims to find, compared, and analyzed learning models that have been used in improved HOTS at the junior high school level. The method used being narrative meta-analysis. The subjects of this study were 2 (two) articles that met inclusion criteria and had passed the PRISMA procedure. The result showed that the effect size values for each group of Project Based Learning (PjBL) assisted by Geogebra, Challenges Based Learning (CBL) and Problem Based Learning (PBL) were 3.27, 2.25, and 1.09. This shows that PjBL assisted by Geogebra have a greater influence than other learning models because the synrax of the learning model applied and the learning media used.

1. Introduction

Regulation of the Minister of National Education Number 22 of 2006 states that the mathematics should be given to all students starting from elementary school, to equip students with logical, analytical, systematic, critical, innovative and creative thinking skills, as well as the ability to work together. These competencies are needed so that students can have the ability to obtain, manage, and utilize information to live better in conditions that are always changing, uncertain, and highly competitive. The purpose of learning mathematics is same with the needs of the Industrial Revolution 4.0 which demands improvements in working methods and increased efficiency in designing products at every stage, therefore this improvement requires competent human resources. There are several future work skills needed, include creativity, critical thinking, mathematical thinking, Information and Comunication, Tehcnology (ICT), and collaboration skills. For this reason, a long-term strategy is needed in designing a national education system to produce human resources who are able to compete in the era of the Industrial Revolution 4.0 (Ansari & Abdullah, 2020). To meet the needs of the industry, human resources must be prepared early on, one of the skills that students must possess is HOTS.

Helmawati (2019) stated that HOTS stimulate students to interpret, analyze, to be able to manipulate previous information so that it is not monotonous. HOTS is defined as the ability to solve problems that involve critical and creative thinking. The process domain used to measure higher order thinking skills in Bloom's revised taxonomy is the domains (4) analyze, (5) evaluate, and (6) create. HOTS referred to in this study are variables measured by researchers based on related learning models in junior high school

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mathematics learning. These variables are higher order thinking skills (HOTS) which include aspects of critical thinking skills (critical thinking), creative thinking skills (creative thinking), and problem solving skills.

Considering that higher-order thinking skills are needed in the Industrial Revolution 4.0 era, developing students' higher-order thinking skills needs to be prepared early on. To achieve this purpose, an effective learning model is needed with various considerations. In developing, creating, selecting, and using a learning model, a teacher is faced with a learning model (Asyafah, 2019). In addition, Retnawati et al., (2018) various educational studies regarding the development of learning models have been carried out to improve higher-order thinking skills from an early age, especially in learning mathematics. Starting from the many studies that examine learning models and their effects on higher-order thinking skills, of course they give different conclusions and raise new problems regarding what learning models are considered to have a greater influence in improving students' higher-order thinking skills. Therefore, the researcher feels the need to systematically analyze the results of the studies that have been carried out to obtain a learning model that successfully improves high-level thinking skills of junior high school students, as well as analyze the conditions that are supporting factors and or inhibiting factors in the related learning model. Then, the results of this study can be implemented in mathematics learning by researchers and teachers to improve students' higher-order thinking skills at the junior high school level or equivalent as an effort to prepare human resources who are ready to compete and contribute in the Industrial Revolution 4.0 era. This study aims to find, compared, and analyzed learning models that have been used in improved HOTS at the junior high school level.

2. Methods

The type of research used is meta-analysis. Meta-analysis is one type of systematic review by collecting data from several independent studies that answer the same problem to produce a single estimate (Ganeshkumar & Gopalakrishnan, 2013). The main purpose of the meta-analysis is to determine the effect size summary by synthesizing data from several research results.Effect size is a quantitative index used to summarize study results in a meta-analysis (Karada , 2015). That is, the effect size reflects the magnitude of the relationship between variables in each study.The approach used is a qualitative approach. Along with the development of the qualitative paradigm, the term meta-analysis is also used in many research studies analyzing similar documents with a qualitative approach (Yulisman & Faradila, 2019). The effect size formula used in this study is ω^2 (Ialongo, 2016) . The formula is as follows.

$$\omega^2 = \frac{SS_{\text{factor}} - (\text{k} - 1)\text{MSE}}{SS_{\text{total}} + \text{MSE}} \quad (1)$$

Formula 1 is used for data in research subjects tested by one way ANOVA. Then proceed to determine the learning model that has a greater influence with different formulas based on known statistical data (Becker & Park, 2011). The formula is as follows.

$$EF = \frac{(\bar{X}_{post} - \bar{X}_{pre})_E - (\bar{X}_{post} - \bar{X}_{pre})_C}{\frac{SDpre_C + SDpre_E + SDpost_C}{3}} \quad (2)$$

Formula 2 is used for statistical data with control and experimental groups and have pretest-posttest data.

$$EF = \frac{\bar{X}_E - \bar{X}_C}{SD_C} \quad (3)$$

Formula 3 is used for statistical data with control and experimental groups and only have posttest ddata. The effect size criteria used in this study are based on Cohen, with a value of 0.00 – 0.20 having a very weak effect, 0.21 – 0.50 having a weak effect, 0.51 – 1.00 having a moderate effect, and greater than 1.00 having high effect.

To support this research, PRISMA Preferred Reporting Items for Systematic reviews and Meta-Analyses) is used, which is a guide to reporting systematic reviews and meta analyzes (Liberati et al., 2009). The subjects of this study were 2 (two) articles that had passed the PRISMA procedure, the process of determining the research subject is presented in the following figure.

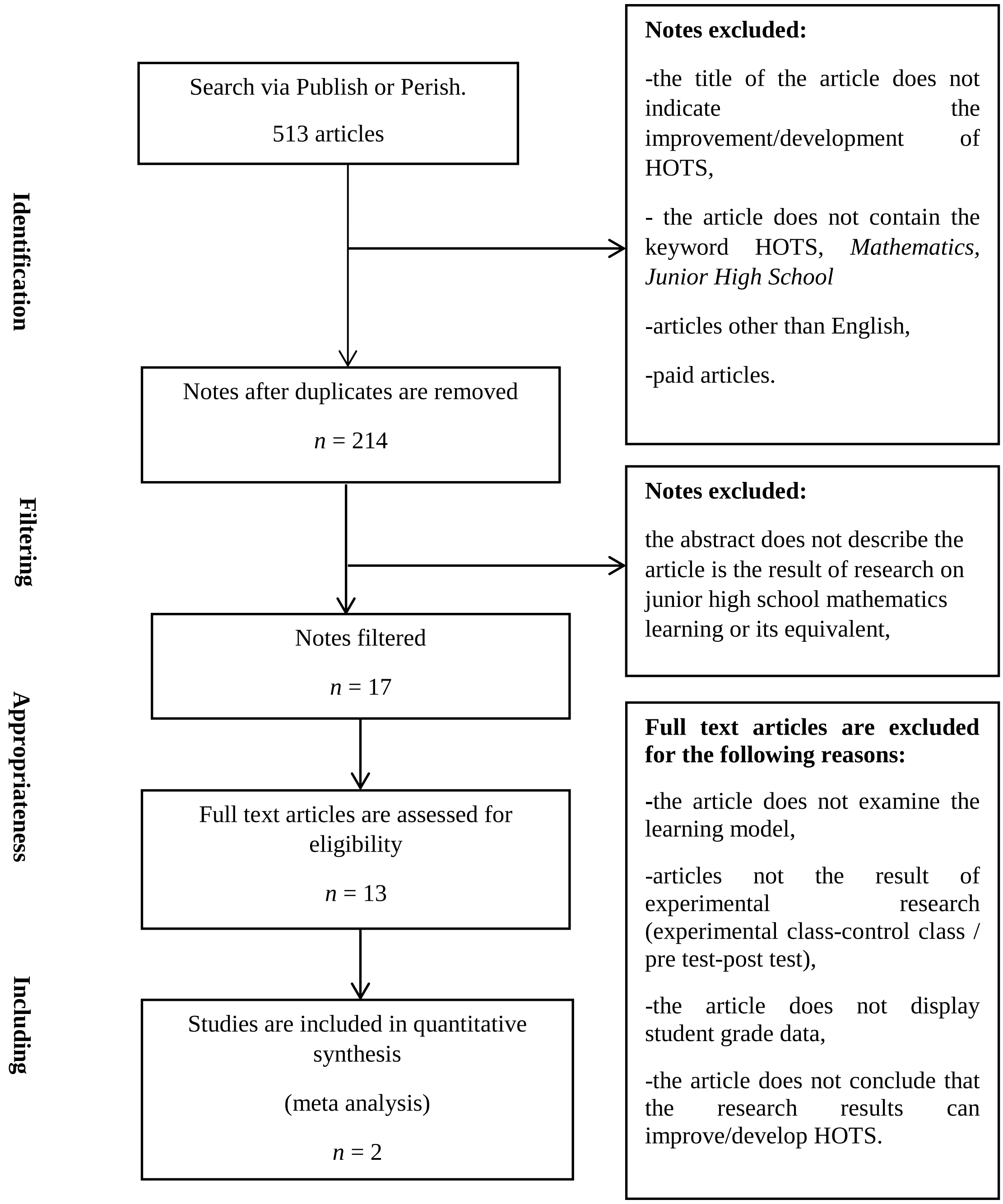

Figure 1. Meta Analysis Procedure based on PRISMA

3. Results & Discussions

The research subjects used in this meta-analysis study were 2 (two) articles which were then coded SJ 1 and SJ 2. SJ 1 was an article with the title Effects of the 21st Century Learning Model and Problem Based Learning Models on Higher Order Thinking Skills by Tumas Yulianto, Ikrar Pramudya, and Isnandar Slamet published in 2019. SJ-1 has 3 (three) experimental group including Challenge Based Learning (CBL), Problem Based Learning (PBL), and Contextual Learning (CTL). While SJ 2 is an article with the title Improving Higher Order Thinking Skills (HOTS) with Project Based Learning (PjBL) Model Assisted by Geogebra by Suherman, MR Prananda, DI Proboningrum, ER Pratama, P Laksono, and Amiruddin published in 2020. SJ-2 has 2 (two) experimental group including Project Based Learning (PjBL) assited with Geogebra as experiment 1, PjBL group as experiment 2, and one control group with conventional learning model . Data statistics and one way test ANOVA of SJ-1 and SJ-2 is presented in the following tables.

Table 1. Data Statistics SJ-1

		CBL	**PBL**	**CTL**
N		94	91	94
Normal	Mean	77.0213	65.5495	54.6809
Parameters	Std.Deviation	9.86410	9.44136	9.94091

Table 2. One Way Test ANOVA SJ-1

ANOVA					
HOTS					
	Sum of Square	**Df**	**Mean Square**	**F**	**Sig.**
Between Groups	2484.65	332	12420.325	129.125	0
Within Groups	26538.059	276	96.189		
Total	51388.71	278			

Table 3. Data Statistics SJ-2

Group	*Pretest*				*Posttest*			
	x_{maks}	x_{min}	$\bar{X}$	S	x_{maks}	x_{min}	$\bar{X}$	S
Experiment 1	36.43	0	11.032	10.057	85.95	52.98	68.7	9.14
Experiment 2	26.9	0	9.483	7.748	72.56	30.48	49.52	12.52
Control	30.48	0.952	14.54	10.12	63.3	16.7	38.78	10.54

Table 4. One Way Test ANOVA SJ-2

ANOVA					
HOTS					
Source of Variances	**Sum of Square**	**Df**	**Mean Square**	$\boldsymbol{F_{observed}}$	$\boldsymbol{F_{critical}}$
Model (A)	13773.49	2	6886.74	59.03	3.1
Error (G)	10033.74	86	116.67		
Total (T)	23807.22	88			

The calculation of the effect size is carried out using Formula 1, then followed by Formula 2 for SJ-2, then Formula 3 for SJ-1 adjusting the statistical data known in each study. The following presents the calculation of the effect size value.

Table 5. Effect Size value with Formula 1

Article Coding	Authors	Formula	EF Value
SJ-2	Suherman et al, 2020	$\omega^2 = \frac{13773.49 - (3-1)116.67}{23807.22 + 116{,}67}$	0.56967742
SJ-1	Yulianto et al, 2019	$\omega^2 = \frac{24840.65 - (3-1)96.189}{51388.71 + 96.189}$	0.478747603

Table 6. Effect Size value

Article Coding	Experiment Group	Control Group	Formula	EF Value
SJ-1	PBL	CTL	Formula 2	1.09332
	CBL	CTL		2.247319
SJ-2	PjBL with Geogebra	Conventional		3.274539
	PjBL	Conventional	Formula 3	1.66832

The analysis was carried out based on the effect size values obtained. Based on Table 5, SJ-2 has larger effect size value than SJ-1, it means that learning model in SJ-2 more influential than SJ-1 . CTL as the control group because it provides a mean difference in negative value. Research on SJ-1 gives the result that CBL learning model has a significant positive impact on higher order thinking skills (HOTS) compared to PBL. This is reinforced by Table 6. So the learning models are considered influential in improving HOTS of junior high school students are CBL and PBL.

Research in SJ 2 showed that the Project Based Learning (PjBL) Assisted with Geogebra experimental group obtained the most significant increase in the average score compared to other groups. This is evidenced by the effect size value which reaches 3.274539. According to Cohen, the effect size value is included in the strong category.Then followed by the Project Based Learning (PjBL) learning model group with an effect size value of 1.66832. This value is also included in the category that has a strong influence on improving students' higher order thinking skills. Because it can be concluded that the Project Based Learning (PjBL) Assisted with Geogebra learning model is more influential in improving students' higher order thinking skills than the Project Based Learning (PjBL) learning model.

The first analysis was conducted by comparing the definition of HOTS and the indicators used by each author (Suherman et al., 2020; Yulianto et al., 2019) in measuring the HOTS of junior high school students. These two definitions have a similar main, namely the level of higher order thinking that involves the ability to think critically, creatively, and problem solving. In line with the definitions taken by the authors of each article, the indicators used in the two articles are analyze (C4), evaluate (C5), and create (C6).

Next is the syntax analysis of the learning model. The CBL syntax used in the SJ-1 study is 1). Big Idea (big idea / main idea). Groups consider topics that can be explored in many ways, that are interesting, and important to students and the wider community. The topic taken in this lesson is geometry. 2). Essential Questions (important questions). Group members propose important questions related to the topic to be studied. In this step, students identify what essential questions it is important to know about the main idea. 3). Challenge (Challenge). From essential questions, challenges are given in the form of questions to produce specific answers or solutions in real terms. 4). Guide Questions. Students generate the questions they need and then generalize to find solutions in solving challenges. 5). Guide Activities. Activities in this step can be in the form of teaching and learning activities, simulations, games, and other types of activities that help students answer guiding questions, build basic concepts, build innovative, insightful, and realistic solutions. 6). Guide Sources. Students carry out learning by utilizing books, notes, the internet, expert opinions, and other sources that can support student activities in developing solutions to guiding questions. 7). Solution (Solution). Each challenge is stated in general terms to consider various solutions. Each solution must be thoughtful, realistic, workable, and clearly articulated. 8). Evaluation & Assessment (Assessment). Solutions are judged on their relation to challenge, suitability of content, purity of communication, applicability, and efficacy of ideas and other general issues. Individual processes as a team when obtaining solutions are also included in the assessment considerations. 8). Publication (Publication). The challenge process provides many opportunities to document experiences and publish them to the general public. Students are encouraged to publish their work online, and to collect feedback. With this syntax, the results of the research in the SJ-1 article that CBL can improve students' higher-order thinking skills are achieved. CBL serves as a framework for several types of pedagogical innovation, with no or limited ideas behind CBL Assessment (Assessment). Solutions are judged on their relation to challenge, suitability of content, purity of communication, applicability, and efficacy of ideas and other general issues. Individual processes as a team when obtaining solutions are also included in the assessment considerations. 8). Publication (Publication). The challenge process provides many opportunities to document experiences and publish them to the general public. Students are encouraged to publish their work online, and to collect feedback. 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Research findings Junita (2016) also shows that the CBL approach can improve students' mathematical creative problem solving (CPS) abilities.

The syntax of the PjBL assited with Geogebra used in the SJ-2 research is 1). the teacher explains the topics to be studied, learning objectives, motivation, and achievement of competencies. 2). The teacher distributes material with the help of the Geogebra application. 3). The teacher divides students into small groups consisting of 4-5 students, each group consists of students with various abilities, ethnicities, races, religions and others. 4). Each group makes a related project plan to solve the problem. At this stage, the teacher designs an assessment rubric. 5). Each group makes a project by understanding a concept or principle related to the material. At this stage, the teacher acts as a supervisor and evaluates. 6). Teachers or schools facilitate students to show their work. At this stage, the teacher gives an assessment of the students' work. 7). Learning evaluation. In previous studies, PjBL had a significant influence on creative thinking skills, learning outcomes (Wahida et al., 2015) and higher order thinking skills (Fitri et al., 2018).

The difference between the two learning models is clearly seen in the stimulus given by the teacher to students. The stimulus for the CBL model is a challenge in the form of questions, while the PjBL model assisted by Geogebra is a project that is planned and completed by students with the help of the Geogebra application. In addition, the learning media used in SJ-2 in the form of the Geogebra application is also another variable that helps students complete the given project. Based on the resulting effect size value, SJ-2 using PjBL assisted by Geogebra has a larger effect size value than SJ-1 using the CBL model.

4. Conclusion

Based on the result of research and discussion, it is found that Challenge Based Learning (CBL), Problem Based Learning (PBL), and Project Based Learning (PjBL) assisted with Geogebra can improve higher order thinking skills (HOTS) of class VIII students in learning mathematics. The effect size values for each group of PjBL, CBL, and PBL learning models are3.274539, 2.247319, and 1.09332. So it can be concluded that; a). PjBL assisted with Geogebra learning model has a greater influence than CBL and PBL in improving students' higher order thinking skills (HOTS) in junior high school mathematics learning, b). CBL learning model has a greater influence than PBL in improving students' higher order thinking skills (HOTS) in junior high school mathematics learning. Conditions that affect a learning model to have a larger effect size value are the syntax of the learning model applied and the learning media used. The stimulus for giving projects in the PjBL assisted with Geogebra syntax is considered to stimulate students to think at a higher level than the challenge stimulus in the CBL syntax in the form of questions. In addition, media assistance in the form of Geogebra in PjBL is also another variable that facilitates students to think at higher levels.

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