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META-ANALYSIS OF THE EFFECT OF LEARNING INTERVENTION TOWARD MATHEMATICAL THINKING ON RESEARCH AND PUBLICATION OF STUDENTS

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Abstract

The purpose of this study was to analyse the effect of mathematics learning intervention on students' mathematical thinking ability. The research method used survey of thesis of the student. The effect of studies applying learning to mathematical thinking was done using meta-analysis techniques. The research finding that research conducted by students by providing learning intervention was able to improve students' mathematical thinking ability. Aspects of mathematical thinking ability include connection ability, communication, representation, problem-solving, logical, critical, creative, analytical, generalization, quantitative, and adaptive thinking. The types of research used by students are dominated by the experiment with mix-method approach and classroom action research. Other methods, research development. The research and publication at the Department of Mathematics Education, Faculty of Educational Sciences have adapted to the trend of mathematics education research on the national and international level.

Keywords: meta-analysis; effect size; learning intervention; the ability of mathematical thinking

Abstrak

Tujuan penelitian ini adalah menganalisis efektivitas pengaruh intervensi pembelajaran matematika terhadap kemampuan berpikir matematis siswa. Metode penelitian yang digunakan adalah survei terhadap skripsi dan publikasi mahasiswa. Pengaruh penelitian-penelitian yang menerapkan pembelajaran terhadap kemampuan berpikir matematis dianalisis dengan teknik meta-analisis. Temuan penelitian mengungkapkan bahwa secara keseluruhan penelitian-penelitian yang dilakukan mahasiswa dengan memberikan intervensi pembelajaran ternyata mampu meningkatkan kemampuan berpikir matematis siswa. Aspek kemampuan berpikir matematika yang meliputi: kemampuan koneksi, komunikasi, representasi, pemecahan masalah, kemampuan berpikir: logis, kritis, kreatif, reflektif, intuitif, penalaran: analalogi, generalisasi, kuantitatif, kreatif, dan adaptif. Metode penelitian yang digunakan mahasiswa didominasi metode eksperimen dengan pendekatan mix-method dan penelitian tindakan kelas. Disamping itu terdapat beberapa mahasiswa memilih metode penelitian pengembangan. Hasil penelitian dan publikasi pada Program Studi Pendidikan Matematika telah menyesuaikan dengan tren penelitian pendidikan pendidikan matematika baik pada level nasional maupun internasional.

***Kata kunci**: meta-analisis; ukuran pengaruh; intervensi pembelajaran; kemampuan berpikir matematis*

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Introduction

Research and publication focus on mathematics learning has been done, whether by students under the guidance of lecturers. The research and publication should have an impact and benefit on improving the quality of mathematics learning in schools, including capacity building and research innovation at the Institute for Education and Teaching Personnel (LPTK) that serves as the implementers of mathematics education. Faculty of Educational Sciences, Syarif Hidayatullah State Islamic University (UIN) Jakarta is one of the LPTK of the State Islamic Religious College (PTKIN) in Indonesia that also holds study programs in mathematics education. Since 1985, the Mathematics Education Program, Faculty of Educational Sciences UIN Jakarta has opened undergraduate Mathematics Education Program and developed research on learning conducted by the students. Publication of the students' research in the form of a thesis has been done through the university repository, accredited journals, indexed international journals, national seminar proceedings, and Scopus indexed proceedings. The results of research and publications of students have been mostly in the form of learning interventions for improving the ability of mathematical thinking.

The improvement of the ability of mathematical thinking, especially in the aspect of High Order Thinking Skills (HOTs), is the current trend of mathematics education research. Leron (2004) defines mathematical thinking as the ability to build reasoning capacity and communicate ideas. Utari (2015), explains that there are several terms related to mathematical thinking such as mathematical abilities, mathematical skills, doing mathematics, and mathematical task. The terms are almost similar, in which it contains activities in the brain that the process cannot be observed, but the results of the process can be analysed. Another definition of mathematical thinking is doing math or mathematical task. Furthermore, Stacey (2006) states that there are four basic processes that show the process of mathematical thinking, namely: (1) specialising, that is trying a special case, looking at examples; (2) generalising, that is looking for patterns and relationships, (3) conjecturing, that is predicting patterns and relationships, (3) convincing, that is finding and communicating the reason why something is correct.

Based on the above description, the mathematical thinking ability is defined as the ability to understand and apply the concepts of mathematics through the process of thinking that includes specializing, generalizing, conjecturing, and convincing. Furthermore, Kadir et al. (2016), asserts that the type or variety of mathematical thinking includes: understanding, communication and representation, connection, problem-solving, reasoning, critical thinking, creative thinking, and reflective thinking. Based on its depth or complexity of mathematical activities involved, mathematical thinking can be classified into two types, namely Low Order Mathematical Thinking (LOMT) and Higher Order Mathematical Thinking (HOMT).

Many efforts have been done to improve students' mathematical HOT skills, but the results have not been satisfactory. The quality of HOTs ability of Indonesian students in mathematics is still low. The result of Trends International Mathematics and Science Study (TIMSS) of 2011 puts the ability of Junior Secondary School students in Indonesia at rank 38 of 42 countries (Mullis, et al, 2012). Problems in TIMSS include low cognitive levels such as remembering, understanding, and applying; and high cognitive levels such as the ability to analyse, generalize, synthesize, rate, and solve the non-routine problems. The TIMSS problem is divided into several more specific

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topics (Witri, et al., 2014) such as (a) Knowing, including recall, recognize, compute, retrieve, measure, and classify/order; (b) Applying, including selecting, representing, modelling, implementing, and routine problem solving); and (c) Reasoning, including: analyse, generalize / specific, integrate / synthesize, justify, and non-routine problem solving.

Furthermore, the result of study Programme for International Student Assessment (PISA) 2015 shows that only about 10% of Indoenesian students that are able to answer the test is at 4, 5, and 6 level. In general, level tests of 4, 5, and 6, contains questions that require students to employ high order thinking, work in complex situations, identify constraints, choose, compare, and evaluate appropriate problem-solving strategies, using extensive reasoning, reflecting, formulating as well as stating the interpretation, and reasoning. This data shows that Indonesian students have not yet developed a high order mathematical thinking skills.

Developing HOTs ability requires an active classroom environment. Without an active learning process students can not develop the capacity to think, reason, and solve problems mathematically (Henningsen and Stein, 1997). Thus, the ability of HOTs can be enhanced through active learning interventions that involving students. Learning intervention is the treatment in the form of learning strategies, approaches, methods, techniques, or models. Thus, learning intervention is a pattern or alternative model of learning, given to learners to improve certain skills in the learning of mathematics.

The Mathematics Education Program of Faculty Sciences UIN Syarif Hidayatullah Jakarta has done many efforts to accommodate research trends to overcome the low ability of mathematical students' thinking. The results of these studies determine the direction and pattern, as well as the strengthening of research at the study program level. The governance concerning theme, problematics, design, methodology, and learning research trends should be able to accommodate the development of mathematics education at the national and international level. This means that good governance in research and scientific publications at the level of the study program plays an important role in research sustainability and improving the quality and innovation of the research-based mathematics learning.

One alternative model of analysis to find the strength of learning instruction interventions that focus on improving the ability of mathematical thinking is Meta-analysis. Lyons (2003) suggests that meta-analysis is a set of statistical procedures designed to combine experimental and correlation research results from independent studies linked to a set of related research problems. Unlike the usual research methods, meta-analyses use summary or statistical essence from several studies independently as raw data.

The *effect size* is used to measure the strength of meta-analysis of a research. According to Borensteins, et. al., (2009), the effect size is a value that reflects the effect of the treatment or the relationship between two variables and is the unit of meta-analysis measurement. The magnitude of the effect size assesses the consistency of influence among the results of the study and calculates its overall effect. Some opinions (Olejnik and Algina, 2003; Huck, 2008; Moore, 2007), concluded that effect size is a measure of the practical significance of the research results, that is the size of the relationship or difference or the relative effect of an independent variable on the dependent variable. This measure complements and enriches the analytical results provided by the statistical tests. Description of the effect size

can be used to compare the effect of a research variable using different measurement scales.

Thus, meta-analysis is an integrative analysis of the results of analyses of studies with the same focus or theme. The meta-analysis method transforms data that is qualitative to quantitative and then uses statistical analysis to derive the essence of information from a number of previous research data. Therefore, the purpose of this study is to test the effectiveness of the mathematics learning intervention on mathematical thinking ability in student thesis research and publication.

Method

The research method used is survey and descriptive-analytics of the results of research and scientific publications related to learning interventions to improve the ability of mathematical thinking.

Participants

Population in this research is the thesis of all student of the class of 2006 until 2012, and all learning-based scientific publication at the Mathematics Education Program of Faculty of Sciences UIN Jakarta. The number of research samples is 200 thesis of students. The unit of analysis of the study is generally quasi-experimental research with a focus on improving the ability of mathematical thinking.

Instrument

The collected study research was then sorted according to the experimental group, namely superior learning intervention and control group with comparative learning interventions. The average data of the sub-study of each experimental group, the control group, and standard deviation of the control group were obtained from each sub-study. The instrument used in the research is the data coding form. The variables used in coding to capture information on the effect size of learning intervention are: (a) Name of researcher and year of study, (b) Subject of education, (c) Independent and dependent variables, (d) Treatment time, (e) Research design, and (f) Validity of test and instrument reliability.

Data Analysis

Data analysis used in this research is the *effect size analysis technique*. The effect size formula used is the formula with eta square (η^2): for experimental research involving only two groups, the experimental group and the control group, using comparative analysis with the t-test analysis technique. Then the effect size formula as follows:

$$\eta^2 = r^2 = \frac{t_o^2}{t_o^2 + db}$$

(Kadir, 2017)

For experimental research involving more than two groups, using comparative analysis with one-way ANOVA analysis technique, with the formula of effect size as below:

$$\eta^2 = \frac{JK_{antara}}{JK_{total}}$$

(Kadir, 2017)

Similarly for experimental research involving two groups and interactions, using comparative analysis with two-way ANOVA analysis techniques, therefore, the effect size of the formula is:

$$\eta_A^2 = \frac{JK(A)}{JK(A) + JK(D)}$$

$$\eta_B^2 = \frac{JK(B)}{JK(B) + JK(D)}$$

$$\eta_{AxB}^2 = \frac{JK(AB)}{JK(AB) + JK(D)}$$

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(Kadir, 2017)

Experimental research with heterogeneous group assumption involves two groups, using the effect size formula as follows:

$$\Delta = \frac{\overline{X}_E - \overline{X}_K}{S_K}$$

(Glass, et al., 1981)

The criteria used for interpretation of result effect size is as proposed by Cohen (1988), that is η^2 = 0.01, small effect; η^2 = 0.06 moderate effect, and η^2 = 0.14 big effect.

Result and Discussion

Data of learning intervention and mathematical thinking ability of 200 undergraduate thesis as analysis unit from this research is presented on Table 1, Table 2, Table 3, Table 4, and Table 5.

Tabel 1. Learning Intervention and Mathematical Thinking Type Conceptual Understanding and Representation

Learning Intervention	Type of Mathematical Thinking	N (%)
Approach: Quantum mind mapping, Problem solving-analogy, Connected, Constructivisme-REACT, Brain Based Learning, Concrete Pictorial Abstract (CPA).	Conceptual Understanding	6
Method: Inside-Outside Circle (IOC), Creative problem solving (CPS), Thinking Aloud Pair, Accelerated Learning, Guided Discovery	Conceptual Understanding	5
Model: Elaboration, Constructivisme type novick, Learning Cycle, Telephone structure, Cooperative: Rotating Trio Exchange, NHT, Co op Co op, Creative Problem Solving (CPS), CPS-Contextual, Search, Solve, Create and Share (SSCS), Modification, Action, Process, Object, Schema (M-APOS), Collaborative Problem Solving, Knisley Technic Storytelling, Generative, Collaborative MURDER, Concrete-Representational-Abstract (CRA).	Conceptual Understanding	16
Strategy/Technic: Heuristik Vee, Scaffolding, Active Knowledge Sharing, Counter Example, The Firing Line	Conceptual Understanding	5
Construktivism REACT Strategy	Mathematics Relational Understanding	1
Media/Tools: Multimedia Interaktif 3D Studio Max, Multimedia-Camtasia, Operation box, Autograph	Conceptual Understanding	4
Total	37 (18,5%)	
Approach: Contextual-REACT, Contextual, Model Eliciting Activities (MEAs), Metaphorical Thinking, Problem Solving	Representation	5
Method: Pictorial Riddle, Diskursif	Representation	2
Model: Cooperative Type Frormulate-Share-Listen-Create, Connected Mathematics Project (CMP), Conceptual Understanding Procedurs (CUPs), Missouri Matematics Project (MMP), Teaching with Analogy (TWA)	Representation	5
Strategy/Technic: Graphic Organizer, VARK Based	Representation	2
Media/Tools: Core Math Tools Application, Wingeom	Representation	2
Total	16 (8%)	

Data analysis result on Table 1, shows that from 200 undergraduate thesis, there are 37 (18,5%) learning intervention to improve conceptual understanding ability. Futhermore, there is 16 (8%) learning interventions to improve mathematical representation ability.

Data analysis result on Tabel 2, shows that from 200 undergraduate thesis that analyzed, learning intervention to improve mathematical connection ability about 13(6,5%) and about 22 (11%) for improving mathematical communication ability.

Data analysis result on Table 3, shows that from 200 undergraduate thesis, learning intervention to improve mathematical problem solving about 19 or 9,5%, problem posing 2 or 1%, and mathematical reasoning ability about 20 or 10%.

Tabel 2. Learning Intervention and Mathematical Thinking Type Connection and Communication

Learning Intervention	Type of Mathematical Thinking	N (%)
Approach: Problem Posing Type Within Solution Based Islamic Context, Brain Based Learning, Visual Thinking	Connection	3
Method: Tugas Superitem Berbasis Taksonomi SOLO	Connection	1
Model: Integrated type Connected, Advance Organizer, Experiential Learning, Learning Cycle 7E, CORE (Connecting, Organizing, Reflecting, Extending), Representation, Oral Language, and Engagement in Mathematics (ROLEM)	Connection	6
Strategy/Technic: Mind Mapping, REACT with Scaffolding Technique	Connection	2
Media/Tools: Software Edraw Mind Map	Connection	1
Total	13 (6,5%)	
Approach: Concrete-Representational-Abstract (CRA), Problem Based Learning, Collaborative Problem Solving, Problem Posing, Diskursif	Communication	5
Method: TAPPS, SQ3R	Communication	2
Model: The Learning Cell, Problem Solving Do Talk Record, Metaphorical Thinking, MMP, Generative, Learning cycle 5E, Cooperative method student facilitator and explaining (SFE), NHT	Communication	9
Strategy/Technic: Word Problem Roulette, Reciprocal Peer Tutoring, Journal Writing in Math, Active Knowledge Sharing, Metakognitive, Problem Solving SSCS.	Communication	6
Total	22 (11%)	

Tabel 3. Learning Intervention and Mathematical Thinking Type Problem Solving, Problem Posing, and Mathematical Reasoning

Learning Intervention	Type of Mathematical Thinking	N (%)
Approach: MEAs, Problem Posing, Discursif, Problem Posing Tipe Within Solution, SAVI	Problem Solving	5
Method: Resitasi	Problem Solving	1
Model: Learning Cycle 5E, Generatif, CUPs, Treffinger, Cooperative Tipe Integrated Reading and Composition (CIRC), Process Oriented Guided Inguiry Learning (POGIL), PBL, Anchored Instruction, REACT with Hands on Activity, ICERE, Flipped Classroom Tipe Peer Instruction.	Problem Solving	12
Strategi/Technic: Conflict Cognitive, IMPROVE	Problem Solving	2
Total	19 (9,5%)	
Model: Cooperative NHT	Problem Posing	1
Strategy/Technic: Writing in Performance Tasks (WIPT)	Problem Posing	1
Total	2 (1%)	
Approach: Realistic Mathematics, Problem Posing Type Post Solution, Metaphorical thinking, Onto-Semiotics	Inductive Reasoning, Analogy, Logic	4
Interlocked Problem Posing, Open-Approach, Mathematics Humanity with Brainteasers	Quantitative, Creative, Adaftive	3
Method: Creative Problem Solving, CPS, Thinking Aloud Pair Problem Solving (TAPPS), Mathematics Modeling	Inductive, Adaptive, Generalization, Reasoning	4
Model: Cooperative Group Investigation, Experiential Learning, CPS, Reflective Learning,	Mathematics Reasoning, Analogy Reasoning, Inductive Reasoning, Creative Reasoning	4
Strategy/Technic: Look For A Pattern, Conflict Cognitive, Concept Map Network Tree, Write in Math,	Analogy, Logic, Mathematics, Generalization	5
Total	20 (10%)	

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Tabel 4. Learning Intervention and Mathematical Thinking Type Creative Thinking, Critical Thinking, and Reflective Thinking

Learning Intervention	**Type of Mathematical Thinking**	**N (%)**
Approach: Open Ended, RME, Problem Posing Tipe Pre-Post Solution, SAVI	Creative Thinking	4
Method: Problem Solving with Wangkat and Oreovoct, Card Games, Guided Discovery.	Creative Thinking	3
Model: Cooperative type Formulate-Listen-Create (FSLC), Connected Mathematics Project, Experiential Learning, Treffinger Based Open-Ended Problem, Cooperative GI, CPS, Simplex Basadur, MURDER, Situation Based Learning (SBL), Dual Treatments.	Creative Thinking	10
Strategy/Technic: Heuristic, Conflict Cognitive, Means Ends Analysis, Knowledge Sharing	Creative Thinking	4
Total	21 (10%)	
Approach: Rigorous Mathematical Thinking (RMT),	Critical Thinking	1
Method: Case Based Learning, IMPROVE, Cooperative TPS, Discovery Guided, TAPPS, Guide method with heuristic strategy	Critical Thinking	6
Model: Eliciting Activities Based Open Ended, Learning Cycle '5E', SSCS, Experiental Learning, PBL.	Critical Thinking	5
Strategy/Technic: Reflective Journal Writing, ECIRR, Graduated Difficulty, KNWSW, MEA, Make an Organized List, IDEAL, Teknik Question Student Have, Think-Talk-Write (TTW), Working Backward, Metacognitive, Conflict Cognitive	Critical Thinking	12
Total	24 (12%)	
Approach: Reciprocal Teaching, Problem Solving with Drawing a Diagram, Analytic and Syntetic, Problem Posing,	Reflective Thinking	4
Method: Cornell- Note Taking, Brainstorming	Reflective Thinking	2
Model: CORE, POGIL, TSOI (Traslating, Sculpting, Operationalizing, Integrating), MASTER, CPS, Contex Based Learning	Reflective Thinking	6
Strategy/Technic:IDEAL	Reflective Thinking	1
Total	13 (6,5%)	

Tabel 5. Learning Intervention and Mathematical Thinking

Learning Intervention	Type of Mathematical Thinking	N (%)
Concept Attainment and Selective Problem Solving Model	Intuitive Thinking	2 (1%)
Heuristic Krulik and Rudnik Model	Algebraic Thinking	1 (0,5%)
Schema Based Instruction (SBI) with FOPS strategy	Higher Order Thinking (HOT) and Disposition	1 (0,5%)
Problem Posing Approach	Analogy Thinking	1 (0,5%)
Problem Solving Model Search, Solve, Create, dan Share (SSCS)	Logic Thinking	1 (0,5%)
Model Cooperative Type Team Accelerated Instruction (TAI)	Mathematical Social Skill	1 (0,5%)
Media Software Geogebra	Math Visualization	1 (0,5%)
Problem Solving Approach with Working Backward Strategy	Writing Mathematics	1 (0,5%)
Model 5E (Engage, Explore, Explain, Extend dan Evaluate) Media of Application Moodle Guided Method with Scaffolding technique Aptitude Treatment Interaction (ATI) Model	Learning Outcome	4 (2%)

Data analysis result on Table 4, show that from 200 undergraduate thesis, learning intervention to improve mathematical creative thinking about 21 or 10%, critical thinking 24 or 12%, and reflective thinking ability about 13 or 6,5%.

Data analysis result on Table 5, shows that from 200 undergraduate thesis, learning intervention for improving intuitive thinking about (1%), algebraic (1%), high order (1%), analogy (1%), logic (1%), mathematical social skill (1%), visualization (1%), writing mathematics (1%), and learning outcome in mathematics about 4 or 2%.

The average value of the effect size of thesis research results from 200 students is presented in Table 6.

Tabel 6. Statistic Eta-Square (η^2) Students'research

N	Valid	200
	Missing	0
Mean		,155213
Std. Error of Mean		,0076272
Median		,120000
Mode		,0459[a]
Std. Deviation		,1078650
Variance		,012
Skewness		1,676
Std. Error of Skewness		,172
Kurtosis		3,553
Std. Error of Kurtosis		,342
Range		,6244
Minimum		,0284
Maximum		,6528
Sum		31,0425

a. Multiple modes exist. The smallest value is shown

The result of analysis as presented in Table 6 shows that from 200 theses of students' research as the unit of analysis in meta-analysis obtained average effect size equal to 0,155. In accordance with the criteria of the eta-squared (η^2) as proposed (Cohen 1988), the effect size obtained is classified as a large effect.

Based on the distribution of effect size data, where the position of the mode is below the average and empirical median, it means that trend of effect size data is still below the empirical average. The trend of data distribution is depicted in Figure 1.

Figure 1 shows that the data effect size has a tendency to accumulate below the empirical average. This finding means that, although the effect size is large, however, the data distribution is still below the empirical average. It means that the distribution data of the effect size of 200 thesis of student studies accumulated below the empirical average, that is below 0.155, but theoretically, the effect size is high based on the agreed criteria.

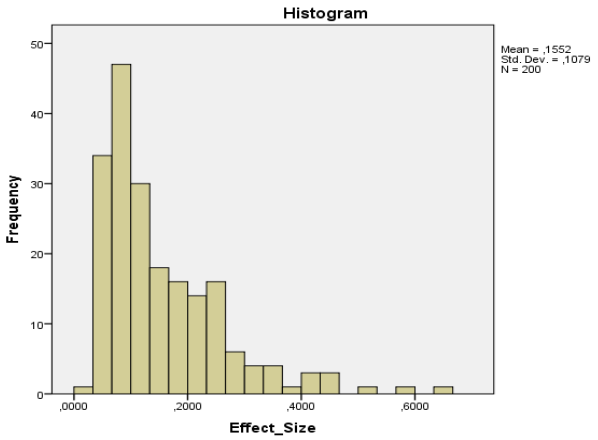

Figure 1. Distribution of η^2 Students'research

Findings of the research reveals that the effect size coefficient belongs to high category. Effect size is a critera that can be used to evaluate learning intervening effect on improving mathematical thinking of this research. In line with (Olejnik and Algina, 2003; Huck, 2008; Moore, 2007), that effect size is a measure of the practical significance of the research results, that is the size of the relationship or difference or the relative effect of an independent variable on the dependent variable. This measure complements and enriches the analytical results provided by the statistical tests. Referring to this opinion, mean that learning intervention which involved various approaches, methods, models, strategies and medias can improve mathematical thinking ability. Findings of mathematical thinking ability in this research include: mathematical concept understanding, representation, connection, communication, problem solving, problem posing, reasoning (analogy, induktif, adaptif, logic, generalization, quantitave), thinking (creative, critical, reflective, intuitive, algebraic, higher order).

In general, mathematical thinking ability that achieved of this research can be categorized as High Order Thinking Skills (HOTs). Thus, the research finding means that intervention as

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learning process which have been done by the student through educative interaction, giving challenging task, and a good classroom management can improve mathematical HOTs. This finding, in line with Henningsen and Stein (1997), implies that developing HOTs ability requires an active classroom environment. Without an active learning process students can not develop the capacity to think, reason, and solve problems mathematically.

Futhermore, Table 7 presents findings on the effect size of students' research by class-year **(2006 – 2012)**

From analysis result in Table 7, except for the year 2006, the average effect sizes of the year 2007 to 2012 are moderate and high according to Cohen's (1988) reference where η^2 = 0.01, small effect; η^2 = 0.06 moderate effect, and η^2 = 0.14 big effect. The average effect size was moderate in 2006, slightly increased in 2007, and the highest achievement is in 2008. The average effect size decreased from the year 2008, the highest achievement, occurred in 2009-2010. There was a slight increase in the year 2011-2012. The findings of the study revealed that, despite the decline and increase, the achievement of research size effect of the students by year is big. The research findings reveal that based on class year (enroll) of student, learning intervention obtained various effect on achieving mathematical thinking on student who involved treatment group (experimental and control gorup).

Table 7. Mean Score of η^2 of the Students' Research by Class-Year

Statistic		*Effect Size* (η^2) by class of the year						
		2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Mean		,093267	,104691	,182984	,157802	,152356	,170997	,169705
95% Confidence Interval	Lower	,062360	,052689	,131235	,123498	,127120	,125650	,121123
	Upper	,124174	,156693	,234733	,192106	,177592	,216344	,218288
5% Trimmed Mean		,087263	,095201	,173120	,144184	,145500	,156334	,162984
Median		,086500	,085200	,141200	,117300	,129700	,122700	,133000
Variance		,003	,006	,016	,012	,008	,017	,010
Std. Deviation		,055810	,077405	,125366	,111465	,090646	,132009	,100797
Minimum		,0401	,0536	,0379	,0524	,0284	,0475	,0564
Maximum		,2545	,3266	,5184	,5981	,4591	,6528	,4040
Range		,2144	,2730	,4805	,5457	,4307	,6053	,3476
Interquartile Range		,0517	,0406	,1725	,1240	,1145	,1558	,1778
Skewness		1,919	2,785	1,191	2,013	1,140	1,831	,800
Kurtosis		4,494	8,312	1,054	5,227	1,509	4,183	-,211

Figure 2 shows the tendency of decline and increase of the average size effect.

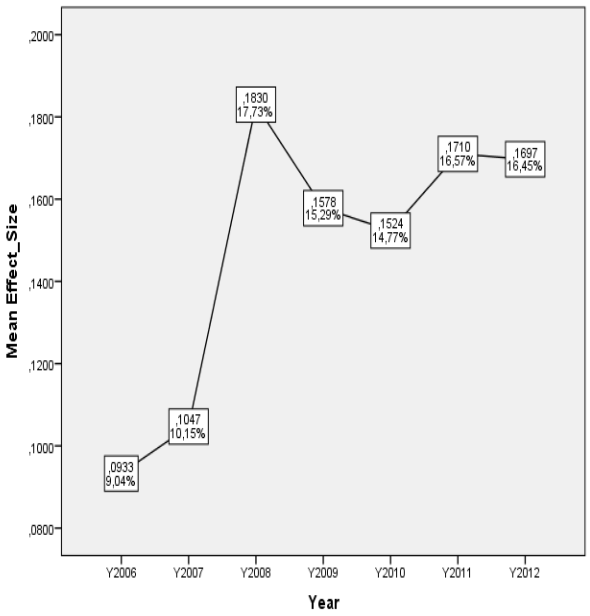

Figure 2. Average *Effect Size* by Class of the Year

The study finds that class of the year intervention of student learning affects the students' mathematical thinking ability. These findings are similar to those of Jacobse and Harskamp (2011) that examined the impact of mathematics learning interventions in Grade VI, based on a research review of 2000 - 2010, with a sample of 65 effect size from 55 basic studies involving 6817 students. The findings of the study reported that statistically, the average effect of learning intervention affect the mathematics achievement (Cohen's d = .58; SE = .07). The study also found that there was no difference in effect size among students with high mathematical ability or low ability. Also, there is no difference between the direct learning method and the guided discovery method. Similar findings related to the use of calculators, in mathematics learning, by Ellington (2003), in his study of 54 studies integrated through meta-analysis to see the effect of calculators on mathematical achievement and student attitudes. The effect size method was developed by Glass, Hedges, and Olkins' (1985). The results of this study reveal that students' operational and problem-solving skills are increasing when the calculator is integrated into testing and learning. Students who use calculators have a better attitude toward math than learning without a calculator.

The findings of the descriptive meta-analysis by class of the year revealed that the distribution of the effect size of student research has heterogeneous trends in seven years, ie 2006, 2007, 2008, 2009, 2010, 2011, and 2012 (p-value = 0.027 <0.05). These findings suggest that the effect size among 200 student studies is very diverse. The highest average effect size occurred in students from 2008 and the lowest students from 2006, indicating the emergence of data outliers. Outlier data is data that is far enough from the values or score of sample distribution among students by year. The existence of outliers in Figure 3.

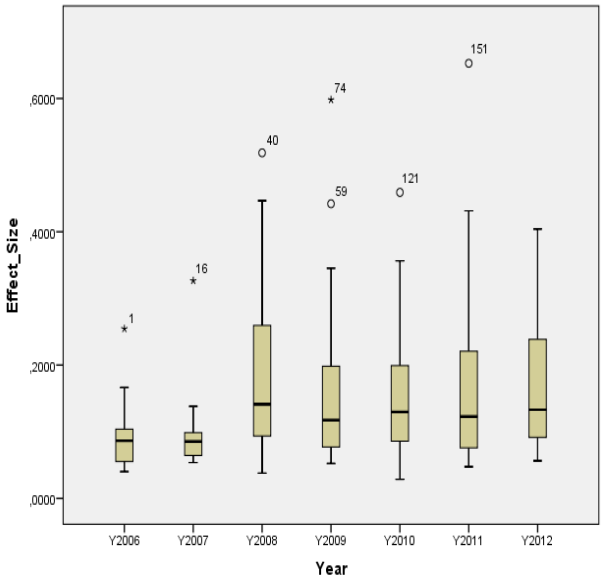

Figure 3. *Boxplot* of the η^2

Figure 3 shows that from the 200 effect size data as the unit of analysis in this study, there are seven data that are classified as effect size outlier, namely data with the thesis serial

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number 1, 16, 40, 59, 74, 121, and 151. The graph in Figure 3 revealed that about 75% of cases have values smaller than 0.2000, while approximately 25% are between 0.2000 and 0.4000. These findings reveal that, in general, thesis at the Department of Mathematics Education, Faculty of Educational Sciencies of Syarif Hidayatullah State Islamic University of Jakarta has η^2 lower than 0.2000 and only a few thesis that has a η^2 value of 0.4000.

Furthermore, the results revealed that, except for 2006, the average effect size of 2007 to 2012 has been in the moderate and high effect size. The findings of this study mean that the intervention of learning by students in their thesis research can improve the ability of mathematical thinking. The independent t-test on the average effect size shows that there is no difference of mean effect effect of student study among the seven years ($F = 1.733$; $df = (6; 193)$; p-value = $0.115 > 0.05$). This means that class of the year does not affect to the effect size of student research. The findings of this study are similar to those of Santosa (2010), which found that theses in the Faculty of Psychology of Sanata Dharma University showed that the independent variables or predictors studied tend to have an effect size *f* that is big. However, Cohen's effect size can not be fully applied in the research at Psychology Faculty of Sanata Dharma University.

These study findings are similar to those of Stone, Getsi, Langer, and Glass; Schaefli, Rest, and Thoma; Willig (In Toeti, 1989) who reported that the effect of treatment in the form of a learning strategy was positive or the experimental group tended to outperform the control group. Associated with the problem-solving approach, research findings by Kadir et al. (2013), concluded that the problem-solving approach in the Science and Mathematics learning was able to improve the respondents' learning outcomes in the experimental group by 1.079 times of the standard deviation of the control group. The problem-solving approach is more effective than other approaches in the control group.

Furthermore, similar research on a meta-analysis of concept map strategy in science and mathematics learning by Kadir (2004) reported that overall mean of concept map effect to student learning process is high, that is about 1.73 times standard deviation of the control group. From the level of education of research subjects, the concept map strategy applied to the teacher gives the highest influence, while the lowest is at the elementary level. Consistent influence is found at the elementary school level. In terms of duration of treatment, the average effect of the concept mapping strategy is highest when treatment is applied for 24 weeks, and the lowest if applied for 6 weeks. Meanwhile, from the type of field of science being experimented, the concept map strategy applied in the field of Science for Teachers gives the highest effect, followed by Ecology and Genetic, while the lowest is in the field of Microbiology. The concept map strategy provides a consistent effect on the field of Ecology and Genetics. In terms of the involvement of experimental variables, the concept map strategy gives the highest effect if the strategy involves the conditions of the season (Summer, Spring, Fall), followed by the concept map strategy with learning conditions (IW, CP, and CP-CM) and gender, while the lowest when the application concept map strategy does not involve other factors. The concept map strategy provides consistent influence when it involves learning and gender conditions.

Research findings related to learning intervention to improve mathematical thinking ability, relevant to the previous research, for instance in Journal for Research in Mathematics Education (JRME) published by National Council of Teacher of Mathematics (NCTM). Sabandar (2009) reported that the trends of

mathematical education research by JMRE from 2009 to 2017 are (1) prove and argumetation, (2) algebraic and its understanding, (3) Problem solving, divergence problem, and representation, (4) cognition, mental model, thinking, reasoning, quantitative reasoning, and students'conception, (5) task design, learning tools, assessment; (6) mathematical problem posing, algebraic thinking, and learning approach, (6) learning and mathematics thinking through robotic game for children.

Although the effect of the learning intervention from the results of this study has shown high, there are limitations of the meta-analysis research. The studies taken as a unit of analysis are largely quasi-experimental, in which the researcher can not control all the external variables that affect the learning intervention. Thus, the results of the research need to be interpreted cautiously. Although there are weaknesses and limitations as disclosed, the results of this meta-analysis have revealed that instructional interventions applied by students in thesis research and publications, in general, it can improve students' mathematical thinking ability in the experimental group higher than the control group.

Conclusion

Overall, students' research by providing learning intervention in the form of learning approach, method, model and learning strategy is able to improve students' mathematical thinking ability. Aspects of mathematical thinking ability include the ability of conceptual understanding, representation, connection, communication, problem solving-posing, thinking ability (creative, critical, reflective, intuitive, algebraic), and reasoning (analogy, logic, inductive, generalized, quantitative, creative, adaptive). Learning interventions by students in thesis research are more varied inquire and discovery methods, Problem Based Learning, Experiental learning, Situation Base Learning, Context-Based Learning, Case-Based Learning, Brain-Based Learning, Schema Based Learning, REAC, CPA, SSCS, M-APOS, CMP, MMP, TWA, ICERE, Learning Cycles, Reflective Learning, CUPs, ECIRR, CORE, GI, NHT, TSOI, CIRC, POGIL, ROLEM, SAVI. Similarly, Problem-solving approaches: CPS, Heuristic Krulik, MEAs, SPS, IDEAL, Look for a Pattern, Working backward, Drawing a Diagram, and Make a list. While the variant approach to problem posing include: type pre-solution, post solution, within the solution, structured, and interlocked. The learning media used in the study is also more varied, for example, Camtasia Studio, Multimedia interactive, Core math tools application, Wingeon, Operation box, Software edraw mind map, and Authograph.

The research method used by students is dominated by an experimental method with the quantitative dominant approach of mix-method. Another research method that is used by students is a Classroom Action Research (PTK). In addition, there are some students who choose the method of research development (R & D) for the development of learning media. In general, learning interventions can give a significant influence on improving students' mathematical thinking ability expecially in school level. The results of students' research have been published in the national and international journals, proceedings of national and international seminars. Research trends and publications in the Department of Mathematics Education of UIN Syarif Hidayatullah Jakarta increasingly adjusted to the trend of mathematics education research both at national and international level.

Recommendations

Based on the meta-analysis findings from the research that has been done by the students

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result, the independence of the research at the Department of Mathematics Education at Faculty of Educational Sciencies of UIN Syarif Hidayatullah Jakarta could be improved through the following programs and activities; 1) Motivate and familiarize students to read, review journal articles (national and international) to find research problems and use the articles from the reputable journal as the main references of the thesis; 2)Revitalize the role and function of an expert commission to guide student thesis proposal. Student guidance should be tailored to the focus and theme of the research undertaken by the lecturer; 3) Require the students to write scientific papers (articles) based on their thesis research under the direction of supervisors and publish them in the scientific forums, national journals, and international journals; 4) Activate the discussion of the study program's consortium related to socialization and dissemination of lecturer research results, discussion and coaching on theme and proposal writing for research: individuals, collectives, and institutions that are funded by the faculty, research institution, and Islamic Higher Education Directorate of Ministry of Religion Affairs; 5) Conduct collaborative or joint research between math education program with the Institute of Educator and Education Personnel (LPTK).

Discussion and coaching of writing Articles of accredited national journal and/or international journal articles, through scientific discussions involving experts and visiting professor.

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