International Journal of Innovation, Creativity and Change. www.ijicc.net
Volume 11, Issue 1, 2020

The Effect of Open-Ended Learning Approaches and Thinking Patterns on Student Mathematical Learning Outcomes

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This study aims to determine the effect of Open Ended Learning Approaches and thinking patterns on student mathematics learning outcomes. The research method used in this study is an experimental method involving two variables, the independent variable (treatment variable) and divergent thinking patterns as the independent variable (moderator variable) using a 3 x 2 factorial design. Further measured variables include two main variables, namely the independent variable and the dependent variable. The results showed that: 1) there was a significant influence of the open-ended learning approach and the direct learning approach on student mathematics learning outcomes; 2) There is a significant influence of thinking patterns on student mathematics learning outcomes. The results of this study indicate that mathematics learning outcomes of students who have divergent thinking patterns are higher than mathematics learning outcomes of students who have convergent thinking patterns; 3) There is an interaction effect between the learning approach and thinking patterns on student mathematics learning outcomes; 4) Mathematics learning outcomes of students who have convergent thinking patterns taught with an open-ended learning approach are significantly higher than mathematics learning outcomes of students who have convergent thinking patterns, taught with the direct learning approach.

Key words: *Open ended, thinking patterns, learning outcomes.*

Introduction

Learning in schools must be continuously reviewed and improved, in order to develop and build student abilities so that the problems they face today can be overcome in the face of a competitive global society and marketplace. The real world problems that will be faced require solutions just as when students are solving mathematical problems and require high-level thinking patterns known as divergent thinking patterns. The pattern of thinking this describes entails that if students are faced with open problems / problems, they can solve them in more than one way.

In the process of learning mathematics, teachers are required to be able to design learning by considering conditions related to the learning process, namely conditions that are engaging and characteristic of students. Students are expected to have a thorough understanding of mathematics, because mathematics is not just about numbers and involves the use of symbols to draw various shapes and an understanding of how much mathematics contributes to other sciences and in everyday life. The fact is that students, in terms of physical and psychological behaviours, still show their dislike of learning mathematics, because it is considered boring learning.

Through learning design and facilitation, the teacher must be able to plan and implement a learning process that can involve students actively, effectively, efficiently and meaningfully. The teacher is also expected to be able to determine the right learning model and approach, be able to encourage students, look for ideas and arrange concepts that are easy to understand so that students will not experience difficulties in understanding mathematics subject matter. However, currently student learning outcomes are still considered low in mathematics when compared with the learning expectations criteria set by the school.

In SMA Negeri 4 Kendari, grade VII students received an average daily score of 62, 59 in the 2015/2016 academic year and an average semester exam score of 65.05, while in the 2016/2017 school year the average score was Daily tests and the average score on student semester exams, 65.75 and 69.85. These values are still low when compared to the Minimum Completion Criteria (KKM) set by schools at 74. In the 2015/2016 academic year the number of students who reached the KKM was 40%, while in 2016/2017 it was 50%. Daaba (2015/2016) explained that the data is a picture of the acquisition of student grades in SMA Negeri 4 Kendari that has not yet reached the KKM target set.

There are two factors that affect student mathematics learning outcomes: external factors and internal factors. External factors are external factors including student learning strategies, learning models, learning approaches and learning methods and abilities of teachers, while internal factors are derived from students, including patterns of thinking, initial knowledge in

the form of concepts, facts and principles in mathematics.

The teacher is one of the resources directly involved in improving student learning outcomes in mathematics and as such the teacher should be able to determine the right approach to the material to be taught through conducting relevant research about how to improve teaching and learning in the classroom. However, the reality is that student mathematics learning outcomes have not seen significant improvement. This is caused by the habits of mathematics teachers in SMA 4, Kendari who always use the direct learning approach, without trying other approaches that can activate students.

The results of this research supports, among other researchers, Faridah (2016: 1061) who found that an open ended approach: (1) increased the ability to think creatively in mathematics with a gain categorized as medium, (2) increased the ability to think creatively in mathematics more than with conventional approaches, 3) increased student confidence with a moderate category gain, and (4) increased student confidence more than the conventional approach. Sulianto's research results (2011: 38-39) concluded that (1) students can achieve mastery learning in contextual learning classes with the open ended approach and (2) the problem solving ability of students who receive mathematics learning using contextual learning with the open ended approach is better than for those students who receive expository learning on triangular material. Reasoning students can achieve medium criteria in contextual learning classes with the open ended approach.

The two research results above show that the open ended learning approach consistently shows an increase in learning outcomes, and that the role of the teacher in planning learning that involves active and creative students is vital. The learning approach allows students to communicate with their peers, complete the assignments / exercises in groups, makes them try to express opinions and allows students encountering difficulty, to have further explanation being explained from friends who already understand, so that the learning approach becomes meaningful. To create active and creative learning, the learning space is arranged in such a way that students feel safe, chairs are arranged that allow students to sit in groups, teachers can freely monitor study groups, adding media and books / teaching materials to improve student learning outcomes. This kind of learning approach clearly requires students to think creatively (divergent thinking).

Application of the approach in learning is very important because it can make students think creatively, develop knowledge systematically, become skilled at working on problems scientifically and build collaboration in learning. The open ended approach to learning in mathematics engages students to identify the problems faced, understand concepts, interpret facts and generalize to find solutions. The teacher should create a learning approach as mentioned above, so students are accustomed to learning by thinking creatively, so as not to

experience difficulties. However, in reality teaching is still dominated by the direct learning approach, so that the students are quickly bored because as passive learner they follow the pattern that has been determined and conveyed by the teacher

Literature Review

Learning Outcomes of Mathematics

Before learning outcomes of mathematics are explained, first learning theories are investigated. Some theories of learning are attributed to educational psychologists, among them Vygotsky as quoted by Siddiqui (2008: 7) who defined learning in the following way:

"Constructivist theory has led to the view that behaviour, skills, attitudes and beliefs are inherently situated, that is, bound to a specific sociocultural setting. According to this view, the learner is enculturated through social interactions within a community of practice. "

According to this view, changes in students' skills and attitudes are approached through social interaction in the practice community and subsequently in the learning process, students are organised in peer groups, get to know each other and cooperate to find their own solutions to the material that the teacher provides. The material presented brings about changes in student behaviour, namely learning progress, marked by the activities carried out such as frequently asking questions, assigning tasks and demonstrating exercises on the board, both individually and in groups.

According to Nggili (2015: 32) learning is a process of behaviour change. Students are said to have learned something, if they demonstrate certain behaviour. In addition it is also necessary to take action as a form of reinforcement of the appropriate responses that have been generated. This form of reinforcement is an important factor in learning, so that students better understand and apply the solutions in their daily lives. The response to the stimulus will be stronger, if the strengthening of the response is increased through feedback. Stimulus, response and reinforcement, if going well in learning, will have a positive impact on student thinking patterns, so that learning is meaningful. Woolfolk (2013: 394) explained that:

"*Determine motivation to learn. The teacher is interested in a certain kind of motivation-student learning motivation. The motivation of students to learn is the nature and circumstances. It involves academic work seriously, tries to get the most out of it, and implements appropriate learning strategies in the process.*

Learning is intended to provide motivation to students and the nature and circumstances of learning require that students are serious about their learning, try to get the most out of it, and apply appropriate learning approaches in the process. Learning as a series of efforts to provide

certain conditions that an individual wants and will work to achieve while eliminating elements they dislike and being prepared for the learning of new material.

Based on the description of the three opinions above, learning is a change in student active behaviour towards positive progress, both individually and in groups. Stimulus, response and reinforcement given appropriately during the learning cycle will affect student thinking patterns, so learning can be meaningful. Learning as a series of efforts carried out with good motivation, in a conducive learning atmosphere engages students without coercion. Thus when learning is a change in behaviour toward progress accompanied by motivation through teacher guidance, and is accomplished without coercion, students will get maximum learning results.

Learning outcomes are very beneficial for student and, with a little guidance, the expected learning outcomes can become a target for student achievement. Why use learning outcomes? The responses to this question include: (1) a statement of good learning outcomes helps students to identify their own targets, and works systematically to demonstrate student achievement against the expected targets, (2) learning outcomes are now required by quality assurance agencies and professional bodies, in review and validation of educational programs throughout the world and (3) learning outcomes can provide one indicator directly of the desired level and depth of learning programs.

If there is guidance and training given by the teacher to students in learning, the benefits will be felt in the learning outcomes achieved by students, while learning outcomes systematically identify the targets to be achieved, required by quality assurance and as an indicator of how far into the learning program achievement has been demonstrated. McEwen (1995: 55) explains that learning outcomes are:

"If a particular student's priority learning outcomes focus primarily on communication, social, and self-care areas, additional learning outcomes may include other items from the same areas as well as learning outcomes from different curriculum areas, such as language arts, math, science, physical education, arts, or computer literacy. The configuration and number of additional learning outcomes will vary for each student based on his or her individual needs and characteristics"

Learning outcomes must be prioritized to individual students with a focus on communication, social, and self-preparation in order to receive subject matter and with additional learning outcomes focused on learning outcomes specific to the curriculum, e.g. mathematics. The number of additional learning outcomes will vary for each student based on their individual needs and characteristics. Of these three elements that determine student learning outcomes, the understanding of communication during teacher knowledge transfer and the impact on discipline and socialisation for students when working in groups, is crucial. Thus these

elements are very important in learning to achieve maximum student results in the short term.

According to Beckmann (2009: 192) planning is important in learning, implementing and concluding learning as an indicator to assess student success. Beckmann further explained that:

"When planning lessons, teachers need to start with considering where they want their students to end. To decide how to teach a lesson, teachers first need to decide what they want students to understand and be able to do as a result of instruction. In this lesson, you will focus on determining these learning outcomes. In some books or some state frameworks, learning outcomes are called expectations, goals, objectives, benchmarks, or standards. In this text, the term learning outcomes are used to be inclusive of those outcomes that are measurable as well as those that are not"

Accordingly, when planning lessons, the teacher must considering the endpoint of the learning. To decide how to teach a lesson, the teacher must first decide what students will understand and will be able to do as a result of teaching and learning; this is the lesson focus and determines student learning outcomes. In some frameworks, learning outcomes are referred to as expectations, goals, objectives, benchmarks or standards. In this research, the term learning outcomes is used to include measurable and non-measurable results. Measurable learning outcomes include all activities planned by the teacher that begin with the introduction of learning and end with assessment. The assessment is used as a benchmark for student success and the learning outcomes are the expectations and goals in learning.

Learning Approach

For every learning episode that takes place, there is an approach that underpins it. The learning approach can be interpreted as a point of view in the learning process, which refers to the occurrence of a process that is still very general in nature; that embodies, inspires, strengthens, and underlies learning methods within a certain theoretical scope. There are two general learning approaches: (1) a student-centred learning approach and (2) a teacher-centred learning approach. Student-centred learning approaches involve activities which require more activity from the student than the teachers. Marbach-Ad (2015: 91) states that student-centred learning approaches are:

"Student experience can be an enabler when faculty members have compelling evidence that a particular teaching approach will improve student learning outcomes and student-faculty interactions. Learning about effective teaching practices and successfully implementing them can require an extensive time commitment, which presents a barrier to '"

Students experience creative teaching approaches where schools have strong evidence that this

teaching approach will improve student learning outcomes. The learning time involved in effectively and successfully implemented teaching practices requires commitment and time can be a barrier, meaning that a student-centred learning approach takes a long time, while the teacher-centred learning approach is an approach that is arranged by the teacher in such a way, that the learning takes place systematically, timed to complete learning activities. Sonnheim (2015: 32) states that:

"Approach (content plan), but as they progress in their studies, the logical approach (process plan) is more appropriate. The underlying hypothesis is that adults are independent and thus self-directing. Merriam concludes that andragogy may not define the uniqueness of adult learning, but it does provide a set of guidelines for designing instruction with learners who are more self-directed than teacher-directed"

Approaches to planning and teaching content, for progress in student learning must be adjusted as possible so that the situation is more suited to the pedagogic approach, whereas the andragogic approach (*process plan*) is more appropriate for adults. The underlying hypothesis is that adults are independent and thus direct themselves. Merriam concluded that the andragogic approach may not define the uniqueness of adult learning but rather provides a set of guidelines for designing teaching that is adapted to the approach (pedagogic or andragogic. As a professional, a teacher must know the conditions of students who learn and whether the learning required is pedagogic or andragogic, as both approaches are equally important. This involves knowing the attitudes, knowledge and skills of the student cohort for each learning environment.

Thinking Patterns

According to Dweck (2006: 18) thinking patterns are: "*Only people with a growth mindset paid close attention to information that could stretch their knowledge*". Only people with a developing mindset can pay attention to information that can stretch (pay attention to) knowledge. This means that if students have a mindset to develop their knowledge and skills, they will pay serious attention to what is presented by the teacher when teaching. Thinking patterns are generally divided into two, namely divergent thinking and convergent thinking.

Divergent Thinking Patterns

Formal education is intended for students who have normal abilities (physically fit and mentally healthy), whereas for students who do not fit this profile, special education is provided. Therefore 'normal' students are expected to have creative thoughts when learning in class. According to Tammy (2012):

"Divergent thinking appears to have an important role in the problem-solving process. In the context of problem solving. Universal thinking refers to generating multiple options for solving a problem. Additionally, when initial solutions do not appear to solve the problem, divergent thinking is required to generate options that go beyond the logic of the options initially generated, for example, if a student needs to solve the problem of getting a ride home from athletics practice".

Divergent thinking has an important role in the process and context of problem solving. Different thinking produces many choices when solving a problem. In addition, when an initial solution does not appear to be able to solve a problem, divergent thinking is needed to produce options that go beyond the logic of the choice that was originally expected and result in problem solving. For example if a student needs to solve a problem to get a ride home from athletics training, the student uses divergent thinking patterns so as to produce a number of solutions e.g., going home with a friend, take a bus, walk, or ride a bicycle. When students use divergent calculated patterns, various solutions become apparent in solving problems.

Divergent thinking is high level thinking, so that a problem can be solved in various ways, as stated by Matusitz (2015: 268):

Divergent thinking underlines a fluid thinking pattern. It is the ability to (1) move from one perspective to another, (2) connect diametrically opposed ideas in a meaningful way. and (3) bring a new idea to accomplishment (ie. high context).

Divergent thinking patterns underline current thinking patterns, namely the ability to, (1) move from one perspective to another, (2) connect diametrically opposed ideas in meaningful ways, and (3) bring new ideas to learning outcomes, namely into high content. Thinking divergently enables students to analyze and combine concepts and ideas, so they can find objective completion results, achieved through nonlinear methods without having to rely on linear methods.

According to Zbarskaya (2017: 68) who quoted the opinions of Emanuel Jauk, Mathias Benedek, and Aljoscha C. Neubauer,:

"*In 2012, Emanuel Jauk, Mathias Benedek, and Aljoscha C. Neubauer from the Department of Psychologists) at the University of Graz in Austria found different patterns of brain activity highlighting divergent and convergent thinking. Divergent thinking is a thought process or method used to generate creative ideas by exploring many possible solutions. Convergent thinking generally refers to accurate answering what are considered more standard knowledge questions. In 1999, Molle, Marshall, Wolf, Fehm, and Bom from the Department of Neuroendocrinology at the Medical University of Liibeck in Germany emphasized that*

divergent thinking involved more complex EEG due to larger number neural assemblies. Creative ideas are associated with a higher EEG alpha activity and a stronger task-related alpha synchronization in the right hemisphere".

In 2012, Emanuel Jauk, Mathias Benedek, and Aljoscha C. Neubauer from the Department of Psychology at the University of Graz in Austria, found that various patterns of brain activity highlight divergent and convergent thinking. Divergent thinking is the thought process or method used to generate creative ideas by exploring the many possibilities of problem solving. Convergent thinking generally refers to accurately answering questions that are considered more standard. Divergent thinking patterns are rarely used by students, because they are accustomed to learning prepared by the teacher which always leads to a direct learning approach, and as such, learner habits are trained in convergent thinking. According to Wayne (2014):

"Divergent thinking is a thought process or method used to generate creative ideas by exploring many possible solutions. It is often used in conjunction with convergent thinking, which follows a particular set of logical steps to arrive at one solution, which in some cases is a 'correct' solution. Divergent thinking typically occurs in a spontaneous, free-flowing manner, such that many ideas are generated in an emergent cognitive fashion ".

Divergent thinking is the thought process or method used to generate creative ideas by exploring the many possibilities of problem solving. This is often used in conjunction with convergent thinking, which follows a series of logical steps to solve a problem and in some cases is the correct methodology for problem solving. Divergent thinking usually occurs spontaneously and is free flowing so that many ideas are generated in this cognitive manner. Students who are accustomed to teaching and learning using an open ended approach, use divergent thinking routinely to generate a range of solutions to the problems faced, especially. In this case, the human thinking patterns are related to brain function consisting of both the left hemisphere and the right hemisphere.

According to Amsyah (2005: 119) processing data into information is closely related to the basic physiological characteristics of the human brain. Researchers have conducted careful studies to learn more about the human brain and how the brain controls the ability to use and manage information. It is known that the brain consists of two sides, the right side and the left side, and the nervous system is connected with the brain in reverse effect. The left brain controls the right body, and the right brain controls the left body. Both sides work separately, if a person has an accident or is hit on the left side of his brain, the right part of the body will bear the most severe consequences.

Convergent Thinking Patterns

According to Kukkonen (2015: 147): "*convergent thinking applies what is known and stays within borders. As the subjects' production was convergent when they remained within the domain of the idea and only applied incremental changes*".The results are consistent with what is learned, because the production of convergent thought patterns remains in the realm of ideas and only applies additional changes. These additional changes will not be too far from what is learned due to the tendency of students to be consistent with what they have received. Furthermore Lang (1994) said that:

Convergent thinking the synthesis of these ideas brings together of ideas. The former may be considered to be die pure creative effort, but the latter involves the processes of predicting how the patterns will function and then evaluating or recognizing the die utility of those patterns. Convergent thinking is the truly creative act in designing since it involves identifying not only patterns that are new but ones that also have utility in terms of the problems they address.

Convergent thinking is a unifying idea and can be considered as a purely creative endeavour, but the latter involves the process of predicting how a pattern will function and then evaluating or recognizing the satisfaction of that pattern. Convergent thinking is a creative act in designing something because it involves identifying not only new patterns but is also used in terms of problem solving faced by students. So this convergent mindset is also important to apply a student's knowledge, statistically in solving problems.

Research Methodology

The research method used in this study is an experimental method involving two variables, the independent variable (treatment variable) and divergent thinking patterns as the independent variable (moderator variable) using a 3 x 2 factorial design. The next measured variable includes two main variables, the independent variable and the dependent variable, which are detailed as follows:

Bound

The dependent variable investigated in this study are the results of a mathematics learning test for class X science students of SMA Negeri 4 Kendari, after receiving a learning process with eight meetings.

Independent

The independent variables investigated in this study are treatment variables: the *open ended*

learning approach variable (A_1) as an experimental class and the direct learning approach variable (A_2) as a control class, while the moderator variable (B) is a pattern of student thinking which includes: divergent thinking patterns (B_1) and convergent thinking patterns (B_2). Placement of students in groups of divergent and convergent thinking patterns is carried out simultaneously based on test results using different instruments. If the score of the divergence of divergent thinking patterns is higher than the score of convergent thought patterns, then these students are grouped with other who show divergent thinking patterns. If the score of convergent thinking patterns is higher than the score of divergent thinking, then these students are grouped in groups of students who have convergent thinking patterns. So the function of the test in this study is to place students in divergent or convergent thinking groups based on demonstrated thinking patterns.

This research was conducted at SMA Negeri 4 Kendari, Southeast Sulawesi in the even semester 2018/2019, which began from December 2018 to April 2019. The time for conducting the research was adjusted to the schedule of learning implementation at the school where the study was conducted. The population of this research is 494 high school students of Kendari, spread over 13 parallel classes and each class has 38 students.

Sampling is achieved by *simple random sampling technique*: said to be *simple* because the sampling of members of the population is carried out randomly, without regard to strata contained in the population. This method can be used if members of the population are considered homogeneous (Siyoto, Sodik, 2015: 65). The steps for sampling were as follows:

a. The study sample was chosen as two *random* classes *randomly*. This selection of the placement of students of class X IPA for each class is irrespective of individual student capabilities; in this case the ability of the class X IPA, for each class is relatively the same, and the *random* process derived class X IPA_2 as an experimental class and class X IPA_5 as a control class.
b. After completing the sample class determination, the experimental class students are taught with the open ended approach and the control class, with a direct learning (expository) approach.
c. The grouping of students into those who demonstrate divergent thinking patterns and those that demonstrate convergent thought patterns is based on the results of tests using divergent thinking instruments and convergent thinking patterns.

Determination of students into groups of divergent thinking patterns and convergent thinking patterns are based on test results. If the test results obtained by students indicate that the value of divergent thinking patterns is higher than the value of convergent thinking patterns, then the students are grouped according to divergent thinking patterns. Conversely if the test results obtained by students indicate that the value of convergent thinking patterns is higher than the

value of divergent thinking patterns they are grouped as convergent thinkers.

Research Results and Discussion

Results of this research data are in the form of raw data from student mathematics learning outcomes when taught using the open-ended learning approach (A_1) and when taught using the direct learning approach (A_2). Furthermore, both approaches involve students who have divergent thinking patterns (B_1) and students who have convergent thinking patterns (B_2). The score of student mathematics learning tests and the scores of thinking patterns instruments are still in the form of raw data that is converted into scores on a hundred scale. The results of the conversion of divergent thinking patterns and convergent thought patterns are used as the basis for grouping students who have divergent thinking patterns (B_1) and students who have convergent thinking patterns (B_2). If the conversion result of the value of the divergent thinking pattern is higher than the value of the convergent thought pattern, then the student is grouped into students who have divergent thinking patterns, and vice versa if the conversion result of the convergent thought value is higher than the value of the divergent thinking pattern then the students are grouped into students which has a convergent mindset.

Based on the grouping, student mathematics learning outcomes can be divided into: (a) Mathematical learning outcomes of students who have divergent thinking patterns who are taught with an *open-ended* approach (A_1B_1), (b) Mathematics learning outcomes of students who have convergent thinking patterns and are taught with a divergent approach (A_1B_2),(c) the results of student mathematics learning which have a pattern of divergent thinking that learned with a straight learning approach (A_2B_1),and (d) the results of student mathematics learning which have a pattern of convergent thinking with a direct learning approach (A_2B_2).

The value of student mathematics learning outcomes was analyzed with descriptive statistics using Microsoft Excel 2013 in order to obtain a picture of the state of the data in the form of average values, variances, standard deviations, maximum values and minimum values. The results of the analysis were also presented in the form of diagrams. After completing the descriptive analysis, statistical analysis is carried out followed by inferential statistical analysis to test the seven hypotheses that have been formulated.

Student mathematics learning outcomes for each group that have been analysed: students who are taught with an open-ended learning approach, students who are taught with a direct learning approach, divergent thinking patterns, convergent thinking patterns, students who are taught with an *open-ended* approach that has a pattern of divergent thinking, students who are taught with *open-ended* approaches that have convergent thinking patterns, students who are taught with direct learning approaches that have divergent thinking patterns and students who are

taught with direct learning approaches that have convergent thinking patterns are presented in Table 1 below.

Table 1: Descriptive Student Mathematics Learning Outcomes

	Treatment Variables (A)	**Approach *Open Ended* (A_1)**		**Direct Learning Approach (A_2)**		**Total**	
Moderator Variables (B)							
Divergent Thinking Patterns (B_1)		n	16.00	n	17.00	n	33.00
		Average	81.88	Average	63.33	Average	72.32
		Variance	50.32	Variance	95.83	Variance	160.06
		Stdv.	7.09	Stdv.	9.79	Stdv.	12.65
		Max	93.33	Max	76.67	Max	93.33
		Min.	73.33	Min.	46.67	Min.	46.67
Convergent Thinking Patterns (B_2)		n	15.00	n	16.00	n	31.00
		Average	69.56	Average	63.75	Average	66.56
		Variance	120.42	Variance	115.37	Variance	122.58
		Stdv.	10.97	Stdv.	10.74	Stdv.	11.07
		Max	90: 00	Max	80: 00	Max	90.00
		Min.	56.67	Min.	50.00	Min.	50.00
Total		n	31.00	n	33.00		
		Average	75.91	Average	63.54		
		Variance	120.53	Variance	102.04		
		Stdv.	10.98	Stdv.	10.10		
		Max	93.33	Max	80.00		
		Min.	56.67	Min.	46.67		

Hypothesis Testing

Hypotheses tested in this study are (1) The average student learning outcomes in mathematics taught with the open ended approach is higher than the average student learning outcomes in mathematics taught using the direct learning approach, (2) Average results learning mathematics students have divergent thinking patterns higher than the average mathematics learning outcomes of students who have convergent thinking patterns, (3) There is an influence of interaction between learning approaches and thinking patterns on student mathematics learning outcomes, (4) Average learning outcomes Mathematics students who have divergent thinking patterns that are taught with the open ended approach are higher than the average mathematics learning outcomes of students who have thinking patterns that are learned by the direct learning approach.

Hypothesis testing in this study was conducted using two-way ANAVA. The ANAVA test calculation results are presented in table 2 below:

Table 2: Summary of Test Results ANOVA

VarianceSource	**JK**	**db**		**F_{count}**	**F_{table} α = 0:05**	
Mechanical Approach 2449,2912449.2915 25,761		1		(A)	4,000	
Thinking Patterns 531,077531.07707 5,586		1		(B)	4,000	
interactions 645,337645.33748		1	(AB)	6,787	4,000	
InGroup	5704,676	60	95,077932			
Total Reduced	9330,382	63				

Discussion

Student Mathematics Learning Outcomes Learned by PBL Model (A_1) and Learned by Direct Learning Model (A_2)

The results of descriptive analysis in this study can be interpreted as student mathematics learning outcomes when taught by the open-ended learning approach (A_1) have an average value of 75.91 with a variance of 120.23, while the mathematics learning outcomes of students who are taught with the direct learning approach (A_2) have an average value of 63.54 with a variance of 102.04. These results indicate the average value of student mathematics learning outcomes taught by the open-ended learning approach (A_1) is higher than the average value of student mathematics learning outcomes who are taught by the direct learning approach (A_2).

Becker & Shimada in Clarkson et al., (2019: 172) explain "*The open characteristic of the problem stimulated children to produce various solutions and to pay attention to mathematical structures embedded in those solutions. It later became a teaching method to develop mathematical thinking*", the nature or characteristics of *open-ended* problems will encourage students to produce various problem solving scenarios by paying attention to the embedded mathematical structure while problem solving, so that the teaching approach motivates students to develop their own way of thinking in mathematics, while Clarkson et al., (2019: 181) states that: " *Using socially open-ended problems offers such an opportunity, where students are placed in a context to develop mathematical models associated with their social values, and also to discuss the possibilities of different models and social values ".*

Socially, *open-ended* problems can provide opportunities for students to be placed in the context of developing mathematical models that require discussion of social values so that the possibility of different social models and values for students are explored. Inprasitha et al. (2015: 187) explain that "*Mathematical activities generated by open-ended problems are very rich and subtle, enabling teachers to evaluate students' higher-order-thinking skills*", activities or activities in mathematics resulting from *open-ended* problems that are very rich creatively, allowing teachers to evaluate student skills in higher-order thinking. This is consistent with the theory developed by Toh & Berinderjeet (2016: 136) which explains "*The open-ended approach was also a pedagogical strategy that intended to foster creative mathematics actions that arouse the pupils' curiosity when solving the problems*". The *open-ended* approach is also a pedagogical strategy intended to foster creative mathematical actions that will arouse student curiosity when solving a problem.

Mathematical Learning Outcomes of Students Who Have Divergent Thinking Patterns (B1) and Convergent Thinking Patterns (B2)

Mathematical learning outcomes of students who have divergent thinking patterns (B_1) have an average value of 81.88 with a variance of 50.32, while the mathematics learning outcomes of students who have convergent (B_2) has an average value of 63.33 with a variance of 95.83. The average value of mathematics learning outcomes of students who have divergent thinking patterns (B_1) is higher than the average value of mathematics learning outcomes of students who have convergent thinking patterns (B_2). This is consistent with the findings of Puccio et al. (2007: 43):

"When you come up with only one pathway forward to a situation, this does not allow for any choices, and without choices, you power is limited - you are forced to accept your lot. When you are able to generate two options, you create a choice, but often these choices are black and white or good and bad. Having two options is not much better than having one. You are forced to pursue one or the other. You enhance your power through the generation of many

diverse and original options. Leaders who have excellent divergent thinking skills empower themselves and others because of the greater number of choices they have, the more likely they are to be successful"

When students are faced with a problem that offers no choices because of limited options in solution, they are forced to accept fate as it is. Further, when students have two choices, this is not very beneficial when compared to just one choice because two choices often involve either a good / bad solution. Teachers who have divergent thinking patterns will strengthen themselves and students so as to create more choices for students and in the end, students are more likely to be successful in dealing with problems where there are diverse choices. Kerr (2009: 252) states that: "*More formally, divergent thinking allows the objective to assess the creative potential. Thus it can be used as either a means for exercising the ideational skills that are associated with creative thinking or used as a psychometric measure to estimate the potential for creative problem solving"*. More clearly, divergent thinking patterns allow the goal to assess creative potential to be better. Thus it can be used as a means to practice ideation skills related to creative thinking or can be used as a measurement to estimate creative problem solving, especially in mathematics learning.

Interaction between Learning Approach and Thinking Patterns on the Result of Math

Testing inferential statistics used the ANOVA two pathways, the source of variance line interaction AXB obtained value of F = 6.79 F (0,05), (1.60) = 4:01 (H_0 rejected), which means that there are significant interaction effect between learning approaches and thinking patterns on student mathematics learning outcomes. This explains that students who are taught with an *open-ended* learning (student-centred) approach, where the teacher acts as a facilitator, can achieve higher results in mathematics compared to students who learn with a direct learning approach (teacher-centred). Way & Beadron (2003: 157) explain "*Children with different learning needs and learning styles, given access to computers, open-ended software (eg Microworlds) and simple problems, often challenge themselves with more and more complex tasks"*. Students with different learning needs and learning styles, if given access to a computer, *open-ended software* (eg Microworlds) and simple problems, will often challenge themselves with more complex tasks. Furthermore Bostrom and Lassen (2006: 179), state that the learning style approach must be based on teaching methods that are in accordance with each student's learning style preferences. This learning style approach also insists that students must initially be instructed according to the method that best suits their needs.

Student Mathematics Learning Outcomes Learned with the Open-ended Learning Approach and Direct Learning Approach to Students Who Have Divergent Thinking Patterns (A_1B_1, A_2B_1)

Descriptive statistical calculations for student mathematics learning outcomes, where teaching and learning is framed through open-ended learning approaches for students who have divergent thinking patterns (A_1B_1) can obtain an average value of 81.88 and a variance of 50.32 while the mathematics learning outcomes of students who are taught with a direct learning approach and have divergent thinking patterns (A_2B_1) can obtain an average value mean 63.33 with a variance of 95.83. The average value of student mathematics learning outcomes taught by the open-ended learning approach, compared to students who have divergent thinking patterns (A_1B_1) is higher than the mathematics learning outcomes of students who are taught by direct learning approaches and who have divergent thinking patterns (A_2B_1).

The results of the inferential statistical test which used the Sceffe t test with the acquisition of the value of $t_{arithmetic} = 5.46$ $t_{table\ (0.05.31)} = 1.70$, which means the mathematics learning outcomes of students who are taught with an *open-ended* learning approach with divergent thinking patterns experience higher mathematical outcomes than students who are taught with the direct learning approach and who think divergently. This is consistent with the theory developed by Banks (2012: 117) that:

Divergent open-ended questioning approach is a type of informal assessment that is consistent with a student-centred approach to mathematics instruction. Open-ended, divergent questioning may be viewed from different points of view and only one right answer.

Divergent and question and answer approaches that *open-ended* are informal types of assessment with student-centred approaches to teaching mathematics. *The open-ended* and divergent problems can be seen from a different angle and do not have one correct answer. Furthermore, the results of research by Fauzi, A., Siti BW and Masrukan. (2018: 16) concluded that (1) Arithmetic learning tools with the developed RME approach are valid for use based on expert judgment, according to the results of small class and large class tests, (2) numerical learning tools with the RME approach are developed effectively. This is indicated by (a) the average value of evaluating classroom communication skills using 73.42 ($\mu > 70$) and 76.6% ($\pi > 75\%$) of classical completeness; (B) the average level of the class using the mathematics learning tool application with the RME approach based on open problems (73.42) is greater than the class not using the mathematics learning tool application with the RME approach based on the open-ended problem (64.57) and (c) from the regression test obtained $t_{count} = 2012) > t_{table} = (1.998)$.

In contrast to students who have divergent thinking patterns, when learning is centred on the teacher, students have more confidence when the teacher directs the learning. Thus it is difficult for such students to be creative and develop themselves as problem solvers because it is the teacher who masters the course of learning. This is consistent with the theory developed by Reys et al. (2019: 72):

"In direct instruction lesson the teacher plays a more central role in directing the instruction. This method is appropriate when the teacher wants to communicate specific knowledge, to introduce new vocabulary or to teach specific procedures. In direct instruction lesson, the teacher exercises more control and the lesson generally has a tighter focus.

In direct learning, the teacher plays a more central role. This method is suitable if the teacher wants to communicate certain sciences, introduce new vocabulary or to teach specific procedures to students. In direct learning, the teacher exercises more control during the process.

Conclusion

1. Overall in this study it was found that there was a significant influence from both the *open-ended* learning approach and the direct learning approach to student mathematics learning outcomes and that the learning outcomes of students who are taught with the open-ended learning approach are higher than the results of learning mathematics students who are taught with the direct learning approach.
2. There is a significant influence of thinking patterns on student mathematics learning outcomes. The results of this study indicate that mathematics learning outcomes of students who have divergent thinking patterns are higher than mathematics learning outcomes of students who have convergent thinking patterns.
3. There is an interaction effect between the learning approach and thinking patterns on student mathematics learning outcomes.
4. Mathematical learning outcomes of students who have convergent thinking patterns taught with the open-ended learning approach are significantly higher than mathematics learning outcomes of students who have convergent thinking patterns who are taught with the direct learning approach.

REFERENCES

Clarkson, P., Wee T.S. dan Jeong S.P. (2019). *Values and Valuing in Mathematics Education: Scanning and Scoping the Teritory*, Switzerland: Springer Open.

Dweck, Carol S. (2006). Mindset: *The New Psychology of Success*. New York: Ballantine and colophon are registered trademarks of Random House, Inc.

Bostrom, L. & Liv M.L. (2006). Learning Style and Student Self-Assessment Skill, *Education + Training: Leaning Styles in Education and Training*, 48(2/3):178-189.

Faridah Nenden, Isroldatun, Aeni Ani Nur (2016). *Pendekatan Open-Ended Untuk Meningkatkan Kemampuan Berpikir Kreatif Matematis Dan Kepercayaan Diri Siswa*. *Jurnal Pena Ilmiah*: 1(1)

Fauzi, A., Siti B. W. Dan Masrukan (2018). Math Learning with Realistic Mathematics Education Approach (RME) Based on Open Source - Ended to Improve Mathematic Communication, *Journal of Primary Education*, 7(1):16.

Inprasitha, M. (2006). zsOpen-Ended Approach and Teacher Education, *Tsukuba Journal of Educational Study in Mathmatics*, 25:176.

Inprasitha, M., Masami I., Patsy W.I. dan Ban H.Y. (2015). *Lesson Study: Challenges in Mathematics Education*, Singapore: World Scientifc Publishing.

Kukkonen, Harri Oinas, Netta Iivari Kari Kuulti, Anssi Öörni Mikko Rajanen (2015). (Eds.): *Nordic Contributions in is Research*. New York, London: Springer International Publishing Switzerland.

Kerr, B. (2009). *Encyclopedia of Giftedness, Creativity, and Talent*. Volume 1. California: Sage Publications.

Nggili , Ricky Arnold (2015). *Belajar Any Where*. *Learining to Know. Learning to Do. Learning to Live Together and Learning to Be.* Guepedia. com Penerbit Online.

McEwen, Irene R. (1995). *Occupational and Physical Therapy in Educational Environments*. New York . London: Printed in the United States of America. The Haworth Press, Inc.

Marbach-Ad, Gili, Laura C. Egan, Katerina V. Thompson. (2015). *A Discipline - Based Teaching And Learning Center : A Model for Professional Development*. Pt: Springer International Publishing Switzerland.

Matusitz, Jonathan. (2015). *Symbolism in Terrorism Motivation, Communication, and Behaviour*. Lanham, Boulder, New York, London: Rowman & Littlefield.

Puccio, G.J., Mary C.M. dan Marie M. (2007), Creative Leadership: *Skills That Drive Change*, California: Sage Publications.

Siddiqui, Mujibul Hasan. (2008). *Educatonal Psychology*. New Delhi: Published by S.B. Nangia A P H Publishing Corporation.

Tammy, Robert J., Heflebower, Marzano. (2012). *Teaching & Assessing 21 st Century Skills*. *The Classroom Strategies Series*. Amerika Serikat: 555 North Morton Street Bloomington, IN 47404 888.849.0851 FAX: 866.801.1447.

Toh, P.C. dan Berinderjeet K. (2016). *Developing 21st Century Compentences in The Mathematics Classroom*, Singapore: World Scientifc Publishing.

Wayne, W. (2014). Psychology : *Themes and Variations, Briefer Edition,* 8th Edition. Content Technologies, Inc. All rights reserved.

Way, J. dan Toni, B., 2003, *ICT and Primary Mathematics*, Philadelphia: Open University Press.

Woolfolk, Anita & Kay Margetts, (2013).. *Educational Psychology Australian Edition*. 3rd Edition. Australia : Pearson Australia (a division of Pearson Australia Group Pty Ltd.

Zbarskaya O. (2006). *Brainstorm! Practice for Unrestricted Imagination and Original Thought*. Santa Barbara, California, Denver Colorado: QPRAEGER An Imprint of ABC-CLIO, LLC, 2017.