The Effect of Open-Ended Learning Approaches and Thinking Patterns on Students' Learning Outcomes in Mathematics

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This study aims to determine the effect of open ended learning approaches and thinking patterns on student learning outcomes in Mathematics. The research method used in this study is an experimental method involving two variables, namely 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 show that: 1) there is a significant influence between the open-ended learning approach and the direct learning approach to student learning outcomes in Mathematics. 2) There is a significant influence of thinking patterns on student learning outcomes in Mathematics. The results indicate that learning outcomes of students in Mathematics who have divergent thinking patterns are higher than the learning outcomes of students who have convergent thinking patterns; 3) There is an interaction effect between the learning approach and thinking patterns on student learning outcomes in Mathematics; 4) Learning outcomes of students in Mathematics who have convergent thinking patterns taught with the open-ended learning approach are significantly greater than learning outcomes of students in Mathematics of students who have convergent thinking patterns and are taught with the direct learning approach.

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

Introduction

Learning in schools must be pursued continuously, in order to develop and build students' abilities so that the problems they face today can be overcome and they are able to compete in society. In solving mathematical problems, students should try to use high-level thinking patterns, namely divergent thinking patterns. This pattern of thinking refers to open-ended problems / which students can solve in one more way.

In the process of learning Mathematics, teachers are required to design learning activities by considering conditions related to the learning process, namely conditions that are fun and characteristic of students. Students are expected to have a correct understanding of Mathematics, as Mathematics does not only consist of numbers, the use of symbols, drawing various shapes, but students must also understand how much Mathematics contributes to other Sciences and everyday life. In fact, students still show their dislike of learning Mathematics, because many consider it a boring subject.

Through learning 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, encourage students, look for ideas and arrange concepts that are easy to understand, so students will not experience difficulties in understanding the subject matter. However, in reality student learning outcomes are still considered low in Mathematics when compared with the learning completeness criteria set by schools.

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 of students' semester exams are 65.75 and 69.85. These values are still low when compared to the Minimum Completion Criteria (KKM) set by schools by 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) explains 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 include 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 sources directly involved in improving student learning outcomes in Mathematics, so that the teacher can determine the right approach to the material to be taught, conducts research that basically improves learning in the classroom. However, the reality of student learning outcomes in Mathematics has not been able to be improved significantly . This is caused by the tendencies of Mathematics teachers in SMA 4 Kendari who always use the direct learning approach, without trying other approaches that can activate students.

Amongst other research findings, Faridah (2016: 1061) shows that, (1) an increase in the ability to think creatively in approaching Mathematics to *open-ended* questions is categorised medium, (2) increase the ability to think creatively in Mathematics with the open-ended approach being better than conventional approaches, 3) increase student confidence with the open-ended approach which has a moderate category gain, (4) increase student confidence with the open-ended approach preferable to the conventional approach. Sulianto's research results (2011: 38-39) conclude that (1) students can achieve mastery of learning in contextual learning classes with open-ended approach (2) the ability to solve problems by students who learn Mathematics using contextual learning with the open-ended approach perform better than learning through expository learning on triangular material. Reasoning students can achieve medium criteria in contextual learning classes using open-ended approach .

The two research results above show that the open-ended learning approach always shows an increase in learning outcomes, so the teacher's role is to plan learning activities that involves active and creative student learning. This learning approach allows students to communicate with their peers, complete their assignments / exercises given in groups, allow students try to express their opinions, , so 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 walk to visit study groups using media and books / teaching materials which can improve learning outcomes for students . This kind of learning approach clearly requires students to think creatively (divergent thinking).

The application of the approach in learning is very important because it can persuade students to think creatively, develop knowledge systematically, be skilled at working on problems and always be scientific, and build cohesion in learning. The open-ended approach to learning in Mathematics indicates how students can identify the problems they face, understand concepts and facts, generalise and find solutions. The teacher should create a learning approach as described above, so that students are accustomed to learning by thinking creatively. However,

in reality the teacher is still subject to the direct learning approach, so that students are quickly bored and engage in passive learning because they always 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, we will examine learning theories. Based on the views of educational psychologists, specifically Vygotsky quoted by Siddiqui (2008: 7) :

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 end acculturated through social interactions within a community of practice. "

According to this view, changes in student skills and attitudes are approached through social interaction in the practice community, which means that in the learning process students get to know each other through co=operation and find their own problems about the material that the teacher provides. The material presented will bring about changes in student behaviour, namely the learning progress includes frequently asking questions, completing assignments, doing exercises on the board both individually and in groups.

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

"*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 serious academic work , , and implementing appropriate learning strategies in the process.*

Learning should provide motivation to students , and apply appropriate learning approaches in the process.

Based on the description of the above three opinions , learning is a change in students' active

behaviour towards positive progress, both individually and in groups. Effective stimulus, response and reinforcement in learning will affect students' thinking patterns, so learning can be meaningful. Learning carried out the good motivation to provide a conducive learning atmosphere, can persuade students to learn without coercion. Thus. learning is a change in behaviour towards progress accompanied by motivation through teacher guidance, and is completed without coercion so that students will obtain maximum learning results.

Learning outcomes are highly beneficial for students, who with a little guidance can be trained to use the expected learning outcomes as a target of student achievement. Why use learning outcomes? This question is explained by the following points: (1) a statement of good learning outcomes helps students to identify their own targets, and works systematically to demonstrate student achievement against expected targets, (2) learning outcomes needed by quality assurance agencies, 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 achieved. McEwen (1995: 55) comments about learning outcomes :

If a particular student's priority learning outcome 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 "

If the learning outcomes are prioritised to certain students focused on Communication, Social, and Self-preparation in order to receive subject matter, while additional learning outcomes may include other items from the same region and learning outcomes in the Curriculum, Mathematics, and the number of additional learning outcomes will vary for each student based on their individual needs and characteristics.

Some of the factors that determine student learning outcomes are understanding, communication teachers transfer knowledge, social aspects when students are able to work with friends and teachers when experiencing difficulties, and preparation as a discipline factor that must be possessed by each student in order to receive lessons or assignments . Thus, these three factors are very important in learning to achieve maximum results.

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

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. "

When planning lessons, the teacher must take ten minutes by considering where the he or she will complete the teaching. In order to decide how to teach a lesson, the teacher must first determine what students will understand and can complete as a result of teaching. The lesson will focus on determining student learning outcomes. Some frameworks, learning outcomes are referred to as expectations, goals, objectives, benchmarks or standards. In this text, the term learning outcomes is used to include measurable and non-measurable results. Measurable learning outcomes are all activities planned by the teacher that begin with the introduction of learning and end with assessment. The assessment is used as a benchmark about student success, even learning outcomes can be said to be expectations and goals in learning.

Learning Approach

All l learning has an approach . A learning approach can be interpreted as a person's point of view of the learning process, which refers to the occurrence of a process that is very general in nature, in which it embodies, inspires, strengthens, and underlies learning methods with a certain theoretical scope. Viewed from this perspective, there are two types of approaches, namely: (1) a student-centred learning approach and (2) a teacher-centred learning approach. Student-centred learning approaches, activities are more widely used by students than 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

Student experiences in teaching approaches can be creative when schools have strong evidence that certain teaching approaches will improve student learning outcomes. Teaching

effective and successfully implemented teaching practices requires commitment and time which can be a barrier, meaning that a student-centred learning approach takes a long time, while the teacher-centred learning approach is arranged by the teacher in such a way that the learning takes place systematically, and there is appropriate time to complete learning activities. Sonnheim (2015: 32) states t:

"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, progress in student learning must be adjusted as the situation is possibly 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 concludes that the andragogic approach may not define the uniqueness of adult learning, but instead provides a set of guidelines for designing teaching that is adapted to the approach (pedagogic or andragogic. A professional teacher must know the conditions of students, whether the learning fits with the pedagogic or andragogic approach, as both approaches are equally important, namely to oversee the attitudes, knowledge and skills of students.

Thinking Patterns

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

Divergent Thinking Patterns

Formal education is intended for students who have normal abilities (physically fit and mentally healthy), whereas special education is provided for abnormal students . Therefore, normal students are expected to have creative thoughts in 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 seems to have an important role in the process and context of problem solving. Different thoughts produce a variety of choices for problem solving . 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 to result in problem solving, for example if a student needs to solve a problem to get a ride home from athletic training. The student uses divergent thinking patterns so as to produce a number of solutions. When going home with a friend, a range of solutions are available, taking a bus, walking or riding a bicycle. This shows that if students use divergent calculated patterns, various solutions will be available in problem solving .

Divergent thinking refers to 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 (i.e. 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. Divergent thinking enables students to analyse 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 Psychology) 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 responses to 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 emphasised that divergent thinking involves more complex EEG due to larger number neural assemblies. Creative ideas are associated with higher EEG alpha activity and a stronger task-related

alpha synchronisation 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 responding to questions that are considered more standard. Divergent thinking patterns are rarely used by students, because being accustomed to the learning prepared by the teacher always leads to a direct learning approach, so that participant 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 a range of problem solving possibilities . This is often used in conjunction with convergent thinking, which follows a series of logical steps to achieve problem solving, which in some cases is correct .

Divergent thinking usually occurs spontaneously and is free flowing, so that many ideas are generated by its cognitive method. Therefore, this is done by students who are accustomed to the teacher using an open-ended learning approach , so divergent thinking will be used by those who require diverse answers. In this case, human thinking patterns are related to brain function consisting of two parts, namely the left and right hemispheres.

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 it controls the ability to use and manage information. It is known that the brain consists of two sides, namely the right and left sides, and the nervous system is connected with the brain cross section. The left brain controls the right body, and the right brain controls the left body. Both sides work separately, so if a person has an accident or is hit on the left side of his or her brain, the right part of his or 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 subject production was convergent when they remained within the domain of the idea and only applied incremental changes.*"

Convergent thinking applies what is known and stays within the boundary learned boundary. 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, student tendency to be consistent with what they have received. Furthermore, as Lang (1994) states:

Convergent thinking synthesises ideas . The former may be considered to be pure creative effort, but the latter involves the processes of predicting how patterns will function and then evaluating or recognising the   utility of those patterns. Convergent thinking a the truly creative act in designing since it involves identifying not only new patterns 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 recognising the pattern satisfaction . Convergent thinking is a creative act in designing something as it involves identifying not only new patterns but also having uses in terms of problems faced by students. Therefore, convergent mindset is also important to have a statistical understanding of students' knowledge in solving problems.

Research Methodology

The research method used in this study is an experimental involving two variables, that is 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:

1. **Bound**
Variable The dependent variable intended in this study is the result of a Mathematical learning test for class X science students of SMA Negeri 4 Kendari, after receiving a learning process with eight meetings.

2. **Independent**
Variables The independent variables intended in this study are treatment variables, namely 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 divergent thinking patterns scores are higher than convergent thought pattern scores, the student meaning is grouped into groups of students who have divergent thinking patterns. If the convergent thinking pattern score is higher than the divergent thinking pattern score, then these students are classified into groups having convergent thinking patterns. So, in this study the test function is to place students in groups that have divergent thinking patterns and groups of students with convergent thinking patterns.

This research was conducted at SMA Negeri 4 Kendari, Southeast Sulawesi in the semester 2018/2019, which began from December 2018 to April 2019. The research period was adjusted to the schedule of learning implementation at the school. The research population consists of 494 high school students of Kendari, spread over 13 parallel classes with each class having 38 people.

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

a. The study sample chose two random classes . The Selection of random sampling consideration of student placement of class X IPA for each class is done by not considering the capabilities of students, in which case the ability of the class X IPA for each class is relatively similar, 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 is taught with a direct learning (expository) approach.
c. The grouping of students into divergent and convergent thinking patterns completed based on the results of tests using divergent thinking instruments and convergent thinking patterns.

The determination of students into groups of divergent and convergent thinking patterns is based on test results. If the value of divergent thinking patterns is higher than the value of convergent thinking patterns in the test results obtained by students,, then they are grouped into divergent thinking patterns, conversely if the value of convergent thinking patterns is higher than the value of divergent thinking patterns in the test results obtained by students ,

they are grouped into convergent thinking patterns .

Research Results and Discussion

The research results consist of raw data from students' learning outcomes in Mathematics which are taught using the open-ended (A$_1$) and direct learning approaches (A$_2$). Furthermore, both approaches involve students who have divergent thinking patterns (B$_1$) and those who have convergent thinking patterns (B$_2$). Students' learned scores in Mathematics 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 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 students are grouped into students who have a convergent mindset.

Based on the grouping, student learning outcomes in Mathematics can be divided into: (a) Mathematical learning outcomes of students who have divergent thinking patterns are taught with an open-ended approach (A$_1$B$_1$), (b) Learning outcomes of students in Mathematics who have convergent thinking patterns are taught with the divergent approach (A$_1$B$_2$),(c). The results of students' Mathematical learning which has a pattern of divergent thinking learned with a straight learning approach (A$_2$B$_1$),and (d) the results of students' Mathematics learning which has a pattern of convergent thinking dibelajarkan with the direct learning approach (A$_2$B$_2$).

Grouping the value of students' Mathematical learning outcomes that have been obtained, analysed with descriptive statistics using Microsoft Excel 2013 in order to obtain a picture of the state of data in the form of average values, variances, standard deviations, maximum values and minimum values. The results of the analysis are also presented in the form of diagrams. After completion, descriptive statistical analysis is carried out followed by inferential statistical analysis to test the seven hypotheses that have been formulated.

For each group that has been analysed, student learning outcomes in Mathematics namely 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 which has a pattern of divergent thinking , students who are taught with an open-ended approach who 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

Moderator Variables (B) / Treatment Variables (A)	Approach *Open Ended* (A₁)		Direct Learning Approach (A₂)		Total	
Divergent Thinking Patterns (B₁)	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 (B₂)	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

The hypotheses tested in this study include (1) The average student learning outcomes in mathematics taught with open-ended approach is higher than the average student learning outcomes in Mathematics taught using the direct learning approach, (2) Average learning results of Mathematics students who have divergent thinking patterns are higher than the average Mathematic learning outcomes of students who have convergent thinking patterns, (3) There is an influence of interaction between learning approaches and thinking patterns on student learning outcomes in Mathematics , (4) Average learning outcomes of Mathematic students who have divergent thinking patterns who are taught with open-ended approach *open ended* are higher than the average mathematical 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 ANOVA. The ANOVA test calculation results are presented in table 2 below:

Table 2: Summary of ANOVA Test Results

Variance Source	JK	db		F_{count}	F_{table} $\alpha = 0:05$	
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 Learning Outcomes in Mathematics Learned by PBL Model (A₁) and Direct Learning Model (A₂)

The results of this study's descriptive analysis can explain that students' learning outcomes in Mathematics taught by the open-ended learning approach (A$_1$) have an average value of 75.91 with a variance of 120.23, while the learning outcomes of students in Mathematics 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 that the average value of students' learning outcome in Mathematics taught by the open-ended learning approach (A$_1$) is higher than the average value of those 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 by paying attention to embedded Mathematical structure with problem solving, so that the teaching approach can motivate students in finally developing their way of thinking in Mathematics. At the same time, Clarkson et al., (2019: 181) state : "*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 discuss the possibilities of different models and social values,*" open-ended social problems can provide opportunities for students to be placed in the context of developing Mathematical models with social values to be discussed. 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 *are* very rich in creativity, thus allowing teachers to evaluate students' higher-order thinking skills. This is in line with the theory developed by Toh & Berinderjeet (2016: 136) which explains that "*The open-ended approach was also a pedagogical strategy that intended to foster creative Mathematical actions that arouse the pupils' curiosity when solving problems,*" the open-ended approach is also a pedagogical strategy intended to foster creative Mathematical actions that will arouse students' 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 Mathematical learning outcomes of students who have convergent thinking patterns (B_2) have an average value of 63.33 with a variance of 95.83. The average value of Mathematical learning outcomes of students who have divergent thinking patterns (B_1) is higher than the average value of Mathematical learning outcomes of students who have convergent thinking patterns (B_2). This is consistent with the theory developed by 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, your 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 the greater number of choices they have, the more likely they are to be successful."

When students are faced with a problem where there is no choice to solve it because of limited choices students are forced to accept their fate . However, when students have two choices, it is not very beneficial when compared to only having one choice because two choices are often mean good or bad . Students are forced to choose from one of two choices. A teacher may provide more diverse choices than the initial choice of two . Teachers who have divergent thinking patterns will strengthen themselves and students so as to create more choices for students and in the end it is more likely that students are successful in dealing with problems they are presented with diverse choices. Kerr (2009: 252) states : "*More formal, 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.*" Therefore, divergent thinking patterns allow the goal of assessing creative potential to be improved. Thus, it can be used as a means to practise idea skills related to creative thinking or as a measurement to estimate creative problem solving, especially in Mathematical learning.

Interaction between Learning Approach and Thinking Patterns related to Mathematical results

Test inferential statistics used in the ANOVA include 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 is a significant interaction effect between learning approaches and thinking patterns on student learning outcomes in Mathematics. This explains that students being taught with an open-ended learning approach (student *open-open-* centred) and teachers acting as facilitators can provide high results regarding student achievement in Mathematics, compared to students who learn with a direct learning approach (teacher-centred) which provides low learning outcomes. Way & Beadron (2003: 157) explain "*Children with different learning needs and learning styles, given access to computers, open-ended software (e.g. Microworlds) and simple problems, often challenge themselves with more and more complex tasks.*" Furthermore, Bostrom and Lassen (2006: 179) state that the results of the study show that the learning style approach is based on teaching methods that are in accordance with each student's learning style preferences. The learning style approach also shows that students must initially be instructed according to the method that best suits their needs.

Students' Mathematical Learning Outcomes Taught with the Open-ended and Direct Learning Approaches to Students Who Have Divergent Thinking Patterns (A_1B_1, A_2B_1)

Descriptive statistical calculations for students' Mathematical learning outcomes taught by the open-ended learning approach of 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 mathematical learning outcomes of students who are taught with a direct learning approach to students who have divergent thinking patterns (A_2B_1) can obtain an average value mean 63.33 with a variance of 95.83. Based on the average value of students' Mathematical learning outcomes taught by the open-ended learning approach, the learning outcomes of students who have divergent thinking patterns (A_1B_1) is higher than the Mathematical learning outcomes of students who are taught by direct learning approaches (A_2B_1).

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

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

Divergent question and open-ended answer approaches are informal types of assessment with student-centred approaches to teaching Mathematics. *Open-ended questions* and divergent approached 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) conclude that (1) Arithmetic learning tools with 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 Mathematical 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 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 but engage in teacher-centred learning, students have more confidence in their learning . Thus, it is difficult for students to be creative and develop because the teacher masters the course of learning. This is consistent with the theory developed by Reys et al. (2019: 72) :

"In direct instruction lessons, 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 lessons, the teacher exercises more control and the lesson generally has a tighter focus."

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

Conclusion

1. Overall, this study found that there is a significant influence between the *open-ended* learning approach and the direct learning approach to student's learning outcomes in Mathematics. The two learning approaches that are used show that the learning outcomes of students who are taught with the open-ended learning approach   are higher than the results of Mathematics students who are taught with the direct learning approach.
2. There is a significant influence of thinking patterns on students' learning outcomes in Mathematics . The results of this study indicate that the Mathematical learning outcomes of students who have divergent thinking patterns are higher than the Mathematics learning outcomes of those who have convergent thinking patterns.
3. There is an interaction effect between the learning approach and thinking patterns of students' learning outcomes in Mathematics .
4. Mathematical learning outcomes of students who have convergent thinking patterns taught with open-ended learning approach are significantly higher than the Mathematical learning outcomes of students with convergent thinking patterns who are taught with the direct learning approach.

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