

# Literature Review: Mathematical Creative Thinking Ability, and Students' Self Regulated Learning to Use an Open Ended Approach

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## ABSTRACT

The ability to think creatively and self-regulated learning is very important in learning mathematics, in order to train students to develop their creativity. But in reality, mathematics learning that is currently happening has not been able to develop mathematical creative thinking skills and **increase students' self-regulated learning**. The purpose of this study is to examine the relationship between the open-ended approach and the ability to think creative mathematically and self-regulated learning and how to implement it in school in the perspective of literature review. The type of research used is literature review, where articles are collected using search engines such as EBSCO, Science direct, and Scopus. Based on the articles collected, the results show that: 1. Mathematics learning to use an open-ended approach has an effect on **increasing students' creative thinking skills and self-regulated learning**, 2. The open-ended approach is **higher in increasing students' creative thinking abilities compared to using a conventional approach**, 3. The open-ended approach to learning has the following steps: a) the teacher organizes students in learning activities; b) the teacher exposes students to open problems; c) the teacher guides and directs students in solving problems with various solutions and various answers; d) students present their work and compare with the work of other students in front of the class; and e) students conclude the subject matter, which is guided by the teacher. 4. To apply open-ended learning, it is necessary to prepare learning that requires high creativity for a teacher.

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## 1. INTRODUCTION

Creative thinking skills in math learning are essential to foster a higher level of thinking for students. According to Winkel creative thinking is a thought that produces creative ideas or new, original, independent and imaginative ways of thinking (Agustina & Noor, 2016). Ruseffendi says creative humans are human beings who are able to benefit others not just for themselves (Meiliana & Aripin, 2019). This shows that developing creative thinking skills towards students is very important to train them to use their creativity early on and well formed into the future.

In addition to developing creative thinking skills, students must also *have Self-Regulated Learning* that trains students to learn independently. This is in line with research that says that *self-regulated learning* is a learning strategy that is able to make students independent in learning and improve their academic achievement (Dinata *et al.*, 2016). Students who study self-learning means that they are not self-learning, *but that high self-regulated learning* can make students achieve their learning goals well.

But the reality is, mathematics learning that occurs today has not been able to optimally develop the ability to think creatively mathematically and *improve the self-regulated -*

*learning* of students. This is reinforced from the results of observations and interviews of writers with teachers in several schools in Marpoyan-Damai sub-district of Pekanbaru city. The results showed that the teacher's learning was too referring to the book, because according to this teacher it was learning that was in accordance with the direction of the 2013 curriculum, but they did not consider whether the designed learning was capable of fostering the ability to think creatively *mathematically and self-regulated learning* students. This is the problem with math learning, math learning that should be able to encourage students to improve their creative thinking and *self-regulated learning* skills but not succeed to the fullest.

The low ability to think creatively mathematically and *self-regulated learning* is not only due to difficult math learning, but also due to other factors such as students themselves, teachers, learning strategies used, and learning environments related to each other (Waluyo, 2018). The factors that can affect students' creative thinking skills and *self-regulated learning* are the need for learning innovation. The innovation can be the application of a learning approach that is able to give students the opportunity to express their ideas and ideas. According to

Sagala teachers are as a source of learning, determinants of learning methods and models, as well as assessors of student learning progress to make learning more effective and efficient to achieve the learning goals themselves (Wanelly & Fauzan, 2020). Therefore, a teacher must have a learning approach that suits the student's condition so that students feel interested in the learning presented by the teacher, thus learning will be able to improve the creative thinking skills of mathematical *and self-regulated learning* students. One of the appropriate learning approaches to addressing the problem of mathematical creative thinking skills and *self-regulated learning* is the *Open-Ended approach*. An approach that gives students the opportunity to gain knowledge, experience, discover, recognize and solve problems with multiple techniques (Zarkasyi, 2015).

Through this paper, the author aims to examine the *open ended approach*, its relationship to Mathematical Creative Thinking ability and *Self-Regulated Learning*, and how it is implemented in the perspective of review *literature*. The benefits of this research are expected to include innovations and guidelines in choosing effective methods for the mathematical learning process.

## 2. RESEARCH METHOD

The method used is library *research*. Literature-based research, which is an international and national literature search

conducted using EBSCO, ScienceDirect, and Proquest/Scopus databases (Priasmoro, 2016). There are several main features that need to be considered in the library study research method: *First*, the author is directly confronted with text/number data. *Second*, library material is interpreted as the second source meaning that the author obtains information from the second party instead of the original from the first party in the field. *Third*, the data obtained is "ready-made" obtained from journal article searches using the keywords "creative thinking ability", "self-regulated learning", and *open ended-approach*. *Fourth*, the library material obtained is not limited to space and time. Data collection techniques are carried out by reviewing several books, literature and other documents that are considered in accordance with the above studies. In this study was conducted by reading, recording and comparing several journals, scientific articles, books, and documents as well as data sources and or other information that is considered relevant to the research then the data is analyzed and summarized in the form of systematic paragraphs and produces conclusions. The electronic search results found are: 35 Journals, 7 proceedings, and 7 research results. Since this study focuses only on analyzing mathematical creative thinking skills and *self-regulated learning* using an *open-ended approach*, 12 manuscripts are selected that are eligible for analysis. The selected manuscript and will be analyzed can be seen in **Table 1**.

**Table 1.** Details of the manuscript to be analyzed

Author (year)	Title of Manuscript	Manuscript Identity
Widya Wanelly dan Ahmad Fauzan (2020)	Pengaruh Pendekatan <i>Open-Ended</i> dan Gaya Belajar Siswa terhadap Kemampuan Berpikir Kreatif Matematis.	Jurnal Basicedu, Vol. 4, No. 3, Hlm. 523-533
Samsul Palah, M. Maulana, dan Ani Nur Aeni (2017)	Pengaruh pendekatan <i>open-ended</i> berstrategi M-RTE terhadap kemampuan berpikir kreatif matematis siswa pada materi persegi panjang	Jurnal Pena Ilmiah, Vol. 2, No. 1, Hlm. 1161-1170.
Egi Agustian, Atep Sujana, dan Yedi Kurniadi (2015)	Pengaruh Pendekatan <i>Open-Ended</i> terhadap Kemampuan Berpikir Kreatif Matematis Siswa Sekolah Dasar Kelas V (2015)	Jurnal Mimbar Sekolah Dasar, Vol. 2, No. 2, Hlm. 234-242.
Ardi waluyo (2018)	Pengaruh Pendekatan <i>Open-Ended</i> terhadap Kemampuan Berpikir Kreatif Siswa Dalam Mata Pelajaran Matematika Di Sekolah Dasar.	Jurnal Pendidikan Sekolah Dasar. Vol. 5, No. 1, Hlm. 105-119.
Ni Pt. Rika Ardiyanti, I Md. Suarjana, Ni Nym. Garminah (2013)	Pengaruh Model Pembelajaran Matematika Berorientasi <i>Open-Ended Problem</i> terhadap Kemampuan Berpikir Kreatif Siswa Pada Mata Pelajaran Matematika Kelas IV SD.	Jurnal Mimbar PGSD UNDIKSILA, Vol. 1, No. 1.
Japemar (2019)	Peningkatan Kompetensi Kognitif Matematika Siswa Menggunakan Pendekatan <i>Open Ended</i> di Kelas X SMA Negeri 1 Ulakan Tapakis.	Jurnal Penelitian Dan Kajian Ilmiah, Vol. 13, No. 11, Hlm. 28-32
Firdaus, Abdur Rahman As'ari, Abd. Qohar (2016)	Meningkatkan Kemampuan Berpikir Kreatif Matematis Siswa SMA Melalui Pembelajaran <i>Open-Ended</i> Pada Materi SPLTV	Jurnal Pendidikan, Vol. 1 No. 2, Bln Februari, Thn 2016, Hal 227–236
Suhandri (2013)	Meningkatkan Kemampuan Berpikir Kreatif Matematis Siswa melalui Pendekatan <i>Open-ended</i> .	Jurnal Gamatika, Vol. 3, No. 2, Hlm. 140-146.
Nenden Faridah, Isro'atun dan Ani Nur Aeni (2016)	Pendekatan <i>Open Ended</i> Untuk Meningkatkan Kemampuan Berfikir Kreatif Matematis Dan Kepercayaan Diri Siswa.	Jurnal Pena Ilmiah, Vol. 1, No. 1, Hal. 1061-1070
Khaspul Khairobi (2017)	Pengaruh Pendekatan <i>Open-Ended</i> Terhadap Kemampuan Komunikasi dan <i>Self Regulated Learning</i> Peserta Didik Kelas IV Mata Pelajaran Ilmu Pengetahuan Alam (IPA) Di MI Ismariah Al-Quraniyyah.	Jurnal Ekp, Vol. 13, No. 3, 1576-1580.
Siti Salamah Br Ginting (2019)	Peningkatan Kemampuan Berpikir Kreatif Matematis dan Kemandirian Belajar Siswa SMP Ar-Rahman Medan Melalui Pembelajaran <i>Open-Ended</i> Berbasis <i>Brain-Gym</i> .	Jurnal AXIOM: Vol. VIII, No. 1, Januari - Juni 2019, P- ISSN : 2087 - 8249, E-ISSN: 2580 - 0450
Suriyani, Hasratuddin, H., & Asmin, A. (2015).	Peningkatan Kemampuan Berpikir Kreatif dan Kemandirian Belajar Siswa MTs Negeri 2 Medan Melalui Pembelajaran Matematika dengan Pendekatan <i>Open-Ended</i> .	Jurnal Tabularasa, Vol.12 No. 3.

## 3. RESULTS AND DISCUSSION

### 3.1 Results

Based on review results, the research design used in the open-

**Table 2.** Percentage Of Research Design

Research Design	Amount	Percentage	Researchers
Eksperimen (Experiment)	9	75%	Widya Wanelly, Ahmad Fauzan (2020), Samsul Palah, M. Maulana, dan Ani Nur Aeni (2017), Egi Agustian, Atep Sujana, dan Yedi Kurniadi (2015), Ni Pt. Rika Ardiyanti, I Md. Suarjana, dan Ni Nym. Garminah (2013), Suhandri (2013), Nenden Faridah, Isro'atun dan Ani Nur Aeni (2016), Khaspul Khairobi (2017), Siti Salamah Br Ginting (2019), Suriyani, Hasratuddin, H., & Asmin, A. (2015).
Class Action Research	2	16,7%	Japemar (2019) dan Firdaus, Abdur Rahman As'ari, Abd. Qohar (2016)
Literature Research	1	8,3%	Ardi waluyo (2018)
	12	100%	

ended approach to mathematics subjects is experimentation, class action research (PTK) and literature. The percentage of use of experimental design, PTK and literature found in the manuscript can be seen in **Table 2**.

Table 2 shows that research that adopts an open-ended approach uses more experimental research design i. e. 9 manuscripts with a percentage of 75%, grade 2 action research scripts with a percentage of 16.7% and literature research 1 manuscript with a percentage of 8.3%. The design of the experiment research is more widely found because the study aims to find out the effect of treatment on controlled conditions (Sugiyono, 2011).

**Table 3.** Education Level that Implements an *Open-Ended Approach*

Education Level	Number of Manuscripts	Percentage	Researchers
SD	7	58,3%	Widya Wanelly , Ahmad Fauzan (2020), Samsul Palah, M. Maulana, dan Ani Nur Aeni (2017), Egi Agustian, Atep Sujana, dan Yedi Kurniadi (2015), Ni Pt. Rika Ardiyanti, I Md. Suarjana, dan Ni Nym. Garminah (2013), Ardi waluyo (2018), Nenden Faridah, Isro'atun dan Ani Nur Aeni (2016), Khaspul Khairobi (2017),
SMP	3	25%	Siti Salamah Br Ginting (2019), Suhandri (2013), Suriyani, Hasratuddin, H., & Asmin, A. (2015).
SMA	2	16,7%	Japemar (2019), Firdaus, Abdur Rahman As'ari, Abd. Qohar (2016),
	12	100%	

Table 3 shows that research into creative thinking skills and self-regulated learning using an open-ended approach is more widely researched in elementary school, namely 7 scripts with a percentage of 58.3%, in junior high school 3 scripts with a percentage of 25% and in high school 2 scripts with a percentage of 16.7%. This shows that the importance of creative thinking and self-regulated learning is established early on in elementary school, but the selection of classes should be more precise because creative thinking is a high level of thinking.

**Table 4.** Summary of Research Results

Authors (year)	Result
Widya Wanelly dan Ahmad Fauzan (2020)	The results of the Creative Thinking Skills Test of grade IV students of SD Kecamatan Lubuk Basung with an open-ended approach are better than students using conventional approaches. Students' creative thinking abilities are auditorial learning styles, visual learning styles, and kinetic learning styles using an open-ended approach better than students using conventional approaches. The results show that the open ended- approach exerts a better influence than conventional approaches in improving students' mathematical creative thinking skills.
Samsul Palah, M. Maulana, dan Ani Nur Aeni (2017)	M-RTE's open-ended strategy approach can have a positive impact on mathematical creative thinking skills. This is seen in the improvement of students' mathematical creative thinking skills in the experiment class. The average pretest score obtained in the experiment class was 33.33 while the average posttest score obtained was 41.11. Thus, an N-gain of 0.10 is obtained. After the average difference test, the results showed that there was an average difference between the pretest and posttest values. Based on this, it can be concluded that the positive influence given M-RTE's open-ended approach to mathematical creative thinking skills occurs significantly.
Egi Agustian, Atep Sujana, dan Yedi Kurniadi (2015)	Both open-ended and conventional approaches can improve the mathematical creative thinking skills of elementary school students on cube and beam materials. But learning using an open-ended approach is better. This can be based on the results of the 3rd hypothesis test by using the Paired Sample T-test. The results of the test received sig(2 tailed) results of 0.000, smaller than the level of significance (0.000 < 0.05), then H0 rejected or H1 accepted, so that from the results of the test it can be known that there is a significant average difference between the results of N-Gain the mathematical thinking skills of students of the experimental group and control on the learning of mathematics with cube volume materials and beams.
Ardi waluyo (2018)	Learning mathematics using an open-ended approach can influence the increasing creative thinking of elementary school students. With an open-ended approach learning is more interesting and fun so that the learning goals will be achieved optimally. The open ended -approach is higher in improving students' creativity thinking abilities than using a conventional approach. To implement open-ended learning, it is necessary to prepare a learning that requires the creativity of a teacher. Therefore, learning mathematics using an open-ended approach is very effective if applied.
Ni Pt. Rika Ardiyanti, I Md. Suarjana, Ni Nym. Garminah (2013)	The results showed there were significant differences in students' creative thinking abilities between the group of students who were learned and the open-ended problem-oriented Mathematics learning model and the group of students who were learned by conventional learning models. The results showed $t_{count} 10.43 > t_{table} 1, 67$ . This significant difference can also be seen from the average score achieved by the group of students learned with the open-ended problem-oriented Mathematics learning model is 46.34 and the average score of the group of students learned by conventional learning model is 35.91. This means that the creative thinking skills of students learned using the open-ended problem-oriented mathematics learning model are better than the creative thinking skills of students who are learned using conventional learning models.
Japemar (2019)	Based on the results of analysis from two cycles of research, there was an increase in the percentage of cognitive competency completion in cycle I by 57.15% increased to 85.71% in cycle II. The increase also occurred in the average student grade of 68.93 to 80.60. Classically the completed learning outcomes of students have achieved a set success of 70%. The increase occurred because of the use of an open ended-approach. Students in learning have a lot of experience to find something to answer problems. Because of these problems that students often experience in daily life. Based on the results of the study obtained the following conclusion: Learning using an open ended-approach can improve the cognitive competency of mathematics students grade X SMA N 1 Ulakan Tapakis. The results of the analysis of research data using the open ended- approach in grade X of SMA Negeri 1 Ulakan Tapakis can be stated cognitive competency of students who achieved a complete percentage of 57.15% in cycle I increased to 80.60% in cycle II.
Firdaus, Abdur Rahman As'ari, Abd. Qohar (2016)	The results of study with the application of open ended-approach learning show that in cycle I has not improved the creative thinking skills of students. Implementation of cycle II the average observation results of teacher and student activity scores of 3.66 and 3.67 are on good criteria, the percentage of final results of the quiz at the end of each study, namely fluency (100%), flexibility (90.33%) and novelty (72.58%), meaning fluency, flexibility, novelty are on the minimum criteria quite creatively. Furthermore, the data of students' creative thinking assessment results are obtained from the final test results of cycle II. Overall students have achieved the minimum criteria quite creatively, which is 25 students with a percentage of success (PK) $\geq 65$ is 80.65 %. Then there are 6 students with a percentage of success (PK) < 65, which is 19.35 %. Based on the determined indicators of success, that the implementation of learning using an open ended-approach in cycle II can already improve students' mathematical creative thinking skills.

### 3.1.2. Education Level Where the Application of Open-Ended Approach

From review results, the open-ended approach is applied to the education level of elementary, junior high and high school. The percentage of open-ended approach application at the level of elementary, junior high and high school education can be seen in **Table 3**.

### 3.1.2. The Influence of the Open-Ended Approach

From review results, the open-ended approach has an influence on improving the creative thinking skills of mathematical and self-regulated learning students. The influence of open ended can be seen on **Table 4**.

Authors (year)	Result
Suhandri (2013)	After the learning process there was an improvement in the mathematical creative thinking skills of the experimental group students who used learning with an Open-ended approach better than the control group or learning using conventional learning. Meanwhile, information about improving students' creative thinking skills after the learning process of teaching in the experiment group and control group was obtained from normalized gain scores, which is data obtained from the difference between pretest and posttest scores. Based on observation and dissemination of questionnaires on the issue of students' attitudes towards open-ended approach learning obtained data, overall the attitude of students is positive towards an open-ended approach to improving the ability of mathematical creative thinking. This can be seen from the average student's attitude score towards mathematical creative thinking of 2.94. This score is greater than the neutral attitude score of 2.38. Similarly, it is seen that students in general expressed a fondness for an open-ended approach to improving mathematical creativity, the results showed 83% of experimental graders favored the use of an open-ended approach and could improve their creative thinking skills
Nenden Faridah, Isro'atun dan Ani Nur Aeni (2016)	The results of the study say that <i>the open ended-approach</i> affects students' creative thinking abilities. It can be seen in the pretest class of experiments obtained an average score of 32.3 medium average posttest value of 62.4. Based on these values, the average difference between the experiment class pretest and posttest values is 30.1 where the posttest is better than the pretest. The average difference in grades in both classes showed that the average grades in the experiment class were greater. Based on statistical tests state that the <i>open ended-approach</i> is better than conventional approach in improving students' mathematical creative thinking skills.
Khaspul Khairobi (2017)	Based on hypothesis calculations <i>The High and Low Self-Regulated Learning</i> Questionnaire shows that $t_{count} = 41,214$ while $t_{table} = 2,037$ with $\alpha = 0.05$ . Thus, the calculation results show $t_{hitung} \geq t_{tabel}$ (H0 rejected and H1 accepted). Meaning there is a differences in <i>Self-Regulated Learning</i> between students who are taught using <i>open ended-approach</i> compared to conventional approach in grade IV MI Ismariyyah Al-Quraniyah Rajabasa Bandar Lampung.
Siti Salamah Br Ginting (2019)	After treatment was given in the experiment class, namely with <i>brain-gym-based open-ended learning</i> there was a significant improvement in mathematical creative thinking skills compared to the control classes given expository learning. Based on the results of the study, the average gain index for each aspect of mathematical creative thinking in the experiment class is higher than the control class that is on the smooth thinking aspect of $0.758 > 0.587$ , flexible thinking aspect $0.833 > 0.313$ , original thinking aspect $0.569 > 0.297$ , elaborative thinking aspect $0.531 > 0.380$ , and for the overall aspect $0.695 > 0.474$ . The results showed that the average increase in student learning self-reliance taught with <i>brain-gym-based open-ended learning</i> was higher than the average increase in student self-reliance skills taught with expository learning.
Suriyani Suriyani, Hasruddin Hasratuddin, Asmin Asmin	The results showed that (1) improved creative thinking skills of students taught using math learning with an <i>Open-Ended</i> approach were better than those taught with conventional learning, (2) <i>improved self-regulated learning</i> using math learning with a <i>better Open-Ended</i> approach than those taught with conventional learning, (3) there is no interaction between the learning approach and the student's early math ability to improve students' creative thinking skills, and (4) there is no interaction between the learning approach and the student's initial math ability to <i>improve the student's self-regulated learning</i> . Based on the research findings <i>open ended-approach</i> can be recommended to be one of the learning approaches used in the main school to achieve creative thinking competency and learning independence.

Based on the some of the study results that have been presented on the *influence of open-ended* approach to the ability of mathematical creative thinking and *self-regulated learning students*, it can be seen that the creative thinking ability of students who follow learning with an *open-ended* approach is higher than in students who follow conventional learning. The *open ended-approach* also has a positive influence on *students' self-regulated* learning. Learning mathematics with an *open-ended* approach can improve students' creative thinking skills. In this case, mathematics learning with an *open-ended* approach can be applied by teachers who teach in schools to improve the creative thinking skills of mathematical and *self-regulated learning students*. Because the *open-ended approach* gives students breadth in answering questions. In the application of an *open ended-approach* teachers should prepare a proper and appropriate learning plan. Written tests used to assess a student's ability to think creatively should also use *open-ended problems or problems*. With open-ended questions, it can open insights so that students can answer questions or solve problems given in various ways.

## 3.2 Discussion

### 3.2.1. Open-Ended Approach

The *open-ended approach* is an innovation in mathematics education that was first conducted by mathematicians in Japan. This approach is the result of research in 1997 conducted by Shimada, Toshio Sawada, Yoshiko Yashimoto, and Kenichi Shibuya (Euis Eti Rohati et al., 2019). The *open-ended approach* is an approach that helps students do problem solving creatively and appreciate the diversity of thinking that presents a problem that has more than one method or solution and may also have many correct answers. The purpose of open ended is not to get an answer, but rather to focus on how to get to the answer. The *Open-ended* approach according to Shimada and Becker is "a learning strategy that creates interest and stimulates creative math activities in the classroom through the collaborative work of students." Lessons using open problem

solving put more emphasis on the process of problem solving activities than focusing on results" (Suhandri, 2013). The *Open ended approach* is a learning approach by presenting a problem that has more than one answer or method of solving (Zarkasyi, 2015). The *open-ended approach* starts with a view of how to objectively evaluate students' abilities and high-level math thinking. In order for mathematics to be loved and studied by all students, then *closed problems* that demand one correct answer should be replaced with *open ended-problems*. An *open ended-approach* is a learning approach that starts with introducing or confronting students on open-ended issues. The *problem of open ended* is a problem formulated has many correct answers (Ruslan & Santoso, 2013). With this activity is expected to bring students to answer problems in many ways, thus inviting the intellectual potential and experience of students in the process of finding something new.

An *open-ended approach* is one that helps students do problem solving creatively and appreciate the diversity of thinking that presents a problem that has more than one method or solution and may also be with many (correct) answers. This approach provides students with the opportunity to gain knowledge, experience, discover, recognize, and solve problems with some of these techniques and approaches are expected to be facilitators in developing and stimulating students' creative thinking and problem-solving skills. With this expectation, mathematics learning with an *open-ended approach* was chosen in this study to look at differences in students' creative thinking skills and mathematical problem solving.

The application of *open-ended learning* with stages: 1) organizes students in learning activities by forming student learning groups of 4-6 people; 2) present an open problem to a group of students in the form of a student activity sheet; 3) direct students in solving the problems presented until the settlement is obtained in a variety of ways; 4) present and compare the work of each group in front of the class; 5)

conclude the materials/findings obtained in learning activities guided by teachers (Lubis *et al.*, 2019). Furthermore, Huda argues that the steps in the *Open ended learning* strategy are: 1) confronting students on open problems; 2) guide students to find patterns in constructing their own problems; 3) let students solve problems with various solutions and diverse answers; and 4) ask students to present their findings (Kurniati & Astuti, 2017). Based on the opinions of the two experts on *the stage of open-ended learning*, both give students the opportunity to investigate various strategies and ways that are believed to be in accordance with the ability to elaborate problems, the difference is only in the grouping of students. The first opinion is the opinion of Becker who implements *open-ended learning* in groups.

The *open-ended approach* can train and foster originality of ideas, creativity, high cognitive, critical, communication interaction, sharing, openness and socialization. Thus, the *open-ended approach* will be able to give students the opportunity to answer various problems through various strategies or means. This is reinforced by the assertion that learning activities with an open ended *approach* should lead students in answering problems in many ways and also have the right answers (Lestari *et al.*, 2016); (Kurniati & Astuti, 2017). In addition, with this *open-ended approach*, students will be directly motivated to solve a problem in various ways with their friends as well as with teachers.

The *open ended* approach has the advantage of encouraging creative activities from students and thinking mathematically on simultaneous problem solving (Wanelly & Fauzan, 2020). This approach provides students with the opportunity to gain knowledge, experience, discover, recognize, and solve problems with several techniques and stimulate students' creative thinking and problem-solving skills (Lubis *et al.*, 2019). Because *open-ended problems* have more than one solution, teachers need to create an assessment Criteria. Sawada (Muhsinin, 2014) has given criteria in assessing the results of students' work, namely as follows: 1. Proficiency, defined as the ability to use several methods of completion. 2. Flexibility, is an opportunity for students to answer correctly for some similar questions. 3. Authenticity, this category is intended to measure the authenticity of students' ideas in providing correct answers. The *Open-ended problem* has a very close relationship with creativity. Because in solving *open-ended problems* requires creative thinking skills and problem solving. The main purpose of students faced with *open-ended problems* is not to get answers but to emphasize more on how to get to an answer (Suherman, 2019). Thus, an *open-ended approach* is not only one way or method of obtaining answers, but several or many ways of solving mathematical problems.

Learning that uses an *open-ended approach* can be interpreted as a collection of evidence or learning results of students that show the effort, development, learning achievement of students over time and from one subject to another. Therefore, students can succeed in learning because more are trained to search for or find their own information (Andriani & Madio, 2013). Learning with an *Open-Ended* approach starts by giving students open problems. Learning activities should lead and lead students in answering problems in many ways as well as perhaps also with many (correct) answers, thereby stimulating students' intellectual abilities and experience in the process of discovering something new (Andriani & Madio, 2013). Both opinions are in line with the advantages of *the open ended approach*, among others: 1)

students take a more active part in learning, and often express their ideas; 2) students have more opportunities to use their knowledge and mathematical skills; 3) students with low abilities can react to problems in some significant way of their own; 4) encourage students to give evidence; and 5) students have a rich and happy experience of their discoveries and receive the consent of friends (Akbar *et al.*, 2017). Furthermore, the *open-ended approach* is intended to allow students to be more creative in developing a mindset in solving the given problem and fostering an independent and responsible attitude in solving the given problem (Amir & Riswati, 2014). Based on some of these opinions, it can be understood that the *purpose of the open-ended approach* in math learning is to improve the creative thinking skills of mathematics simultaneously in order to develop to the maximum, giving students the freedom to think in making progress solving according to their abilities, attitudes and interests through various strategies and ways that it believes in solving problems thus shaping the student's mathematical intelligence.

An *open-ended problem* is an open problem that has many correct answers. These open problems are grouped into three types, namely: (1) problems that can be solved in varying ways, (2) problems that have varied answers, and (3) problems that can be developed by changing the condition of the previous problem (Putri, 2017). Giving teachers *open ended problem* is expected to explore student reasoning and help teachers evaluate the diversity of students' knowledge and can encourage students' creative thinking.

### 3.2.2. Creative Thinking

Creative thinking is the embodiment of high-level thinking. Creative thinking is at the highest level of thinking after retention, basic thinking, and critical thinking. Creative thinking is also included in reasoning. Thus, to achieve creative thinking these four types of thinking must be mastered. Creative thinking can be defined as a combination of logical thinking and divergent thinking based on intuition but has a realized purpose (Pehkonen & Helsinki, 1997). In particular it can be said that creative thinking as a unit or a combination of logical thinking and divergent thinking in order to produce something new. Something new is one indication of creative thinking in mathematics (Ginting, 2019). Creative thinking as a combination of logical thinking and divergent thinking based on intuition in consciousness. Therefore, creative thinking involves logic and intuition together.

Mathematical creative thinking skills are part of life skills that need to be developed especially in the face of an increasingly tight era of information and competitive atmosphere. Therefore, the creative thinking skills of mathematics are very important for students to deal with changes and be able to produce something new in the future. Another ability that students should have besides creative thinking is the ability to be independent, which is attitudes and behaviors that do not easily rely on others in completing tasks.

Munandar explains the sense of creative thinking is the ability to find many possible answers to a problem, where the emphasis is on quantity, preciseness, and diversity of answers (Purwaningrum, 2016). This understanding indicates that a person's creative thinking ability is higher, if he or she is able to show many possible answers to a problem. However, all of those answers must be appropriate and appropriate, in addition the answers must vary (Yuliana, 2015). In general, creative children have a high curiosity, have a wide interest, and love creative

passions and activities. Creative children and adolescents are usually quite independent and have confidence. They are more likely to take risks than children in general, meaning that in doing something that for them is very meaningful, important, and likable, they don't care too much about criticism or ridicule from others.

The development of creative thinking skills is one of the main focuses in mathematics learning. Because mathematics materials are so complex and in combination with each other, mathematics learning needs to be designed in such a way as to potentially develop students' creative mathematical thinking skills. This mathematical creative thinking ability must continue to be developed and trained. One of them is applying learning that can give students the opportunity to express and develop their ideas freely but still under the guidance of teachers as facilitators (Akbar *et al.*, 2017). Dengan thus, guru can train students' mathematical creative thinking skills in a learning atmosphere in the classroom.

Creative thinking has two important components: logic and intuition (Nurhikmayati & Sunendar, 2020). According to Evans creative thinking is detected in four elements: sensitivity, smoothness, flexibility, and authenticity (Dahlan *et al.*, 2017); (Muhtadi & Sukirwan, 2017). The sensitivity referred to here is sensitivity to problem situations concerning the ability to identify problems, being able to distinguish facts that are irrelevant to the problem, including distinguishing relevant concepts about the actual problem. This sensitivity also includes what a person feels in connection with an identified problem, such as a related concept, an appropriate strategy for solving the problem. The flexibility of intent here refers to the ability to build diverse ideas. Flexibility is as a variation that shows the wealth of ideas and efforts of the person concerned in building ideas towards the expected solution. Authenticity is the ability to generate unusual ideas and solve problems in unusual ways. This authenticity appears in a variety of forms, from simple or informal to later can be developed into more complete.

Creative thinking contains aspects of cognitive, affective, and metacognitive skills (Widiawati *et al.*, 2019); (MZ, 2017). These cognitive skills relate to the ability to identify problems and opportunities, compose good and different questions, identify relevant and irrelevant data, productive problems and opportunities. In addition, this ability is also related to the ability to generate many ideas, produce different ideas, as well as new products or ideas, examine and assess the relationship between options and alternatives, change old mindsets and habits, build new relationships, expand and update plans or ideas. Some steps to creative thinking are: asking questions, transforming information into new and open minded views, finding relationships between different things, looking at each other, making something new and different, and considering intuition (Sariningsih & Herdiman, 2017). Creative thinking can also be interpreted as a mental activity that a person uses to build a new idea or thought. Another opinion of Pehkonen, he views creative thinking as a combination of logical thinking and divergent thinking based on intuition but still in consciousness (Amidi & Zahid, 2016). The intent of divergent thinking itself is to provide an assortment of possible answers to the same question.

According to Munandar, creative thinking has 5 indicators, further, creative thinking skills developed in the form of description questions with indicators of smoothness, flexibility, authenticity and elaboration (I. W. S. Putri *et al.*, 2017). Other opinions also say that creative thinking indicators that can be

used in research include: 1) fluency, 2) flexibility, and 3) novelty (Rahmazatullaili *et al.*, 2017). Creative thinking skills are indispensable to students given that today science and technology are evolving rapidly and enabling anyone to obtain information quickly and easily from sources around the world.

Characteristics of creative thinking include: 1) Curiosity characterized by investigation, asking, seeking a deeper understanding, 2) smoothness to form a number of ideas, 3) authenticity, 4) the ability to enrich and develop a product or idea or situation so as to be more interesting, 5) the ability to imagine, and 6) flexible thinking skills that mean finding many different alternatives resulting in a variety of ideas, answers or questions that vary (Susilo, 2015). Thus, students are triggered by their curiosity to master learning materials, easy to understand newly acquired concepts so as to bring forth a new set of concepts that can give understanding to students.

One approach that is able to provide solutions in improving the quality of math learning, especially the ability to think creatively mathematically is an *open-ended* approach. This is because this approach starts with presenting a problem to students who have the correct solution of more than one (Soeyono, 2013). It is also suggested by Sewada that *the open-ended approach*, teachers are able to provide a problem situation to students whose solutions can be obtained in various ways (Utami *et al.*, 2020). In addition, through *open-ended*, students' understanding can be developed in teaching mathematics in schools (Mihajlović & Dejić, 2015). This is one way to improve the creative thinking skills of students, where that mathematical creative thinking trains students to see a problem from a different point of view and connect it to their knowledge so as to produce varied solutions that are new to open mathematical problems.

Shimada defines learning with an *open-ended approach* starting with presenting *open-ended problems* first and then learning is processed by using many correct answers to give students the experience of discovering something new (Euis Eti Rohati dkk, 2019) (Rudyanto, 2016). With an *open-ended* approach in mathematics subjects, an open math problem is required. According to Japar learning with an *open-ended* approach begins by giving open problems to students (Muhsinun, 2013). Open problems will make students look for open solutions as well. Solutions or troubleshooting can be searched in a variety of ways. This, which makes the *open-ended approach* make students creative in learning mathematics. According to Coney it takes open questions to apply an open-ended approach to math learning (Rudyanto, 2016). The open questions used in the *open-ended* approach have the following characteristics: 1) involve important mathematics; 2) produce diverse answers; 3) requires communication; and 4) clearly stated (Waluyo, 2018). Thus, it is understandable that the hallmark of an *open-ended approach* is a learning approach that starts with giving open problems to students formulated with multiple correct answers or many appropriate solutions.

Regarding the relationship of *open-ended* approach to creative thinking, researchers have conducted research that says that: 1) math learning using an *open-ended approach* is very effective if applied to primary school students to deed and develop creative thinking skills (Waluyo, 2018); 2) learning with an open ended approach that can improve students' mathematical creative thinking skills (Firdaus *et al.*, 2016); and 3) open-ended approach is able to have a positive influence on students' creative thinking skills (Amir, 2010). Based on the exposure of the results of studies that have been done by some

of these researchers, it shows that *the open-ended approach* is able to influence the creative thinking abilities of students.

### 3.2.3. Self Regulated Learning

Self-reliance is the meaning of *the word self-regulated learning*. Zimmerman was the first academic to propose self-regulated learning in educational psychology. *Self-regulated learning* is a learning process in which students use self-regulation skills, such as self-assessment, *self-directing*, control and adjustment, in order to gain knowledge (Akbar et al., 2017). *Self-regulated learning* can be interpreted as an effort to conduct learning activities alone or with the help of others based on their own motivation to master a particular material and or competency so that it can be used to solve problems it encounters in the real world (Amir & Risnawati, 2015). The *concept of self-regulated learning* is one of the important concepts in the theory of social learning. *Self-regulated learning* is a way of learning individually active students to achieve academic goals by controlling behavior, motivating themselves and using their cognitive in learning. In summary, *self-regulated learning students* can be observed the extent of their active participation in exerting metacognitive processes, motives and behaviors as they study.

Self-reliance is the attitude of a person who has knowledge of effective learning strategies and how and when to use his knowledge. Furthermore, a person who has self-reliance learns if able to manage his motivation that is motivation that comes from outside and from within him. Meanwhile, according to Masruri learning independence is an attitude formed due to the careful design of the learning process. The self-sustaining attitudes or behaviors formed here are deliberately formed and not self-formed.

*Self-regulated learning* is the ability of students to organize themselves in learning or also called *student learning independence*. In principle, *self-regulated learning* places importance on a person's ability to organize and control one's own, especially when facing a task. *Self-regulated learning students*, can be observed the extent of their active participation in exerting metacognitive processes, motivations and behaviors as they learn to learn (Hamundu et al., 2017). Based on that understanding, it can be concluded that *self-regulated learning* is part of the theory of cognitive learning that is closely related to behavior, motivation, and environment that can affect a person's achievements in learning.

*Self-regulation learning* is an activity to monitor and control the learning itself. Learning settings have several components, such as motivation, belief origin (*epistemic*) learning, metacognition, learning strategies, and prior knowledge. Motivation helps learners take the effort necessary to monitor and control learning. Epistemic beliefs are what learners believe about the nature of learning. Metacognition is thinking about the mind, which is the ability to understand what needs to be done in a given state (Reed & Giessler, 1995). Corno and Mandinach divide *the components of self-regulated learning* into five important components grouped into two categories: 1) the process of obtaining information, which includes preparedness (receiving and following the path of information and monitoring; 2) the transformation process of the ability to select, connect, and plan (Setiani et al., 2018). Based on some of these opinions on *the components of self-regulated learning*, the four components of *self-regulated learning* include: 1) time; 2) strategy; 3) basic knowledge; and 4) trust.

The above four components describe the concept of self-arrangement which is a concept consisting of four main components namely time, strategy, basic knowledge and trust. Using these four plans will help students become self-reliant because it gives them a clear plan to improve their success in learning math and science, while also helping them to understand the integral relationship between knowledge, strategy and motivation. Without self-regulating skills, students will be at risk of despair or failure due to their learning problems and lack of ability. Individuals who apply *self-regulated learning* will experience a change in learning habits, namely by organizing and organizing themselves in such a way that it can determine the learning goals, learning needs, and strategies used in learning that leads to the achievement of goals that have been formulated. Self-reliance is a learning activity conducted by an individual with his freedom in determining and managing his/her own teaching materials, time, place, and utilizing the necessary learning resources. With the granting of freedom students have the ability to manage the way of learning, have a high sense of responsibility and are skilled at utilizing learning resources.

Zimmerman explained *self-regulated learning indicators* consist of: evaluation of the progress of the task, organizing the subject matter, making plans and learning objectives, seeking information, recording important things, regulating the learning environment, consequences after working, recurrence and recalling, asking peers, asking for help teachers/teachers, asking for adult help, recurring previous assignments or tests, repeating notes, recurring textbooks (Utari et al., 2018). Indicators of self-reliance of learning according to Sumarmo is as follows: (1) choose the purpose of learning; (2) resolve difficulties; (3) utilization of facilities; (4) cooperative nature; (5) building meaning and (5) self-control (Siregar, 2019). While according to Sumarmo the indicators of learning self-reliance are: (1) learning initiatives, (2) diagnosing learning needs, (3) setting targets and learning goals, (4) monitoring, regulating and controlling learning progress, (5) viewing difficulty as a challenge, (6) utilizing and *finding relevant sources*, (7) selecting and implementing learning strategies, (8) evaluating learning processes and outcomes and (9) having a self-concept (Siregar, 2019); (Setiani et al., 2018).

That attitude and creative thinking habits will essentially shape and foster *self-regulated learning mathematics*. Butler advises teachers should help students carry out a flexible and *adaptive self-regulated learning cycle* by analyzing tasks, selecting and implementing strategies, monitoring themselves and reflecting (Meiliana & Aripin, 2019). Self-learning is not self-learning. *Self-regulated learning* is considered to be able to make students get the expected grades, *basically self-regulated learning* if applied by the student personally will motivate the student not to stop learning and not rely on others in the learning process so that the student will receive the learning results as expected.

Improvement of the learning process to improve self-reliance and problem-solving skills can also be done by applying the right learning approach so that learning goals can be achieved. One of the steps that teachers can take to improve the learning independence of students is to provide learning in which open problems are presented both process and answer so as to invite students to hone their thinking skills. An approach is needed to convey learning that can improve students' attitudes or make students think positively, especially in math learning. Teachers can present nuanced learning of problem solving and

constructivism as one of the efforts to improve students' creative thinking skills and learning independence. Such learning, among others, is math learning with an *Open-Ended* approach. The *Open-Ended approach* promises an opportunity for students to investigate various strategies and ways they believe in accordance with their elaboration skills (Suriyani, 2015). *Open ended approach* in learning process can support improving *self-regulated learning or student learning independence* (Mahanani et al., 2019).

This statement is reinforced by the results of the study which said that: 1) there are differences in the effect of the application of *problem-based learning with open ended approaches and problem-based learning* without an open ended approach to improving the creative thinking skills of students who *have high self-regulated learning* (Akbar et al., 2017); 2) improved *self-regulated learning* of students taught using math learning with an *Open-Ended* approach better than those taught with conventional learning (Suriyani, 2015); and 3) improved *self-regulated learning* of students taught using math learning with an *Open Ended* approach is better than those taught with conventional learning (Suriyani et al., 2015). Based on the exposure of the results of the studies that have been conducted by some of these researchers, shows that the *open-ended* approach is able to influence the *self-regulated learning* of students.

#### 4. CONCLUSION

Based on the results of rievun conducted using library *research method* can be concluded that 1. Learning mathematics using an *open-ended approach* affects the improvement of creative thinking skills and *self-regulated learning* of students, 2. The *open-ended approach* is higher in improving students' creative thinking skills than using a convesional approach, 3. The *open ended* approach in learning has steps namely: a) teachers organizing students in learning activities; b) the teacher confronts the student on an open issue; c) teachers guide and direct students in solving problems with a variety of solutions and answers; d) students present the work and compare with the work of other students in front of the class; and e) students conclude lesson materials guided by the teacher, 4. To implement *open-ended learning*, it is necessary to prepare learning that requires high creativity for a teacher.

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