

Active Learning Optimization to Improve Students Critical and Creative Mathematical Thinking

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Abstract—The purpose of this paper is to describe how mathematics educators to face of ASEAN Economic Community (AEC) by optimizing active learning to improve students critical and creative mathematical thinking. Human resources should be formed in this era is that having a competitive mental. Education is one of solution to developing knowledge and skills so as to create the character of a good human resources. In essence, learning is not transfer of knowledge activity but a process of interaction between the students and his environment. Learning paradigm in the 21st century refers to active learning, where educators as facilitators. Usually, traditional teaching is concentrated to lower order thinking skills (recall and basic). Improve critical and creative thinking skills of student is the focus in mathematics education since critical and creative thinking skills is the higher order thinking skills. Kinds of active learning methods: (1) Individual exercises, like the one minute paper, daily journal, reading quiz; (2) Socrates Method, like quiz/test questions; (3) The direct input, like finger signal, flash cards, quotations; (4) Motivator critical thinking; like the pre-theoretical institutions quiz, puzzles/paradoxes; (5) Collaborations, like discussions, note comparison, evaluation of another students work; (6) Cooperative learning, like cooperative group in class, active review sessions, work at the blackboard, concept mapping, visual list, jigsaw group project, role playing, panel discussions, debate, games.

Keywords: *active learning, critical mathematical thinking, creative mathematical thinking*

I. INTRODUCTION

Education is a determinant of the development and progress of a nation. In general, the purpose of education is providing a usable environment allows students to develop the potential and ability to optimally so that they can work for themselves, society and nation [1]. Lickona [2] suggest that the basic fundamental purpose of education according to Socrates is able to form human being smart and better, is aligned with that of education in Indonesia is aimed at educating the nation. The main focus in establishing the knowledge and skills of human resources of this nation that is by education. According to the UNDP report, the value of Human development index, Indonesia in 2014 amounted to 0.684 rated 111 of 188 countries while in ASEAN under Singapore, Brunei, Malaysia and Thailand.

Mathematics is a lesson that did not evolve naturally on students because mathematics is an abstract, rigor and coherence. Mathematics will be understood by student if the educator uses in learning the proper way. Referring to the constructivist learning theory, mathematics studied cooperatively and educators as facilitators. A student will not be able to understand the math if students allowed to find out their own without help of the teacher so that students need scaffolding in learning mathematics. Mathematics has many roles in life, therefore educators should establish that students who have creative and critical thinking skills in studying mathematics.

In the face of free trade and competition as well as the face of the times in the 21's era, there are four skills to be developed by educators to students by National Education Association are critical thinking, communication, collaboration and creative thinking. With attention to low Indonesia's human development index necessary to do an investigation of Indonesian education, especially in mathematics learning. According to survey results Trend in International Mathematics and Science Study (TIMSS), Indonesia began in 1999 in the position of 34 from 48 countries, in 2003 in the position of 35 from 46

countries, in 2007 in the position of 36 from 49 countries and in 2011 in the position of 36 from 40 countries. While according to a survey from Program for International Student Assessment (PISA), studies committed from 2000 position Indonesia of 39 from 41 countries, in 2003 in the position of 38 from 40 countries, in 2006 in the position of 50 from 57 countries, in 2009 in the position of 61 from 65 countries and in 2012 in the position of 64 from 65 countries [3]. Based on these survey results it appears that Indonesia mathematics achievement in the world cannot be proud.

Education studies has done by the government of Indonesia on the curriculum changes from 2004 that is competency-based curriculum, curriculum 2006 that Education Unit Level Curriculum and national curriculum in 2013 that its use is still not evenly distributed in Indonesia. This is caused by the pros and cons from the education unit. The curriculum applied reflected the education in the 21st century. However, on the ground of learning, educators have not been fully implemented as expected by the learning curriculum. There are still some educators who still use traditional learning in mathematics learning. In traditional learning to the student memorization of understanding so that not returning critical and creative thinking students in mathematics learning. Bransford in Sukarno [4] stated that the most fundamental problem is the traditional education failed to produce the ability to solve problems in life. Because traditional learning only gives simplified and decontextualized problems and not relevant to daily life. While the expectation is that the learning of mathematics education can be implemented in daily life so that mathematics is not considered as an abstract science.

Of the problems that exist in the Indonesian education system are methodologically then there are several ways needed to be done. One strategy that has been, is and will be applied is active learning. Active learning can develop and increase critical and creative learning. Critical and creative learning are higher order thinking skills (HOTS). Minister Regulation the Republic of Indonesia 22 of 2006 of the content standards stated that Mathematics is given to all students to equip them with the ability to think logically, analytical, systematic, critical, and creative, as well as the ability to cooperate. The purpose of this paper is to describe how mathematics educators to face of AEC by optimizing active learning to improve students critical and creative mathematical thinking and this paper is expected to be used as consideration in choosing a model of learning that human resources can be compete in the era, especially for educators who want to grow and develop aspects of students critical and creative mathematical thinking.

II. ACTIVE LEARNING

Learning is something that happens as a result or consequence of experience and precede changes in behavior [5]. Then learning can be defined as the process of abstracting past experience with knowledge gained is now forming a new knowledge that will change the behavior of a depressed individuals. While learning is a process of creating conditions conducive for teaching and learning communication interactions occur between educators, students, and other learning components to achieve the learning objectives. Active learning essentially been there since the time of Socrates, but in fact active learning developing new else in the 21st century.

Active learning is one alternative in cultivate students' critical and creative thinking. Which comes from learning and creative. What is meant here is the interaction of learning and learning communication between educators, students, and other learning components to achieve the learning objectives. While that is activities engagement students in the learning process. So we can say active learning is a model / strategy in learning activities by using the full potential of students optimally, with the aim that they can achieve satisfactory results or objectives according to the personality characteristics possessed by the student [6]. Active learning is very important according to the statement proposed by Silberman [7] in his book, that "More than 2400 years ago Confucius stated: what I hear I forget, what I see I remember and what I do I understand. From this statement it can be said that active learning can provide a deeper understanding to students compared to learning that is not active as teacher-centered learning or traditional learning.

According to Meyers and Jones that "active learning derives from two basic assumptions: (1) learning its by its very nature an active process and (2) that different people learn in different ways." Meanwhile, according to Simons that active learning has two dimensions, independent learning and active working [8]. From the opinion of experts, it can be concluded that active learning is learning in which

students work active in collecting information learning so that educators as facilitators of learning, in active learning, we will not find another lecture for the students to dominate the classroom than educators, educator only duty deploying the learning process. Implement thinking skills and learning to the level of control of new knowledge and skills effectively are essential for students in active learning. In the active learning is expected to involve high-level skills such as creative and critical thinking are not just memorize, know or understand but also apply, analyze, evaluate and create. In active learning, there are three important goals that need to be fulfilled by educators at the beginning of learning: (1) building a team, aims to have the leaners are able to know each other between each other and will influence the creation of a spirit of cooperation and interdependence among participants students (2) the assertion, in terms of educators will be able to learn the attitudes, knowledge, and experience for the smooth students in the learning process (3) the involvement learn immediately, here educators will be able to generate early interest students in learning activities.

There are several methods used in active learning is student-centered learning, self-regulated learning, collaborative learning, learning-to-learn, problem-based learning (PBL), project-based learning, inquiry-based learning. Some of these methods has a characteristic, advantages and weakness of each. According to Paulson and Faust there are several options of active learning which is based on things related to the learning context [4]:

1. Individual Exercise like (1) The “One Minute Paper”; (2) The Muddiest (or Clearest) Point; (3) Effective Responses; (4) Daily Journal; (5) Reading Quiz; (6) Clarification Pauses; (7) Response to Demonstration or other teacher-centered activity
2. Direct input, like (1) Finger Signals; (2) Flash Cards; (3) Quotations
3. Mate, like (1) discussion; (2) Note Comparison/Taking; (3) Evaluation of Another Students Work
4. Question and answer like (2) Wait Time; (2) Peer Summary; (3) The Fish Bowl; (4) Quiz/Test Questions
5. Motivator Critical Thinking like (1) The Pre-Theoretic Institutions Quiz; (2) Puzzles/Paradoxes
6. Exercise Cooperative Learning like (1) Cooperative Groups in Class; (2) Active Review Sessions; (3) Work at the Blackboard; (4) Concept Mapping; (5) Visual Lists Jigsaw; (6) Group Project; (7) Role Playing; (8) Panel; (9) Discussions; (10) Debates; (11) Games.

III. STUDENTS CRITICAL AND CREATIVE MATHEMATICAL THINKING

Thinking is one of the activities that occur in human life continue. One example of thinking activities is when someone tries to find ways solve a problem. For example, Ani and three of her friend had a rectangular shaped cake, they want the cake is divided into four equal parts.

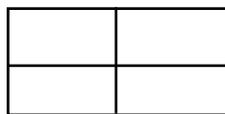


FIGURE 1

When they cut the cake they think is there any other way?

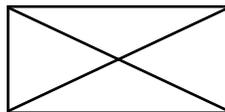


FIGURE 2

Or, what if?

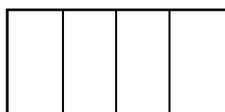
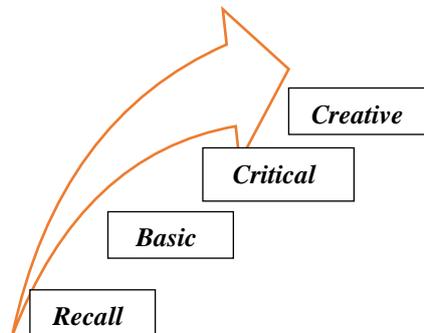


FIGURE 3

From these example it can be concluded that thinking is a mental activity that involves the brain's performance to an information that can lead to the development of an idea or concept.

There are some education experts argued about the meaning of thinking. Gestalt said that the thinking process cannot be observed using human sensory organs and thinking is a psychic activeness are abstract [9]. While Ruggiero stated that thinking is a mental activity in helping to solve problems, make decisions or satisfy curiosity. Based on the expert opinion that thinking is abstract mental activity in order to find solutions to a problem [10]. In general, that there are two levels of thinking, LOTS (Lower Order Thinking Skills) and HOTS (Higher Order Thinking Skills). LOTS a recall and basic while HOTS is a critical and creative. HOTS is expected ability in mathematics because it can form human resources have the critical and creative thinking skills. critical and creative thinking skills are skills needed in this era.



A. Critical Thinking

Critical thinking is one indicator of HOTS. There are some experts who express opinions about critical thinking skills, one of is Edward Glaser. Critical thinking by Edward Glaser in Fisher are: (1) An attitude would think deeply about issues and things that are within the reach of one's experience; (2) Knowledge of the methods of inspection and logical reasoning; (3) A kind of a skill to apply these methods [11]. Ennis in Feldman argues that critical thinking is the ability to give a reason and reflective focused on what is believed and done [12]. It can be said that critical thinking is analytical and reflective in check, connect, collect, organize, memorize, analyze information and evaluate a problem or situation then this could mean is able to draw conclusions from the data given and are able to determine inconsistencies and contradictions in the group data. If a student is able to think about what if in answer to non-routine math problems that young people have the critical thinking skills.

According to Glaser, while the foundation of critical thinking skills including the ability to [11]: (1) Know the problem; (2) Finding ways that can be used to address these problems; (3) Collect and collate the necessary information; (4) Know the assumptions and values that are not otherwise; (5) Understand and use appropriate language, clear and distinctive; (6) Analyze the data; (7) Assess the facts and evaluate statements; (8) Know the relationship between problems; (9) Appealing conclusions and similarities necessary; (10) Test the commonalities and the conclusions that someone grab; (11) Reconstitute the patterns of a person's belief is based on a broader experience; (12) Make an accurate assessment of things and certain qualities in everyday life.

Moreover, there are examples of some critical thinking styles are:

Explorer	See all sides of a situation or problem Identify the core elements of a problem or situation Want to know Looking for new development
Students	Intelligent Researching other solutions to a problem Doing task Correcting errors
Warrior	Accepting the challenge Persevering

	Faced with a difficult problem
Cicerone	Guiding others Looking ahead Planning a series of actions
Detective	Questioning the thoughts and actions tolerating uncertainty Pursuing elements of fact that are not clear

There are four strategies that can increase critical thinking skills, are:

- 1) The willingness to look at yourself
There are several steps that must be done, are:
 - a) Ask questions why. In other words, do not accept the things that are seen or heard away.
 - b) Identify and resist your bias. Bias can lead to inaccuracies in perception. To eliminate it, we must continue to train our thinking muscles.
 - c) Recognize your thought process, and skip unproductive thinking strategies and learn new strategies are effective. That is not affected by the different strategies used by others when they face problems or new challenges. Convince yourself that every person has a different strategy when faced with a problem or challenge.
- 2) Evaluation of are constantly
Steps in this strategy, are:
 - a) Getting other feeds from other sources. This means did not limit yourself, check or accept a perspective or input from others.
 - b) Raised the quality of the existing answers. Each question has an answer that can be judged rightly or wrongly, try to find the best method to achieve a better answer or correct.
- 3) Constantly are not prejudiced
Steps for this strategy, are:
 - a) Accept other people who might have a different perspective. That is trying to position themselves to be someone else and feel the viewpoint used by the other person. Essentially tries to respect the other person's perspective.
 - b) Finding agreement. If there is disagreement, trying to recollect and focus on opposite viewpoints that caused the disagreement.
 - c) Recognizing that there are often some solutions to a problem. There is a way out of every problem. So never stop to find various way out of the problems existing.
- 4) Commitment to the decision taken
Steps for this strategy, are:
 - a) Creating limit of clear analysis. Starting from the basic assumption that obvious and then develop to the stage logical and reasonable.
 - b) Get answers to the most credible, rather than waiting for total accuracy be assured that there are still many unknowns in this world, but if we want to try it will not be impossible, all that can be known and refined.
 - c) Recognizing the need for agreement or consensus in creating your decision. Account the social context of decisions already taken. Unconscious in ourselves that we live in the real world rather than in cyberspace.

B. Creative Thinking

Hosnan [6] states that the other qualities that necessary developed on the Curriculum 2013 includes creativity, independence, cooperation, solidarity, leadership, empathy, tolerance and life skills of students to form the character as well as the increase of civilization and dignity of life of a nation. According Maite and Laura “Creativity is the capacity to create, to produce new things” [13]. Isaksen declared that creative thinking is a process of forming an idea related to aspects of fluency, flexibility, novelty, and original. While McGregor declared that creative thinking is a process that leads to new knowledge, new ways of know something [14]. Based on expert opinion it can be concluded that creative thinking is a mental activity used by someone to build on the ideas that generate new knowledge. Creative thinking

usually caused by problems not ordinary that creative thinking is a process of construction of ideas that lead to the acquisition of new insights or new ways to produce a concept on the existing problems. In mathematics, students' creativity will appear when educators provide a non-routine problem for students. Creative thinking is rational and reflective. The activities carried out such unify ideas, create new ideas, and determine its effectiveness. The results of this thinking skills is something complex. Creative thinking also includes the ability to draw the conclusion that the end result is usually produced the new ones. Students who have high creativity in solving non-routine problems in mathematics will ask himself, Is there another way?

Pehkonen said creativity is not only found in learning the art, science and so on, but can also be found in the learning of mathematics [15]. Krutetskii declared that mathematical creative thinking ability is the ability to get the solution of a mathematical problem is easily and flexibly [14]. It can be concluded that creative thinking ability is the way an individual mathematical construct an idea in solving non-routine problems in mathematics. Characteristics of students who have a creative personality in Munandar by Csikszentmihalyi [1]:

- 1) The creative individual has the physical energy to fully concentrate on working for hours, and they also can be calm and relaxed depending on the circumstances.
- 2) Ability to convergent and divergent thinking
- 3) Having a combination of playfulness and discipline
- 4) Personal creative can alternately in issuing the imagination and fantasy but still thinking realist.
- 5) Shows tendency either introversion or extroversion
- 6) Have an attitude humble and proud of his work at the same time
- 7) Have a tendency psychological androgyny
- 8) Tends independently even perverse but could remain conservative and traditional
- 9) It is passionate when it comes to their work
- 10) Brush the open and sensitivity often makes him suffer when their work gets a lot of critical.

In general, students who have creative curiosity, interests and passions to get something done. They are more willing to take risks in trying to find something new of a problem. If they still think of a problem is still possible to get an answer in any other ways, then they will try.

IV. ACTIVE LEARNING TO IMPROVE STUDENTS CRITICAL AND CREATIVE MATHEMATICAL THINKING

As the country became a member of ASEAN and Indonesia agreed AEC then require workers who have critical and creative thinking skills are able to contribute energy and thoughts for science, culture, technology, and prosperity of the nation. Cicero said that the character of the citizens is the nation's welfare [16]. This statement indicates that the skills and character of human resources shows the character of a nation, the welfare of a nation depends on the character of human resources. Creativity is a matter that can be established anywhere, one is in school. At school, the educator has a greater role in shaping the character of students. Educators can foster creativity, curiosity and motivation for students. Instead, educators can also cripple creativity, curiosity and motivation in students. This is because educators have more opportunities to excite or cripple creativity, curiosity and motivation of students rather than their parents. Educators have a duty to evaluate the work, attitude, and behavior of students.

In essence it must be recognized that educators cannot teach creativity but educators can allow creativity appear, nurture and excite growth. The most important way to encourage intrinsic motivation in school is establish classroom environment that is free of obstacles that can damage students self-motivated. In addition, the best way for educators to develop students' creativity is to encourage intrinsic motivation. The meaning of intrinsic motivation here is the motivation that comes from within the student. Intrinsic motivation is very influential on the smooth running of the learning process and the results that will be obtained. This intrinsic motivation will grow if the educator can be a model for intrinsic motivation for the child to freely express their interests and personal challenge to solve a problem or complete a task. Moreover, to some extent educators can also teach the skills of creative ways of thinking confront problems creatively, or techniques to come up with original ideas. Educators should give the broadest possible opportunity for students to express their opinions. Let them freely express what they want to submit. Do not limit. Whether right or wrong, leave it alone. Later slowly educator directing

or guiding students to gain knowledge and insight into the true Learning from experience that one sometimes it will make students become more remembered [1].

Has been mentioned before that active learning is a model approach that has types such as PBL, PjBL, the inquiry and so on. Based on research that has been done by Hidayat (Lecturer STKIP Siliwangi Bandung) entitled “Meningkatkan kemampuan Berpikir Kritis dan Mahasiswa Kreatif Matematika SMA Melalui Pembelajaran Kooperatif Think-Talk-Write (TTW)”, which states the results that the increased ability to think critically and creatively math students whose learning using cooperative learning Think-Talk-Write (TTW) is better than learning to use conventional methods (KONV) is based on the ability students of high, moderate, and less. Increasing students' critical thinking skills of mathematics derived from conventional learning and TTW in terms of the ability of students are high, medium and low. As for the students creative thinking abilities derived from TTW and KONV on aspects of high ability and are in high qualification [17]. Meanwhile, a second study conducted by Ade Rohayati, Jarnawi Afgani Dahlan, Nurjanah students Department of Mathematics Education FPMIPA of Indonesian Education University entitled “Improving the Ability of Thinking Critical, Creative, and Reflective High School Students Through Education Open-Ended” stating the results that the increased abilities creative thinking of students who get teaching problem solving mathematical (Open-Ended) better significantly compared with students who get expository [18]

V. CONCLUSION

Active learning is learning there since the time of Socrates. As stated by John Dewey that learning activities must be active, directly engage students, learner-centered (SCL = Student Centered Learning). There are several methods used in active learning is student-centered learning, self-regulated learning, collaborative learning, learning-to-learn, problem-based learning (PBL), project-based learning, inquiry-based learning. Then should educators in the era now using active learning in teaching because active learning can improve students critical and creative thinking that will be useful in facing era. Some studies have been conducted by education experts. The results of their research are active learning can improve students critical and creative mathematical thinking

REFERENCES

- [1] Utami Munandar, “Kreativitas & Keberbakatan, strategi mewujudkan potensi kreatif dan bakat”. Jakarta: Gramedia Pustaka Utama, 1999.
- [2] Thomas Lickona, *Educating for Character: How Our Schools can Teach Respect and Responsibility*. New York: Bantam Books, 1991.
- [3] Budi Murtiyasa, “Tantangan pembelajaran matematika era global”. <https://publikasiilmiah.ums.ac.id/handle/11617/6005>
- [4] Sukarno. “Implementasi pendidikan Karakter di Sekolah dan Perguruan Tinggi melalui Pembelajaran Aktif”. Unpublished
- [5] Hergenhahn and Olson. “Theories of learnig”. Jakarta: Kencana. 2008
- [6] Muhammad Hosnan, “Pendekatan saintifik dan kontekstual dalam pembelajaran abad 21”. Bogor: Ghalia Indah. 2014.
- [7] Mel Silberman, *Active Learning 101 Strategi Pembelajaran Aktif*. Yogyakarta: Yappendis. 2009.
- [8] Ali Mahmudi, “Implementasi konsep pembelajaran active learning sebagai upaya untuk meningkatkan keaktifan mahasiswa dalam perkuliahan”. <http://staff.uny.ac.id/sites/default/files/132280878/13>.
- [9] Novi Marlioni, “Peningkatan Kemampuan Berpikir Kreatif Matematis Peserta didik Melalui Model Pembelajaran *Missouri Mathematics Project* (MMP)”. *Jurnal Formatif* (12-26). <http://journal.lppmunindra.ac.id>. 2015.
- [10] Vincent. R. Ruggiero, “The art of thinking, a guide to critical and creative thought”. New York, NY: Addison Wesley. 1998
- [11] Alec Fisher, “Critical thinking: an Introduction”. Cambridge university press, 2007.
- [12] Feldman, Daniel, A. “Critical thinking”. Crisp Publicatio. 2002.
- [13] Maite, G., & Laura, B. “Effect of a play program on creative thinking of preschools children”. *Journal of Psychology*, 14, 2, 608-618 <http://www.redalyc.org/pdf/172/17220620009.pdf>. 2011
- [14] Ali Mahmudi, “Megukur kemampuan berpikir kreatif matematis”. Makalah disajikan dalam konferensi matematika nasional XV di UNIM. 2010
- [15] Erkki Pehkonen, Vol 29, Issue 3, pp. 63-67. <http://link.springer.com/article/10.1007%2Fs11858-997-0001-z#page-1>. 1997.
- [16] Hughes, E. H & Hughes, A.G. *Learning and Teaching*. (diterjemahkan oleh Irwan Kurniawan dengan judul Pengantar Psikologi Pembelajaran Modern) Bandung : Nuansa Cendekia. 2012.

- [17] Hidayat. "Meningkatkan kemampuan Berpikir Kritis dan Mahasiswa Kreatif Matematika SMA Melalui Pembelajaran Kooperatif Think-Talk-Write (TTW)" <http://publikasi.stkipsiliwangi.ac.id/files/2012/09/Makalah-Seminar-Kritis-Kreatif-PDF.pdf>. 2012.
- [18] Ade Rohayati, "Meningkatkan Kemampuan Berpikir Kritis, Kreatif, dan Mahasiswa Reflektif SMA Melalui Pendidikan Open-Ended". <http://journal.fpmipa.upi.edu/index.php/jpmipa/article/viewFile/230/145>.