SCIENTIFIC LEARNING TO IMPROVE CRITICAL THINKING ABILITY

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Abstrack

The importance of the ability to think critically in mathematics learning is contrary to the fact that the development of these abilities is still not optimal. Not many teachers creatively develop critical thinking skills during the learning process. The consequence of the implementation of the 2013 curriculum is the use of a scientific approach to learning, including mathematics. Steps in scientific learning include: (1) observing; (2) ask; (3) collecting information; (4) associate; and (5) communicating. These five steps provide great opportunities for students to be able to develop mathematical critical thinking skills. This study describes the implementation of a scientific approach in learning mathematics, especially in improving mathematical critical thinking skills.

Keywords: Scientific Learning and Critical Thinking Skills

PREFACE

Implementation the curriculum 2013 is one of the government's efforts to continuously improve the education system in Indonesia. The curriculum 2013 was developed with various reasons (Kemendikbud, 2013). These reasons include: (1) reasons related to the future challenges, and (2) reasons related to the competencies needed in the future. One of the challenges related to the competencies needed in the future by all students is the ability to think clearly and critically. Critical thinking ability is a high order thinking ability that requires a person to have thinking skills, originality of ideas, high flexibility and flexibility in finding solutions to the problems faced.

Wahab (in Maulana, 2012) argues that there are four reasons for the need to develop critical thinking skills among students, namely: (1) the demands of the times which require students to search, choose and use information for the life of society and state; (2) every student is always faced with various problems and choices, so that they are required to be able to think critically and creatively; (3) the ability to see things with different ways of solving problems; and (4) critical thinking is an aspect of solving problems creatively so that students can compete fairly and be able to cooperate with other nations. Students who have critical thinking skills will have high competence and are always able to find solutions to every problem faced in accordance with the demands of the times.

According to Glaser (in Fisher, 2009) states that mathematical critical thinking is an attitude of thinking that demands efforts to examine every assumptive belief or knowledge based on the supporting evidence and the subsequent conclusions that resulted. In simple terms the ability to critical thinking mathematically is thinking attitude in solving problems that is full of consideration based on existing information. The critical thinking skills is not only needed by students in learning, but it takes all people to be able to adapt to their environment.

Someone who is often critical shows that he has a strong understanding of something. Do not immediately accept what is given, but seek the truth of what is received. Someone who has the critical thinking skills will always try new things, suspect, predict the possibilities that can occur and will eventually find a solution to the problem faced.

The reality that occurs in the field is that critical thinking skills have not been optimally developed. In this case, the role of the teacher is very important for the development of students' thinking skills. But not many teachers can creatively create a learning environment that encourages students to think critically.

As expressed by Jacqueline and Brookes (Santrock, 2007) that few schools teach students to think critically. The school actually encourages students to be smart in memorizing and giving the right answers without rethinking the origin of the answers obtained. this situation can lead to low critical thinking skills of students.

One learning approach that can be used as a solution to this problem is the application of a scientific approach. The scientific approach itself is an approach suggested in the curriculum of 2013 to be applied in every learning at school. The scientific approach is characteristic and a major factor in the curriculum 2013 development. The Ministry of Education and Culture (2013) provides its own conception that the curriculum 2013 emphasizes the modern pedagogical dimension of learning, namely using a scientific approach. The scientific approach in question includes observing, asking, collecting information, associating and communicating. In particular, in the mathematics lesson the scientific approach cannot always be done procedurally for each subject matter.

In scientific learning there are stages of learning activities that students must go through. In each stage students are required to be able to develop their own potential in carrying out these scientific activities. The process of observing, asking, gathering information, associating and communicating requires good thinking skills because students learn actively find their own knowledge in constructing concepts, laws and mathematical ideas.

Students learn how to formulate problems from the stages of observing, then gather information related to what has been formulated in the form of questions, analyze existing data then try to apply formulas, concepts or ideas obtained in an answer and finally must be able to make conclusions with the truth that he believes to communicate in various ways such as discussions or presentations. These activities are believed to be able to develop the mindset of students to become increasingly critical, because students try to find step by step in the process of finding solutions.

In accordance with the Ministry of National Education's (2013) statement, the curriculum 2013 is a competency-based and science-based curriculum where the students' own discoveries are the main things in learning activities.

In its implementation, there are still many teachers who find it difficult to apply scientific learning. It also has an influence on the development of students' mathematical abilities. Therefore, the authors attempt to provide an overview of how the implementation of scientific learning in mathematics learning, especially in improving the mathematical critical thinking skills so that educators, especially teachers, can apply scientific learning optimally

LITERATURE STUDY

a. Scientific Learning

Learning with a scientific approach is learning that is based on the scientific method in its implementation. The scientific method is the technique of formulating questions and answering them through observation activities and conducting experiments. In the application of scientific methods there are activities observed such as observing, asking, exploring, associating and communicating (Kemendikbud, 2013).

Kemendikbud, (2013) states that learning with a scientific approach makes learning more active and not boring, students can construct their knowledge and skills through the facts found in the field investigation for learning.

Hope K. Gerde (2013) states that the application of scientific methods to explore science to children provides a systematic way to involve children in observing, asking, predicting, trying, summarizing and sharing results. Teacher assistance is still needed in the process.

Suhartati (2016) states that teachers need to strengthen their ability to facilitate students so that they are trained to think logically, systematically, and scientifically, this is the principle of the scientific approach. However, the teacher's assistance must decrease with the growing adult students or the higher class of students.

In each learning process must still apply scientific values or traits and avoid non-scientific values or traits. The stages in the scientific approach in learning are observing, questioning, trying (Experimenting), reasoning (Associating), communicating (Networking).

1) Observing
Observing activities are the main stage in the scientific approach process. Observing is very meaningful because students can see, listen to, read and identify objects or problems in a real and attentive manner so that students will find their own facts and information related to the relationship between objects observed with prior knowledge.

In observing activities takes quite a long time, this is because in the process of observing not only requires the ability to think in assessing an object or problem but requires supporting evidence which of course can spend a relatively large cost and energy. Therefore, there needs to be a limitation carried out by the teacher as a control in the process of observing.

Daryanto (2014) revealed that the observing method is very useful for the fulfillment of students' curiosity, so that the learning process has a high meaningfulness. The emergence of students' curiosity is an important thing that must be in every lesson. Students who do not want to know anything about the object or problem they are facing will not be able to find information and solutions to what they are facing. Thus, observing activities is an important initial part in scientific learning activities.

2) Questioning
At this stage, students are given the widest opportunity to ask questions about the object or problem they are facing. Starting from observing activities, students will get information or problems from what is observed which in the end will be many problems that arise when students find things that are not or less understood.

Students ask when students do not understand something that is being

faced. Not all students have good skills in asking, both verbally and in writing. Sometimes students are confused about what to ask. Through this questioning activity, it is expected that each student is able to make questions that can answer what was not understood in previous observing activities.

Daryanto (2014) reveals that effective teachers are able to inspire students to improve and develop the realm of their attitudes, skills and knowledge. Thus the teacher is expected to encourage students to actively ask, so that the realm attitudes, skills and knowledge of students' will develop by asking.

3) Trying (Experimenting)
The activity of trying or experimenting is a follow-up to the stage of observing and asking. Information obtained from the results of observing and questioning activities is followed up by conducting experiments. Experiments in this case can be interpreted differently according to their respective subjects, especially for the material or substance that is appropriate.

In Permendikbud Number 81a of 2013, it is said that exploration activities can be carried out through experiments, reading sources other than textbooks, observing objects / events, interview activities with resource persons and so on.

Trying activities include: (a) determining themes or topics that are in accordance with basic competencies according to curriculum requirements; (b) study the ways of using tools and materials available and must be provided; (c) learn the relevant theoretical basis and the results of previous experiments; (d) conduct and observe experiments; (e) record the phenomena that occur, analyze and present data; (f) make conclusions on the results of the experiment.

4) Reasoning (Associating)
Reasoning or associating activities are the activities of processing information that has been collected, both limited from the results of experimental activities or the results of observing information gathering activities. (Permendikbud Number 81a Th 2013). The reasoning process requires high-level thinking skills, students must be able to connect the information obtained from the results of the experiment, observe and ask questions with the knowledge previously possessed. The reasoning process means identifying and finding patterns from the linkages of information obtained until finally it can determine the right way or formula to be used as a solution.

5) Communicate (Networking).
According to Permendikbud Number 81a, the activity of communicating is conveying the results of observations, conclusions based on the results of the analysis orally, in writing or in other media. The activity of communicating is the final stage of learning activities through scientific methods. Students are expected to be able to convey the results of the analysis that has been carried out, both orally and in writing or through other media. Students can share information that has been generated through group discussions, presentations, final reports, videos, audio and so on. In this activity students can develop good communication skills in delivering their own observations and analysis.

b. Mathematical Critical Thinking Ability

The ability to think critically is an important component that students must have, especially in the process of learning mathematics. Mahmuzah's Opinion (2015) Content Mathematical material and critical thinking skills are two closely related things, this is because mathematical material can be

understood through the ability to think critically and think critically trained through learning mathematics. The linkages make critical thinking abilities essential for life and function effectively in all aspects of life. Not only important in learning mathematics, but also very much needed in everyday life in dealing with various problems.

T. Jumaisyaroh E.E. (2014) Critical thinking is a thought process for analyzing arguments and generating ideas for each meaning to develop a logical mindset. While Sutarmo (2012) states that the ability to think critically, the brain is forced to think seriously to solve problems faced by individuals who think about actions to be taken later. With the compulsion to think, allows each individual to produce ideas that come suddenly to solve the problem faced. The ability to think critically makes individuals more critical in looking at things, not directly accepting what is given but first digesting information received with what is known so as to be able to analyze that information with better and more accurate conclusions.

Indicators of critical thinking skills include the following: (1) *elementary clarification* (giving a simple explanation) that is, focusing on achieving general clarification of a problem through analysis of arguments, questions or answers, (2) *basic support* (building basic skills), namely using and processing information there is to solve the problem, (3) *inference* (concluding), which is to make and decide conclusions inductively or deductively, (4) *advances clarification* (making further explanations), namely considering the results of induction, (5) *strategies and tactics,* namely determining strategies and tactics to solve problems.

METHODOLOGY

This research is a study of literature. The literature review reviewed supports the theoretical analysis approach including: a study of legislation, regulations, procedures, methods and situation analysis. Sources of research studies are reference books, scientific journals and other supporting media.

Literature studies that produce theory references will be used as supporting theories and the main tools for further implementation in the form of field research both in experimental and development research.

RESULTS AND DISCUSSION

As stated in the introduction that the curriculum 2013 development of has its own reasons, one of them is the competencies needed in the future. the intended competency contains mathematical abilities including critical thinking skills which are high-level thinking skills. This ability certainly cannot be obtained only by reading and writing but more than understanding and reasoning.

In the curriculum 2013, it is not limited to rearranging the competency standards and basic competencies of the previous curriculum, but the learning process to achieve the expected competencies is corrected and adjusted to the needs. There are learning principles contained in the Minister of Education and Culture Regulation number 65 (Kemendikbud, 2013), including the following:

a. From students who are told to students who find out.
b. From the teacher as the only source of learning to be learning based on various learning sources.
c. From the fixed approach to the process as strengthening the use of scientific approaches.

d. From content-based learning to competency-based learning.
e. From learning that emphasizes a single answer, towards learning with multi-dimensional truth answers.
f. From partial learning to integrated learning.
g. From verbalism learning to applicative skills.
h. Improvement and balance between physical skills (hardskill) and mental skills (soft skills).
i. Learning that prioritizes civilization and empowerment of students as lifelong learners.
j. Learning that emphasizes values by giving leadership (ing ngarso sung tulodo), building willingness (ing madyo mangun karso), and developing students' creativity in the learning process (tut wuri handayani).
k. Learning that takes place at home, at school and in the society
l. Learning that applies the principle that anyone is a teacher, anyone is a student, and anywhere is a class.
m. Use of information and communication technology to improve the efficiency and effectiveness of learning, and
n. Recognition of individual differences and background of students.

There are many changes made in the curriculum 2013. These changes will bring up two possibilities, namely ease and difficulty for both students and teachers. For students, the ease will be obtained when all scientific steps can be passed well, so that understanding of the concepts learned will be easier to master and the ease for teachers is obtained when the teacher is not the only source of learning but a facilitator for achieving learning steps. While the difficulties will be more obtained by students and teachers, this is because almost all learning processes require high-level thinking skills, both for students who undergo the learning process and for facilitating teachers. In this case, the teacher acts to provide stimulus so that the creativity and critical attitude of students emerge and make changes to their mindset, of course it is not easy.

In the curriculum 2013, the recommended approach in learnig is learning scientific approach. In the scientific approach, all learning processes in the curriculum 2013 are summarized in learning steps known as 5M, namely observing, asking, trying, reasoning and communicating. The five steps of learning can develop students' critical thinking skills which is one of the competencies that must be possessed and is the reason for the curriculum 2013 development. The following is the implementation of the scientific approach in developing critical thinking skills:

a. Observing

Observing activities are not just seeing and paying attention to something with the eyes, but observing can be done with all five senses carefully. In mathematics learning, observing activities can be in the form of mathematical objects, mathematical problems or activities related to mathematical concepts.

According to As'ari (2015) what students need to observe is actually very dependent on what messages are found in basic competencies in their curriculum. Understanding correctly the message of a basic competency will lead to deeper observation of an object, problem or concept.

The following is an example of the implementation of activities observed in the Pythagorean Theorem material that is oriented towards improving critical thinking skills.

Basic competencies:

3.6 Explain and prove the pythagorean and triple pythagorean theorems

These basic competencies can be translated into two sub-competencies, including:

1. Explain the pythagorean and triple pythagorean theorems
2. Prove the pythagorean and triple pythagorean theorems

Associated with explaining of the pythagorean theorem, students are expected to understand the definition of the Pythagorean theorem carefully so that it will be able to explain what the Pythagorean theorem is.

The process of observing what can be done can be seen from the following activities. Students are asked to fill in questions like the following

> After you know and understand the relation of the sides of the right triangle ABC (previously given an understanding of the relation of the sides of the right triangle ABC), try to observe and examine how the sides correspond to the following triangle DEF and PQR!

From these activities, students are expected to develop the ability to think critically by observing a picture of a right triangle given by answering a follow-up question that can provide an opportunity to explain the results of previous observations.

> Notice the triangle DEF and PQR above! (previously described there are right triangles DEF and PQR)
> Are there differences between the two triangles above? Try to mention!
> Try to show where the right angle is located on the triangle DEF and PQR!
> Try explaining how the sides of the triangle DEF and PQR triangle relate!

b. Asking

Asking activities is an activity to generate willingness to find out and increase students' curiosity. In this activity, it is no longer the teacher who asks questions, but the teacher facilitates students to ask questions and is required to ask questions. In order for students to actively ask questions about the material being discussed, the teacher should assign to make a question sentence that contains words related to the concept being studied. In addition to making question sentences, As'ari (2015) provides one of the ways that can be done so that students actively ask is "introducing an interesting phenomenon that students have never known before."

The following is an example of the implementation of the asking activities in the Pythagorean Theorem material which is oriented towards improving critical thinking skills.

> After you observe the relationship between the sides of the various right triangles, try making 3 sentences questions containing at least a mixture of 2 or 3 words from the following words:
> i. Triangle ii. Corner iii. Side
> Note: May include images to clarify questions.

Basically asking activities will appear suddenly when students understand what is observed. In making questions, the teacher can ask students to work together in groups so that the questions that arise become more varied and quality. Students will work together to give their best ideas for making questions discussed in groups.

The variety of questions that arise will encourage students to think critically in determining which questions to use and which are not or whether there are questions that need improvement. Thus, asking questions in this activity is

very good in developing critical thinking skills.

c. Trying

In the activity of trying or stating a truth, the process of gathering information is needed first, the information is related to theorem, nature or concept that relates and supports the truth of the concept in the material being discussed. In trying activities, it can be done by answering questions that contain concepts that have been observed previously.

Trying activities are also a follow-up to asking activities that require information. Students will try to explore the information needed to answer the questions they have made themselves, then apply them to an experiment. In Permendikbud Number 81a of 2013, it is said that exploration activities can be carried out through experiments, reading sources other than textbooks, observing objects / events, interviewing activities with resource persons and so on. Thus, this activity is part of exploitation activities.

The following is an example of the implementation of trying activities in the Pythagorean Theorem material which is oriented towards improving critical thinking skills.

Basic competencies:

4.6 Resolving problems related to pythagorean theorem and triple pythagorean.

These basic competencies can be translated into two sub-competencies, including:

1. Resolve problems related to the Pythagorean theorem
2. Resolve problems related to triple Pythagoras

Regarding the resolution of problems related to the Pythagorean theorem, the pythagorean theorem can be used to determine whether a triangle is a right triangle, a pointed triangle or a blunt triangle. Trying activities is an activity of digging up information by students by answering the questions provided.

The following is an example of the implementation of trying activities on pythagorean theorem material that is oriented to improving critical thinking skills.

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Look at the table below !

	Triangle A	Triangle B	Triangle C	Triangle D	Triangle E
Squared Length of the shortest right side	1^2	2^2	3^2	4^2	5^2
Length of the other side of the right angle			4^2		
Hypotenuse Long Squares					13^2

Fill in the table above with the following conditions.

a. complete the second line in the table above according to your wishes.
b. Complete the third line using the Pythagorean theorem.
c. Pay attention to the number pattern you get.
d. Determine which triangle includes right triangle, pointed triangle and blunt triangle based on the concept that has been obtained!

In trying activities, students will search for information to answer and complete the table. Given the empty table to be filled will encourage students to think critically in determining the value that must be filled in accordance with the belief in the information obtained. This activity will improve students' critical thinking skills.

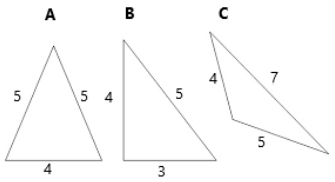
d. Reasoning

Reasoning activity is the activity of looking for a link between one concept and another related concept that can finally conclude a new concept. Students are expected to be able to find a relationship between existing facts and information that has been obtained

from previous activities. After finding the relationship, students are expected to find the correct pattern and conclusion.

In this reasoning activity can be used information or facts that can be used as a basis for students to find an expected conclusion.

The following example of the implementation of activities is based on pythagorean theorem material that is oriented to improving critical thinking skills.



Of the three triangles A, B and C above, specify:

a. The number of scabs from each side of the triangle.
b. What is the relationship between the hypotenuse and the number of other side scabs?
c. How does the shape of a triangle relate to the answer to part (b)?
d. Try to connect your answer with the answer from the "try" activity! What can be concluded? Explain!

The above question is an example of reasoning activity in an effort to make an expected conclusion. Reasoning in this case encourages students to actively think critically how to find relationships, patterns and conclusions from existing facts with the knowledge that has been obtained previously.

e. Communicating

Communicating means that the conclusions that have been obtained and believed the truth must be conveyed to others both in oral, written form and through other media. The benefits obtained by sharing the findings with all students and teachers are improvements through criticism and suggestions. These findings may be directly accepted by the truth and may have to be corrected with the advice given.

In communicating activities, students learn how to maintain the idea of the findings produced and learn how to criticize the findings of others. Indirectly communicating activities will increase self-confidence and inspiration to make further findings and will certainly improve students' critical thinking skills.
The following is an example of the implementation of activities communicating on pythagorean theorem material.

After you know how to identify right triangles, pointed triangles and blunt triangles using the Pythagorean theorem, try to present the procedure and explanation in front of the class. Then discuss your findings with your teacher and friends!

The implementation of scientific approaches in mathematics learning requires good collaboration between teachers and students. Every step in scientific learning requires facilities, creativity and support from the teacher. According to Suhartati (2016) that teachers need to strengthen their ability to facilitate students so that they are trained to think logically, systematically and scientifically. Therefore, the teacher does not only act as a facilitator but more than that the teacher needs to better understand the meaning and relationship of each activity in the scientific approach so that students are able to carry out scientific learning optimally.

In relation to the ability to think critically, each activity in scientific learning can be made in an effort to develop mathematical critical thinking

skills. Every scientific activity encourages students to be able to analyze concepts, statements or questions given then can gradually find a pattern that leads to a logical conclusion. This is in accordance with the statement of T. Jumaisyaroh E.E. (2014) Critical thinking is a thought process to analyze arguments and bring ideas to every meaning to develop a logical mindset. This means that the scientific approach is part of the process of developing critical thinking skills.

This study of the implementation of scientific learning oriented to critical thinking skills is expected to be able to provide a general picture, especially for mathematics teachers in order to develop critical thinking skills through scientific learning.

CONCLUSIONS AND RECOMMENDATIONS

a. Conclusion

Learning with a scientific approach is one of the learning methods that can develop students' critical thinking skills. Each step in scientific activities can be made in an effort to encourage students to think critically.

b. Suggestion

Based on literature review on the implementation of scientific learning in an effort to improve critical thinking skills, the authors provide several suggestions, including the following:

a. Scientific learning contains activities that require high-level thinking skills, therefore it is recommended for teachers to always prepare for optimal learning before learning is carried out.
b. Teachers are expected to change their mindset first in understanding the curriculum 2013 so that they can adapt each scientific step well.

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