Application of “what-if” learning strategy to improve students’ mathematical critical thinking skills in statistical method I subject

I P A A Payadnya and I M D Atmaja
Departements of Mathematics Education, Faculty of Teacher Training and Education, Mahasaraswati University Denpasar, Denpasar, Bali, Indonesia
Email: adeandre@unmas.ac.id

Abstract. The aim of this study was to improve students’ mathematical critical thinking skills through the application of “What-If” learning strategies. This research was motivated by the lack of critical thinking skills of students in the Statistical Method I subject. Critical thinking skills are very important to bring someone to think and work carefully, sorting out relevant information, solving problems, and doing tasks on a bigger scale. This research is a classroom action research consisting of two cycles. The subjects of this study were class IIA students of Mathematics Education Study Program, Faculty of Teacher Training and Education, Mahasaraswati University Denpasar as many as 16 students in academic year 2018/2019. Data collection techniques used was observation, interviews, and tests. This study used 2 data analysis techniques namely qualitative analysis and quantitative analysis. Qualitative analysis uses models such as mathematical models and analyses that are carried out limited to data management techniques by performing descriptions. Quantitative data analysis measures the learning outcomes in the form of scores and percentages using a simple level of calculation such as average score and learning completeness percentage. The results of this study showed an improvement in students' mathematical critical thinking skills from the first cycle to the second cycle. In the first cycle, the average score of students’ mathematical critical thinking skills was 71.125 with the learning completeness percentage only reached 62.5%. In the second cycle, the average score of students’ mathematical critical thinking skills increased significantly by 84.125 with the learning completeness percentage reached 87.5%. This study concluded that the application of "What-If" learning strategies can improve students' mathematical critical thinking skills in the subject of Statistical Method I.

Keywords: "What-If" Learning Strategies; Mathematical Critical Thinking Skills; Statistical Method I

1. Introduction
Mathematics learning in higher education is no longer in the procedural domain and focuses more on the application of high-order thinking skills (HOTS). One of the high-order thinking skills that is important for the development of students is mathematical critical thinking skills. [1] stated that critical thinking skills will lead students to think and work thoroughly. Critical thinking will also help someone in sorting out relevant information. This is very useful for solving problems and doing bigger tasks.
According to [2], Critical thinking is the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action. Furthermore, [3] stated that critical thinking is important for the future of students, given that it prepares students to face many challenges that will arise in their lives, careers and at the level of their personal obligations and responsibilities.

The fact is that students' mathematical critical thinking skills in Indonesia are still lacking, although mathematical critical thinking skills are very important for student development. Study conducted by Trend in the International Mathematics and Science Study (TIMSS) [4] shows evidence that non-routine mathematical questions that require critical thinking (high-order thinking skills) are not answered correctly by Indonesian students, and Indonesian students’ achievements were still below average, while the achievement percentage for cognitive domain was 35% for knowing, 40% for applying and 25% for reasoning. In line, study by [5] states that the average value of mathematical critical thinking skills and students is less than 50% of the ideal score.

The ability to think critically is closely related to college mathematics material. One material that requires sufficient mathematical critical thinking skills is Statistical Method I. Statistical Method I is an important statistical material for students to learn the basics of research statistics which will greatly assist students in studying research statistics for their final assignments. Statistical Method I is not only learns and applies formulas, but also understands the essence of the statistical concept itself and applies good thinking skills to be able to learn and solve various statistical problems.

The results of observations conducted by the researchers on class IIA Mathematics Education Study Program at Mahasaraswati University Denpasar showed that students were still very difficult to demonstrate mathematical critical thinking skills. Students tend to still understand the concept of statistics on a basic and procedural basis without being able to deeply analyse the non-routine problems given. In this case, Statistical Method I subject focuses on the basics of statistics and their development towards research statistics. Characteristics of class IIA show that students are not able to understand the concept and are only focused on memorizing and applying formulas.

The lack of mathematical thinking skills of students in the Statistical Method I subject requires serious handling. The solution can be done by applying the right learning model and strategy. One of the appropriate learning strategies used to improve students' mathematical thinking skills is the "What-If" learning strategy. "What-If" learning strategy is a learning strategy that uses a series of questions in learning that are developed from the "What-If-Not" strategy. The "What-If-Not" learning strategy was first put forward by [6]. [6] classify the level of problem posing on two levels, which are "accepting problems" and "challenging problems". At the level of "challenging problems", new questions can be arised from these problems. The "What-If" learning strategy was developed by [7] by giving wider space to the possibility of generating new ideas and developing thinking skills through "Not" omission. The emergence of new ideas from these problems will improve the ability to think critically.

Research conducted by [7] found that the application of the "What-If" learning strategy can improve students' critical thinking and divergence in solving open-ended mathematical problems. Students who are taught by using the "What-If" learning strategy can find various possibilities and new ideas in solving open-ended mathematical problems and can provide appropriate reasoning. In addition, research on the application of the "What-If-Not" learning strategy has been carried out by [8] who found that the use of the "What-If-Not" strategy is an effective strategy in problem posing to increase creativity. This strategy helps students to ask fluency and variety of questions, so that the questions posed by students can allow these questions to be unusual questions raised by other students (originality).

Based on the problems described above, the researchers deemed it necessary to conduct research on “Application of ‘What-If’ Learning Strategies to Improve Students' Mathematical Critical Thinking Skills Statistical Method I Subject”. The purpose of this study was to determine the improvement of mathematical critical thinking skills of class IIA students of Mathematics Education Study Program, Mahasaraswati University Denpasar in Statistical Method I subjects who learned by using "What-If"
learning strategy. This research will be useful to help students improve their abilities in mathematical concepts and as an alternative to lecturer in carrying out classroom learning activities.

2. Method

2.1. Research Design
The research design used was a classroom action research with the aim of improving the quality of classroom learning practices. The researcher used model from Kurt and Lewin which consisted of two cycles, each cycle consisting of three meetings with details two meetings for face to face learning activity and one meeting evaluation. Each cycle consists of four stages, namely (1) planning, (2) action, (3) observation, (4) reflection [9].

2.2. Location and Research Subject
This research was conducted at the Mathematics Education Study Program at Mahasaraswati University Denpasar. The subjects in this study were the students of class IIA of the Mathematics Education Study Program totaling 16 students. Subjects were chosen due to significant problems in terms of mathematical critical thinking skills especially in Statistics Methods I subject which are very important in research statistics. The researchers conduct research with the aim of improving the quality of teaching in mathematics education study programs using the "What-If" learning strategy.

2.3. Research instrument
In this study data collection was done using several ways as follows:

1) Test used to measure the improvement of the ability level of class IIA students in Mathematics Education Study Program, Mahasaraswati University Denpasar. The test used in this study was an essay test specifically arranged for measuring the students’ critical thinking skills. This test consist of 4 to 5 problems related to Statistical Method I materials (validity, reliability, normality, homogenity). The test used in this study was validated by using the content validity test (expert test) involving two experts who were lecturers of mathematics education specializing in research statistics. The mathematical critical thinking skills indicators used to scoring students’ answer [10]. The results of the content validity test show the instrument of Cycle I Post-Test and Cycle II Post-Test instruments have a validity value of 1 or very high,

2) Observations in this study used unstructured type observation that were carried out by observing directly in each activity that took place,

3) Documentation of data originating from documents such as written documents in the form of mathematical critical thinking skills, learning motivation, literature books that are closely related to research object information,

4) Interviews conducted with a number of students related to the research. This study used unstructured type interviews.

2.4. Data analysis technique
This study used 2 data analysis techniques namely qualitative analysis and quantitative analysis. Qualitative analysis in this study used models such as mathematical models and analyzes that are carried out limited to data management techniques by performing descriptions. Whereas, quantitative analysis is carried out by measuring learning outcomes in the form of average scores and percentages and also students’ completeness level using a simple level of calculation. The simple level calculation using formula as follows:

1. Students’ mathematical critical thinking skills average scores:

\[ \bar{X} = \frac{\sum X}{N} \]

Information:

\( \bar{X} \) : average scores
\[ \sum X \] : sum of students’ score  
\[ N \] : total of students

2. Students’ learning completeness:
\[ KB = \frac{T}{N} \times 100\% \]

Keterangan:
KB : learning completeness  
T : number of students who reach/pass the learning completeness level  
N : total of students

The minimum average determined in this research is 70 (B) with minimum learning completeness level is 80%.

3. Results and Discussion

3.1. Results
The initial description obtained by the researcher after giving the initial test and observing the IIA students of Mathematics Education Study Program Mahasaraswati University Denpasar is that most students do not have a strong foundation in statistical material. Students express statistics more as material that relies on calculations, memorization and application of formulas.

a) Cycle I
Planning
Researchers compiled Weekly Learning Plans (RPM) and Student Worksheets (LKM) for Statistical Method I for the first and second meetings. The material taken by researchers in this first cycle was to test the validity and reliability of the research instruments. The RPM and LKM compiled by researchers use the principle of "What-If" question in it which is the core of this research to improve students' mathematical critical thinking skills. In addition to compiling RPM and LKM, researchers also compiled learning videos presented at the beginning as a warm-up to convey the basics of statistics to students. Learning videos are compiled using Microsoft Power Point applications which are then recorded on screen by using a special screen recording application.

Action
The learning videos that are played contain the basic concepts of statistics so that it is very useful for students to enter the research statistics material that is widely presented in Statistical Method I course 1. After the presentation of the learning video, researchers begin to start the main material by having students form small groups consist of 3-5 people and then share the LKM with students in each group. The researcher began the initial explanation of the material and after that directed the students to work on the LKM that had been prepared. In the fist two meetings students learned the concept of validity and then given a set of data that are gained from instrument trial which is the students had to determine the validity and the reliabilty of the instrument. The LKM contains "What-If" questions that students must answer according to their respective knowledge and perceptions. The next activity is the students have to present their works on LKM and begin discussion with other group. At the end of learning activity, the researcher also developed "What-If" questions verbally to students to further improve students’ thinking skills. This activity took place for two meetings and at the third meeting the researchers gave a post-test to measure the improvement of students’ mathematical critical thinking skills.

Observation
Activities in Cycle I generally run well with students who seem to focus in learning acticity. With the help of learning videos researchers can maximize concentration and student interest in the material presented. Student responses to the "What-If" question are quite positive even though many students are confused. However, in the first cycle learning activity, intense discussions that were expected to be carried out by students do not occur because the "What-If" question is only presented in the LKM and orally delivered by the lecturer. This makes the learning activity ran in one direction, especially in the
discussion of "What-If" questions which are actually expected to trigger students in developing their mathematical critical thinking skills.

Reflection
Reflection priority of the first cycle is the lack of active discussion of the "What-If" question by students because the questions submitted are still in one-way, from the LKM or lecturer to students. The improvement that the researchers did was to revise the form of the LKM which also gave instructions to students to compile their own "What-If" questions in each group which would later be submitted to other groups. This is expected to make the discussion more intense and students become more active as it creates an academic tournament atmosphere so students can further develop their mathematical critical thinking skills.

b) Cycle II
Planning Revision
From the reflection of cycle I related to the one-way discussion that took place on the "What-If" question, the researcher made changes that focused on LKM that contained direction for students to develop their own "What-If" questions so that discussions between students would be better.

Action
In this second cycle, the action given is almost the same as the first cycle. The lecturer provides introductory material and then distributes the LKM to students to be discussed in each group. However, the difference is in the LKM, in addition to answering the "What-If" questions, students are also asked to prepare their own "What-If" questions which will be submitted to other groups. The materials in the second cycle was test of normality and homogeneity of variance. In this materials students are being introduced to the concepts of normality and homogeneity of the data, not only to knowing the formula, but also understand the meaning and characteristics of normal and homogen data and use this concept on real research. After the LKM’s execution activities take place, students are asked to present the results of their group's work and also submit "What-If" questions that they arrange to other groups. In this activity the discussion took place very intensely and students seemed active. At the end of the second cycle, students were again given a post-test question to measure the increase in their mathematical critical thinking skills.

Observation
The activities in the second cycle went very well. Changes to LKM that provide opportunities for students to compile their own "What-If" questions and submit them to other groups evoke an atmosphere of competition between groups. This makes discussions that occur between students better and students compete to be able to think more critically in order to be able to make varied questions to be submitted to other groups. This causes students to develop their critical thinking skills.

Reflection
In general, learning in the second cycle has taken place very well, actively, and effectively. Students can receive, understand, and compile "What-If" questions so that they can further develop their mathematical critical thinking skills.

4. Discussion
In the initial cycle, the average score of students’ mathematical critical thinking skills was 68 with the student learning completeness 43.75% which was still less from the minimum desired level of 70. This shows that there are things that need to be improved in the learning process. Then, in cycle I, the learning process was carried out using video media and LKM that presented "What-If" questions. Changes seen in the development of students' mathematical critical thinking skills from 68 to 71.125 in average with learning completeness reached 62.5%. However, this value does not meet the minimum completeness goal.

To accommodate this, the researcher observed that the discussions that occurred between students were less effective, where they were only conducted in one direction from the lecturer to the students in the discussion of "What-If" questions. "What-if" questions as the key in this study are only presented in the LKM and asked by the lecturer to the students. This causes a lack of "What-If"
question discussion between students so that students cannot develop their mathematical thinking skills to the fullest.

The step taken by researchers to overcome the shortcomings in cycle I to be improved in cycle II was to add points in student LKMs which direct students to compile their own "What-If" questions and submit to other groups. This gave rise to a competitive atmosphere between students so that students could better understand the "What-If" questions well and use their thinking power to the maximum to be able to arrange various "What-If" questions to be submitted to other groups. This active thinking process makes students' critical thinking skills become more developed. Evident from the results obtained by students at the end of the second cycle where the average score of students' mathematical critical thinking skills reached 84,125 with learning completeness reaching 87.5%. This shows that the Statistical Method I subject learning by using the "What-If" learning strategy proved effective in improving students' mathematical critical thinking skills.

Table 1. Data Tabulation Regarding Student Score Improvement

| Aspek                             | Initial Cycle | Cycle I | Cycle II |
|-----------------------------------|---------------|---------|----------|
|                                  | Mean          | Initial Test | Post-test 1 | Post-test 2 |
| Mean                             | 68            | 71.125   | 84.125    |
| Students’ learning completeness   | 43.75%        | 62.5%    | 87.5%     |

From the interview, students said that “What-If” learning strategy is very interesting and fun. Students stated that at the first time they confuse with “What-If” question but with the help of the researcher they begin to understand and starting to consider that “What-If” question is challenging and give them opportunity to expand their critical thinking skills.

5. Conclusion
The conclusions obtained in this study are as follows: 1) Significant increase occurred in the score of mathematical critical thinking skills of class IIA students of Mathematics Education Program at Mahasaraswati University Denpasar in Statistical Method I subject after being taught with "What-If" learning strategies with achievements in the first cycle with details of average score is 71,125 followed by learning completeness only reached 62.5%, and in the second cycle researcher get that mathematical critical thinking skills of students experienced an increase in average reaching 84.125 and in learning completeness by reaching 87.5%, 2) Application of "What-If" learning strategies in class IIA Mathematics Education Study Program at Universitas Mahasaraswati Denpasar in Statistical Method I went effectively and can improve students’ mathematical critical thinking skills.

6. Suggestion
The suggestions from this study are as follows: 1) Developing "What-If" learning strategies in terms of material, competencies, and variations, 2) Developing modules and learning media based on "What-If" learning strategy, 3) "What-If" learning strategy needs to be implemented in other type of research for further development.

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