



## Socrates questions to optimize students critical thinking

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### Abstract

The ability to think critically is one of the abilities that must be possessed by students in facing the rapid development of the times. Students' critical thinking skills can be developed through Socratic questions. This research is to find out 1) the types of Socratic questions used in learning and 2) whether Socratic questions can optimize students' critical thinking skills. The method used is a qualitative and quantitative approach with a pretest-posttest one group design. The research subjects were mathematics education students who attended linear algebra courses at Muhammadiyah Metro University. Data collection was carried out through observation and tests with descriptive qualitative and quantitative data analysis techniques. Socratic questions asked by lecturers in learning linear algebra include questions of clarification, investigative assumptions, reasons, investigative evidence, and beliefs. Socrates' questions can stimulate students' critical thinking activities to strengthen their understanding of concepts. Students' critical thinking skills increased in the medium category. The types of Socratic questions used in learning are distinguished based on three stages, namely in the introduction stage, the types of questions asked by the lecturer are clarification questions. At the core stage, Socratic questions include questions of clarification, investigative assumptions, evidence/reasons, and beliefs. And in the concluding stage, Socrates' question is a clarifying question. Socratic questions used in learning can optimize students' critical thinking skills. The results of this study are expected to be a reference for lecturers in applying Socratic questions in learning, especially in linear algebra courses.

## INTRODUCTION

Higher education is one of the critical resources that will help unlock human potential (Lefifi & Kiala, 2021). For this reason, universities must be able to produce students who engage, excel (Mokiy, 2019), and able to accept rapid technological developments (Maskur et al., 2020). One of the skills needed by students in facing challenges is critical thinking. This statement follows (Siswati, 2019) that the abilities that the younger generation must possess in facing the industrial revolution 4.0 are the ability to think critically, creatively, innovatively, communicate, cooperate, and be confident. Critical thinking is one of the 21st-century skills students need to have (Putri & Sueb, 2021; Rushton & Corrigan, 2021; Saphira et al., 2022). therefore, Nugraha & Suparman (2021) and Yuliani et al. (2021) stated that learning in the 21st century must be designed so that it can grow students' critical abilities.

Critical thinking is an indicator for students to develop the world of work and solve problems of daily life (Firdaus et al., 2015; Kusmaharti, 2022). Critical thinking skills help students compete in increasingly competitive lives and technological developments.

(Prihartini et al., 2016) Critical thinking indicators include analyzing and clarifying questions, finding and guessing existing assumptions, compiling clarifications and explanations, and making conclusions and arguments. Critical thinking focuses on decision-making that begins with reflection and evaluation. This factor does critical thinking a type of higher-order thinking. This thinking activity requires deep thinking, discipline, and logistics to make the right decision (Yunarti, 2016).

Mathematics and thinking are two things that cannot be isolated, students should be able to associate thoughts with one another to understand mathematics, so they can utilize numerical models to solve the given problems (Yuliani & Suragih, 2015). In other words, Critical thinking skills can be developed in learning mathematics. One of the mathematics courses that can develop students' critical thinking skills is linear algebra. This is because, in this course, students begin to develop reasoning consistently so that the means of thinking are effective in dealing with mathematical or non-mathematical problems (Rizkiana & Warmi, 2021). This is in line with Sulistiani & Masrukan, (2017) stated that developing critical thinking skills provides opportunities for students to analyze their thoughts to conclude facing challenges and solving problems. For this reason, the quality of learning needs to be considered for preparing students who can think.

Questions have a critical part in realizing compelling learning. Lecturer questions can stimulate students to think to construct knowledge. This is in line with Cahyani et al., (2016), stating that questions in the learning process in the form of interrogative sentences or orders require students to respond to gain knowledge and improve thinking skills. The quality and quantity of questions the lecturer gives will determine the implementation of meaningful learning. Good questions encourage students to interact actively so that learning feels fun and meaningful. Yunarti, (2016) states that a good question is a question that is clear, purposeful, and able to develop students' thinking skills.

Furthermore, Faizah et al., (2018) stated that the types of questions given in learning were not only at the knowledge level but continued with questions at the level of understanding, application, analysis, evaluation, and creation. Knowledge questions only require students to memorize facts/definitions in the book so that students' thinking does not develop. Lecturers must pay attention to the quantity and quality of questions asked in learning to stimulate students to think critically (Dias et al., 2017; Juwita & Fauzan, 2020). However, there are still questions in learning that have not been qualified, so they have not been able to develop students' thinking. The study's results (Faizah et al., 2018) show that the questions asked in learning are still at the level of low thinking ability.

Quality questions will lead students to provide meaningful responses. Structured and systematic questions will increase the participation of all students involved in learning (Cahyani et al., 2016). Furthermore, Kurniastuti et al., (2018) state that questions that can stimulate thinking, further inquiry, and raise new questions will increase student involvement in meaningful and deeper learning. One form of a question that can be used in meaningful learning is the Socratic question. Socrates is the name of a great thinker of ancient Greece (470-399 BC) who devised the Socratic method. Pangestuti & Latifah, (2019) states that Socratic is a learning method carried out by discussion by confronting students with Socratic questions to find solutions.

Furthermore, Yunarti (2011) states that the discussion conducted by the teacher and students in Socratic learning is a discussion that contains constructive questions and questions that explore critical thinking skills with cross-questioning. Therefore, the questions asked must be based on learning experiences so that students can answer questions and construct knowledge based on discussions. Socratic questions are questions in learning activities that can stimulate students' critical thinking skills. This claim is in line with Delić & Bećirović, (2016), who stated that Socratic questions are guided questions in discussion to stimulate students critically in reflecting on understanding related to the material. Socratic questions mean not just meaningless questions but questions that can respond to students to always think. According to (Rahmawati & Suwarjo, 2021), the advantage of Socratic questions is that it encourages students to think critically. However, the disadvantage of Socrates's questions in learning includes taking a long time, debates between students and teachers, and a heavy atmosphere if students are not ready. Yunarti, (2011) states that Socratic questions include clarifying questions, investigative assumptions, research reasons and evidence, points of view and perceptions, implications and consequences of investigations, and questions about questions. At the same time, Syanas et al., (2019) in her research stated that Socrates' questions in learning consisted of questions that investigated assumptions, reasons, and evidence.

Furthermore, the results of Marlita et al., (2019) state that Socrates' questions often arise include types of clarification and reasons and investigative evidence, while the critical thinking skills that arise are interpretation and analysis. Previous research has shown that Socratic can improve critical thinking skills (Ismah & Muthmainnah, 2021; Pangestuti & Latifah, 2019; Syanas et al., 2019; Yunarti, 2011). In class, the teacher poses Socratic questions. At the same time, students examine and assess their thoughts to enable them to develop their thinking while expressing thoughts openly, thereby increasing their critical thinking (Grace & Maigue, 2020). The teacher asks a series of questions structured on students. Through the process, students answer questions and experience their thoughts in context so that students can find the answer based on thought and their abilities; thus, Socrates' questions require teachers and students to think critically (Wahyuni & Iqbal, 2021). This statement follows Marlita et al., (2019); the questions in Socrates are used to test values, principles, and values of someone's belief. This means that Socrates' questions are very important in developing critical thinking skills. For this reason, lecturers must be able to develop Socratic questions in learning.

Linear algebra is one of the compulsory subjects that undergraduate students at the University of Muhammadiyah Metro must take. This course helps students develop reasoning skills and think logically, analytically, systematically, and critically. Based on the results of observations in linear algebra lectures shows that linear algebra learning is carried out in group discussions. Lecturers assist each group in discussions and use LKM (student worksheets) as learning media. Furthermore, preliminary research conducted by Vahlia et al., (2021) shows that students' critical thinking skills are still very lacking. Students have not been able to interpret problems, analyze, evaluate and draw conclusions correctly. In addition, several previous studies from Basri et al., (2021); Setiana et al., (2020); Zakaria et al., (2021) also show that students' critical thinking skills are still lacking and need to be developed. Today's learning is still not optimal in developing students' critical thinking. Thus, there are

still very open opportunities to explore how to optimize critical thinking skills in learning. One of the efforts to optimize critical thinking skills can be made through Socrates' questions in learning. This study aims to determine whether Socrates' questions can optimize critical thinking skills.

## METHODS

This type of research is qualitative research. This type of research follows the characteristics of the research problem, namely the questions asked by the lecturers and the students' responses in learning that takes place naturally. This research was conducted in the UM Metro mathematics education study program for the 2021/2022 academic year. The research subjects were mathematics education students who took linear algebra courses. The object of this research is students' critical thinking skills in learning linear algebra with Socratic questions. The research instrument is an observation sheet and a critical thinking ability test. Research data consists of qualitative data and quantitative data. Qualitative data is in the form of Socrates questions posed by lecturers and student responses in linear algebra learning, while quantitative data is in the form of students' critical thinking ability test results. The data collection procedure was carried out by making observations during linear algebra learning and critical thinking skills tests. Observations were made to obtain data on Socrates' questions posed by lecturers and student responses in linear algebra learning. In this study, Socratic questions include clarifying, investigation assumptions, evidence, reason, perceptions, implications, and consequences of investigations, and questions about questions. Socratic indicators are presented in the following table 1:

**Table 1.** Socrates Types Questions

No.	Socrates Types Questions	Critical Thinking
1	Clarifying	Interpretation, analysis, evaluation
2	Investigation assumption.	Interpretation, analysis, evaluation, decision making
3	Investigation evidence	Analysis, evaluation
4	Reason	Analysis, evaluation
5	Perception	Analysis, evaluation
6	Implications and consequences of investigations	Analysis
7	Questions about questions	Interpretation, analysis, decision making

Observations were carried out by lecturers of the mathematics education study program. Furthermore, the test is carried out for all students who take linear algebra courses. The test obtains data on students' critical thinking skills before and after learning. Data analysis was done through data reduction, presentation, conclusion drawing, and verification. In the reduction stage, the data needed are selected according to the research objectives, and the data is not used.

Furthermore, the data in the form of Socratic questions asked by students and student responses were described using simple words. Then, draw conclusions based on field findings. Data verification is collected as evidence to determine whether the conclusion is appropriate.

## RESULTS AND DISCUSSION

Linear algebra learning is carried out for students of the mathematics education study program for the 2021/2022 academic year. Learning is carried out in small group discussions through problem-based learning. Students are given problems. Learning is carried out through 3 stages, namely, 1) the preliminary stage, namely the lecturer conveys the purpose and importance of the material and checks students' understanding of the prerequisite material; 2) The core stage is the delivery of material by providing problems related to linear algebra material to be solved in group discussions; 3) The closing stage is the submission of conclusions, evaluation, and follow-up in learning. At each stage of learning, the lecturer asks questions to facilitate students' understanding of the material. The study was conducted in eight meetings with a duration of 2x50 minutes. From the first to the seventh meeting, the material presenters were discussed, and in the eighth meeting were given a critical thinking ability test. The results of direct observations showed that during the learning process, the lecturer asked Socrates questions to guide students in finding solutions to problems. The questions asked by the lecturer in learning linear algebra already cover the cognitive level of knowledge to evaluation. The learning objectives very much determine the questions asked by the lecturer in learning. In addition, the material's scope and depth also determine the lecturer's questions. Socrates' questions appear at all stages of learning, namely the preliminary stage, core activity, and closing. The types of Socratic questions that arise at each stage of learning are different. Socrates' types of questions at each stage of learning are presented in table 2 below:

**Table 2.** Socrates Types Questions

No.	Learning Stages	Socrates Types Questions
1	Introduction	Clarifying
2	Core Activities (discuss)	Clarifying, Investigation assumption/evidence, reason, belief.
3	Closing stage	Clarifying

In the preliminary stage (introduction), the types of questions asked by the lecturer are clarifying questions. Clarifying questions at the preliminary stage are used by lecturers to determine the level of student understanding regarding the prerequisite material/previous material. Students must state definitions and interpretations of concepts and examples, not examples. This question is very important at the introductory stage because it will lead students to re-expose previously studied material. The clarifying questions asked by the lecturers include "What do you understand about vectors?" This question requires students to explore all their memories and understandings related to vector concepts. Through this question, students not only mention the definition of a vector but also the interpretation of a vector by mentioning examples and not examples. However, in learning, the student's response to the lecturer's question is only limited to mentioning the definition. Students have not expressed their interpretation by providing examples and not examples.

Furthermore, to reveal students' understanding, the lecturer provides follow-up questions as responsive questions/comments on the student's answers. With these responsive questions, the lecturer can reinforce student answers and clarify whether the answers are

appropriate or not. If the student's answer is inappropriate, then with responsive questions, students can reveal further information related to student understanding. Responsive questions will encourage students to explore the answers expressed more deeply. The lecturer's questions at the introductory stage are very important to create the initial conditions for learning so that students' initial activities support learning.

At the core stage, the types of Socratic questions arise more than in the preliminary and closing stages. Socrates' questions that arise at the core stage include clarifying questions, investigative assumptions, evidence/reasons, and beliefs. This question arose during the class discussion. Lecturers use clarifying questions to find out students' interpretations. The clarifying questions that arise include "what do you mean by ....?, Is there another way? Do you know another example of....?. The clarifying questions that arise encourage students to interpret, analyze and evaluate their understanding so that they arrive at the correct solution. The research assumption questions that arise include "What are your assumptions?, What is your basis for choosing this?, What about these assumptions?". These investigative questions will encourage students to interpret their knowledge, analyze, evaluate, and make decisions regarding the correctness of their answers.

Furthermore, the questions of evidence or reasons that arise include "why do you think this is true? why do you think this is wrong? what is the basis that changed you to change your mind?". Questions that require evidence/reasons for student answers will encourage students to evaluate and analyze the correctness of the answers. While the confidence questions that arise include Are you sure about this? Why are you sure? For that, are you still sure about your previous answer? Questions related to student's beliefs about their answers will encourage them to analyze, evaluate, and make decisions.

In the closing stage, Socrates' questions that arise are clarifying questions. This clarifying question encourages students to interpret their understanding of what has been obtained. The questions at this stage include "What do you understand .... ? what conclusions can you make? These questions encourage students to interpret and analyze all the correct final answers.

The results of the pretest and posttest of students' critical thinking in linear algebra learning are presented in table 3 as follows:

**Table 3.** Result Pretest And Posttest

Average Pretest	Average Posttest	N-Gain	Conclusion
70	87,2	0,57	Medium

Based on table 3 above shows that the calculation of the N-Gain score obtained results of 0.57 or the medium category. This shows that Socrates' questions in learning are effective in optimizing students' critical thinking skills. The results showed that the lecturer's questions could increase the interaction of students with lecturers and students with students so that learning was effective. Through questions, Socrates can guide students to construct and solve problems so that students are actively involved. Questions that guide students have a greater impact on learning (Guspatni, 2017) because questions are a way of guiding students to complete the assigned tasks (Suparman, 2021). Guiding questions will help students recall prior knowledge. Students can generate knowledge or ideas in memory through appropriate

Socratic questions that will be used in constructing new knowledge and solving problems. The lecturer's questions are questions that require students to think. This follows the character of linear Algebra material, one of the courses that require students to think critically. Socrates' questions that arise encourage students to interpret, understand, analyze, evaluate, and make decisions. All of these activities are higher-order thinking activities or critical thinking. Students' responses or answers to lecturers' questions need to get a lecturer's response. The lecturer's response can be through response/advanced questions if the student's answer is incomplete/not appropriate.

Through follow-up questions, students can encourage them to improve their answers and develop further answers supporting their opinions. Thus, appropriate responsive questions will encourage students to think more specifically about the information needed to answer questions (Suparman, 2021). This is indicated by students' responses in revealing their knowledge. Students try to uncover examples and not examples of vectors. In addition, follow-up questions help students test the truth of the expressed ideas. This is in line with Yunarti, (2016) that questions can motivate students to test the truth of the ideas expressed. Through the Socratic questions, the learning process can indirectly develop ways of view and thinking through collaborative question-and-answer dialogue between students and educators or with other students (Danawak, 2022).

For this reason, the lecturer must respond to students' answers until the student's answers have been validated. Socrates' systematically arranged questions can explore students' critical thinking in gaining knowledge or solving problems. Thus, in learning, it is better to always raise Socratic questions that can optimize students' critical thinking as an important skill in facing globalization.

## **CONCLUSIONS**

Socratic questions posed by lecturers in learning can optimize students' critical thinking skills. Students' critical thinking skills increased in the medium category. Socrates' questions asked by the lecturer consisted of clarifying questions, investigating assumptions, reasons, investigative evidence, and beliefs. The types of Socratic questions used in learning are distinguished based on three stages, namely at the preliminary stage (introduction), the types of questions asked by the lecturer are clarifying questions. At the core stage, the Socratic questions include clarifying questions, investigative assumptions, evidence/reasons, and beliefs. And in the closing stage, Socrates' questions are clarified. These questions require student responses to think critically. The lecturer's questions in learning can direct students in constructing and solving problems so that learning runs effectively and can optimize students' critical thinking skills. The lecturer should ask questions that can guide and explore student understanding.

## **AUTHOR CONTRIBUTIONS STATEMENT**

RD and NN worked as the main drafter in this research. Data collection and instrument design assisted by IV, TY and MM.

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