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Critical Thinking Ability Through Experiential Learning In The Calculus Class A A Abdullah, W N Shanti, D A Sholihah Department of Mathematics Education, Universitas Alma Ata, Yogyakarta, Indonesia Email : anis02108882@gmail.com Abstract. This quasi-experimental study aims to develop students' mathematical thinking skills in calculus classes. The learning model used is experiential learning, where students develop mathematical concepts from their own experience, data obtained from Student Worksheets, observations of student activity sheets in discussions to solve problems, and draw conclusions through critical thinking processes. The results of the study show that students' critical thinking skills that can be developed in this learning model are: interpretation, analysis, evaluation, and making conclusions.

With an average score of students before and after getting the following treatment 59.55 and 73.18. An increase in the average value of critical thinking skills along with the increasing number of students who are categorized as very critical and critical in the hierarchy of critical thinking abilities category. Introduction The ability to think critically is an important skill that students need to develop while at university. The ability to think critically is one of the assets students must possess in facing the industrial revolution 4.0.

The ability to think critically is a must-have requirement for improving the quality and competitiveness of human resources.[1] The National Research Council, 2012 states that critical thinking skills are important because students who have good critical thinking skills will be able to become critical consumers of science. Universities need to develop graduates who are able to make well-informed judgements and who are capable of making connections between their learning and practice.

Graduates of the future will need to deal with the unknown and solve problems that may not even exist currently[2]. The importance of critical thinking skills has led to research on critical thinking skills. The habit of critical thinking will improve the mathematical ability of students, because the students are encouraged to perform various activities such as: face many challenges in learning, finding new things, and resolving the problems of non-routine [3]. Various studies have shown that Indonesian students' critical thinking skills are still relatively low [4] [5] [6].

Furthermore, the level of critical thinking skills of each person is different and the difference can be seen as a continuum that starts from the lowest to the highest degree. it can be known that the quality of critical thinking varies from student to the others. This difference is in the form of the characteristic phases of critical thinking raised by the students in the certain level of critical thinking. the level of critical thinking ability consists of level 0 (not critical), level 1 (less critical), level 2 (quite critical), and level 3 (critical)[7].

The achievement of students' critical thinking skills is influenced by many factors, including the process and conditions of learning. The learning process is closely related to the learning design conducted by the lecturer. If the learning process goes well, the learning objectives will also be achieved[8]. One good learning model is learning from experience. The learning model that makes experience the first step is experimental learning. Many researchers have shown positive results in the development of students when they are taught through direct experiments.

The majority of research results have shown that students are more interested in science and other subjects because they are taught using this method[9]. In addition, direct experiments can create excitement among students as they develop their interest in learning Science. People both children and adults remember things better when they learn while doing. This theory builds on the six propositions shared by these scholars. 1. Learning is best understood as a process, not in terms of results. 2. All learning is relearning.

Learning is best facilitated by a process that draws students' beliefs and ideas about a topic so that they can be examined, tested, and integrated with new, finer ideas. 3. Learning requires conflict resolution between adaptation modes which are dialectically opposed to the world. Conflicts, differences, and disagreements are what drive the learning process. 4. Learning is a whole process of adaptation of the World. Not just the result of cognition, learning involves the integrated function of total people thinking, feeling, understanding, and behaving. 5. Learning outcomes of synergistic transactions between people and the environment. 6.

Learning is the process of creating knowledge[10]. According to the Association for Experiential Education (AEE), experiential learning is a philosophy and methodology where educators engage directly in motivating learners and reflection is focused on improving knowledge, developing skills[11]. Experiential learning so that teaching and learning processes run effectively, students must have four abilities namely "concrete experience (sample word, feeling), reflective observation (watching), abstract conceptualization (thinking), and active experimentation (doing) [12]. / Figure 1.

Experiential Learning Cycle Based on some of these studies, researchers feel the need to conduct a study related to the presence or absence of the influence of experiential learning methods on the Critical Thinking Ability of Students. The study was conducted on S1 students of Mathematics Education Study Program at Alma Ata University in Yogyakarta who took Calculus 1. 2. Methods This research is a quasi-experimental study with a single group pretest-posttest design. This research is focused on developing thinking skills which include observational skills, making hypotheses, planning research / experiments, controlling variables, interpreting data, drawing conclusions, predicting, applying and communicating.

The study population was all Mathematics Education Students at Alma Ata University, which consisted of three classes. From the population, one class (one batch) was randomly sampled as a research sample, then the class got learning by using the experiential learning model. The instrument used to collect data was a critical thinking ability test. Meanwhile, to test the effect of experiential learning models in improving critical thinking skills, data were analyzed using paired t-tests.

Benchmarks for the success of the implementation of this study can be seen from the results of the measurement of process skills which tend to increase and better learning outcomes. Result and Discussion At the first meeting, students get a test to measure students' critical thinking skills before getting treated. Furthermore, lecturers put emphasis on the course of the learning process with an experimental learning model. The lecturer first gives direction to the expected learning process. The implementation of experimental learning is supported by lesson plans and student worksheet that have been adapted to the learning model.

Students' thinking skills in experimental learning are developed through problem solving inquiry activities as set out in the student worksheet. Each question in the student worksheet is adjusted to the ability to think that is developed and ordered systematically according to the knowledge to be reconstructed. After getting treatment, students again get a test to measure critical thinking skills after treatment. Analysis of

students' critical thinking skills tests is presented in Table 1.

This assessment is based on thinking skills tests conducted before and after treatment. Table 1. Critical Thinking Skills Test Pretest and Posttest Scores Total and Subscales

	Pre-Test	Post Test	p Value	Mean	SD	Mean	SD	Total Critical Thinking Score
Interpretation	59,55	73,18	0,009*	11,241	4,156	18,64	3,931	
Analysis	59,55	73,18	0,046*	15,45	3,503	18,64	3,233	
Evaluation	59,55	73,18	0,026*	14,09	3,015	17,27	4,101	
Inference	59,55	73,18	0,046*	14,55	2,697	18,64	4,523	

*An asterisk indicates statistically significant change; SD, standard deviation. For the Critical Thinking Skills Test, the students' total scores improved from a mean of 59.55 (SD 9.683) to a mean of 73.18 (SD 11,241) with a statistical significance of $p = 0.009$.

A further analysis of the test revealed that students made statistically significant changes in every subscales of the Critical Thinking Skills Test: interpretation, analysis, evaluation, and inference ($p < 0.05$). (Table 1, fig.2). / Figure 2. Critical Thinking Skills Test pretest (black bars) and posttest scores (gray bars). Furthermore, based on Critical Thinking Skills Test scores, students' critical thinking skills can be grouped as follows Table 2. Grouping of critical thinking ability level

Level	Pre-Test	Post Test	Total Students	Mean
Level 3	0	2	90	
Level 2	2	75	4	77,5
Level 1	7	58,6	5	63
Level 0	2	47,5	0	0

Based on table 2.

it appears that there is an increase in the number of students at levels 2 and 3, as well as a reduction in the number of students at levels 1 and 0. So that the conclusion is that there is an influence of the application of experiential learning learning models in increasing students' critical thinking skills. These results are in line with research which states that experiential learning models can improve critical thinking skills[13].

This is because students are directly involved in the learning experience, students construct their own knowledge of concepts with prior experience and use concepts that have been found themselves to solve problems [14]. Based on a theoretical study, the experiential learning model steps include concrete experience, reflective observation, abstract conceptualization, and active experimentation. The learning process with experimental learning has relevance to indicators of critical thinking skills, namely, interpretation, analysis, evaluation, and decision[15]. / Figure 3.

Correlation experimental learning aspect with core critical thinking skills The first step concrete experience is able to bring up indicators of interpretation on the ability to think critically that is the ability to understand or express the meaning of data or situations presented in a mathematical problem. In the Concrete experience, students learn from specific experiences and are sensitive to situations. The second step reflective

observation is able to bring up the indicators of analysis on **the ability to think critically**, namely the ability to identify the relationship between the data provided and reasoning given arguments.

In **Reflective observation, students make** observations before making a decision, students observe the environment from different perspectives. and observing various things to get a meaning. The third step abstract conceptualization is able to bring up the evaluation indicators on **the ability to think critically** that is the ability to evaluate every aspect that exists in a particular problem or situation. In Abstract conceptualization, students conduct logical analysis of ideas and act according to the understanding of a situation.

The fourth step of active experimentation is able to bring up the decision indicators on **the ability to think critically**, namely the ability to make conclusions from a mathematical problem. In Active experimentation, students do various things with people and take action based on events, including risk taking. This description identifies that **students' critical thinking skills can** develop by applying experiential learning to classroom learning. this is supported by each step in experimental learning being able to grow indicators of critical thinking skills. 4.

Conclusion Based on the discussion above **it can be concluded that students' critical thinking skills can** be developed by experimental learning in the calculus class. **The results showed that the** stages in experimental learning were able to develop students' critical thinking skills. **The students' critical thinking skills that** can be developed in this learning model are: **interpretation, analysis, evaluation, and** making conclusions. With an average score of students before and after getting the following treatment 59.55 and 73.18.

An increase **in the average value of critical thinking skills** along with the increasing number of students who are categorized as very critical and critical in the hierarchy of **critical thinking abilities** category. Acknowledge The researchers **would like to express** gratitude to the Indonesian Ministry of Research, Technology and Higher Education for funding this research.

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