Efforts to improve students' mathematical critical thinking ability by using Team Assisted Individualization learning model

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Abstract. The development of critical thinking is the goal of the Indonesian education curriculum. However, research on how to develop and improve these abilities is still rarely studied. In this article, we offer a team assisted individualization-learning model in improving critical thinking skills. The objectives of this study were (1) to describe the improvement of students' mathematical-critical thinking skills using the Team Assisted Individualization learning model, (2) To determine the increase in students' critical thinking skills after team assisted individualization learning has carried out. This study used experimental research. The subjects in this study were fourth-semester students of the Khairun University mathematics education program. The instrument used was a question describing students' mathematical-critical thinking skills. Data have been analyzed per indicator and as a whole using descriptive analysis, namely benchmark reference guidelines (PAP) scale five and Normalized Gein. Data were analyzed using the inferential analysis to determine the increase in students' mathematical critical thinking skills, namely hypothesis testing (one-sample t-test). The result of the data analysis showed an increase in students' mathematical critical thinking skills, which were interpreted moderately after implementing the assisted individualization team learning model.

1. Introduction
Mathematics is a subject to be taught at every level of education. The purpose of studying mathematics is to shape students' attitudes and put pressure on the arrangement of reasoning and skills in applying mathematics. It is in line with the opinion of Sumarmo [1], which states that the visions of mathematics education from basic to tertiary education have been divided into two development directions: meeting the present and future needs. The first vision directs mathematics learning to understand mathematical concepts and ideas that are applied to solve routine and non-routine problems, reasoning, communicating, and making mathematical connections and other sciences. The second vision directs mathematics learning towards the future, namely to reason logically, systematically, critically, carefully, honestly, discipline, develop creativity, and develop an objective and open attitude.

The Higher Education Curriculum (K-DIKTI) [2], which is based on the Indonesian National Qualifications Framework (KKNI), states that the minimum learning outcomes of the Undergraduate
Mathematics Program consist of two products. First, the ability in the field of work which consists of (1) being able to develop mathematical thinking, starting from procedural/computational understanding to broad understanding, including exploration, logical reasoning, generalization, abstraction, and formal evidence; (2) Able to observe, recognize, formulate and solve problems through a mathematical approach with or without software assistance; (3) Able to reconstruct, modify, analyze/think in a structured manner on the mathematical problems of a system or problem, assess its accuracy and interpret it; (4) Able to take advantage of various alternative mathematical problem solving that are available independently or in groups for the right decision-maker; (5) Able to adapt or develop themselves, both in mathematics and other relevant fields. Second, mastery of knowledge consists of (1) mastering mathematical theoretical concepts including mathematical logic, discrete mathematics, algebra, analysis, and geometry, as well as probability theory and statistics; (2) Mastering the principles of mathematical modelling, linear programming, differential equations, and numerical methods.

The minimum learning achievement of the undergraduate mathematics education program consists of three abilities [2]. First, the knowledge in the field of work which consists of (1) being able to apply pedagogic concepts and principles, didactic mathematics and mathematical science to plan, manage, implement, evaluate, by utilizing science and technology which has been orienting towards life skills; (2) Able to design, carry out research and publish results so that they can have been using as alternative solutions to problems in the field of mathematics education. Second, the ability in the field of knowledge which consists of (1) Mastering the concepts, structure, material and scientific mindset of mathematics needed to carry out learning in primary and secondary education units as well as studies to the next level; (2) Mastering pedagogical concepts and principles, didactic mathematics to support his professional duties as a mathematics educator. Third, the managerial abilities which consist of (1) being able to make strategic decisions in the field of mathematics education based on relevant information and data; (2) Able to manage mathematics education resources, organizations, and communicate the results of their management responsibly to stakeholders.

Based on the K-DIKTI, the abilities that become the minimum learning outcomes in both the undergraduate mathematics program and the undergraduate mathematics education program include the ability to think critically. It shows that one of the important aspects of mathematics in higher education is critical thinking. It is in line with the Committee on the Undergraduate Program in Mathematics recommended by the Committee in Mathematics [3], namely "six basic recommendations for majors, programs and courses in mathematics should be activities that will assist students in analytical development, critical reasoning, problem-solving, and communication skills. According to [4], critical thinking is a thought process to compile, organize, remember, analyze arguments, and provide interpretations based on valid perceptions (logical reasoning). Critical thinking includes the ability to read with understanding, identify important and irrelevant materials, the ability to draw correct conclusions from a set of data, the ability to determine inconsistencies and contradictions from a collection of data, and critical thinking is analytical and reflexive [4].

According to Richard Paul [5], critical thinking is a model of thinking about any substance or problem, in which the thinker improves the quality of his thinking by skilfully handling the structures inherent in thinking and applying intellectual standards to it. Meanwhile, according to [6], critical thinking is a directed and transparent process used in mental activities such as solving problems, making decisions, persuading, analyzing assumptions, and conducting scientific research. In line with this, Ennis has quoted as saying [7] that the aspects of critical thinking are focus, reasons, inference, situation, clarity, and overview. Based on the above statement, thinking critically could make and train someone to do (doing math) in mathematics learning. Mathematical critical thinking skills are high-level mathematical abilities. This study has been measured using indicators of revealing facts needed to solve a problem, determining the consequences of a question taken as a decision, and expressing concepts in solving a problem.

The information obtained in observing fourth-semester students of the Khairun University mathematics education program has been found that, those mathematical abilities, especially critical
thinking skills, and we are still in the low category. These students' low ability could be seen from the results of data analysis on students' initial abilities, which showed that none of the 41 students who took the initial test achieved the minimum completeness score. However, it needs to be realized that this critical thinking ability may not just appear in students but requires development. One alternative that can improve students' critical thinking skills is to use the Team Assisted Individualization (TAI) learning model.

The TAI learning model is cooperative learning whose rationale is to adapt teaching to individual differences related to student abilities and student achievement [8]. In this lesson, students are given assignments individually, and those friends in one group check the answers to the assignments. It can solve the problem of students who are accustomed to relying on one member of the group to complete assignments. Tasks in the TAI learning model can equalize students' understanding of the material because working on problems in assignments must be done gradually. Students will be motivated to learn the material by doing tasks quickly and accurately. It is in line with the opinion [9] that the advantages of TAI learning are that students are taught how to work together in groups and involve students to learn actively.

The TAI learning model has been proven to improve students' critical thinking skills. It can be seen from the results of research conducted [9], which explains that after the TAI model has been applied students' critical thinking skills increase. The result of this study showed similar findings as the previous research conducted by [10], which explained that after the TAI model was applied, students' critical thinking skills increased where the increase was interpreted as moderate. [11] also shows that students' critical thinking skills increase by applying the TAI learning model. [12] research results show that the TAI learning model positively affects students' critical thinking skills. It indicates that the TAI model affects students' critical thinking skills.

Based on the description above, researchers are interested in conducting studies to trace learning activities carried out in growing and strengthening the ability to think critically in mathematics using the team assisted the individualization learning model. It is expected that the results obtained in this article can be a reference and discourse for mathematics education practitioners at Khairun University to understand better the role of the assisted individualization team learning model in improving students' critical thinking skills as well as a form of contributing to the advancement of Indonesian human resources to prepare math educators for the 4.0 industrial revolution.

2. Method
The design of this research is experimental with a pre-experimental design type One-Group Pretest-posttest. This research took place at Khairun University, where all semester IV students of the mathematics education program for the 2015/2016 academic year with 91 people. Meanwhile, the sample in this study was 41 students of fourth-semester in class A. The sampling technique used was purposive sampling. The sample selection in this study becomes the consideration for the sample experienced problems identified during initial observation. The sample was able to represent the characteristics of the entire population.

The data collection instrument in this study was a test instrument in the form of an essay. The test questions given are linear program questions. There were two questions in the test instrument in this study, namely the pretest and posttest questions. The items have been made in the form of an essay that requires students' critical thinking skills. The pretest was given to measure students' initial ability towards the material to be taught. Meanwhile, a posttest was given to measure students' mathematical critical thinking skills after receiving learning treatment using the TAI learning model. The number of each question (pretest and posttest) consists of 2 numbers, where each number of students have asked to reveal the facts needed to solve a given problem, determine the effect (mathematical model) of a statement taken as an alternative to the question presented and reveal the minimum benefit by using the simplex method on the given problem.

The validity of this study's data has been carried out by testing test instruments' validity and reliabilities. Evidence of the validity of the tools used in this study is content validity and construct
validity. Content validity has been carried out by three experts. Meanwhile, the construct validity used product-moment correlation. Based on the analysis results, it has been found that the product-moment correlation was 0.8625, indicating that the test was valid. Furthermore, reliability results show Alpha Cronbach 0.72. It shows that the test is reliable; according to the statement [13], a reliable score test has accepted if the minimum standard reaches 0.65. For the students, achievement score to qualify a standard reference guideline of scale five has been used. Meanwhile, to determine the increase in students' critical thinking skills, the N Gain <g> formula is used to define whether there is an increase in mathematical critical thinking skills after the implementation of the TAI model, the hypothesis test has been operated with the t-test statistic.

3. Result and Discussion
The data described in this study were the test results of students' critical thinking skills. The test results provide information about students' abilities before and after the learning process which have been carried out using the TAI learning model. Based on the research that has been done, it has been found that there were differences in students' critical thinking abilities after the TAI learning model was applied to the linear program material. It can be seen from data processing results, which showed an average pretest score of 23.27 and a post-testest score of 70.0976. Based on the results of pretest and posttest data processing, it can be seen that there is an increase in students' critical thinking skills as seen from the difference in the pretest-posttest average score of 46.8276 with an N-Gain value of 0.61, which is in the moderate category.

The TAI learning method combines cooperative learning with individual learning [14]. Students individually learn the material and complete the researcher's assignments. The students join their respective study groups, and students with superior abilities assist other students in discussing the tasks given by the researcher. This learning model indirectly trains students to play a more role in class. Suppose some students experience learning difficulties individually. It will be significantly helpful by applying this method, while students who can learn individually, their understanding will increase with group learning. It is because students have been trained to analyze and discuss the subject matter in groups, correct each other, and exchange opinions to improve students' critical thinking skills. It is a way of learning that can ensure the involvement of all students.

The result of a processing Hypothesis test for increasing critical thinking was done by using a one-sample t-test. This test was conducted to determine whether there is an increase in the students' mathematical critical thinking skills after implementing the TAI learning model. The results of the one-sample t-test with the help of SPSS can be seen as follows.

![T-Test](image)

**Figure 1.** The results of the one-sample t-test with SPSS
The data presented in Figure 1 shows that it has obtained $t$-count 23.427, the df (degree of freedom) value is 40, and the sig value. (2-tailed) or the significant value of the two-tailed test is 0.000. If we compare the value of $t$, then $t$-count more than $t$-table. This is because for df 40 and $\alpha / 2$ is 0.025, the obtained $t$-table is 2.021. Because $t$-count more than $t$-table, it can be concluded that null hypothesis has been rejected [15], which means that learning using the TAI model can improve students' critical thinking skills. Apart from the $t$-count, the sig results have also been seen. (2 tailed) where the sig level is smaller than alpha (0.000 < 0.05). It shows that the use of the TAI model can improve students’ critical thinking skills.

Before being treated with the TAI learning model, the results of semester IV-A students' critical thinking ability of the Khairun University mathematics education program were low. Students' low critical thinking skills can be seen from the pretest data analysis, which shows that all 41 students who took the initial test indicated failed or none of them achieved the minimum completeness score. After the TAI learning model was applied, it has been seen that not all students were unable to complete the minimum completeness score (see Table 1). Each student has given the first two questions to work on as an exercise in his or her abilities. After that, students will be brought to groups to discuss the practices that have been previously given. In a group work, students collaborate with their friends to solve the questions provided, and all group members are responsible for the overall answer as a shared responsibility. Representatives of the group come forward to present the results of group work. Other groups respond to questions and evaluate the results of the discussion, and refine the researcher's answers. This learning procedure can improve students' critical thinking skills.

| Table 1. Indicator critical thinking skills |
|--------------------------------------------|
| Indicator                                | Mastery level | Qualification | Frequency | Presentation |
| Showing facts that have been used to solve problems | 91% – 100%   | Very well     | 38        | 92.68%       |
|                                            | ≤ 60%         | Failed        | 3         | 7.32%        |
| Determining the effect of a statement that has taken as a decision | 91% – 100%   | Very well     | 20        | 48.78%       |
|                                            | 71% – 80%     | Enough        | 12        | 29.27%       |
|                                            | ≤ 60%         | Failed        | 9         | 21.95%       |
| Being able to express a concept in solving problems | 91% – 100%   | Very well     | 10        | 24.39%       |
|                                            | 71% – 80%     | Enough        | 13        | 31.71%       |
|                                            | ≤ 60%         | Failed        | 18        | 43.90%       |

Based on Table 1, it can be seen that the total number of students who answered with excellent qualifications was at most indicator 1, which was 38 people or 92.68%. Meanwhile, the students who answered the questions with failed capabilities were at indicator 3, namely 18 people with a presentation of 43.90%. It identifies that students can express the facts needed to solve a problem. Still, some students have not been able to express concepts in solving problems. Students' difficulty influences it in determining the consequences of a statement taken as a decision.

From the students’ answer sheets before the implementation of the TAI learning model, the researcher got information that most students could not solve the questions because: (1) they were not able to reveal the facts contained in the items; (2) calculation error; (3) do not understand inequality settlement; (4) do not understand in making iterations for simplex tables; (5) students’ have difficulties in making a new simplex table iteration, if there is still a value on the z row (objective function) that is not negative or not zero. After students gave treatment using the TAI learning model, significant changes occur, and students can understand what was previously unclear. Giving personal questions followed by this group provides knowledge to students to be trained and accustomed to thinking and solutions to linear program problems. It is in line with [16], which states that everything new emerges
with triggers, including growing from further information, new technology, new learning strategies that are more varied, new systems of collaboration and competence, exploration of new areas of information sources-exploring new communication forums, developing new and more varied assessment strategies.

From the explanation above, it can be said that there is an increase in students' critical thinking skills after the implementation of the TAI learning model. The results of the study also illustrated that the application of the TAI learning model could improve the critical thinking skills of semester IV-A students of the mathematics education study program at the Faculty of Teacher Training and Education at Khairun University through 3 learning stages, namely: (1) the team stage which emphasizes the provision of material, perceptions, and students' prior knowledge; (2) the assisted setting which emphasizes the optimization of group discussions; (3) the individualization stage which underscores the ability for students to express the results of their thoughts to find out how the learning targets achieved by students. It is in line with [8] opinion, which explains the important components in TAI that will affect students' mathematical abilities: first, teams, namely forming groups where students have divided into small groups; second, teaching group; and third, student creative.

This increase in critical thinking skills results from the help of Student Worksheets, and class discussions or interactions carried out in working on Student Worksheets. These results are the same as the results obtained by research conducted by [11]. They explained that applying the assisted individualization team model equipped with Student Worksheets (LKS) could improve critical thinking skills and student learning achievement. The determining factor is dominant at the assisted stage; namely, students who study in structured groups tend to be more cooperative and help each other more than learning alone [8]. The grouping stage is an important step in learning with TAI [17]. In grouping, a teacher must emphasize and foster student perceptions that the group's success determines individual success.

Another thing that needs to be known from the TAI learning model is the way of grouping students, wherein one group must have a heterogeneous level of ability (high, medium, and low), and if necessary, they must come from different races, cultures, and ethnicities and consider gender [18]. Each component in this learning model provides benefits to all parties (lecturers and students); creative students will help weak peers. Thus, they can develop their abilities and skills. Vulnerable students will be assisted in understanding the subject matter because there is no competition between students. It is because they work together to solve problems. Students expect help from the lecturer and are also motivated to learn quickly and accurately in all materials. Lecturers only use half of their teaching time, so it is easier to provide individual assistance. Most students admit that by applying this learning model, difficult problems will be easier to solve. When the TAI learning model is applied during learning, the influence of motivation and environment (friends) affects the enthusiasm and activeness of students in the class. Using this strategy enables further researchers to conduct further research on motivation and the environment on student enthusiasm and activity in class.

4. Conclusion

Based on the results of data analysis and discussion, it can be concluded that by using the team assisted individualization learning model, the critical thinking skills of fourth-semester students of Khairun University increased with moderate interpretation. Therefore, the Team Assisted Individualization learning model should be applied in the teaching and learning process, especially in mathematics material and linear programs, because it improves mathematical critical thinking skills. For further research on the team assisted individualization learning model that leads to students' critical thinking abilities, researchers suggest that other studies increase research subjects, literature, and the number of previous studies indexed by Scopus. Also, the efficiency of available time needs to be considered so that the target can be achieved. It needs to be done because the learning model's application requires a relatively longer time than learning without using a learning model (conventional learning). Thus, these recommendations and suggestions will study the team's
application assisted the individualization learning model towards students' critical thinking skills of higher quality.

References

[1] Sumarmo U 2005 Pengembangan berfikir matemaitk tingkat tinggi mahasiswa SLTP dan SMU serta mahasiswa strata satu (S1) melalui berbagai pendekatan pembelajaran. Laporan Penelitian Hibah Penelitian Tim Pascasarjana-HTPT Tahun Ketiga (Bandung: Tidak diterbitkan)

[2] Karlimah 2010 Mengembangkan Kemampuan Komunikasi dan Pemecahan Masalah serta Disposisi Matematis Mahasiswa PGSD melalui Pembelajaran Berbasis Masalah (Disertasi pada SPs UPI Bandung: Tidak diterbitkan)

[3] Tim Kurikulum dan Pembelajaran 2014 Buku Kurikulum Pendidikan Tinggi. Direktorat pembelajaran dan Kemahasiswaan (Direktorat Jendral Pendidikan Tinggi Kementrian Pendidikan dan Kebudayaan)

[4] Wijaya C 2007 Pendidikan Remedial Sarana Pengembangan Mutu Sumber Daya Manusia (Bandung: PT Remaja Rosdakarya)

[5] Fisher A 2009 Berpikir Kritis Sebuah Pengantar diterjemahkan oleh B Hadinata (Jakarta: Erlangga)

[6] Johnson E B 2007 Contextual Teaching and Learning: Menjadikan Kegiatan BelajarMengajar Mengasyikkan dan Bermakna diterjemahkan oleh A Chaedar Alwasilah (Bandung: Mizan Learning Center)

[7] Lipman M 2003 Thinking in Education (New York: Cambridge University Press)

[8] Slavin R 2005 Cooperative Learning Teori, Riset dan Praktik diterjemahkan oleh N Yusron (Bandung: Nusa Media)

[9] Akhirman A dan Ma’Rifah N N 2019 Peningkatan Kemampuan Berpikir Kreatif Matematik melalui Penerapan Pembelajaran Kooperatif Tipe TAI dan Soal Open Ended J. Pendidik. Mat. Raflesia 4 36-43

[10] Putri D A, Suwatno S dan Sobandi A 2018 Peningkatan Kemampuan Berpikir Kritis Siswa melalui Metode Pembelajaran Team Games Tournaments dan Team Assisted Individualization J. Managerial 17 1-16

[11] Sari D R, Masykuri M, dan Mulyani S 2018 Penerapan Model Pembelajaran Kooperatif Team Assisted Individualization (TAI) Dilengkapi LKS untuk Meningkatkan Kemampuan Berpikir Kritis dan Prestasi Belajar Siswa pada Materi Kelarutan dan Hasil Kali Kelarutan Kelas XI IPA 3 SMA Negeri 2 Boyolali J. Pendidik. Kim. 7 12-18

[12] Tamsar T A R 2018 Pengaruh Model Pembelajaran Kooperatif Tipe Team Assisted Individualization (TAI) Terhadap Kemampuan Berpikir Kritis Siswa di Kelas VIII SMP CARTESIUS: J. Pendidik. Mat. I 49-61

[13] Ebel R L and Frisbie D A 1986 Essential of educational measurement (New Jersey: Prentice- Hall, Inc)

[14] Fathurrohman M 2006 Model-Model Pembelajaran Inovatif (Yogyakarta: Ar-Ruzz Media)

[15] Cressie N A C, Shefffield L J, and Whitford H J 1984 Use of the one sample t-test in the real world J. Chronic Dis. 37 107-114

[16] Krisdiana I, Apriandi D, dan Setiansyah R K 2014 Analisis kesulitan yang dihadapi oleh guru dan peserta didik sekolah menengah pertama dalam implementasi Kurikulum 2013 pada mata pelajaran matematika (studi kasus eks-karesidenan Madiun) JIPM (Jurnal Ilm. Pendidik. Mat.) 3

[17] Tinungki G M 2015 The Role of Cooperative Learning Type Team Assisted Individualization to Improve the Students' Mathematics Communication Ability in the Subject of Probability Theory J. Educ. Pract. 6 27-31

[18] Isjoni 2012 Pembelajaran Kooperatif Meningkatkan Kecerdasan Komunikasi antar Peserta Didik (Yogyakarta: Pustaka Pelajar)