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Developing Undergraduate Critical Thinking Skills in Mechanics through the Use of Case Method-Based Teaching Materials with QR Code Videos

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Abstract

This research aims to evaluate the effectiveness of using case method-based teaching materials with QR code videos on undergraduate students' critical thinking skills in mechanics. This research used a quasi-experimental method with a post-test-only control group design. A sample of 2 classes was taken using a purposive sampling technique. The experimental class used case method-based mechanics teaching materials and videos in QR codes, while the control class used print-outs of material summaries. Data collection was carried out through observation and critical thinking skills tests. Critical thinking skills test results data were analyzed using descriptive and inferential statistics. The t-test of two independent non-homogeneous samples is used to test the hypothesis of differences in means. The t-test results showed a difference in the average critical thinking skills scores of experimental and control class students with $t_{count} = 2.911$, greater than $t_{table} = 1.681$ at $d_f = 42.62$ (rounded up to 43). Based on these results, using case method-based mechanics teaching materials and videos in QR codes effectively develops students' critical thinking skills with an effectiveness level of 0.82, which means highly influential.

Keywords: teaching materials, mechanics, case method, videos in QR codes, critical thinking skills

INTRODUCTION

The rapid development of science and technology in the 21st century follows a logarithmic pattern, causing the Higher Education Standards (SN-Dikti) to adapt to these changes. One of the characteristics of learning in SN-Dikti is centered on students or Student-Centered Learning (SCL), one of the main principles of which is to foster critical thinking as a tool for developing science (Ministry of Education and Culture, 2020). Critical thinking skills are essential in the 21st century, where individuals are required to analyze, evaluate, and interpret information appropriately in facing increasingly complex global challenges (Wulandari et al., 2021). By fostering critical thinking, skills such as curiosity, observation, identification, and analysis of students can be improved (Pratiwi, Suwono, and Susilo, 2015), which ultimately contributes to improving learning outcomes. Students who have critical thinking skills tend to be more active in understanding concepts, connecting theory with practice, and finding innovative solutions, so the SCL-based learning approach not only helps academic

understanding but also prepares them to become adaptive and competitive individuals in the world of work and social life (Fazriyah et al., 2017).

Critical thinking means thinking deeply and logically about a problem based on relevant information (Roza, Erida, and Siregar, 2022). Critical thinking is a high-level thinking skill related to the ability to identify, analyze, and solve problems creatively and think logically to produce the right considerations and decisions (Idris, 2018). Critical thinking skills can be measured with instruments designed to test aspects such as Interpretation, Analysis, Evaluation, Explanation, and inference (Lina & Desnita, 2022). This skill is not a skill that can develop by itself along with human physical development, but must be trained (Idris, 2018; Nurman et al., 2022). Critical thinking can also be developed through various appropriate learning media to help improve critical thinking skills by providing challenges that encourage students to explore concepts, construct arguments, and solve problems systematically (Syukri et al., 2023).

Critical thinking skills can be trained by implementing a learning strategy. This strategy can be in the form of using a learning model or method or teaching materials that are oriented towards critical thinking skills. Based on the results of the documentation study, learning in the Mechanics course in the Odd Semester of the 2022/2023 Academic Year has not trained the critical thinking skills of students of the Science Education Undergraduate Study Program. Learning in the course is directed at achieving content knowledge only, not critical thinking skills so that when students are asked to work on case-based questions, students cannot solve them. Students are still confused about analyzing which content knowledge is used to solve the case. One effort to overcome this problem is by learning the case method. This is because the case method is able to provide a complex and contextual learning experience so that students not only memorize content but can also find out the relationship between the material taught and real-world situations (Andayani et al., 2022). The case method is the best method to prepare students for leadership challenges and through the dynamic process of exchanging perspectives, arguing and defending points, and building on each other's ideas, students become adept at analyzing problems, exercising judgment, and making difficult decisions (Fatimah and Taufiq, 2022).

Case method learning is active learning that focuses on a case that involves students learning by doing. Cases can be real or fictional stories that contain "educational messages" or retell events, problems, dilemmas, and theoretical or conceptual problems that require analysis and/or decision-making (Cahyono, 2021). The case method is a participatory discussion-based learning method to solve a problem case. The application of this method will help students hone and improve critical thinking skills to solve a problem (Fauzi et al., 2022).

Research on learning with the case method on critical thinking skills has been conducted by Hodijah, Hastuti, and Zevaya (2022), who concluded that the application of the case method in the International Trade Engineering course can improve students' critical thinking skills. This research is in line with research by Roza, Erida and Siregar (2022) which applied the case method in the Service Marketing course. In addition, Laili, Sudarti, and Supriadi (2023) have researched the effect of learning using the case method on physics learning regarding temperature and heat on inference skills as a critical thinking skill indicator.

The results of the study by Nurman et al.(2022) revealed that the application of the case method could not run optimally because students could not understand the case-based tasks given. According to Andayani et al. (2022), lecturers find it difficult to formulate factual and contextual problems, so the application of the case method can only be carried out at certain meetings. Therefore, in order for case method learning to run properly, preparations are needed such as semester learning plans and teaching materials that have been developed based on the case method. Research on the use of teaching materials to improve student's critical thinking skills was conducted by Suparni in 2016. However, research on the use of case method-based teaching materials has not been conducted.

Based on the descriptions that have been presented, a study will be conducted with the title "Developing Undergraduate's Critical Thinking Skills in Mechanics through the Use of Case Method-Based Teaching Materials with QR Code Videos." This study aims to evaluate the effectiveness of using case method-based mechanics teaching materials with QR Code videos on students' critical thinking skills. The presence of QR Code videos in the teaching materials is expected to provide a clearer picture of the case and concept of mechanics.

METHODS

The research method used in this study is a quasi-experiment. The research design used is a posttest only control group design. In this study, two classes were used, namely one class was given experimental treatment and one class was given treatment as a comparison (control). The two classes were given treatment and a posttest after the treatment.

The research procedure consists of Pre-Research, Research, and Post-Research. In the pre-research stage, the preparation of learning devices consists of a semester learning plan, mechanics teaching materials based on the case method with QR code video, and critical thinking skills test instruments. Then, the selection of classes was carried out, namely the experimental class and the control class. In the research stage, the experimental class was given treatment in the form of the use of mechanics teaching materials based on the case method with QR code video. While the control class used mechanics teaching materials in the form of printouts of material summarized from textbooks. After that, both classes were given the critical thinking skills test. During the research, the conditions of the control class and the experimental class were kept the same, especially in terms of the length of learning time, the mechanics concepts studied, the test questions, and the length of time to complete the test. Finally, descriptive and inferential data analysis was carried out in the post-research stage. The results of the data analysis were then described and discussed to draw conclusions.

This research was conducted at the FKIP University of Bengkulu in the odd semester of the 2023/2024 academic year. The population in this study were all students who contracted the Mechanics course. The selection of this research sample used purposive sampling. Purposive sampling is a method of taking samples based on certain considerations or objectives and certain characteristics or traits already known (Arifin, 2014). The consideration of sample selection in this study was the impossibility of random student selection because students who contracted the Mechanics course had been divided according to their study programs and classes. The implementation of the study included all students in two classes from the science education study program because of the result of the observation mentioned in the introduction.

The test instrument was used to measure students' critical thinking skills. The test is in the form of an essay consisting of five items with each item used to assess one indicator of critical thinking. The test used has been tested for content validity by experts. The results of the students' critical thinking skills test were analyzed descriptively to calculate the overall average and per indicator. In addition, the results of the student's critical thinking skills test were also analyzed inferentially with inferential statistics consisting of data normality test, data homogeneity test, hypothesis test, and effect size.

RESULTS AND DISCUSSION

Result

This study was conducted to determine whether there was a difference in critical thinking skills between experimental class students who used case method-based teaching materials with QR code videos and control class students who used printed-out teaching materials in the form of textbook summary materials. This study was conducted in 3 meetings. The first meeting was about uniformly accelerated linear motion, the second was about parabolic motion, and the third was about force. After learning, both classes were given a posttest of critical thinking skills with indicators of analysis, interpretation, inference, explanation and evaluation.

The teaching materials used in this study are case method-based mechanics teaching materials using QR code video. This teaching material presents case examples and case discussions related to physics concepts, especially Mechanics. This teaching material is designed with the concept of printed teaching materials but is equipped with QR code video cases or case simulations. The teaching material has the following structure in FIGURE 1.

FIGURE 1 shows that point number 6 contains detailed contents of the teaching materials, consisting of learning outcomes, cases, lesson summaries, student discussion sheets, practice questions, and self-assessments. The case section contains a short discourse about the case, a screenshot of the case video or case simulation, and a QR code image of the video. The student discussion sheet contains a case (there is a QR code for the case video that can be scanned and watched using each student's cellphone) and questions that require students to explain and solve the case.

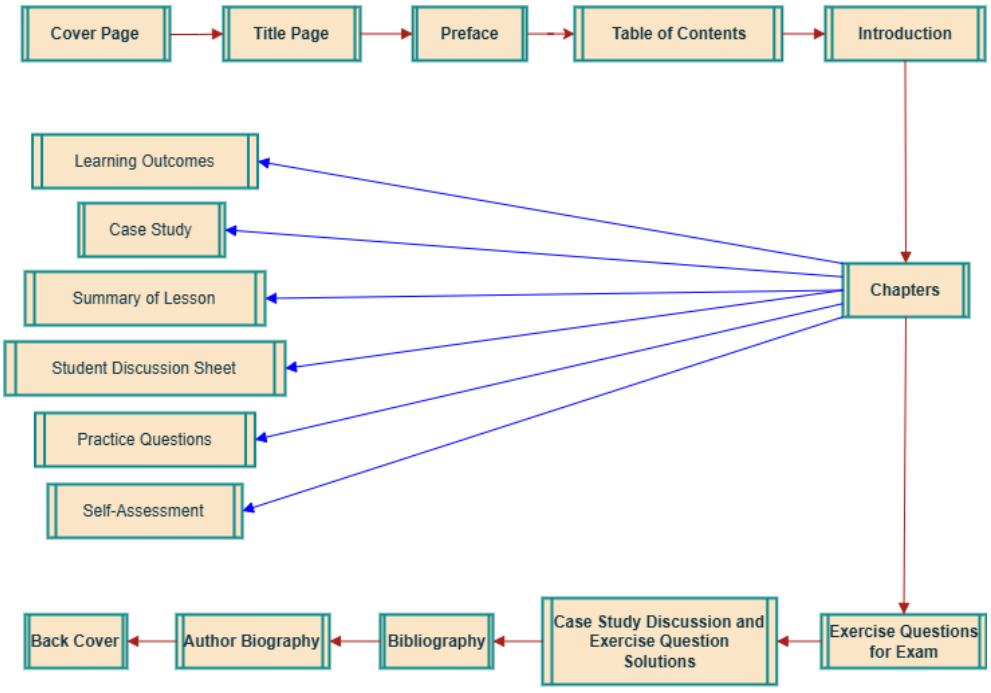
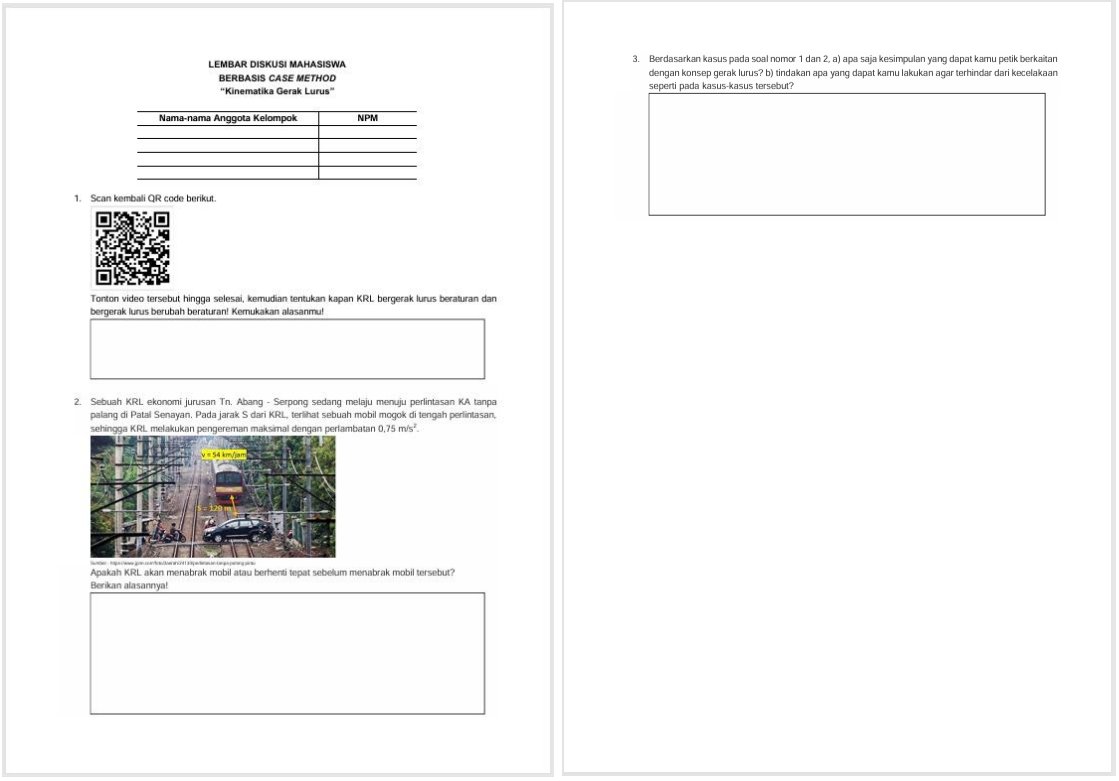


FIGURE 1. Structure of teaching materials

The steps for using case method-based mechanics teaching materials with QR code videos in the experimental class to develop students' critical thinking skills are 1) students are given printed books on the sections to be studied per meeting, 2) the lecturer explains the material, 3) students discuss in groups and work on student discussion sheets, 4) students present case solutions, 5) with the lecturer's direction, students discuss in class to get the right case solution, 6) students conclude the lesson and fill out the self-assessment sheet, and 7) the lecturer gives students the task of doing practice questions.

The steps for using mechanics teaching materials based on the case method, supplemented with QR code videos in the experimental class, are designed to systematically develop students' critical thinking skills. The learning process begins with providing printed books to students, covering the material to be studied in each session. Next, the lecturer explains the key concepts in the material to establish a strong foundational understanding. After the material presentation, students are divided into discussion groups to work on student discussion sheets containing guiding questions and case scenarios relevant to the mechanics concepts being studied. In the next stage, students are asked to present the solutions they have discussed, which are then tested and further explored through a class discussion led by the lecturer. In this discussion, students are encouraged to evaluate various perspectives and consider the most appropriate approach to solving the given problem. Through this process, students not only develop critical thinking skills but also enhance their communication and collaboration abilities in problem-solving. After the class discussion, students are required to summarize and conclude the learning outcomes they have gained and complete a self-assessment sheet as a reflection of their understanding and engagement in the learning process. As a follow-up, the lecturer assigns individual tasks in the form of practice questions aimed at reinforcing the learned concepts and assessing students' ability to apply their understanding independently. FIGURE 2 shows a screenshot of the student discussion sheet used in the learning process to help them develop critical thinking skills through an interactive case method.



LEMBAR DISKUSI MAHASISWA
BERBASIS *CASE METHOD*
"Kinematika Gerak Lurus"

Nama-nama Anggota Kelompok	NPM

1. Scan kembali QR code berikut.

Tonton video tersebut hingga selesai, kemudian tentukan kapan KRL bergerak lurus beraturan dan bergerak lurus berubah beraturan! Kemukakan alasanmu!

2. Sebuah KRL ekonomi jurusan Tn. Abang - Serpong sedang melaju menuju perlintasan KA tanpa palang di Patal Senayan. Pada jarak S dari KRL, terlihat sebuah mobil mogok di tengah perlintasan, sehingga KRL melakukan pengereman maksimal dengan perlambatan 0,75 m/s^2.

Apakah KRL akan menabrak mobil atau berhenti tepat sebelum menabrak mobil tersebut? Berikan alasannya!

3. Berdasarkan kasus pada soal nomor 1 dan 2, a) apa saja kesimpulan yang dapat kamu petik berkaitan dengan konsep gerak lurus? b) tindakan apa yang dapat kamu lakukan agar terhindar dari kecelakaan seperti pada kasus-kasus tersebut?

FIGURE 2. One of Student Discussion Sheet

FIGURE 2 shows that on the student discussion sheet, there is a QR code containing a direct link to a YouTube page of a simulation of an accident between a train and a public transportation car in Depok on June 16, 2023, created by the Dean Railfans account. The video contains a chronology of events and a simulation of the collision that occurred. A screenshot of the simulation video can be seen in FIGURE 3.

FIGURE 3. Some screenshots of simulation video of collision case on railway track (source: https://www.youtube.com/watch?v=3FZqiX83xZ4)

Students are asked to watch the video to find out how the collision occurred. Next, students are asked to determine the uniform linear motion and uniformly accelerated linear motion carried out by the train and state the reasons for their answers. Then, in the following question on the student discussion sheet, students are asked to solve similar case problems using physics concepts. In the last question, students are asked to conclude the concept of linear motion and the actions that need to be taken to avoid the accident. These questions are indeed directed according to the indicators of critical thinking skills, namely analysis, interpretation, inference, explanation, and evaluation. The integration of videos in the form of QR codes and discussion questions that are in accordance with the indicators of critical thinking skills in the student discussion sheet is a strong stimulus in developing students' critical thinking skills in the experimental class. A control group was created to find out how effective it was. Students in the control class learned using printed-out teaching materials in the form of summary materials from textbooks for each meeting. After obtaining the teaching materials, the lecturer explained the material and asked students to do exercises that were not case-based.

The mechanics learning in the experimental and control classes was carried out in three meetings, and then the students were tested on their critical thinking skills. FIGURE 4 shows the results of critical thinking skills.

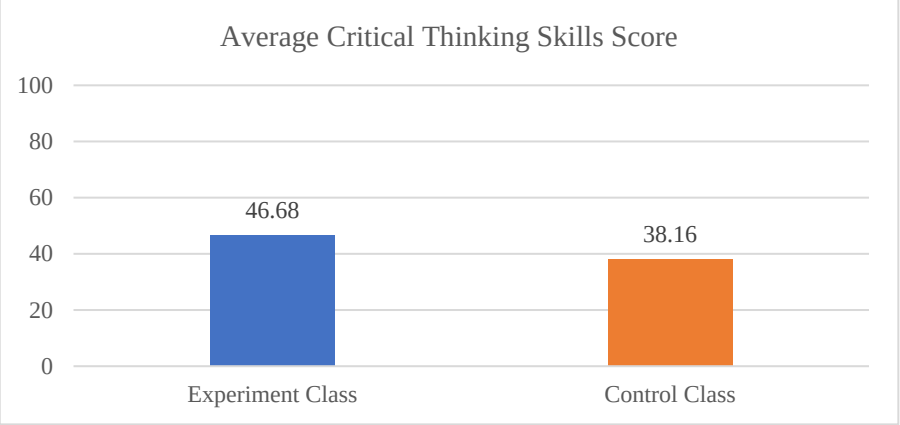


FIGURE 4. Average Critical Thinking Skills Score

Based on FIGURE 4, the average value of critical thinking skills of the experimental class is 46.68 and the control class is 38.16. FIGURE 4 shows that the experimental class score is higher than the control class. The average value of critical thinking skills indicator can be seen in FIGURE 5.

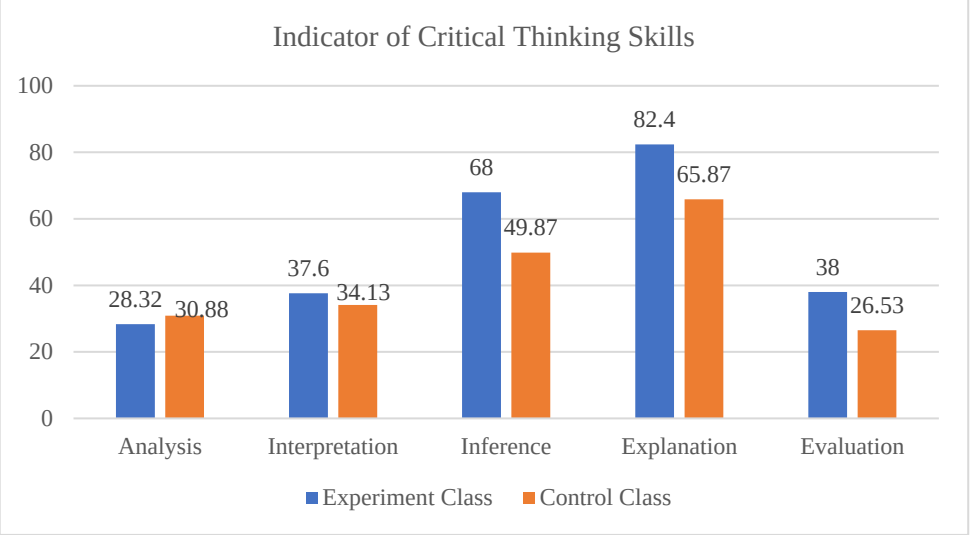


FIGURE 5. Average critical thinking skills score for each indicator

FIGURE 5 shows the average value of the experiment on the indicator analyzing the experimental class of 28.32 and the control class 30.88. On the interpreting indicator, the experimental class got an average value of 37.6 and the control class got an average value of 34.13. Inference indicator, the experimental class got an average value of 68 and the control class got an average value of 49.87. Explanation indicator, the experimental class got an average value of 82.4 and the control class got an average value of 65.87. Evaluating the indicator, the experimental class got an average value of 38 and the control class got an average value of 26.53. These results show that the experimental class scores higher than the control class on the interpretation, inference, explanation, and evaluation indicators. Still, on the analysis indicator, the control class's score is higher than the experimental class, but by a very small difference.

Furthermore, the results of the critical thinking skills test were analyzed using inferential statistics. Here are the results of the analysis.

TABLE 1. Results of inferential statistics

Test	Result	Conclusion	Information
Normality with Shapiro-wilk test	$p_{count} = 0.979$ $p_{table} = 0.918$	$p_{count} > p_{table}$	Data are normally distributed
Homogeneity with F test	$F_{count} = 2.102$ $F_{table} = 1.984$	$F_{count} > F_{table}$	Data are not homogeneous
The difference in the average of two independent samples with normally distributed and non-homogeneous data	$t_{count} = 2.911$ $t_{table} = 1.681$ $d_f = 42.62 \approx 43$	$t_{count} > t_{table}$	There is a difference in the average value of critical thinking skills of students in the experiment class and the control class.

TABLE 1 shows that the critical thinking skills data of students in the experimental and control classes are normally distributed and heterogeneous. The results of the t-test of the average of two independent non-homogeneous samples indicate a difference in the average value of students' critical thinking skills in the experimental and control classes. Furthermore, the level of effectiveness of the case method-based mechanics teaching materials with QR code video is calculated using the Cohen formula effect size. The result is 0.82 with the High Influence criteria.

Discussion

This study was conducted to test the effectiveness of previously developed case method-based mechanics teaching materials with QR code videos on students' critical thinking skills. Case method-based mechanics teaching materials with QR code video are teaching materials used for mechanics material in the Mechanics course in the Science Education Study Program, FKIP, Bengkulu University. The teaching materials are used for learning for third-semester students.

Based on interviews with students during the previous 2 semesters, learning had not been directed toward case discussions and critical thinking skills. The case method is a learning method in accordance with the main performance indicators point 7 in the Minister of Education and Culture Decree Number 3 of 2021. This method is expected to be implemented in universities because it directs student-centered learning so students can think critically. Columbia University has noted the instructional benefits of this method, including greater student engagement in their learning, deeper understanding of student concepts, stronger critical thinking skills, and the ability to make connections across content areas and see problems from multiple perspectives (Columbia Center for Teaching and Learning, no date). Akinbobola and Bada (2018) also explained that many institutions promote case-based learning because it teaches relevant facts, principles, and concepts in the context of real-world or authentic

situations. Context is more motivating for students and provides a concrete framework from which difficult concepts can be more easily understood.

During learning in experimental class, case method learning activities consist of (1) introduction, including group division, explaining learning objectives, and distributing cases per group; (2) core activities, including discussions that include identifying facts and concepts in cases, connecting shared information, analyzing factors related to cases, concluding problems, finding alternative solutions to problems and determining problem-solving; (3) closing, including presentation of problem-solving and conclusions from case studies. Meanwhile, in the control class, a print-out of the summary of the material was used and then non-case exercises were given to be completed.

The treatment given to the experimental class and the control class was then tested for its effectiveness on students' critical thinking skills by giving them a post-test. The results can be seen in FIGURE 1 and FIGURE 2, which have been presented previously. FIGURE 1 shows that from a range of 0-100, the average value of critical thinking skills of students in the experimental class is 46.68. This result is higher than the control class which obtained an average value of 38.16. The difference in the average value of critical thinking skills shows that the treatment in the experimental class can train students' critical thinking skills better. This is supported by the results of the inferential analysis in TABLE 1, namely the results of the average difference test of two independent samples with normally distributed but heterogeneous data, there is a difference in the average value of critical thinking skills of students in the experimental class and the control class with t_{count} (2.911) > t_{table} (1.681) at d_f = 42.62 ≈ 43. This means that the use of case method-based mechanics teaching materials with QR code videos can train students' critical thinking skills better than print-outs of material summaries with an effectiveness level in the high influence category (0.82).

The results of this study are in line with the study by Sofia et al. (2023), which tested the effectiveness of using case method-based e-modules on critical thinking skills. Sofia et al. stated that the use of case method-based e-modules effectively improved students' critical thinking skills in the PPh 21 material in the Income Tax Management course. In addition, the study by Fauzi et al. (2023) also revealed that the case method can improve students' critical thinking skills with N-Gain in the high category in learning Elementary School Mathematics Education courses. Ririen and Irawati (2023) revealed that students' critical thinking skills improved after learning Statistics II courses with the case method. Hodijah, Hastuti, and Zevaya (2022) also revealed something similar in their research: students' critical thinking skills increased from quite good to good in learning International Trade Engineering courses. Laili, Sudarti, and Supriadi (2023) also found that the case method can improve critical thinking skills, especially in the inference skill indicator on temperature and heat.

The use of video QR codes, in this case, method-based mechanics teaching material, is to help students understand cases by showing real cases or case simulations. This is in accordance with the statement by Septiani (2022) which states that showing video clips with QR-Code is more effective in understanding explanatory texts and can help students think at a high level and critically.

FIGURE 2 shows that the experimental class's average value of critical thinking skills is higher in the interpretation, inference, explanation, and evaluation indicators than in the control class. However, the average value of critical thinking skills in the analysis indicator of the control class is higher than the experimental class with the smallest difference compared to other indicators. This shows that the two classes have analytical abilities that are not much different. The control class has actually been able to identify information about questions and related concepts (analyze indicators) through printouts of material summaries, lecturers' explanations, and non-case practice questions. However, other critical thinking skill indicators have not been developed through these activities. Different from the learning activities in the experimental class, where there is the use of case method-based mechanics teaching materials with QR Code videos, lecturer explanations, and case discussions. In the case method in the core activities, students conduct discussions to identify facts and concepts in the case, connect information together, analyze factors related to the case, conclude problems, find alternative solutions to problems, and determine problem-solving. These activities develop analysis and interpretation skills. While in the closing activities that include the presentation of problem-solving and conclusions from the case study, help develop explanation, inference and evaluation skills.

Although the critical thinking skills of the experimental class are higher than the control class, the average value of critical thinking skills is still below 50. FIGURE 2 shows only the inference and explanation indicators have values over 50, namely 68 and 82.4, respectively, for the experimental class. While for the control class only the explanation value is 65.87. This is because to train critical thinking skills must be done continuously. This is because to develop students' critical thinking skills must be done continuously, it cannot be achieved in just 2-3 learning meetings. Students need to be accustomed and accustomed to using their critical thinking skills to solve cases or problems in everyday life. Prayogi and Widodo (2017) stated that critical thinking skills must be trained consistently so that critical thinking skills can improve. The same thing was also expressed by Hidayanti and Alim Syahri (2020) that critical thinking skills are not innate and do not develop naturally. Critical thinking skills are intellectual potential that can be developed through the learning process. Critical thinking skills can also be improved by using appropriate learning media such as QR Code Video because students not only gain a deeper understanding of concepts, but are also involved in the process of analysis, evaluation, and reflection (Firdaus et al., 2021).

CONCLUSION

Based on the results and discussions that have been presented, the use of case method-based mechanics teaching materials with QR code video is effective in developing students' critical thinking skills with an effectiveness level of 0.82 (highly influential). The suggestion that can be given is the need for continuity in implementing learning with the case method with the hope that students' critical thinking skills will increase and be better as provisions for students in the future when artificial intelligence (AI) technology dominates human life. In addition, future research can be done by studying with larger samples, varied educational settings, or other STEM fields to validate and expand on these findings.

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