Pengaruh Penerapan E-modul Interaktif Termodinamika *Berbasis Collaborative Teamwork* Learning Menggunakan *Quiz*iz Terhadap Hasil Belajar Siswa kelas XI di MAN 3 Muaro Jambi

(The Effect of Implementing an Interactive Thermodynamics E-Module Based on Collaborative Teamwork Learning Using Quizzes on the Learning Outcomes of Grade XI Students at MAN 3 Muaro Jambi)

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ABSTRACT. This study aims to determine the effect of implementing an interactive e-module on the Thermodynamics material, developed using Collaborative Teamwork Learning and supported by quizzes, on the learning outcomes of Grade XI students at MAN 3 Muaro Jambi. The research method used is a quasi-experimental pretest-posttest control-group design. The research sample consisted of two classes: the experimental class, which used the interactive e-module, and the control class, which used conventional learning methods. The instrument used in this study was a learning outcome test validated by experts. Data analysis was conducted using the Mann-Whitney U test in SPSS to determine differences in learning outcomes between the two groups. The test results showed a significance value (Asymp. Sig. 2-tailed) of $0.000 < 0.05$, indicating that the null hypothesis (H_0) was rejected. This shows a significant difference in learning outcomes between the experimental and control classes. Students who learned using the interactive e-module, supported by Quizizz, showed greater improvement in learning outcomes than those in the control class. These findings indicate that the use of an interactive e-module with a collaborative approach and reinforcement through quizzes can significantly enhance students' understanding of Thermodynamics concepts.

INTRODUCTION

Learning materials are all forms of content or learning resources designed and used to assist educators in delivering instructional material and to facilitate students in achieving the expected competencies. These materials include information, concepts, theories, or skills that are systematically organized to support the learning process [1].

The development of information and communication technology has driven a transformation in education, particularly through the creation of more interactive and adaptive learning media. One innovation in learning is the use of interactive e-modules that integrate media such as text, images, audio, and video, along with other interactive features [2]. This interactive e-module provides a more engaging learning experience and can enhance students' motivation and understanding of the subject matter. In the context of physics learning, particularly in thermodynamics, which students often perceive as abstract and complex, interactive e-modules can facilitate understanding of these concepts. By presenting the material visually and interactively, students can more easily connect theory with real-world phenomena, thereby improving their learning outcomes [3].

An interactive e-module is a digital learning resource designed with interactive features to enhance student participation and understanding. This module typically includes text, images, videos, animations, simulations, and practice exercises that can be accessed flexibly on digital devices [4]. This aligns with the learning styles of today's students, who are inseparable from the digital world, particularly mobile phones and the internet. The use of audiovisual media engages multiple senses and body organs, such as the ears (audio) and eyes (visual), allowing information and learning materials to be conveyed in a way that is easier for students to understand [5]. This is also emphasized by Wahyuni et al., who state that good learning media can foster students' enthusiasm and motivation to learn, making the material easier to understand and leading to more satisfying learning outcomes.

Therefore, one of the media that can be used in science learning is instructional video [6]. In this case, the e-module includes instructional videos. The use of engaging media in learning can enhance students' motivation and facilitate the understanding of abstract concepts. At the high school level, interactive e-modules are highly beneficial in science learning because they can visually and contextually explain complex scientific processes.

In addition, the Collaborative Teamwork Learning (CTL) approach has been proven effective in enhancing students' social and cognitive skills. Through group collaboration, students can engage in discussions, share knowledge, and solve problems together, which ultimately improves their understanding and learning outcomes [7]. The integration of interactive e-modules with the CTL approach is expected to create a more dynamic and effective learning environment. Using Quizizz as an evaluation tool within the interactive e-module also provides students with immediate feedback, allowing them to assess their understanding of the material. This enables students to correct their mistakes and deepen their comprehension quickly.

Implementing quizzes in the learning process at the high school level offers significant benefits. According to [8] [9], Digital quizzes with interactive and gamification features can enhance students' motivation and interest in learning by making the learning process more enjoyable and engaging. In addition, online quizzes provide real-time feedback, allowing students to correct mistakes and improve their understanding of the material immediately [10] [11]. The use of quizzes as formative evaluation can improve students' learning outcomes, especially in science subjects, as quizzes encourage students to review and understand the material more deeply [12]. Interactive quizzes can enhance student engagement and participation, especially when conducted in groups or with competitive elements. On the other hand, digital quizzes also make it easier for teachers to monitor and evaluate students' understanding quickly and accurately, allowing learning strategies to be adjusted according to students' needs [13]. Thus, the implementation of quizzes serves not only as an evaluation tool but also as an effective learning medium to enhance the quality of the learning process in high schools.

Based on the above background, this study aims to determine the effect of implementing an interactive thermodynamics e-module based on Collaborative Teamwork Learning using Quizizz on the learning outcomes of grade XI students at MAN 3 Muaro Jambi.

RESEARCH METHOD

This study is a quasi-experimental research using a pretest-posttest control-group design, aimed at determining the effect of an interactive e-module based on Collaborative Teamwork Learning (CTL) integrated with Quizizz on the learning outcomes of grade XI students in the topic of Thermodynamics at MAN 3 Muaro Jambi. The population of this study consisted of all grade XI students, and the sample was selected using purposive sampling, with class XI MIPA 1 as the experimental group and class XI MIPA 2 as the control group, each consisting of 30 students.

The research instrument used was a multiple-choice test consisting of 20 questions, which had been validated and tested to assess validity, reliability, difficulty level, and discriminating power. Data collection techniques included pretest and posttest to measure students' learning outcomes before and after the treatment, as well as observation to monitor the learning process.

The data were analysed using descriptive and inferential statistics, including an independent-samples t-test, assisted by SPSS. Prior to the t-test, the data were tested for normality and homogeneity to ensure the assumptions of parametric analysis were met. The testing criteria indicated that if the p-value < 0.05, there was a significant effect; whereas if the p-value ≥ 0.05, there was no significant effect.

RESULTS AND DISCUSSION

Before implementation, the interactive e-module based on Collaborative Teamwork Learning using Quizizz underwent validation testing by experts to assess its feasibility, and it was deemed suitable for implementation. Based on validation results from material, media, and practitioner experts, the developed product was found to be of very good quality and appropriate for school trials. Furthermore, based on students' responses, comments, and suggestions, it was revealed that students were interested in and enjoyed the interactive e-module on Collaborative Teamwork Learning using Quizizz, giving it very positive feedback.

The results of implementing the interactive e-module were analyzed to determine its effect; therefore, an independent t-test/ANOVA was conducted to examine the causal relationship between variables X and Y. Before

this, prerequisite tests were carried out to determine whether the data were normally distributed and homogeneous. The following are the statistical test results obtained using SPSS software.

1. Normality Test

The Normality Test aims to determine whether the students' pretest and posttest scores are normally distributed or not. The normality test used in this study was the Shapiro-Wilk test. The results are shown in Table 1.

Table 1. Normality Test

code		Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
pretest & posttest	pretest control group	0,331	25	0,000	0,693	25	0,000
	posttest control group	0,149	25	0,159	0,913	25	0,035
	pretest experiment group	0,273	24	0,000	0,771	24	0,000
	posttest experiment group	0,206	24	0,010	0,899	24	0,020

Based on the Shapiro–Wilk normality test, the significance value (Sig.) was 0.000. Since the p-value is less than 0.05, the data are not normally distributed. Therefore, the assumption of normality for the data is not met.

2. Homogeneity Test

Next, a homogeneity test will be conducted on the pretest and posttest data, as shown in the table below:

Table 2. Homogeneity Test

Test of Homogeneity of Variance					
		Levene Statistic	df1	df2	Sig.
pretest dan posttest	Based on Mean	4.660	3	94	.004
	Based on Median	1.511	3	94	.217
	Based on Median and with adjusted df	1.511	3	53.798	.222
	Based on the trimmed mean	3.861	3	94	.012

Based on the results of Levene's test, a significance value (Sig.) of 0.004 was obtained. Since this value is less than 0.05, it can be concluded that the data do not have homogeneous variances. In other words, there is a difference in variance between the compared groups, indicating that the assumption of homogeneity of variance is violated.

3. *Mann-Whitney U Test*

The following table presents the results of the Mann–Whitney U test analysis.

Table 3. *Mann-Whitney U test*

Test Statistics	
	Posttest
Mann-Whitney U	3.000
Wilcoxon W	328.000
Z	-5.987
Asymp. Sig. (2-tailed)	.000

The Mann–Whitney U test is a non-parametric test used to compare two independent groups when the data are not normally distributed. This test aims to determine whether the medians differ between two unrelated groups. In this study, the posttest data from the experimental and control classes were analyzed to examine the effect of using the interactive e-module based on Collaborative Teamwork Learning with Quizizz.

To analyze the data, the Mann–Whitney U test was conducted with the following hypotheses:

H₀ (Null Hypothesis): There is no difference in scores between the two groups, meaning there is no significant effect on learning outcomes after the implementation of the interactive e-module based on Collaborative Teamwork Learning using Quizizz.

H₁ (Alternative Hypothesis): There is a difference in scores between the two groups, meaning there is a significant effect on learning outcomes after the implementation of the interactive e-module based on Collaborative Teamwork Learning using Quizizz.

The decision in the Mann–Whitney U test is determined based on the significance value (p-value) compared with the established significance level ($\alpha = 0.05$). If the p-value is less than 0.05 (p-value < 0.05), the null hypothesis (H₀) is rejected, indicating a significant difference between the two groups being compared. Conversely, suppose the p-value is greater than or equal to 0.05 (p-value ≥ 0.05). In that case, the null hypothesis is not rejected, indicating that there is no significant difference between the two groups.

After the data were analyzed using SPSS statistical software, the results of the Mann–Whitney U test showed a significance value (Asymp. Sig. 2-tailed) of 0.000 < 0.05. Since the significance value is less than 0.05, H₀ is rejected, indicating a significant effect on learning outcomes after implementing the interactive e-module based on Collaborative Teamwork Learning using Quizizz. Thus, learning using the interactive e-module based on Collaborative Teamwork Learning with Quizizz produced significantly different results compared to conventional learning.

During the research process, several findings supported the acceptance of H₁. In the experimental class that used the interactive e-module, students appeared more enthusiastic and active during the learning process. The developed e-module allowed students to learn independently while collaborating with their group members to understand thermodynamics concepts. The interactive features in the e-module, such as animations, simulations, and Quizizz-based quiz exercises, captured students' attention and helped them transform abstract material into more concrete, easily understood concepts.

Throughout the learning activities, students demonstrated active, enthusiastic attitudes as they completed tasks under the teacher's guidance. Their engagement was evident when they worked in groups to conduct simple experiments following the steps provided in the e-module. The use of the e-module provided a new learning experience for students, as previously, they had only followed the teacher's directions; this time, they could learn independently by following the module's instructions.

The e-module, which included a Student Worksheet (LKPD)**,** further piqued students' interest because the worksheet could be completed directly, and their results could be downloaded. This made students more enthusiastic and responsive during learning activities. Moreover, students' enthusiasm was evident during group quizzes. At the end of the lesson, students were given a competency test that could also be completed directly through the e-module, and the results could be downloaded. This condition indicates that the use of e-modules can create a more interactive and motivating learning atmosphere, providing students with a new and enjoyable learning experience.

These findings show that improvements in students' learning outcomes are reflected not only in numerical analyses but also in classroom learning processes. Students appeared more active, responsive, and motivated in participating in each activity, whether working in groups, completing worksheets, or answering quizzes and competency tests. Therefore, the improvement in learning outcomes can be demonstrated not only quantitatively but also qualitatively through direct observation of students' engagement in the learning process.

Many educational strategies can encourage students to engage in positive and creative thinking while overcoming challenges in their studies. Collaborative learning strategies can enhance student engagement, improve learning outcomes, and develop teamwork skills. Learners perceive peer learning as supportive of social, cognitive, and collaborative engagement. Discussion forums help strengthen communication skills and foster a sense of togetherness, while peer review activities provide early feedback and train students to accept constructive criticism [14]. Group work enhances cooperation and collaboration skills, emphasizing the benefits of peer learning in education for improving student engagement and readiness. These findings are consistent with previous research, which showed that integrating digital education can create a more interactive learning environment and actively support student engagement in the learning process [15]. Thus, the use of digital tools in learning has been proven effective in enhancing the quality of student interaction and learning outcomes. In addition, compared to traditional teaching, team-based learning shows better student performance, though the difference is not always statistically significant. This meta-analysis supports the implementation of team-based learning across various educational contexts [16].

In addition, learning with the Collaborative Teamwork Learning approach encourages students to engage in discussions, exchange ideas, and solve problems together. The interactions that occur within groups strengthen conceptual understanding because students do not merely receive information passively from the teacher but actively construct knowledge through collaboration. This aligns with constructivist theory, which states that knowledge is built through experience and social interaction.

On the other hand, in the control class that used conventional teaching methods, learning activities were still dominated by the teacher. Students tended to be passive, listening to explanations without much participation in learning activities. As a result, students' cognitive and affective engagement in understanding thermodynamics concepts was limited. Some students also showed confusion in connecting theoretical concepts to their everyday applications.

The difference in learning activities between the two classes affected the learning outcomes. Students in the experimental class showed a larger increase in final test scores than those in the control class. This indicates that using an interactive e-module based on Collaborative Teamwork Learning, supported by Quizizz, can create more meaningful learning experiences, enhance motivation, and deepen students' conceptual understanding.

Overall, the results of this study support the hypothesis that implementing an interactive e-module with a collaborative approach and evaluation via Quizizz is effective in improving students' learning outcomes. These findings are also consistent with previous research showing that interactive, collaborative learning media can increase student engagement, strengthen critical thinking skills, and foster a deeper understanding of the material.

CONCLUSION

The effect of using the interactive e-module was tested by comparing the control and experimental classes. Based on posttest results from both groups, the analysis showed a significant impact on learning outcomes after implementing the interactive e-module on Collaborative Teamwork Learning using Quizizz. Thus, learning through the interactive e-module based on Collaborative Teamwork Learning with Quizizz produced significantly different results compared to conventional learning.

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