

The Effect of the Game Based Learning Model on Improving Learning Outcomes and Critical Thinking Skills of Vocational High School Students

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ABSTRACT

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This study aims to determine the effect of a Quizizz-based Game Based Learning model on improving learning outcomes and critical thinking skills in the Basic Machining course for Grade X Machining Engineering (TPM) students at SMK Nasional Malang. The research used a quantitative Quasi-Experimental design with a Nonequivalent Control Group layout. The population consisted of Grade X TPM students at SMK Nasional Malang. Data were collected through interviews, observation, tests, and questionnaires. The results showed a posttest mean of 82.5 with 85% mastery learning in the experimental class, compared with a posttest mean of 81 with 70% mastery learning in the control class. Students' critical thinking skills averaged 76.09% in the experimental class and 71.7% in the control class. These findings give vocational teachers empirical evidence for adopting Quizizz-based Game Based Learning to strengthen both technical mastery and critical thinking in machining education, underlining the model's contribution as a practical, low-cost alternative to conventional instruction in vocational classrooms.

Keywords: *Generation Z, Hoaxes, Digital Literacy, Media Education, Digital Natives*

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INTRODUCTION

The advance of Information and Communication Technology (ICT), spreading across every aspect of life (social, cultural, political, and educational) in the era of the Industrial Revolution 4.0, poses a considerable challenge for teachers in Indonesia. Educators are expected to bring current technological developments into their teaching, so that students become competent and able to keep pace with the times. Vocational High School (SMK) continues on from junior secondary education, with the main goal of preparing a skilled, professional workforce with the strong discipline that today's job market demands. Improving the quality of learning is one way to work toward that goal, which calls for an engaging learning model capable of keeping students motivated. Given today's technology, teachers can shift away from conventional models toward digital media and one option being the game-based Quizizz platform, which can help shape students into more independent, actively communicative learners with solid soft skills.

SMK graduates are prepared to enter the workforce, where every worker inevitably faces a range of technical and non-technical challenges and often the hardest part of the job. Workers who manage to solve these problems tend to succeed, so SMK graduates should ideally build strong soft skills before entering the workplace, so they are already accustomed to handling problems once they start working. Among the many soft skills SMK graduates need are communication, critical thinking, good conduct, teamwork, and leadership.

One issue Indonesia currently faces in education is an emphasis on students' technical skills (hard skills), while soft skills and critical thinking among them receive comparatively little attention. Critical thinking does not appear on its own; students need time to repeat and deepen

their understanding of the material they study. Generally, the better a student's critical thinking, the better their academic achievement tends to be. On the evaluation side, teachers still rely mostly on conventional paper tests, so students who lack the basic skills struggle to understand and answer the questions given. Mirdad (2020) argues that a learning model is a design built around a systematic set of steps for use in a learning activity. One learning method considered effective today is Game Based Learning, a game-based technique that can help boost students' potential and their capacity to absorb knowledge.

Observations made during the Teaching Assistance (AM) program at SMK Nasional Malang showed that the learning methods currently in use leave students fairly passive. This shows up in students rarely asking questions or responding to questions from the subject teacher, which in turn causes learning outcomes to fall short of the set standards. Building a more engaging classroom atmosphere that students enjoy is one reason to bring in the Game Based Learning model for assessing learning outcomes, since it tends to make students more enthusiastic and interested in working through quizzes. One learning medium suited to applying Game Based Learning is the Quizizz application.

At present, teachers (AM) at SMK Nasional Malang still rely on conventional, paper-based assessment, an approach clearly less relevant today and one that leaves students bored and unmotivated to complete their work. This is considered fairly ineffective, since students stay passive during learning activities, especially in question-and-answer sessions and discussions. Many students also lean on their classmates during discussions. A number of factors influence the learning outcomes of Grade X TPM students at SMK Nasional Malang, among them responsibility, learning motivation, and classroom atmosphere. Choosing the right learning model can therefore make it easier to raise both student learning outcomes and their motivation to take part in ongoing learning activities.

One advantage of the Game Based Learning model is that teachers rarely use it yet, even though it is fairly effective at keeping students motivated to work through problems because of its game-based format; it can raise learning motivation and improve learning outcomes. The Quizizz-based Game Based Learning model is expected to help address the problems that arise during learning.

METHOD

Type of Research

This study is using a Quasi-Experimental method. This approach was chosen because the students' initial ability and classroom conditions were treated as equivalent. The research applied a Nonequivalent Control Group design, similar to a pretest-posttest control group design, except that the experimental and control groups were not selected at random. The study began with a pretest to gauge students' starting condition in learning Basic Machining. After the treatment, a posttest measured the final outcome and any difference between the experimental and control groups. Two variables were investigated: the dependent and independent variables. The research design is shown in Table 1.

Table 1. Research Design

Group	Pretest	Treatment	Posttest
Experimental	O1	X	O2
Control	O3		O4

Notes: O1 = initial ability test, experimental class (pretest); O2 = final ability test, experimental class (posttest); O3 = initial ability test, control class (pretest); O4 = final ability test, control class (posttest); X = treatment.

This study used a pretest to measure students' initial ability before treatment in both the experimental and control classes. The experimental class then received the Quizizz-based Game Based Learning model, while the control class continued with the conventional learning model. After treatment, a posttest measured students' final ability. The study subjects numbered 40 students, later split into two groups based on their pretest results: Group A as the experimental class and Group B as the control class. The experimental class comprised 20 students (Group A), and the control class comprised 20 students (Group B).

Data Validity

The research instruments included pretest and posttest items, along with instruments for learning effectiveness, critical thinking aspects, modules, teaching materials, and teaching media. All instruments were validated beforehand by expert validators – in this case, the teacher in charge of the Basic Machining course and a lecturer from the Faculty of Engineering, Universitas Negeri Malang.

Instrument Trial

Before use, the research instrument was tested in two stages. The first was a validity test to determine whether the instrument was valid, carried out on 30 Grade X students using SPSS 26, comparing the calculated r-value against the table r-value; an item was considered valid if the calculated value exceeded the table value. This left 20 valid items out of the original 30. A reliability test followed, also run in SPSS, based on the Cronbach's alpha coefficient – the higher the alpha, the higher the reliability. The reliability test results are shown in Table 2.

Table 2. Item Reliability Test Results

Cronbach's Alpha	N of Items
0.875	20

Table 2 shows a Cronbach's alpha coefficient of 0.875, indicating high reliability. The 20 items were then assessed for discriminating power: one item showed very good discrimination ($r = 0.840$) and the remaining 19 showed good discrimination (r between 0.40 and 0.70). A difficulty index test followed, which classified 2 items as difficult and the remaining 18 as moderate.

Data Collection Techniques

Data collection combined interviews, observation, tests, and document review.

1. Interviews were used to gather verbal data and to identify why students found the Basic Machining course difficult to follow. The researcher interviewed several Grade X TPM students at SMK Nasional Malang along with the teacher of the course.
2. Observation took place in the Grade X TPM classroom at SMK Nasional Malang during Basic Machining lessons. The researcher directly observed teacher and student activity to track improvement in learning outcomes and critical thinking skills.
3. Tests were used to gather information on students' current knowledge or changes in that knowledge over a given period. This study used a pretest and posttest to measure improvement in Basic Machining learning outcomes.
4. Questionnaires were used to gather data on students' critical thinking skills, distributed directly both before and after the treatment.

Data analysis

Data analysis in this study combined descriptive and inferential statistics, processed with SPSS. Descriptive statistics summarized the pretest and posttest scores for learning outcomes and critical thinking skills, including the mean, maximum, and minimum values for each class. The normalized gain (N-Gain Score) was then calculated to determine the percentage improvement in learning outcomes and critical thinking skills before and after treatment, following the procedure of Hake (1998) and interpreted using Hake's categorization as cited in Nurani (2014) and Meltzer's classification as cited in Yahya (2020), which classify the result as ineffective, fairly ineffective, fairly effective, or effective. For inferential analysis, prerequisite tests were carried out first. A normality test (Kolmogorov-Smirnov and Shapiro-Wilk) checked whether the pretest and posttest data for both learning outcomes and critical thinking skills were normally distributed, with a significance value above 0.05 taken to indicate normal distribution. Once normality was confirmed, a paired sample t-test was used to examine the mean difference between the pretest and posttest scores within each class (experimental and control). A homogeneity test (Levene's test of homogeneity of variance) was then conducted to determine whether the posttest variances of the two classes were homogeneous, again using a 0.05 significance threshold. Finally, an independent samples t-test was applied to compare the posttest means of the experimental and control classes and to test the study's hypothesis,

following the decision rule that H0 is accepted and H1 rejected when the significance value is at least 0.05, and rejected otherwise (Prayitno, 2014).

RESULT AND DISCUSSION

Student Learning Outcomes

Once initial learning-outcome data for Grade X TPM students at SMK Nasional Malang had been collected, students were ranked by score to form two groups: Group A, the experimental class, taught with the Quizizz-based Game Based Learning model, and Group B, the control class, taught with the conventional model. Students with high scores were assigned to the control class, while those with moderate and low scores formed the experimental class.

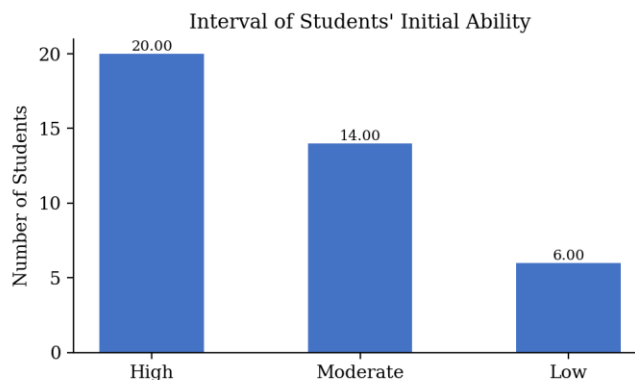


Figure 1. Interval of Students' Initial Ability

The initial-ability data grouped 20 students into the high category, 14 into the moderate category, and 6 into the low category. Students in the high category joined the control class, while those in the moderate and low categories joined the experimental class.

Initial learning-outcome data came from a pretest given to both classes before either learning model was applied. The pretest used 20 multiple-choice items, already tested and validated by the validators. The pre-treatment learning outcomes for the control and experimental classes are shown in Figures 2 through 4.

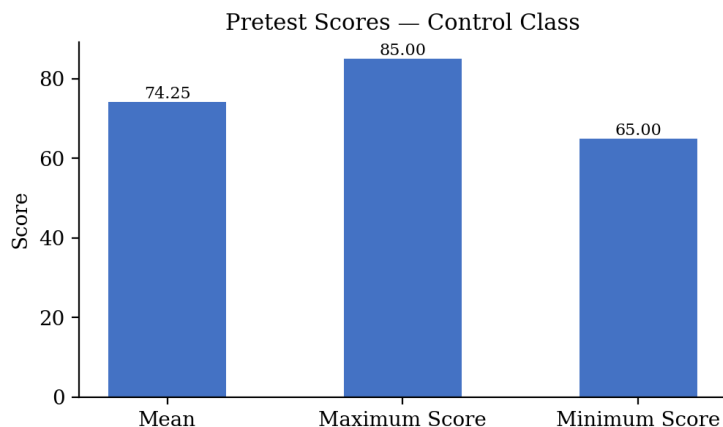


Figure 2. Pretest Scores — Control Class

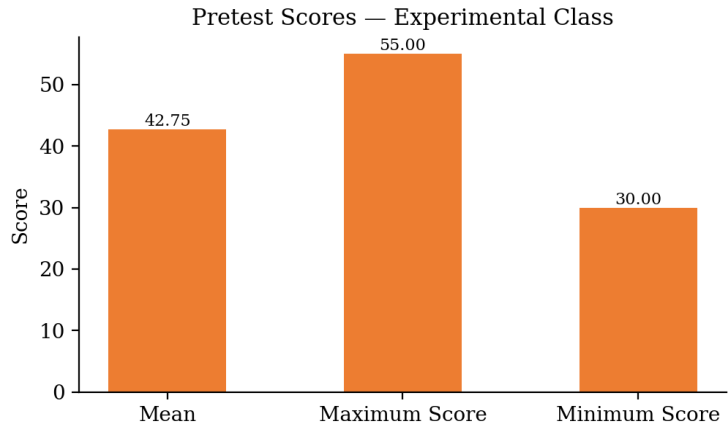


Figure 3. Pretest Scores — Experimental Class

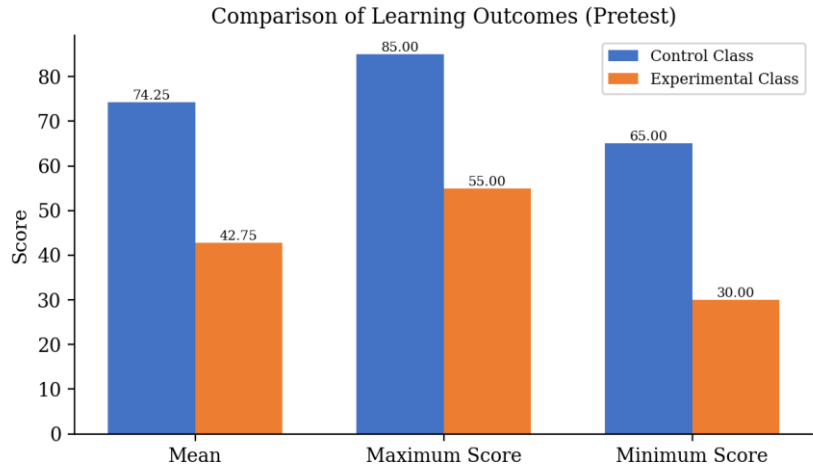


Figure 4. Comparison of Learning Outcomes (Pretest)

Figures 2 and 3 show that, before treatment, the control class recorded a pretest mean of 74.25, with a maximum score of 85 and a minimum of 65, while the experimental class recorded a pretest mean of 42.75, with a maximum score of 55 and a minimum of 30.

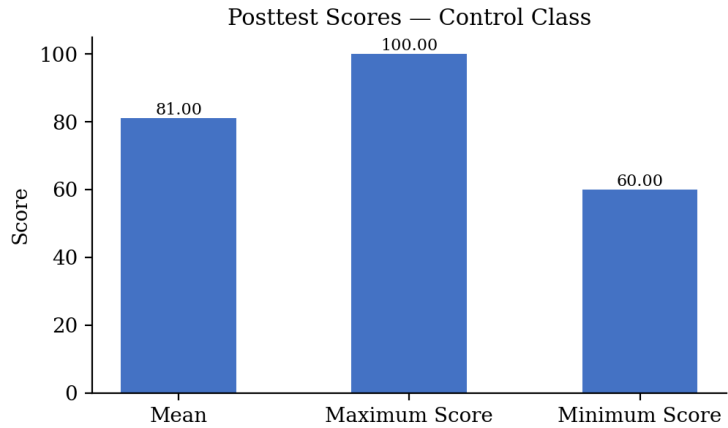


Figure 5. Posttest Scores — Control Class

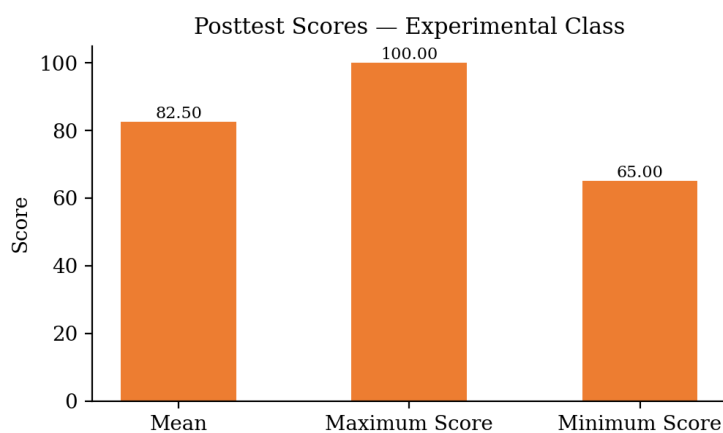


Figure 6. Posttest Scores — Experimental Class

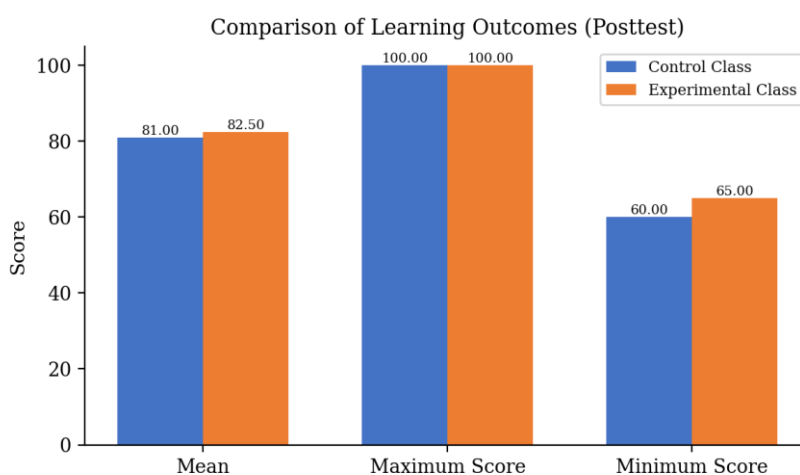


Figure 7. Comparison of Learning Outcomes (Posttest)

Figures 5 and 6 show that, after treatment, the control class, taught with the conventional model, recorded a posttest mean of 81, with a maximum score of 100 and a minimum of 60, while the experimental class, taught with the Quizizz-based Game Based Learning model, recorded a posttest mean of 82.5, with a maximum score of 100 and a minimum of 65.

Once the pretest and posttest scores for each sample had been collected, the normalized gain (N-Gain Score, NGS) was calculated to determine the percentage improvement in learning outcomes before and after treatment. Using SPSS, the NGS was calculated for every student in each class, then evaluated against Hake's categorization (Nurani, 2014, p. 37). The N-Gain Score results, expressed as percentages for each class, are shown in Figure 8.

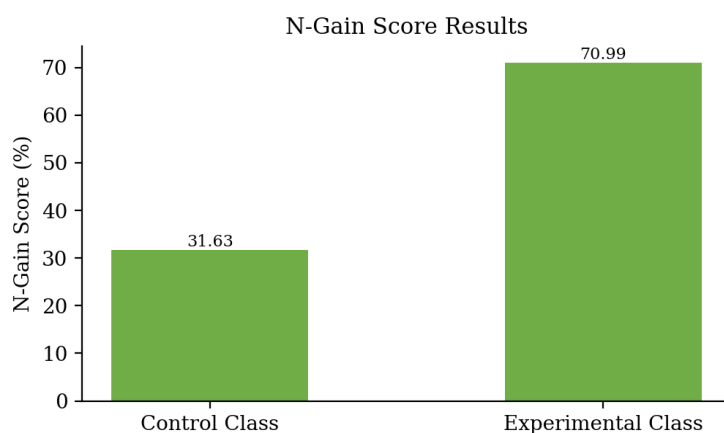


Figure 8. N-Gain Score Results

The N-Gain Score test in Figure 8 shows a value of 70.99% for the experimental class taught with the Quizizz-based Game Based Learning model, which can be considered fairly effective. Following Meltzer (as cited in Yahya, 2020, p. 48), this classification is based on N-Gain percentages: below 40% is ineffective, 40–55% is fairly ineffective, 56–75% is fairly effective, and above 76% is effective.

Students' Critical Thinking Skills

Students' critical thinking skills were measured with a questionnaire distributed after the pretest and again after the posttest. The critical thinking indicators covered elementary clarification, forming the basis for a decision, drawing inferences, providing further clarification, and estimation.

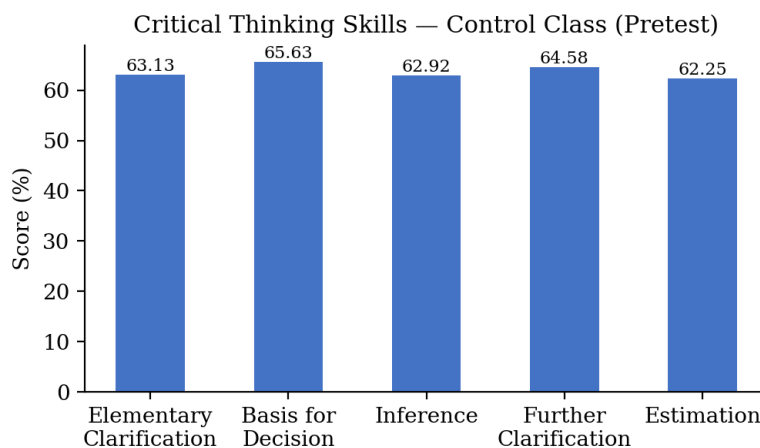


Figure 9. Critical Thinking Skills — Control Class (Pretest)

Figure 9 shows that, before treatment, the control class scored 63.13% for elementary clarification, 65.63% for the basis for decision-making, 62.92% for inference, 64.58% for further clarification, and 62.25% for estimation.

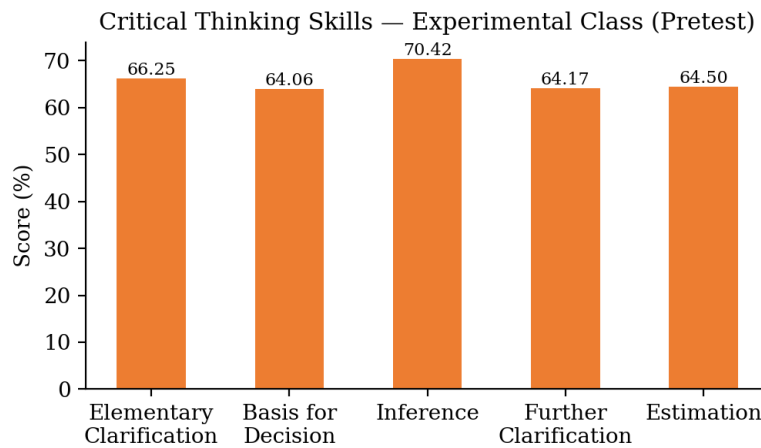


Figure 10. Critical Thinking Skills – Experimental Class (Pretest)

Figure 10 shows that, before treatment, the experimental class scored 66.25% for elementary clarification, 64.06% for the basis for decision-making, 70.42% for inference, 64.17% for further clarification, and 64.5% for estimation.

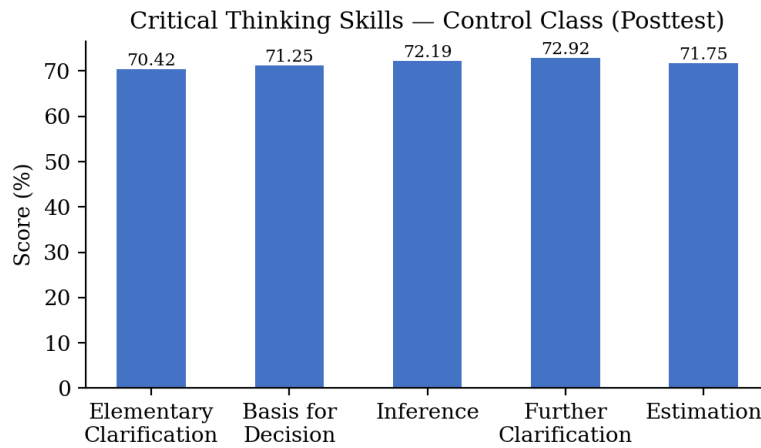


Figure 11. Critical Thinking Skills – Control Class (Posttest)

Figure 11 shows that, after treatment, the control class scored 70.42% for elementary clarification, 71.25% for the basis for decision-making, 72.19% for inference, 72.92% for further clarification, and 71.75% for estimation.

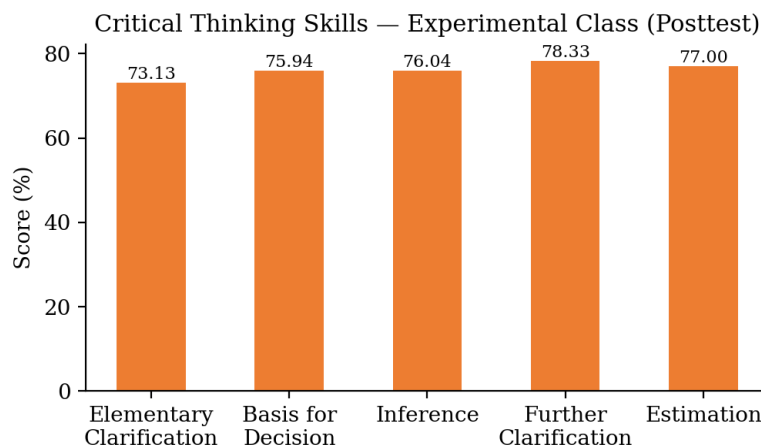


Figure 12. Critical Thinking Skills – Experimental Class (Posttest)

Figure 12 shows that, after treatment, the experimental class scored 73.13% for elementary clarification, 75.94% for the basis for decision-making, 76.04% for inference, 78.33% for further clarification, and 77% for estimation.

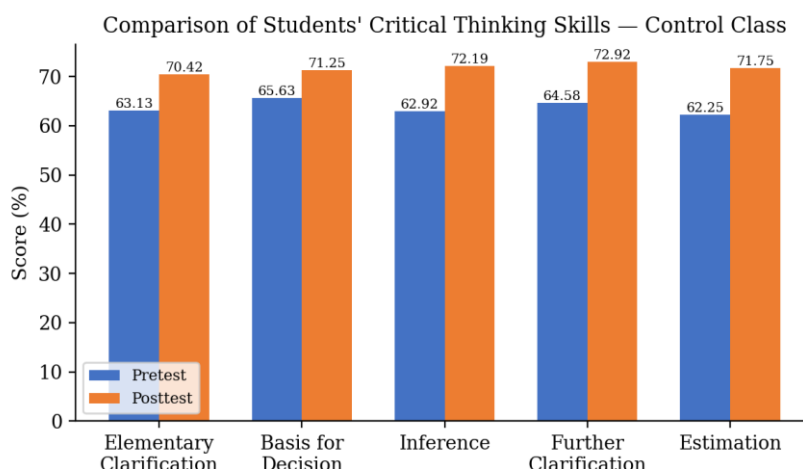


Figure 13. Comparison of Students' Critical Thinking Skills — Control Class

Comparing the control class's critical thinking scores before and after treatment (Figure 13), several indicators improved: elementary clarification rose by 7.29%, the basis for decision-making by 5.62%, inference by 9.27%, further clarification by 8.34%, and estimation by 9.5%.

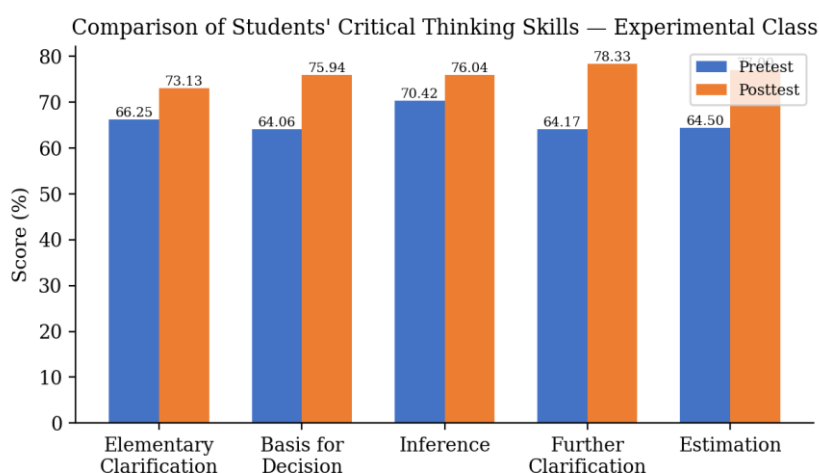


Figure 14. Comparison of Students' Critical Thinking Skills — Experimental Class

Comparing the experimental class's critical thinking scores before and after treatment (Figure 14), several indicators improved: elementary clarification rose by 6.88%, the basis for decision-making by 11.88%, inference by 5.78%, further clarification by 14.16%, and estimation by 12.5%.

Prerequisite Test for Learning Outcomes

A normality test was run to check whether the analyzed variable followed a normal distribution data are normally distributed if the significance value exceeds 0.05, and not normally distributed otherwise. The Kolmogorov-Smirnov and Shapiro-Wilk test results, computed in SPSS 26, are shown in Table 3.

Table 3. Normality Test Results — Learning Outcomes

Class	K-S Stat.	df	K-S Sig.	S-W Stat.	df	S-W Sig.
Pretest Experimental	0.117	20	0.200*	0.959	20	0.529
Posttest Experimental	0.126	20	0.200*	0.940	20	0.240

Class	K-S Stat.	df	K-S Sig.	S-W Stat.	df	S-W Sig.
Pretest Control	0.149	20	0.200*	0.951	20	0.388
Posttest Control	0.180	20	0.089	0.925	20	0.126

The normality test using either Kolmogorov-Smirnov or Shapiro-Wilk produced significance values above 0.05, so the study data can be considered normally distributed. Since the data were normal, the paired sample t-test, a parametric statistic, could be used to check for a mean difference between two paired samples. The results are shown in Table 4.

Table 4. Paired Sample T-Test Results – Learning Outcomes

Pair	Mean	SD	SE Mean	CI Lower	CI Upper	t	df	Sig. (2-tailed)
Pretest-Posttest Experimental	-24.500	9.162	2.049	-28.788	-20.212	-11.959	19	0.000
Pretest-Posttest Control	-17.250	9.101	2.035	-21.509	-12.991	-8.476	19	0.000

Pair 1 produced a significance value (2-tailed) of 0.000, below 0.05, confirming a mean difference in learning outcomes between the experimental class's pretest and posttest under the Quizizz-based Game Based Learning model. Pair 2 likewise produced a significance value of 0.000, confirming a mean difference between the control class's pretest and posttest.

Before running an independent samples t-test on the two classes, a homogeneity test was required to check whether the data were homogeneous, using the test of homogeneity of variance data are considered homogeneous when the sig. value based on mean exceeds 0.05. The results are shown in Table 5.

Table 5. Homogeneity Test Results – Learning Outcomes

Basis	Levene Statistic	df1	df2	Sig.
Based on Mean	1.032	1	38	0.316
Based on Median	0.958	1	38	0.334
Based on Median and adjusted df	0.958	1	37.907	0.334
Based on trimmed mean	1.078	1	38	0.306

The sig. value based on mean was 0.316, above 0.05, so the posttest variances of the experimental and control classes were considered homogeneous. The data therefore satisfied the requirements to proceed with the Independent Samples T-test. This test comparing the means of two independent groups (Prayitno, 2014) accepts H₀ and rejects H₁ when the significance value (α) is at least 0.05, and rejects H₀ otherwise. The hypothesis test results are shown in Table 6.

Table 6. Hypothesis Test Results – Learning Outcomes

Assumption	Levene F	Levene Sig.	t	df	Sig. (2-tailed)	Mean Diff.	SE Diff.
Equal variances assumed	1.032	0.316	4.404	38	0.000	19.750	4.485
Equal variances not assumed			4.404	36.739	0.000	19.750	4.485

The significance value (2-tailed) of 0.000 is below 0.05, confirming a difference in learning outcomes between the Quizizz-based Game Based Learning model and the direct/conventional model. H₀ is rejected and H₁ accepted, meaning the Quizizz-based Game Based Learning model had an effect on the learning outcomes of Grade X TPM students in the Basic Machining course.

Prerequisite Test for Critical Thinking Skills

The same normality, paired sample t-test, homogeneity, and independent samples t-test procedures were applied to the critical thinking data. The Kolmogorov-Smirnov and Shapiro-Wilk results are shown in Table 7.

Table 7. Normality Test Results – Critical Thinking Skills

Class	K-S Stat.	df	K-S Sig.	S-W Stat.	df	S-W Sig.
Pretest Experimental	0.156	20	0.200*	0.931	20	0.160
Posttest Experimental	0.080	20	0.200*	0.970	20	0.762

Class	K-S Stat.	df	K-S Sig.	S-W Stat.	df	S-W Sig.
Pretest Control	0.149	20	0.200*	0.956	20	0.464
Posttest Control	0.117	20	0.200*	0.969	20	0.743

As with the learning-outcome data, all significance values exceeded 0.05, confirming a normal distribution and clearing the way for a paired sample t-test, shown in Table 8.

Table 8. Paired Sample T-Test Results – Critical Thinking Skills

Pair	Mean	SD	SE Mean	CI Lower	CI Upper	t	df	Sig. (2-tailed)
Pretest-Posttest Experimental	-8.000	3.026	0.677	-9.416	-6.584	-11.822	19	0.000
Pretest-Posttest Control	-6.400	2.303	0.515	-7.478	-5.322	-12.426	19	0.000

Pair 1 confirms a mean difference in critical thinking skills between the experimental class's pretest and posttest under Quizizz-based Game Based Learning (sig. = 0.000). Pair 2 confirms the same for the control class's pretest and posttest (sig. = 0.000).

Table 9. Homogeneity Test Results – Critical Thinking Skills

Basis	Levene Statistic	df1	df2	Sig.
Based on Mean	1.444	1	38	0.237
Based on Median	1.427	1	38	0.240
Based on Median and adjusted df	1.427	1	37.079	0.240
Based on trimmed mean	1.453	1	38	0.235

The sig. value based on mean was 0.237, above 0.05, confirming homogeneous variance and clearing the way for an Independent Samples T-test, shown in Table 10.

Table 10. Hypothesis Test Results – Critical Thinking Skills

Assumption	Levene F	Levene Sig.	t	df	Sig. (2-tailed)	Mean Diff.	SE Diff.
Equal variances assumed	1.444	0.237	2.468	38	0.018	3.800	1.540
Equal variances not assumed			2.468	35.689	0.019	3.800	1.540

The significance value (2-tailed) of 0.018 is below 0.05, confirming a difference in critical thinking skills between the Quizizz-based Game Based Learning model and the conventional model. H0 is rejected and H1 accepted, meaning the Quizizz-based Game Based Learning model affected the critical thinking skills of Grade X TPM students in the Basic Machining course.

Prerequisite Test for the Combined Effect on Learning Outcomes and Critical Thinking Skills

A final set of tests examined the combined pretest and posttest data for both learning outcomes and critical thinking skills together. The normality test results are shown in Table 11.

Table 11. Normality Test Results – Combined

Variable	K-S Stat.	df	K-S Sig.	S-W Stat.	df	S-W Sig.
Pretest, Learning Outcomes	0.124	40	0.126	0.924	40	0.010
Posttest, Learning Outcomes	0.114	40	0.200*	0.948	40	0.065
Pretest, Critical Thinking	0.080	40	0.200*	0.980	40	0.676
Posttest, Critical Thinking	0.104	40	0.200*	0.971	40	0.374

The paired sample t-test results for the combined data are shown in Table 12.

Table 12. Paired Sample T-Test Results – Combined

Pair	Mean	SD	SE Mean	CI Lower	CI Upper	t	df	Sig. (2-tailed)
Pretest-Posttest Learning Outcomes	-23.250	17.779	2.811	-28.936	-17.564	-8.271	39	0.000
Pretest-Posttest Critical Thinking	-7.200	2.775	0.439	-8.088	-6.312	-16.408	39	0.000

The homogeneity test results for the combined data are shown in Table 13.

Table 13. Homogeneity Test Results – Combined

Basis	Levene Statistic	df1	df2	Sig.
Based on Mean	41.616	3	156	0.364
Based on Median	41.104	3	156	0.403
Based on Median and adjusted df	41.104	3	93.513	0.403
Based on trimmed mean	41.624	3	156	0.380

With the data confirmed as homogeneous, the Independent Samples T-test proceeded on the combined data, with results shown in Table 14.

Table 14. Hypothesis Test Results – Combined

Assumption	Levene F	Levene Sig.	t	df	Sig. (2-tailed)	Mean Diff.
Equal variances assumed	20.391	0.000	11.455	78	0.000	22.600
Equal variances not assumed			11.455	54.543	0.000	22.600

The significance value (2-tailed) of 0.000 is below 0.05, indicating a difference in learning outcomes and critical thinking skills between the Quizizz-based Game Based Learning model and the direct/conventional model. H₀ is rejected and H₁ accepted, confirming that the Quizizz-based Game Based Learning model affected both the learning outcomes and critical thinking skills of Grade X TPM students at SMK Nasional Malang in the Basic Machining course.

Student Learning Outcomes in the Basic Machining Course

Students' grasp of the Basic Machining material was assessed by giving a pretest before instruction began the control class under the conventional model and the experimental class under the Quizizz-based Game Based Learning model with the pretest administered before treatment in each class. The test, given to Grade X TPM students at SMK Nasional Malang, gauged students' initial ability and determined which class control or experimental each student would join. The pretest consisted of 20 multiple-choice items completed in 20 minutes. Of the 40 students, the 20 with higher scores joined the control class under the conventional model, while the 20 with moderate scores joined the experimental class under the Quizizz-based Game Based Learning model.

Before students moved to their assigned classes, the researcher explained the material to everyone; the experimental class then moved to a separate room to complete the posttest prepared for the Quizizz-based Game Based Learning model, while the control class stayed with the subject teacher and completed a conventional paper-based multiple-choice posttest. The comparison of pre- and post-treatment learning outcomes showed a rise of 6.75 points in the control class, with an N-Gain Score of 31.63%, and a rise of 34.75 points in the experimental class, with an N-Gain Score of 70.99%. The N-Gain calculation indicates that the Quizizz-based Game Based Learning model can be considered fairly effective. Aini (2018) similarly found that applying a Game Based Learning model raised learning outcomes by 69% in the control class and 81% in the experimental class of that study. Meanwhile, the N-Gain calculation suggests the conventional model here was less effective, consistent with Peranginangin (2020), who found conventional teaching less effective than an elaboration-based model, since conventional teaching relies mainly on lecturing and question-and-answer sessions.

Improving learning outcomes calls for evaluation as a way of measuring how well students absorb the material a teacher presents. According to Kpolvie (as cited in Andriani et al., 2019), one benchmark for measuring learning outcomes is reflecting on the learning activity itself and choosing an appropriate learning model. Quizizz-based Game Based Learning is one option; Prasetya (2013) describes Game Based Learning as a student-centered model that uses electronic games for instructional purposes. Quizizz is one such electronic game Anggreni (as cited in Asiana et al., 2022) notes that Quizizz stands apart as an educational application because it carries game-like features such as avatars, themes, and music. After comparing the

control and experimental classes' learning outcomes, a hypothesis test produced a significance value (2-tailed) of 0.000, below 0.05, confirming a difference in learning outcomes between the Quizizz-based Game Based Learning model and the direct/conventional model; H₀ was rejected and H₁ accepted, indicating that the Quizizz-based Game Based Learning model affected the learning outcomes of Grade X TPM students at SMK Nasional Malang in the Basic Machining course.

Critical Thinking Skills of Grade X TPM Students at SMK Nasional Malang

The critical thinking skills of Grade X TPM students at SMK Nasional Malang, as one measure of soft skill, were gathered through a questionnaire distributed before treatment to capture students' initial ability and again after treatment in each class. The questionnaire contained 20 questions, completed through Google Forms. The comparison shows the control class's critical thinking skills rose by 6% after treatment, while the experimental class rose by 8%. Cahyono (2017) argues that critical thinking should be nurtured and taught across every subject, since it is not an innate trait and does not develop on its own it has to be deliberately cultivated as a soft skill.

Game Based Learning's role in building critical thinking showed up in the questions given to students, mapped against the critical thinking aspects of elementary clarification, forming the basis for a decision, drawing inferences, providing further clarification, and estimation. In the control class, the elementary-clarification indicator rose by 7.29%, from 63.13% before treatment to 70.42% after; in the experimental class it rose by 6.88%, from 66.25% to 73.13%. Students were able to explain material the teacher had presented, analyze the questions asked, and answer both direct questions and test items. This aligns with Arfianawati et al. (2016), citing Ennis, who identified three indicators within elementary clarification: focusing a question, analyzing arguments, and asking and answering clarifying questions.

In the control class, the basis-for-decision-making indicator rose by 5.62%, from 65.63% to 71.25%; in the experimental class it rose by 11.88%, from 64.06% to 75.94%, reflecting the fact that SMK students need to be able to make decisions, since graduates will soon enter an industry where sound workplace decision-making matters. This is consistent with Patton and McMahon (as cited in Arjanggi, 2017), who argue that students can develop a working understanding of the critical-thinking process and apply it later to career decisions. In the control class, the inference indicator rose by 9.27%, from 62.92% to 72.19%; in the experimental class it rose by 5.78%, from 70.42% to 76.04%. Students were able to draw a conclusion about the material the teacher had explained and justify it based on what they had learned. Amalia (2017) describes drawing an inference as the step of reaching a conclusion from available data, done logically and in line with an empirical method.

In the control class, the further-clarification indicator rose by 8.34%, from 64.58% to 72.92%; in the experimental class it rose by 14.16%, from 64.17% to 78.33%. Having listened to and absorbed the material, students were able to elaborate further on their answers, even if their wording differed from one student to another while the substance stayed consistent, since each student understands material somewhat differently. Herunata et al. (2020) note that students who answer correctly do not necessarily share the same reasoning each follows a different line of thought when elaborating an answer. In the control class, the estimation indicator rose by 9.5%, from 62.25% to 71.75%; in the experimental class it rose by 12.5%, from 64.5% to 77%. Answering the test items required students to make reasonable estimates, and they were able to do so accurately. This matches Sakinah and Nasution (2022), who found that students could estimate reasonable answers to the questions given.

Students who meet all the critical-thinking aspects can be considered critical thinkers. Siswono (2016) explains that a student is thinking critically when they can choose their words carefully in a statement, need conviction before drawing a conclusion, identify important assumptions stated or unstated behind a conclusion, continually re-examine their assumptions, evaluate opinions, and accept or reject a conclusion accordingly. Having established the difference in critical thinking skills between the control and experimental classes, a hypothesis test an Independent Samples T-test followed. The analysis produced a significance value (2-tailed) of 0.018, below 0.05, confirming a difference in critical thinking skills between the

Quizizz-based Game Based Learning model and the conventional model. H0 is rejected and H1 accepted, meaning the Quizizz-based Game Based Learning model affected the critical thinking skills of Grade X TPM students in the Basic Machining course. This is supported by earlier work from Kurniawan (2022), who found that Game Based Learning using card-game media improved the critical thinking skills of Grade V students at SD Negeri 2 Kedungsarimulyo in the first semester of the 2022/2023 school year.

The Effect of the Quizizz-Based Game Based Learning Model on Improving Student Learning Outcomes and Critical Thinking Skills

The Game Based Learning model has an effect on, and can help develop, both learning outcomes and critical thinking skills. Noor (2020) notes that Quizizz can serve as an alternative teaching trick, making learning enjoyable without diminishing the substance of the lesson, which in turn helps keep students actively engaged. Isjoni (2012, p. 147) describes a learning model as a strategy teachers use to raise learning motivation, shape students' attitudes toward learning, build critical thinking and social skills, and improve overall learning outcomes. Winatha (2020) adds that this model helps students construct their own learning through an enjoyable experience, which naturally feeds back into their interest and motivation to learn.

On the elementary-clarification indicator in the posttest, experimental-class students answered a question about the manufacturing process and were able to explain its basic concept, showing that they could ground their answer in evidence and, in doing so, exercise critical thinking. In question 1, which represented this indicator, 13 students (65%) answered correctly. On the basis-for-decision-making indicator, the posttest asked students about the tool used to clamp a workpiece on a milling machine; students were able to identify the correct clamping tool, honing their critical thinking by deciding among options including, in one item, unfamiliar foreign terminology. In question 14, which represented this indicator, 15 students (75%) answered correctly.

On the inference indicator, the posttest asked students to draw a conclusion about the difference between CNC and conventional machines; students were able to identify the difference and, in doing so, sharpen their critical thinking by drawing a conclusion to reach the correct answer. In question 18, which represented this indicator, 14 students (70%) answered correctly. On the further-clarification indicator, the posttest asked about the function of coolant; students were able to elaborate on coolant's proper function, sharpening their critical thinking through further explanation to reach the correct answer. In question 10, which represented this indicator, 18 students (90%) answered correctly.

On the estimation indicator, the posttest asked students to identify which option was not a clamping method used on a milling machine; students were able to estimate the correct exception among the clamping methods, sharpening their critical thinking in the process. In question 9, which represented this indicator, 17 students (85%) answered correctly.

The posttest items covered several aspects of students' critical thinking. Devi (2020) identifies five such aspects: elementary clarification, forming the basis for a decision, drawing inferences, further clarification, and estimation. Several of these aspects improved among Grade X TPM students at SMK Nasional Malang in the Basic Machining course, alongside a rise in learning outcomes as measured by the tests given. The posttest was administered under a different learning model in each class: the experimental class under Quizizz-based Game Based Learning, and the control class under the conventional model.

DISCUSSION

Taken together, these results confirm that the Quizizz-based Game Based Learning model significantly improved both the learning outcomes and the critical thinking skills of Grade X TPM students in the Basic Machining course, with the experimental class recording a larger N-Gain Score (70.99%) than the control class (31.63%) and a larger rise in critical thinking scores (8 percentage points versus 6). This pattern indicates that embedding gamified, game-based assessment within a technical vocational subject can raise both cognitive mastery and higher-order thinking simultaneously, a relevance that matters directly for vocational teachers must balance hard-skill instruction with the soft-skill demands of today's workplace.

These findings align with a substantial and growing body of research on game-based and gamified learning. Mao et al. (2022), in a meta-analysis of 21 effect sizes, found that game-based learning has a significant positive overall effect on students' critical thinking ($g = 0.863$), a magnitude consistent with the gains observed here. Sailer and Homner (2020) similarly reported small-to-moderate positive effects of gamification on cognitive learning outcomes across their meta-analytic sample. Bai et al. (2020) found that gamification reliably improves student learning outcomes when game elements are paired with structured instructional design rather than used in isolation. At the platform level, Zhao (2019) and Pitoyo et al. (2020) found that Quizizz-based classroom activities raised student engagement and had a positive washback effect on learning, and Inderanata (2022) documented comparable gains in learning outcomes among engineering students using Quizizz, closely mirroring the technical, machining-oriented context of the present study. Dewani et al. (2023) found Quizizz-supported media effective for improving achievement and independent learning in a vocational beauty-education course, reinforcing the plausibility of the effect observed among Grade X TPM students here.

Where the present findings diverge from some prior studies, the divergence is informative. Unlike Kwangmuang et al. (2021), found that a dedicated higher-order-thinking-skills curriculum produced uniformly large gains across all indicators, the Quizizz-based Game Based Learning model in this study produced uneven gains across the five critical-thinking indicators, with further clarification rising by 14.16% but inference rising by only 5.78% in the experimental class; this discrepancy likely reflects differences in instructional focus (a single gamified assessment tool rather than a full curriculum redesign), population (vocational machining students rather than general secondary students), and exposure time (a short classroom intervention rather than a semester-long program). Similarly, Bai et al. (2020) cautioned that gamification's effect on learning outcomes is often smaller than its effect on motivation, the present study found a substantial N-Gain difference (70.99% versus 31.63%) between classes; this can be attributed to the combination of Quizizz with a Nonequivalent Control Group design in which the experimental class began from a markedly lower pretest baseline (42.75) than the control class (74.25), giving it more room to improve, a methodological factor that should temper direct comparison with studies using randomized, equivalent groups. These contextual and methodological differences suggest that the size and consistency of game-based learning's effect depend heavily on baseline ability, exposure duration, and how tightly the game mechanics are integrated with the subject's technical content, a nuance highlighted by Chen and Wu (2021) in their study of digital role-playing games for critical thinking.

The principal contribution of this study lies in its direct, quasi-experimental test of a Quizizz-based Game Based Learning model on two outcomes simultaneously, technical learning outcomes and critical thinking skills, within a specific vocational machining course (Basic Machining, Grade X TPM) rather than in a general or language-learning classroom, where most prior Quizizz research has concentrated (Yunus, 2021; Zuhriyah & Pratolo, 2020). By mapping posttest items directly onto Ennis's critical-thinking indicators (elementary clarification, forming the basis for a decision, drawing inferences, further clarification, and estimation) and cross-referencing them with N-Gain-based learning-outcome data, this study offers a more granular picture of how a single gamified assessment tool can influence both hard-skill mastery and higher-order thinking in a technical and vocational education setting, an intersection that remains underexplored in the Quizizz literature (Mao et al., 2022).

Practically, these findings suggest that vocational teachers in technical subjects such as Basic Machining can adopt Quizizz-based Game Based Learning as a low-cost, readily available tool for reinforcing both content mastery and critical thinking, provided it is paired with clear game rules and content aligned to course competencies. At the school-management level, principals are encouraged to support teacher training in gamified assessment platforms, since Sailer and Homner (2020) found that gamification's cognitive benefits are more stable when methodological rigor and instructional alignment are high. Academically, this study extends the game-based learning literature by demonstrating its applicability to technical, competency-based vocational subjects rather than only general or language education, and it suggests that future researchers replicate this design across other machining or engineering competencies,

use randomized or better-matched control groups to isolate the model's effect from baseline-ability differences, and track critical-thinking gains over a longer period to establish whether the improvements observed here are sustained (Kwangmuang et al., 2021; Facione & Facione, 1996).

CONCLUSION

This study's findings can be summarized as follows. Learning outcomes for the Grade X TPM experimental class taught with the Quizizz-based Game Based Learning model rose from a pretest mean of 42.75 to a posttest mean of 82.5, a gain of 39.75, with 85% of students reaching mastery learning; the control class, taught with the conventional model, rose from a pretest mean of 74.25 to a posttest mean of 81, a gain of 6.75, with 70% mastery learning. The N-Gain Score reached 70.99% for the Quizizz-based Game Based Learning model, compared with 31.63% for the conventional model. Critical thinking skills in the experimental class rose from a pretest mean of 65.88% to a posttest mean of 76.09%, a gain of 8 percentage points, while the control class rose from 63.7% to 71.7%, a gain of 6 percentage points. The hypothesis tests confirmed that the Quizizz-based Game Based Learning model had a significant effect on both the learning outcomes and the critical thinking skills of Grade X TPM students in the Basic Machining course at SMK Nasional Malang.

Building on these findings, school principals are encouraged to recommend that teachers adopt the Quizizz-based Game Based Learning model to address classroom challenges, and to provide the facilities and support needed for learning to run smoothly. Teachers may consider using the Quizizz-based Game Based Learning model to help raise students' learning outcomes and critical thinking skills, thereby improving mastery learning rates. Students engaging with the Quizizz-based Game Based Learning model are encouraged to pay closer attention and stay engaged throughout the learning process, and to participate more actively so as to sharpen their critical thinking. Future researchers are encouraged to conduct similar studies across a wider range of subjects, using this study as a reference and building further on the relationships between different learning models; the present findings could also be refined further, since the students' mastery learning rate remains below 90%.

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