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The RADEC learning model assisted by an e-learning application in fostering the high-order thinking skills of aspiring primary school teachers

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Abstract

This paper investigates the performance of the RADEC learning model(TRLM) assisted by e-learning to foster higher-order thinking skills (HOTS) in aspiring primary school teachers. No one has researched HOTS in the implementation of TRLM, which is held online in mathematics materials. A quasi-experimental design was employed in this research. Aspiring primary school teachers who are studying at Semarang State University were the subject of this paper. The aspiring primary school teachers are currently in their second semester of study. There were two classes through simple random sampling: one performed TRLM assisted by e-learning, and one control class. HOTS was measured using essay questions with HOTS indicators, specifically analysing, evaluating, and creating. The question was valid and reliable. The study results showed that the average post-test score of the experimental class was higher than that of the control class. There is an increase from pretest to posttest in both the control and experimental classes. However, when checked, the N-Gain score percentage of the experimental class showed that the increasing HOTS is quite effective. At the same time, the control class was ineffective. TRLM-assisted e-learning increases the HOTS of aspiring primary school teachers and is more effective than the control class.

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1. Introduction

21st-century skills are the direction of education goals worldwide. HOTS are in high demand in the 21st century (G. S. Pratama & Retnawati, 2018; Susantini et al., 2024). Mastering HOTS is essential in this century. Learners must master HOTS to face complex challenges(Xiao et al., 2025). Learning in Indonesia is currently being directed toward developing HOTS. HOTS refers to learners' higher-order thinking abilities (Ichsan et al., 2019; Mulianingsih et al., 2025). In addition to having low-level thinking skills (LOTS), learners are required to achieve HOTS(Kusuma et al., 2017). HOTS encompasses high-level thinking skills essential for a person's intellectual and competence development (Lismaya et al., 2025).

Various learning models were developed to foster these 21st-century skills. TRLM can be implemented to encourage 21st-century skills. This model was developed by Soepandi in 2017. Constructivism served as the framework for developing this model. This model provides space for learners to learn actively and productively. TRLM encourages critical thinking skills(Y. A. Pratama et al., 2019). TRLM affects learners' high-level thinking skills(Y. A. Pratama et al., 2020). The TRLM model also received a good response from teachers who were learning practitioners. The competency of prospective educators to plan learning is positively influenced by TRLM(Hany Handayani et al., 2019). Most teachers state that TRLM is easy to recall, comprehend, and practice 21st-century skills; additionally, teachers are enthusiastic about investigating the application of TRLM (Sopandi, 2019). Cognitive learning outcomes can be enhanced through TRLM(Fiteriani et al., 2024). The TRLM application proved to be innovative and useful (Hayati, Kadarohman, Sopandi, Martoprawiro, et al., 2023).

TRLM can be implemented online(Sukardi et al., 2021). However, no study has been done on whether the implementation of TRLM online can increase HOTS. The implementation of TRLM online has been applied primarily to the field of science, whereas this research focused on mathematics materials, particularly geometry. Researchers are interested in using this model online. In online learning, effective planning is necessary (Maranna et al., 2025). E-learning offers several potential benefits, including flexibility and innovation in learning strategies (Shwetha & Banu, 2025). E-learning can foster HOTS(Rezaei & Beheshti Shirazi, 2024). Several studies have shown that learning innovation has been improved to elevate HOTS by implementing theoretical philosophy into practice and integrating it with media properties(Kwangmuang et al., 2021). Media supports the improvement of pupils' HOTS. TRLM supports critical thinking skills, while online learning can also increase HOTS. The rationale of this paper is to determine whether TRLM, assisted by e-learning implementation, can encourage HOTS of aspiring primary school teachers.

2. Literature Review

2.1 HOTS

HOTS is closely related to Bloom's Taxonomic Cognitive Level (G. S. Pratama & Retnawati, 2018). There are six cognitive categories in the original Bloom's Taxonomy(Gozali et al., 2021). If written from highest to lowest, they are evaluation, synthesis, analysis, application, understanding, and knowledge. In its development, the taxonomy was refined. If mentioned from top to bottom, the order of refinement of Bloom's taxonomy is creating, evaluating, analyzing, applying, understanding, and remembering. The HOTS category encompasses the ability to analyze (C4), evaluate (C5), and create (C6) (Armala et al., 2022). The involvement of individual assessments in the process of reasoning, analysis, evaluation, and creative idea generation to identify problems and make informed decisions is utilized in evaluating HOTS (Ismail et al., 2024).

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2.2 E-Learning

COVID-19 has accelerated the implementation of e-learning in educational organizations worldwide (Fouda et al., 2025; Mastour et al., 2025; Osiesi et al., 2025). E-learning is growing rapidly compared to conventional learning (Ge, 2025). The creation of e-learning platforms and resources has increased in recent years (Selcuk et al., 2025). The delivery of instructions digitally through various media and internet platforms is called e-learning (Ahmed et al., 2025). E-learning can be implemented synchronously or asynchronously(Zsifkovits et al., 2025). E-learning has advantages over conventional learning (Piaw et al., 2025). Students can access information easily from anywhere and at any time through mobile phones, tablets, personal computers, and other devices (Nakada et al., 2025; Tahura et al., 2025). The e-learning system utilizes information technology for the learning application (Garavand et al., 2025). E-learning requires educator innovation and technology that can support the learning system (Suratmi et al., 2022). E-learning enhances education with a variety of opportunities for students and faculty (Mastour et al., 2025).

2.3 TRLM

In its implementation, TRLM requires learners to engage in independent learning by reading the material and answering initial questions before attending the class (Setiawan et al., 2020). TRLM is a general instructional strategy to establish proficiency in learner concepts (Sukardi et al., 2021). TRLM can foster learners' critical thinking competence(Y. A. Pratama et al., 2019). This model is also considered innovative and useful(Hayati, Kadarohman, Sopandi, Martoprawiro, et al., 2023). This model step is (1) Read, (2) Answer, (3) Discuss, (4) Explain, and (5) Create. TRLM uses its phase according to the model name (Y. A. Pratama et al., 2020). TRLM can be implemented with an online model (Sukardi et al., 2021).

3. Method

3.1 Research procedure

This research is a quasi-experimental design. The e-learning-assisted RADEC learning model is an independent variable in this paper. The dependent variable of this study is the HOTS possessed by aspiring primary school teachers. Researchers selected the Google Classroom and Zoom applications to support the implementation of this learning model. The Read and Answer steps are performed in Google Classroom. Discussion and explanation steps are performed with the Zoom application. Products in the create step are collected in Google Classroom. Hence, a combination of asynchronous and synchronous learning models was used in the implementation of this study.

3.2 Population and sample

This research involved aspiring primary school teachers of Universitas Negeri Semarang in the second semester of the population. This research was conducted in the Mathematics Deepening Course. In total, there are 10 classes, with learners in each class at the same level of ability. The ten classes are distributed normally and homogeneously. The researchers chose samples with a simple random sampling technique. Two classes were randomly selected: Class P and Class Q. Class P consisted of 47 learners. Class Q included 44 learners.

Class P is arranged as an experimental class. Class Q is arranged as a control class. Class P obtained deepening learning of mathematical material with TRLM assisted by e-learning. Class P utilized the model of case methods commonly employed by lecturers. Although both classes employed different forms of learning, research in both classes was conducted with the same frequency, consisting of three meetings. The learning materials in both classes were also the same,

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namely geometry. The pretest was done before the first meeting. A post-test was conducted after the third meeting.

3.3 Research Instrument

The HOTS of aspiring primary school teachers was measured using a test instrument consisting of six essay questions. The questions consisted of two questions with a cognitive analysis level (C4), two questions with a cognitive evaluation level (C5), and two questions with a cognitive creation level (C6). Before experimenting, the researchers conducted a trial of the problem. Previously, each question item was tested for validity. The test used the Pearson Product-Moment Correlation test. The analysis was then continued with the instrument reliability test. The test used for this was the Cronbach's Alpha Test. The test results stated that all six items were valid. The question instrument has a reliability value of 0.689. This means that the problem is reliable.

3.4 Data Collection Technique

This study employs the test as a data collection technique. The researchers administered a pretest prior to the implementation of learning using TRLM, assisted by e-learning and control classes. Subsequently, the researchers conducted three learning sessions. Finally, the researchers administered a posttest after the learning implementation for both classes.

3.5 Data Analysis Technique

The analysis was conducted using Microsoft Excel and SPSS version 23 software. The data will be checked for normality to determine the form of the data's distribution. The writers used the independent sample t-test to equate the control and experimental classes. The data compared were the post-test scores of the two classes. The writers used a paired sample t-test to determine the improvement between the pretest and posttest in the experimental and control classes. N-Gain percentage was used to prove the effect of increasing HOTS in the control class and experimental class.

4. Results

TRLM steps are read, answer, discuss, explain, and create. These steps are combined with e-learning. In the reading step, learners are asked to read independently the teaching materials that have been distributed through Google Classroom. At this stage, learners are immersed in reading and understanding in diverse and varied contexts (Fiteriani et al., 2024). By reading, learners understand, interpret, apply, analyze, synthesize, and evaluate the content and messages encoded in the text to acquire knowledge(Ament et al., 2025). Previously, the lecturer had divided learners into several heterogeneous groups. After the reading step, followed by the answer step, the lecturer distributed learner worksheets, which learners completed independently, and then proceeded to a group discussion before the online lecture. During online face-to-face learning using Zoom, each group presented the results of their discussion to their peers to gather feedback and suggestions in this explanation step. At this stage, the lecturer ensures the correctness of the material presented. The last step is the creation step, in which the lecturer encourages learners to apply their creative thinking skills to develop the product. This product can be a video or a report summarizing the discussion results. Researchers conducted this learning exercise during three meetings, administering pre tests and post tests. For control classes, lecturers only use Google Classroom-assisted e-learning models. Before conducting data analysis, the researchers tested the normality of the data using the Shapiro-Wilk test. All data are normally distributed. This is evident in Table 1.

Table 1. Test of normality of data

	N	Statistical Test	Asym. Sig (2-tailed)	Meanings
Class Q Pretest (control)	44	0.975	0.437	Normal
Class P Pretest (experiment)	47	0.985	0.817	Normal
Class Q Post-test (control)	44	0.953	0.069	Normal
Class P Post-test (experiment)	47	0.965	0.176	Normal

Then, the researchers compared the results of the post-test from the control class and the experimental class using TRLM assisted by e-learning. The results of the independent sample t-test are obtained in Table 2.

Table 2. Sample independent t-test

	Levene's Test for Equality of Variances		t-test for Equality of Means	
	F	Sig	t	Sig. (2-tailed)
Equal variances presumed	2,360	0.086	-10.727	0,000
Equal variances not presumed			-10.770	0,000

Table 3. Average of pretest and post-test experimental class and control class

Class	N	Average	Std. deviation	Std. Mean Error
Control	44	70.57	5.87935	0.88635
Experiment	47	84.11	6.35700	0.92726

From Table 3, we can see that the average post-test score of the control class was 70.57, while the average post-test score of the experimental class was 84.11. Hence, the average score of the experimental class is higher than that of the control class. The increase in HOTS is seen from the paired sample t-test in Table 4. The effectiveness of increasing HOTS will then be seen through the interpretation of the N-gain percentage. It is visible in Table 5.

Table 4. Paired sample t-test: control and experiment class

	t	Sig. (2-tailed)
Pretest and Post-test in Control Class	-11.959	0.000
Pretest and Post-test in Experiment Class	-14.135	0.000

Table 5. N-Gain score percentage

Class	N-Gain Score Percentage	Interpretation
Control	38.19%	Not Effective
Experiment	65.28%	Effective Enough

From the data above, it is observed that the N-Gain score percentage of the control class is 38.19%, which falls within the ineffective category. The value of the N-Gain score percentage for the experimental class is 65.28%, which falls within the fairly effective category.

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To learn more about learners' HOTS, we categorize learners into three groups: medium, low, and high-low. Categorization of learners based on hypothetical statistics. Learners are said to be in the low category if the post-test learner's score is less than 79.67. Learners are categorized as being in the medium category if their score falls between 79.67 and 87.33. Meanwhile, if the post-test learner's score is more than 87.33, the learner is in the high category. A large number of learners can be seen in each category in Table 6. From each of these groups, one was taken to see the results of his work.

Table 6. Categories of learners' ability

Category	Many Learners
Low	16
Moderate	17
High	14

Table 7. Error Analysis of Low-Ability Learners in Post-Test

	No 1		No 2		No 3		No 4		No 5		No 6	
Error Types	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Concept error	√	√	√	√	√	√	√	-	√	-	√	√
Procedure error	√	√	√	√	√	√	√	√	√	-	√	√
Engineering error	√	√	√	√	√	√	√	√	√	√	√	√

Table 8. Error analysis of medium-ability learners

Error Types	No 1		No 2		No 3		No 4		No 5		No 6	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Concept error	-	-	-	-	√	√	-	-	√	-	√	-
Procedure error	√	-	√	-	√	√	√	-	√	-	√	√
Engineering error	√	√	√	-	√	√	√	√	√	√	√	√

Table 9. Error Analysis of High-Ability Learners

Error Types	No 1		No 2		No 3		No 4		No 5		No 6	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Concept error	-	-	-	-	-	-	-	-	-	-	√	-
Procedure error	-	-	√	-	√	-	√	√	√	-	√	-
Engineering error	√	-	√	-	√	-	√	√	√	√	√	-

We will attempt to analyze the errors in learners' work in the experimental class while they work on HOTS problems in the pretest and posttest, based on their mathematical abilities. J1 is a learner with a low category, J2 is a learner with a medium category, and J3 is a learner with a high category. We will examine the differences between the three errors when working on some of the HOTS questions provided. Several types of errors can occur when solving mathematical problems. These errors include conceptual, procedural, and technical errors (Seah, 2005). A misconception is an inability to understand a concept. Procedural errors occur when there is an inability to perform manipulations, such as selecting formulas and steps used. A technical error is an error resulting from careless calculation (Susantini et al., 2024). Six questions were tested in both the pretest and post-test. HOTS-based question levels are based on the categorization of thinking skills offered by the revised Bloom's Taxonomy. Problems number one and four are questions with a cognitive level of C4, which requires analysis. Problems 2 and 5 are questions with level C5 or evaluation. Problems no. 3 and 6 are questions with a level of C6 or higher. Error analysis for subject J1 can be found in Table 7, subject J2 in Table 8, and subject J3 in Table 9.

5. Discussion

At the first meeting, the material discussed was objects in geometry. In the Learner Worksheet, learners identify coplanar points, collinear points, and non-collinear points using the provided images. Previously, a definition of these points was provided in the teaching materials that were previously given. Apparently, even though the teaching materials are clearly defined, an exciting debate is underway among groups of learners. Each group has a different answer to this. This is where the role of lecturers in leading learners' opinions in the right direction becomes important. However, the purpose of this model is to encourage learners to think critically and engage in active discussions in the right direction.

An exciting debate also took place at the second meeting when learners were asked to identify the forms of polygon construction. The picture below is an example of a learner debate. Some stated that the two buildings were polygons, while others stated that they were not polygonal forms.

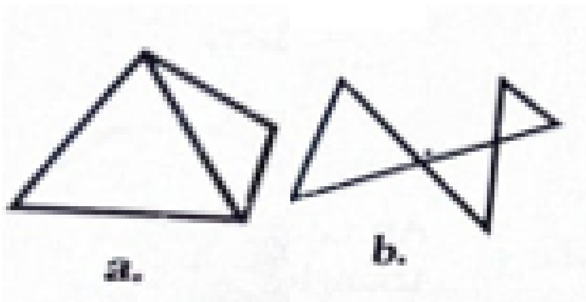

Figure 1. Builds that become learner debates

Meeting three was no less exciting than the previous two meetings. A heated debate ensued when learners were asked to determine all angles with at least one side tangent to a given image. Differences of opinion arise due to differences in viewpoints. This research is quantitative, so it is necessary to check whether the data is distributed normally. Table 1 shows the Asym. Sig (2-tailed) for the control class pretest, experimental class pretest, control class posttest, experimental class posttest in succession is 0.437, 0.817, 0.069, 0.176. Table 1 presents the results of the Asymmetric Analysis. Sig (2-tailed) for the four data points is more than 0.05. We conclude that all data are normally distributed.

After confirming this, the researchers looked at the average disparity between the two classes. We used an independent sample t-test to see the difference in average HOTS between the experimental class and the control class. In Table 2, the value of Sig. for equal variances is 0.086, indicating that the data variance is homogeneous; therefore, we choose to assume equal variances. Because the value of Sig. for the t-test is 0.000 less than 0.05, there is a difference between the

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average of the experimental class and the average of the control class. The results showed a difference in the average HOTS between the experimental class and the control class.

To find out which is better, we can look at Table 3. In that table, we compare the average HOTS of the control and experimental classes. In the control class, it is evident that the average HOTS score is 70.57. Meanwhile, the average HOTS in the experimental class was 84.11. This shows that the average HOTS of the experimental class is superior.

Next, we look at Table 4. In the table, we compare the difference in the average HOTS pretest and posttest scores between the control and experimental classes. In the table, it is known that the Sig. (2-tailed) for the control and experimental classes, the value is the same, which is 0.000. This is clearly less than 0.05, so it can be concluded that a HOTS is increasing in both the control and experimental classes.

To determine the effectiveness of increasing HOTS of TRLM assisted by e-learning, the researchers looked for the value of the N-Gain score percentage both in the experimental class and in the control class. This is evident in Table 5. The N-Gain Score percentage in the experimental class was 65.28%, while the control class was 38.19%. The N-Gain score percentage is considered ineffective if it is below 40%. An N-Gain score percentage between 40% and 55% is considered less effective. The N-Gain score percentage between 56% and 75% is considered quite effective. An N-gain score above 76% is said to be effective. The N-Gain score percentage of the experimental class in the study showed that the category was quite effective. Meanwhile, the N-Gain score percentage of the control class was ineffective. Hence, it can be concluded that TRLM, assisted by e-learning, can be considered a means to foster learners' HOTS. TRLM can enhance learners' actual competence and potential (Hayati, Kadarohman, Sopandi, Pratiwi, et al., 2023). TRLM has a positive impact(Setiawan et al., 2020). This learning model also increases learners' motivation(Fatayan et al., 2023). TRLM can improve learners' mathematical literacy(Guslisnawati et al., 2024). In the "Answer" step, learners can apply their abilities from LOTS to HOTS(Suratmi et al., 2022). TRLM, assisted by e-learning, incorporates independent learning activities that evolve into active learning online. With independent learning activities and active online learning activities, learning is more effective compared to other forms of learning in higher education (Poondej et al., 2025). The RADEC, based on Google Classroom, can enhance learners' understanding of the concept (Siregar et al., 2020). TRLM can also enhance learners' HOTS (H. Handayani et al., 2019).

From Table 7, it can be seen that J1 was unable to solve most of the HOTS problems at levels C4, C5, or C6. In the pretest, J1 performs all the analyzed errors. Then in the posttest, J1 made a concept error of 66.67%, a procedure error of 83.33%, and a 100% technical error. This means that there is an increase in ability after implementing TRLM learning assisted by e-learning. J1 needs to practice understanding the concept and practice very hard to correct errors in procedures and techniques. J1 never rewrote what was known in the question. This allows him to misunderstand the concept of the given problem. Because the misconception made affects the next calculation (Nugraheni, Waluya, et al., 2021). The level of proficiency among learners in understanding concepts remains inadequate (Luga et al., 2025). Many learners have difficulty reading HOTS questions (Armala et al., 2022). Indonesian learners struggle to integrate information and formulate real-world problems into material concepts (Khaeruddin et al., 2023).

Error analysis for subject J2 is presented in Table 8. J2 made a 50% conceptual error, a 100% procedure error, and a 100% technical error in the pretest. At the posttest time, it can be noticed that J2 made a concept error of 16.67%, a procedure error of 33.33%, and a technical error of 83.33%. J2 gets better after implementing TRLM, assisted by e-learning. It is known that J2 was able to understand the problem and determine the formulas and steps needed to solve the HOTS level C4 and C5 problems; however, they were still not thorough in solving them. J2 has not been able to solve the HOTS level C6 problem. J2 still needs to practice to correct procedural and technical errors.

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Knowing the formulas and steps involved is the key to success in solving HOTS problems (Nugraheni, Sukestiyarno, et al., 2021). A2 sometimes also directly answers questions that can lead to misconceptions when solving problems. J2 needs to be consistent and more demanding in solving problems. J2 is often careless in doing calculations. Learners with medium abilities often fail to re-examine the solutions they obtain (Natsir et al., 2025).

Table 9 shows that during the pretest, J3 made a concept error of 16.67%, a procedural error of 83.33%, and a technical error of 100%. While post-testing, J3 made only 16.67% procedural errors and 33.33% technical errors. J3 also gets better. J3 has been able to solve most of the C4, C5, and C6 level HOTS problems; however, they are sometimes still not thorough. J3 does not make misconceptions. This means that J3 has thoroughly grasped the material's concept. J3 sometimes lacks focus, resulting in a calculation error. The calculation error caused the solution obtained not to match (Nugraheni, Waluya, et al., 2021). J3 has more detailed answers than J2. He answered coherently and easily.

6. Conclusion and Implications

In the explanation of the implementation of TRLM assisted by e-learning, it was concluded that TRLM assisted by e-learning is proven to make learners think critically and actively. There was a difference in the average HOTS between the control and experimental classes. The average HOTS post-test score of the experimental class was superior. There was an increase in the HOTS scores between the pretest and posttest in both the experimental and control classes. However, the rise in HOTS in the control class was ineffective.

Meanwhile, the increase in HOTS in the experimental class was quite effective. We declare that this model can foster the HOTS of aspiring primary school teachers. From the analysis of student work results, it can be concluded that learners' HOTS has improved, both for learners with low, medium, and high abilities. Learners with low abilities have not completed most of the HOTS questions at the C4, C5, and C6 levels in the pretest and posttest. However, in the posttest, especially numbers 4 and 5, he did not make a conceptual error. Learners with low abilities have weaknesses in understanding concepts, procedures, and techniques. Learners with medium ability tend to struggle with concept, procedural, and technical errors, which prevent them from solving HOTS level C4 and C5 problems. Students in the medium category have experienced an improvement in HOTS. Of the 6 HOTS questions, he made a conceptual mistake on only 1 question, specifically in the C6 question. From the six questions, he made procedural errors in only two questions. Learners with medium ability have not been able to solve C6 problems. Learners with moderate abilities need guidance to be more thorough, so they do not often commit carelessness in solving problems. Learners with high abilities experience increasing improvements in HOTS. In the procedure, the error rate decreased from 83.33% to 16.67% during the posttest. The technical error rate in the pretest decreased from 100% to 33.33% at the posttest. High-ability learners have been able to solve HOTS level C4, C5, and C6 problems; however, they sometimes rush through calculations, resulting in incorrect answers. For further research, it would be worthwhile to examine whether this model also affects other fields.

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