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Dummy Regression and ANOVA in an Experiment on the Use of the RADEC Model for Mathematical Problem-Solving Ability

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Abstract

This study aims to (1) describe the effect of the RADEC model on mathematical problem-solving ability, and (2) describe the comparison between one-way analysis of variance and dummy regression used in this research. This study is a combination of experimental research and literature study with both quantitative and qualitative elements. The results show that (1) the use of the RADEC learning model has a significant effect on mathematical problem-solving ability, with an effect size of 16.7%, and the RADEC learning model is more effective than the conventional model in improving mathematical problem-solving skills; (2) one-way analysis of variance and dummy variable regression are data analysis techniques that can be used simultaneously or complement each other in experimental research on the RADEC learning model's effect on mathematical problem-solving ability.

Keywords: RADEC; One-Way ANOVA; Dummy Regression, mathematical problem-solving

INTRODUCTION

Mathematical problem-solving ability is recognized as one of the essential competencies that students must acquire in order to succeed in higher education and beyond. This study adopts Polya's framework of problem-solving, as described in *How to Solve It* (Polya, 2004), which consists of four sequential stages: (1) understanding the problem, (2) devising a plan, (3) carrying out the plan, and (4) looking back. These stages highlight problem-solving not merely as a procedural activity, but as a structured cognitive process that fosters deeper understanding and reasoning.

Despite its importance, the low level of mathematical problem-solving skills among university students remains a persistent issue. This is particularly evident in informatics students, who require strong mathematical foundations to engage with concepts and algorithms rooted in logic, algebra, calculus, and statistics. Preliminary observations in the Differential Calculus course, which included problem-solving type questions, revealed that students' performance was below the expected standard. The average score was 53, significantly lower than the target score of 70. Although a small number of students achieved the maximum score, less than 60% reached the passing threshold. These findings indicate that many students lack the necessary problem-solving skills to meet the demands of their studies.

The low level of mathematical problem-solving ability can be attributed to several factors. Broadly, these can be classified into internal and external factors. Internal factors include a lack of understanding of fundamental mathematical concepts, difficulties in applying these concepts to problem-solving tasks, limited critical and analytical thinking skills, and low self-confidence in solving mathematical problems. External factors, on the other hand, involve ineffective teaching methods, insufficient support from teachers and the learning environment, and limited opportunities to practice and develop problem-solving skills.

Educators have long experimented with various models, methods, strategies, and approaches to minimize the large number of students who struggle with mathematical problem-solving skills. One instructional model that is considered promising in improving students' mathematical problem-solving ability is the RADEC learning model. This model employs five stages aligned with its acronym: Read, Answer, Discuss, Explain, and Create (Pratama, Sopandi, & Hidayah, 2019; Pratama, Sopandi, Hidayah, & Trihatusti, 2020). The RADEC model is viewed as particularly suitable for the Indonesian educational context, as its syntax is simple, memorable, and encourages active student engagement.

Therefore, this study aims to: (1) describe the effect of the RADEC learning strategy on students' mathematical problem-solving ability, and (2) compare the results of dummy regression analysis and one-way ANOVA as data analysis methods in this research.

The significance of this study lies in its dual contribution to both mathematics education and informatics learning. First, it provides empirical evidence on the effectiveness of the RADEC model in enhancing students' mathematical problem-solving ability, thereby offering educators a practical and contextually relevant instructional strategy. Second, by comparing dummy regression analysis with one-way ANOVA, the study contributes to methodological discussions in educational research, particularly regarding the suitability of statistical techniques for analyzing experimental data.

For Informatics students, the study highlights the importance of strengthening mathematical problem-solving skills as a foundation for mastering computational concepts, algorithms, and data analysis. Enhanced problem-solving competence will enable students not only to succeed academically but also to apply mathematical reasoning in developing software solutions, optimizing algorithms, and addressing complex problems in the field of computer science. In this way, the findings of this research have broader implications for curriculum design, teaching practices, and the professional readiness of future graduates.

METHODS

This study employed an experimental method with both quantitative and qualitative approaches. The quantitative approach was used to accommodate the first objective, namely describing the effect of the RADEC model on mathematical problem-solving ability, while the qualitative approach was applied to address the second objective, namely describing the comparison between one-way analysis of variance (ANOVA) and dummy regression analysis used in this study.

The research was conducted in the Informatics Study Program, Faculty of Engineering and Computer Science, during the 2024/2025 academic year, with Class C and Class B assigned as the experimental and control groups, respectively. Meanwhile, Class A was selected as the trial class for instrument testing. The experimental and control groups were determined randomly by class using cluster random sampling.

Data collection was carried out through documentation, interviews, and tests. Documentation was used to obtain the list of participants (second-semester students in Class B and Class D) as well as the grade records of all students in the Integral Calculus course in the first semester of the 2024/2025 academic year. The scores from Differential Calculus in the first semester were utilized to ensure that the sample groups had relatively equal abilities before the treatment was applied. Interviews were conducted to collect qualitative data in the form of student responses regarding the implementation of the RADEC model in the Integral Calculus course. Meanwhile, tests were used to measure students' mathematical problem-solving ability after the implementation of the RADEC learning model. The problem-solving test instrument was developed based on indicators of mathematical problem-solving skills, designed in the form of open-ended questions, and was piloted in Class A. The results were then analyzed to ensure that the test instrument was valid and reliable.

The data analysis employed in this study included dummy regression analysis, which is a statistical method used to analyze the relationship between a dependent variable and one or more independent variables, where the independent variables are categorical and represented as dummy variables. As stated by Barreto and Howland (2005), *"Dummy regression is a statistical technique used to model a relationship between a dependent variable and categorical independent variables by transforming them into binary (0/1) variables."*

As a comparison, analysis of variance (ANOVA) was also applied in this study to compare the mean scores of the two sample groups, namely the group taught using the RADEC model and the group taught without it. This method helps to determine whether the observed differences between the groups are statistically significant or merely due to chance. Conceptually, ANOVA compares the variation between groups with the variation within the groups. If the variation between groups is greater than the variation within the groups, the mean differences between groups are considered statistically significant. The test statistic used in ANOVA is the F-test. There are two types of ANOVA: one-way ANOVA and two-way ANOVA. In this study, which examines the effect of the RADEC model on mathematical problem-solving ability, one-way ANOVA was deemed appropriate since only one independent variable was involved.

RESULTS AND DISCUSSION

The findings of the dummy regression analysis reveal a clear advantage of the RADEC learning model over conventional approaches. Students who engaged in RADEC-based instruction demonstrated an average mathematical problem-solving ability score of 84, compared to 73.56 for those taught with traditional methods. This difference underscores the positive contribution of RADEC in fostering higher-order thinking skills.

Moreover, the F-test confirmed that the regression model was statistically valid and met the linearity assumption, thereby strengthening the reliability of these results.

Table 1. F-Test Results

Model	SS	df	MS	F	Sig.
Regression	1715.4	1	1715.4	12.27	0.000
Residual	8525.87	61	139.77		
Total	10241.27	62			

Furthermore, the significance test of the regression coefficients can be seen in the following table:

Table 2. Regression Coefficient Test

Model	Coefficients		t	Sig.
	B	Std. Error		
(Constant)	73.563	2.090	35.199	.000
Model	10.437	2.979	3.503	.001

From the table above, it can be concluded that the regression coefficients for the constant (73.56) and the learning model variable (10.44) are both significant, since their probability values are less than 0.05.

The results of both tests are sufficient to serve as the basis for concluding that the effect of the learning model on mathematical problem-solving ability is significant. The coefficient of determination ($R^2 = 0.167$) indicates that the learning model contributes positively by 16.7%. Although this contribution is relatively small, the previous tests showed that the effect is statistically significant. Since in the dummy regression RADEC is coded as 1 and the conventional model as 0, these findings can be generalized to conclude that the RADEC model has a significant effect on mathematical problem-solving ability, contributing 16.7%.

A one-way analysis of variance (ANOVA) was also conducted to examine whether there is a significant difference between the RADEC and conventional models in terms of mathematical problem-solving ability. The results are presented in the following table:

Table 3. Table Result One Way Anova Test

	SS	df	MS	F	Sig
Between Group	1715.40	1	1715.40	12.27	0.001
Whithin Group	8525.88	61	139.77		
Total	10241.27	62			

The results of the one-way ANOVA provide further evidence of the effectiveness of the RADEC model. The significant F value indicates that the differences in mathematical problem-solving ability between the RADEC and conventional groups were not due to chance. Descriptive analysis confirmed that students taught with RADEC consistently achieved higher scores than those taught with the conventional model. This finding suggests that the structured stages of RADEC—reading, answering, discussing, explaining, and creating—actively engage students in the learning process, fostering deeper understanding and stronger problem-solving skills. In contrast, conventional approaches tend to emphasize procedural learning, which may limit students' ability to apply concepts to novel problems.

The results of students' mathematical problem-solving ability in the class taught with the RADEC model, which outperformed the control class taught with the conventional model, demonstrate the superiority of RADEC. This finding is consistent with the learning conditions observed during the implementation. Students were better prepared because they had already read the materials recommended by the lecturer beforehand. When presented with questions or problems, students were enthusiastic in responding. Likewise, during group discussions, the process went smoothly since students already had a foundation of understanding from the reading and answering stage. In the Explain stage, it was not difficult for the lecturer to select a student as a resource person to present the material to the whole class. Finally, in the Create stage, students were able to develop mathematical problem-solving tasks based on real-world contexts, complete with solutions and explanations.

The RADEC learning model has been proven successful by several researchers, as it represents an innovative instructional approach tailored to the Indonesian educational context, where students are required to grasp concepts within a limited timeframe (Hidayah et al.).

The dummy regression analysis of this study concluded that the RADEC model had a significant effect on mathematical problem-solving ability and quantified its contribution to student achievement. Meanwhile, the one-way ANOVA demonstrated that RADEC was significantly more effective than the conventional model, as reflected in the higher average problem-solving scores.

Several studies have been conducted on the RADEC learning model. For example, Riska (2025) concluded that both the RADEC model and students' learning styles simultaneously influenced mathematical problem-solving ability. Similarly, Yuliani (2023) found that RADEC had a significant effect on students' mathematical critical thinking ability.

The positive effect of RADEC on problem-solving ability can be attributed to the proper implementation of each stage in the experimental class. In the first stage, Reading, students were given opportunities to read and gather information from multiple sources, such as textbooks and scientific journals available online. As a result, they were able to understand the material and complete pre-learning tasks, which ranged from basic to complex problem-solving. This activity was conducted independently at home or outside the classroom prior to the lesson and briefly revisited at the beginning of class. When encountering difficulties, students could seek clarification from peers, the lecturer, or through digital resources such as AI tools.

The second stage, Answer, required students to complete worksheets containing problem-solving tasks related to the pre-learning material. Observations revealed that students could independently identify which parts of the material they struggled with and evaluate their own learning behaviors, such as whether they were active or passive readers, their interest in the material, and their level of comprehension. By reviewing these worksheets, the lecturer gained valuable insight into students' learning conditions.

The third stage, Discuss, involved group discussions based on students' responses and conclusions. The lecturer motivated students who had successfully solved certain problems to guide their peers, while those who struggled were encouraged to ask questions. The goal was to ensure effective peer-to-peer communication and collaborative problem-solving. The lecturer also monitored discussions to identify potential resource persons for the Explain stage and to detect questions or concepts that posed difficulties for multiple groups. When discussions stalled, the lecturer intervened to facilitate progress until satisfactory outcomes were achieved.

The fourth stage, Explain, required students to present their group discussions in a plenary session. A selected student acted as a resource person, explaining key concepts to the class. The lecturer ensured the accuracy of the content, clarified misconceptions, and encouraged other students to ask questions, challenge ideas, or provide additional insights. At this stage, the lecturer also elaborated on important concepts not fully understood during the group discussions, using demonstrations, lectures, or other methods as necessary.

The final stage, Create, encouraged students to apply their knowledge to generate creative ideas or innovative solutions in the form of problems or products. When students struggled to formulate creative tasks, the lecturer provided guidance by introducing potential approaches. These creative outputs could be developed individually or collaboratively, depending on the learning objectives.

Mathematical problem-solving ability is a crucial skill, enabling students to apply mathematics to solve problems not only within mathematics itself but also in other disciplines and real-life situations (Soedjadi, 2000). According to Harahap and Surya (2017), mathematical problem-solving ability is a complex cognitive activity involving processes that require multiple strategies. Ulva (2016) similarly emphasized that problem-solving is a process demanding systematic thinking and reasoning.

The two analytical methods used in this study—dummy regression and one-way ANOVA—produced similar yet complementary results. Regression analysis is more suitable for determining whether an effect exists and estimating its magnitude, while ANOVA is more appropriate for comparing which model produces better outcomes. The use of both analyses in tandem enriched the findings and provided stronger evidence.

CONCLUSIONS AND SUGGESTIONS

Conclusion

This study provides empirical evidence that the RADEC learning model exerts a significant and positive influence on students' mathematical problem-solving ability, explaining 16.7% of the variance in performance. Compared to conventional instruction, the RADEC model yielded superior outcomes, underscoring its effectiveness as an innovative, structured, and student-centered pedagogical approach. The integration of dummy regression and one-way ANOVA analyses offered complementary perspectives, thereby reinforcing the robustness and validity of the findings.

Suggestions

It is recommended that mathematics educators at various educational levels—ranging from primary to higher education—consider adopting the RADEC model as a viable alternative to traditional teaching approaches in order to enhance students' problem-solving competencies. For future research, scholars may extend the application of RADEC to diverse subject areas, examine its long-term effects on higher-order thinking skills, and investigate its integration with digital and technology-enhanced learning environments to further maximize its pedagogical potential.

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