

Project Based Learning Assisted by R Software in Learning the Newton Raphson Method

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ABSTRACT

This study aims to analyze the effect of the implementation of Project Based Learning (PjBL) assisted by R software on students' analytical skills in learning the Newton–Raphson method in the Numerical Methods course. The study used a quantitative approach with a one-group pretest–posttest pre-experimental design. The subjects were 20 students of the Actuarial Science Study Program at Darunnajah University. The research instruments were an analytical skills test and a project assessment rubric. Data were analyzed using descriptive statistics, the Shapiro–Wilk normality test, hypothesis testing using paired sample t-test, and N-Gain analysis assisted by R software. The results showed a significant increase in students' analytical skills after the implementation of PjBL assisted by R software ($t = 159.32$; $p < 0.001$) with an average N-Gain value of 0.577 in the moderate category. The increase in analytical skills was also reflected in the students' process of analyzing iterations, interpreting numerical results, and evaluating Newton–Raphson method solutions through computational-based projects. Thus, Project Based Learning assisted by R software is effective in improving students' analytical skills in learning the Newton Raphson method.

Keywords: Project based learning, R software, Analytical skills.

1. INTRODUCTION

Numerical Methods is an essential course in higher education that requires students not only to understand mathematical concepts but also to develop strong analytical skills in solving computational problems (Burden, R. L., & Faires 2015). One of the core topics in this course is the Newton–Raphson method, which is widely used to determine the roots of nonlinear equations through an iterative process. Mastery of this method requires students to analyze iteration steps, convergence behavior, and the selection of appropriate initial values. However, in instructional practice, many students experience difficulties in analyzing the iterative process and interpreting numerical results meaningfully.

The integration of digital technology in mathematics learning has been widely reported as an effective approach to improving conceptual understanding and learning outcomes. Previous studies indicate that technology-based learning media, such as GeoGebra and augmented reality, can enhance

student engagement and learning achievement in mathematics education (Nuraini et al. 2025). Innovative learning media also contribute to the development of conceptual understanding and mathematical literacy, which are closely related to students' analytical skills (Fajriyah and Nuraini 2024). Nevertheless, many technology-based learning implementations still focus primarily on improving learning outcomes rather than explicitly developing analytical skills.

R software is an open-source numerical computing tool that supports flexible numerical computation and data visualization. The use of computational software in mathematics learning enables students to explore abstract concepts more concretely through simulations and numerical experiments (Wulandari et al. 2025). In higher education, particularly in actuarial science and applied mathematics, computational tools have been applied to strengthen students' understanding of calculus and numerical analysis concepts (Nuraini et al. 2024). However, the use of software alone does not automatically improve analytical skills if it is not supported by an appropriate learning model.

Project based learning (PjBL) is a learning model that emphasizes active student involvement through the completion of contextual and meaningful projects (Bell 2010). Previous research has shown that PjBL is effective in enhancing higher-order thinking skills, including analytical and problem-solving skills in mathematics learning (Chapra 2015). Despite these advantages, empirical studies that integrate Project-Based Learning with numerical computing software, particularly R software, in learning the Newton–Raphson method remain limited.

Based on this gap, this study presents a pedagogical innovation by integrating Project-Based Learning with R software in teaching the Newton–Raphson method, with analytical skills positioned as the primary learning outcome. Unlike previous studies that mainly focus on learning achievement or conceptual understanding, this research emphasizes the measurable improvement of students' analytical skills through computational project-based activities. Therefore, this study aims to examine the effect of Project-Based Learning assisted by R software on students' analytical skills in learning the Newton–Raphson method.

2. METHODS

This research uses a quantitative approach with a pre-experimental type design. *one-group pretest–posttest design*, which aims to determine the effect of learning treatments on improving student abilities before and after the learning intervention (Mulyatiningsih 2014). This design is commonly used in educational research to evaluate the effectiveness of learning models when researchers only involve one group of subjects.

The research subjects consisted of one class of Actuarial Science students from Darunnajah University, selected purposively. The purposive selection of subjects was carried out by considering the suitability of student characteristics to the research objectives, particularly involvement in project-based learning and use of computational software (Rahmah et al. 2025).

The independent variable in this study was the implementation of Project Based Learning (PjBL) assisted by R software, while the dependent variable was students' analytical skills. Project Based Learning was chosen because it has been proven effective in improving higher-order thinking skills, including mathematical analysis and problem-solving skills through structured and contextual project activities (Adinda et al. 2025).

The research instrument consisted of an analytical skills test in the form of descriptive questions structured based on analytical skills indicators, including the ability to identify problems, analyze iteration processes, interpret numerical calculation results, and evaluate numerical solutions. This measurement of analytical skills aligns with mathematics education research that emphasizes higher-order thinking skills as the primary outcome of project-based learning (Widodo and Kadarwati 2013). Furthermore, a project assessment rubric was used to assess students' performance in implementing the Newton–Raphson method using R software.

Data analysis was carried out with the help of R software which includes descriptive statistical analysis and hypothesis testing using *paired sample t-test* for normally distributed data or Wilcoxon test *signed-rank test* if the data is not normally distributed. In addition, the improvement of students' analytical skills was analyzed using N-Gain to determine the level of learning effectiveness, which is widely used in mathematics education research (Meltzer 2002).

3. RESULTS AND DISCUSSION

This section presents the results of the analysis of research data obtained from the analytical skills test and student project assessment after the implementation of Project Based Learning (PjBL) assisted by R software in the Newton–Raphson method learning. The data analyzed include the results of the pretest and posttest of student analytical skills, the analysis prerequisite test, the hypothesis test, and the analysis of the improvement of analytical skills using N-Gain. The presentation of the results of this study aims to provide an empirical overview of the effect of the implementation of project-based learning supported by R software on student analytical skills.

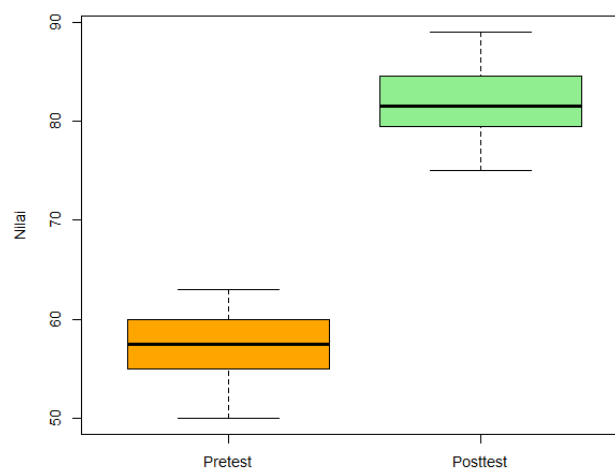


Figure 1. Comparison of Pretest and Posttest results.

The boxplot shows that posttest scores for students' analytical skills were higher than pretest scores, as indicated by an increase in the median and overall distribution of scores. The more homogeneous distribution of posttest scores indicates that the improvement in analytical skills occurred evenly across almost all students. These findings indicate that Project-Based Learning (PBL) with the assistance of R software is effective in improving students' analytical skills in the Newton Raphson method.

1. Descriptive Statistics of Students' Analytical Skills

The results of descriptive statistical analysis show an increase in students' analytical skills after the application of Project Based Learning (PjBL) assisted by R software in Newton Raphson method learning.

Table 1. Descriptive Statistics of Pretest and Posttest Scores ($n = 20$).

Statistic	Pre-test	Post-test
Min. Value	48	72
Max. Value	70	90
Avarage	57.85	81.40
Standard Deviation	7.12	6.35

Based on Table 1, the average value of students' analytical skills increased by 23.55 points after implementing project-based learning with the help of R software.

2. Data Normality Test

Normality tests were performed using the Shapiro–Wilk test to ensure the selection of the appropriate hypothesis test.

Table 2. Results of the Shapiro–Wilk Normality Test.

Data	W Statistic	<i>p-Value</i>
Pre-test	0.98078	0.9437
Post-test	0.98221	0.9593

The normality of the data was tested using the Shapiro–Wilk test at a significance level of 0.05. Data are considered normally distributed if the p-value is greater than 0.05.

3. Hypothesis Testing (Paired Sample t-test)

Test *paired sample t-test* used to determine the differences in students' analytical skills before and after learning treatment.

Table 3. Results of the Paired Sample t-test on Students' Analytical Skills.

t	df	<i>p-Value</i>
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Pre-test-Post-test	159.32	20	2.2e-16
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The paired sample t-test was conducted to examine the difference between pretest and posttest scores. The results indicate a statistically significant improvement in students' analytical skills after the implementation of Project-Based Learning assisted by R software.

4. Analysis of Analytical Skills Improvement (N-Gain)

To determine the level of improvement in students' analytical skills, N-Gain calculations were carried out.

Table 4. N-Gain Analysis of Students' Analytical Skills Improvement.

Indikator	Value
Mean N-Gain	0.57
Min. N-Gain	0.42
Max. N-Gain	0.71
N-Gain Category	<i>Medium</i>

The N-Gain analysis shows a mean value of 0.56, which falls into the medium improvement category. This result indicates that the implementation of Project-Based Learning assisted by R software led to a meaningful improvement in students' analytical skills. When viewed alongside the paired sample t-test results and the boxplot visualization, the N-Gain findings confirm that the observed improvement is not only statistically significant but also educationally relevant.

5. Strengthening Results Through Project Processes Using R Software

The results of this study indicate an improvement in students' analytical skills after implementing Project-Based Learning (PjBL) with the R software in the Newton Raphson method. This improvement is evident both in the results of the analytical skills test and in the students' process of completing numerical projects. This finding aligns with recent research that suggests project-based learning can encourage active student engagement and develop higher-order thinking skills in mathematics (Aini et al. 2023).

Quantitatively, the improvement in students' analytical skills was demonstrated by a significant difference in pretest and posttest scores and a moderate to high N-Gain value. These results indicate that R-assisted PjBL is effective in improving students' abilities in identifying problems, analyzing iteration processes, interpreting numerical calculation results, and evaluating Newton Raphson method solutions. These findings support the research findings of (Syahputra and Sinaga 2024) who concluded that PjBL contributes positively to improving computational and analytical thinking skills in mathematics learning.

In terms of the learning process, the improvement in students' analytical skills is also reflected through project activities carried out using R software. Students not only apply the Newton–Raphson method formula mechanically, but also engage in the process of function analysis, determining initial guesses, and evaluating the convergence of iteration results. The use of R software allows students to conduct flexible numerical explorations, for example by modifying initial guesses and observing changes in the resulting number of iterations. This type of exploratory activity has proven effective in developing mathematical analysis and problem-solving skills (Indranuddin, Susetyarini, and Miharja 2024).

The integration of Project-Based Learning (PjBL) and R software in this study provides a meaningful learning experience because students are faced with authentic numerical problems and solved using a computational approach. This is in line with the findings of (Aini et al. 2023) who stated that the application of Project-Based Learning (PjBL) in numerical methods courses can improve the quality of learning through active student involvement in the numerical analysis and modeling process. Furthermore, (Amaliyah et al. 2024) emphasized that project-based learning can strengthen numeracy and mathematical literacy skills, which are closely related to analytical skills.

Thus, the results of this study reinforce the findings of previous research and provide new contributions to the context of numerical methods learning in higher education. The novelty of this study lies in the emphasis on analytical skills as the primary learning outcome through the integration of PjBL and R software, particularly on the Newton Raphson method. These findings imply that the use of computing technology needs to be combined with appropriate learning models to optimize the development of students' higher order thinking skills.

CONCLUSION

Based on the research results and discussion, it can be concluded that the implementation of Project-Based Learning (PjBL) assisted by R software has a positive effect on improving students' analytical skills in learning the Newton Raphson method in Numerical Methods courses. This improvement is demonstrated by the significant difference between pretest and posttest results and the N-Gain score, which is in the moderate to high category.

In addition to improved test scores, students' analytical skills are also reflected in the computational-based project completion process, where students are able to identify numerical problems, analyze iteration processes, interpret calculation results, and evaluate Newton–Raphson method solutions using R software. The integration of PjBL with R software provides a meaningful learning experience and encourages students to actively engage in the systematic numerical analysis process.

Therefore, Project-Based Learning assisted by R software can be used as an effective alternative learning model to improve students' analytical skills in learning numerical methods in higher education, particularly in Newton–Raphson material. This research is expected to serve as a reference for lecturers

in developing project-based learning integrated with computing technology.

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