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Comparing debian linux and windows server in project-based learning for network service configuration: effects on problem-solving skills in vocational education

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ABSTRACT

The swift evolution of technological innovation has increased the demand for vocational graduates who possess strong technical competence and problem-solving skills in network system administration. Debian Linux and Windows Server are two operating systems widely used for configuring and managing network services in both educational and industrial environments. However, few studies have investigated the effect of server systems, specifically Linux and Windows, on the enhancement of students' problem-solving ability. In an attempt to fill this gap, this study examined the problem-solving skills of vocational students to the degree that Project-Based Learning (PjBL) involved server systems. With regard to the role of the server platform, this study empirically posits the characteristics that are ideal for the enhancement of problem-solving skills. The study was experimental and utilized both a control and experimental group of vocational students. The study was developed based on previously published research and the study author's experience and involved an instrument for the assessment of the degree of students' problem-solving skills. The data were analyzed quantitively. The outcomes demonstrated that problem-solving skills for both Debian Linux and Windows Server systems were improved; Windows Server improved skills even further when used with PjBL in a structured, planned manner. PjBL alone improved the skills of students. Additionally, the study provided valuable evidence for the role of pedagogy in technical education. The findings of this research demonstrates theoretical significance for the interaction of the discipline of vocational education. They are also practical for educators, as they provide guidance in the processes of selection and fusion of server systems and educational methodologies that promote critical and advanced cognitive skills in students.



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Introduction

In the contemporary digital age, information technology networks fulfill a pivotal function in the world of education, especially vocational education (Hamedinasab, 2024). Aligned with the rapid advancement and utilization of technological innovations, the need for specialists within the domain of information technology continues to increase and has gained prominence as a vital driving force across multiple domains of human activity (Kraus et al., 2023; Ni, 2025). Adjusting qualifications to the needs of industry 4.0 places emphasis on swiftly building workers' ability to adjust to the fast-evolving requirements from modern work environments

(Guerlinguer et al., 2023; Szabó et al., 2023). Vocational education institutions play an essential role in producing graduates with technical and adaptive abilities required to thrive in diverse and dynamic industrial environments, preparing them for workforce readiness in the context of technological and workforce changes (Kholifah et al., 2025; Pan et al., 2025; Rajamanickam et al., 2024). Among essential competencies in modern IT curricula, mastery of server operating systems particularly Linux Debian and Windows Server is crucial, as these platforms are widely adopted for service configuration, deployment, and maintenance in both industrial practice and educational laboratory environments (Koratagere et al., 2023; WEI et al., 2023). However, although their widespread adoption, there is limited understanding of how these platforms interact with pedagogical frameworks, including Project-Based Learning (PjBL), to foster advanced cognitive abilities, including problem-solving, critical analysis, and adaptive reasoning. PjBL has been shown to improve these skills in vocational contexts through active involvement in practical task projects demanding iterative problem-solving, collaboration, and reflective practice (Ahmad et al., 2023; Rozan et al., 2024). The proper incorporation of operating systems in vocational education will contribute to workforce readiness in an increasingly growing industry (Jia & Huang, 2023; Noordin et al., 2025).

Within the ever-evolving technological innovation, the selection characteristic of the right operating system for network service configurations is a significant challenge for educational institutions (Li et al., 2023; Somaraj, 2024). This study compares the Debian Linux OS and Windows Server OS to examine their influence on learners' problem-solving ability. As stated by the research of (Al'-Hanani et al., 2023), many students face challenges in configuring and managing network services by using Linux, on the contrary, Windows Server is more often chosen due to its higher level of familiarity and more accessible graphical user interface. The complexity of the Linux user interface, especially in terms of window management and customization options, can create difficulties for students, potentially reducing efficiency and productivity, as students may spend more time navigating the system rather than focusing on learning activities (Cruz et al., n.d.). Meanwhile, Windows Server offers more extensive official support and a graphical interface that allows students to understand basic networking concepts more quickly (Marinovic et al., 2025). However, there has been no in-depth research on the influence of these two operating systems on learners' capabilities for resolving issues in vocational education. This study intends to explore these differences and provide insight into their impact on learners' capacity to address network problems common in the industry.

Prior research has detailed the technical characteristics of the Linux and Windows operating systems, such as system reliability, usability, and system flexibility (Antwi, 2025; Maolia & Aprilliana, 2024), but few studies have explored them empirically and the extent of their impact on the students' learning outcomes or have linked their choice of platform to the degree of their pedagogical effectiveness (Tang et al., 2022; Zhong et al., 2024). Even as those research described students' challenges with configuring Linux as opposed to working with Windows Server, those studies have rarely built a comparative framework or offered a structured PjBL combination (Al'-Hanani et al., 2023; Marinovic et al., 2025). PjBL has proven to be of significant importance concerning the increasing number of youth who possess developed problems due to a lack of facilities, project management, curriculum, and the instructor's ability to adapt the curriculum and connect it to the new framework (Muhtar et al., 2025; Rizkylillah et al., 2025; Sánchez-garcía & Reyes-de-cózar, 2025; Tan et al., 2025). This demonstrates a distinct research void, with the relationship between the characteristics of the server platform, the characteristics of the server platform, and the extent to which vocational IT education problem-solving skills are developed.

To fill this gap, this study aims to analyze how the PjBL mode implemented affects the development of learners' problem-solving skills when using Debian Linux and the Windows Server Operating System for Vocational Students. The study intends to answer the question, which of the mentioned platforms helps learners problem-solving skills better, through hands on network service configuration PjBL. The complicatedness of the interface and the level of support and familiarity impact the learners' ability to understand, analyze, and solve network-based problems. The study also looks at the positive side of PjBL and explains learning by focusing on the engagement, reflective and practical skills PjBL strongly advocates for which combines skills and even teaches theoretical concepts. The study hopes to contribute the initial design of classes by demonstrating how employment of learning environments, instructional practices approaches can optimize the higher-order skills and technical skills necessary for mastering network technology (Mwansa et al., 2024; Noguera et al., 2024; Zulpykhar et al., 2023).

The main goal of this research is to evaluate and contrast Debian Linux OS along with Windows Server OS in network service configuration management as well as their influence on students' problem-solving competencies using (PjBL) approach in vocational education. Based on the conceptual framework of constructivism according to Jean Piaget in (Erawati & Adnyana, 2024), which posits that students build their knowledge through practical experience, this study explores how both operating systems provide opportunities

for students to develop technical skills directly. Mastery of technical skills through practical experience in network service configuration on Linux and Windows Server operating systems is a crucial aspect of vocational education, as it directly supports the cultivation of problem-solving competencies that are the main competencies necessary to equipping learners for the needs of today's workforce (Dao et al., 2024; Guan, 2025). This study aims to compare Debian Linux OS and Windows Server Os in the management of network services as well as their impact on students' problem-solving competencies in vocational education, consistent with prior investigation emphasizing the significance of operating system comparisons across the context of IT teaching (Amin et al., 2025). This study examines how both operating systems support the development of students' technical skills, which are important in vocational education, as well as prepare students to compete in the workforce, in accordance with contextual learning theories that emphasize the importance of real-life experiences in upskilling (Rahman et al., 2024).

Method

Research Design

This research utilizes a quasi-experimental framework using a non-equivalent control cohort model to compare the impact of Linux and Windows Server on students' problem-solving skills. By utilizing pre-existing classes, the research conducts a pre-test (O1, O2) to establish a baseline before implementing Project-Based Learning (PjBL) treatments (X1, X2). The effectiveness of each operating system is then evaluated through a final post-test (Y1, Y2) to determine which environment yields superior analytical outcomes.

Table 1. Study Framework

Group	Pre-Test	Treatment	Post-Test
A (Control)	O_1	X_1	Y_1
B (Experiment)	O_2	X_2	Y_2

Participant and Sample

This research was carried out from December 2025 to March 2026. The research activities took place at SMK Negeri 1 Kediri and SMK Negeri 2 Kediri, taking into account the availability of computer laboratory facilities, curriculum suitability, and the school's support for the implementation of this experimental pedagogical research. The implementation addressed in this research was adjusted to the learning schedule of subjects related to server operating systems and computer networks. The research sample was determined through the purposive sampling methodology, the sample was meticulously chosen using precise inclusion standards aligned with the research purposes. The sample comprised of four classes, namely class XI TKJ 1 and XI TKJ 2 at SMK Negeri 1 Kediri as an experimental group with Windows Server treatment, and class XI TKJ 1 and XI TKJ 2 at SMK Negeri 2 Kediri as a control group with Debian Linux treatment. In total, the study involved 120 students' as research participants, with each group consisting of 60 students' who were involved in the learning intervention as well as assessment activities.

Data Instrument

The research instruments were systematically developed and validated by experts to ensure their validity, precision, and alignment with the intended pedagogical goals. After the validation process, the instruments were administered to 11th-grade students from four different classes who had completed learning activities related to network configuration and server management. The assessment consisted of six open-ended essay questions designed to measure students' problem-solving ability, with each question representing a specific problem-solving indicator based on the theoretical perspectives proposed by (Nurhadi, 2004) and (Crebert et al., 2011). Respondent answers are quantified through a five-point scoring system, with 5 being "very precise, detailed and systematic," and 1 being "inadequate, irrelevant, or off topic." To aid in understanding and comparison across students, assessment scores are translated onto a common scale out of 100 points, as shown in the table below. This methodology allows us to balance demonstrating students' performance levels while keeping the assessments' nuances intact. Formula Calculation for Final Score:

$$Final\ Score = \left(\frac{\sum X}{6 \times 5}\right) \times 100$$

Notes:

$\sum X$ = total score obtained by students.
6 = total number of essay questions.
5 = maximum score per question.
×100 = converts the score to a percentage (0–100).

Table 2. Questions

Questions	Point Scale
Explain the steps you need to take to identify problems with this DHCP server. What are the possible causes of this problem?	1-5
Explain the steps you should take to diagnose why the site is inaccessible. What aspects should be checked first to ensure the server is functioning properly and can serve user requests?	1-5
Analyze the possible causes of the DNS server's failure to complete domain name resolution requests. Determine the factors that may be contributing to this.	1-5
Based on the results of your inspection, draw conclusions about the root cause of the problem and the appropriate solution to address it.	1-5
Evaluate the impact of this problem on network outages and what steps can be taken to resolve it.	1-5
Explain the troubleshooting steps you would take to ensure the web server can properly serve HTTPS requests. Include an analysis of the possible causes and appropriate solutions.	1-5

Table 3. Problem Solving Indicators

Dimension	Indicators
Identifying Problems	Students can recognize the signs of and the initial causes of a service outage for the DHCP Server.
Formulating Problems	Students can formulate diagnostic procedures for Web Server access problems.
Analyzing Problems	Students can analyze the causes of DNS Server failures in resolving domain names
Drawing Conclusions	Students can summarize findings from an analysis and identify a solution to a problem related to DHCP Server.
Conducting Evaluations	Students can assess the impact of DNS disruptions on the functioning of the network and identify measures for improvement.
Solving and Resolving Problems	Students are able to troubleshoot and provide HTTPS configuration solutions on Web Servers.

Data Analysis

Research data were examined through several suitable statistical procedures to strengthen the consistency and precision of the outcomes. Initially, the assessment instrument underwent validation procedures utilizing validity and reliability testing to establish measurement precision and internal coherence across all items. After confirming that the instrument met the required criteria, descriptive analytical techniques were applied to synthesize the data distribution, which comprised the mean and standard deviation, along with the lowest and highest metrics. Prior to hypothesis testing assumption assessments were performed, encompassing normality and homogeneity evaluations, to verify that the data satisfied the prerequisites for parametric analysis. Subsequently, inferential statistics were applied, where an independent samples t-test served to explore variations across the experimental and control cohorts, along with a paired samples t-test was performed to analyze the improvement between pre-test and post-test assessment outcomes within every cohort. The statistical computations were executed utilizing IBM SPSS Statistics Version 26, adopting significance threshold set at alpha level of (0.05).

Research Procedure

The present research was carried out using a quasi-experimental design, as outlined by (Campbell & Stanley, 1966), with one experimental and one control group. The study began with an initial diagnostic phase aimed at determining students' problem-solving skills concerning the given materials on configuring servers. After this, six essay questions aimed at upper-order thinking concerning analysis and control of systematized problem-solving were created. The instrument was sent to an expert for review to evaluate content validity, instructional objectives alignment, and clarity of the instructional and assessment components. After revisions, the instrument was approved for use in the field.

After the validation phase, both groups completed a pre-test to collect initial data regarding students' problem-solving ability. The Instructional treatment was then applied during the allotted class time. Instructional sessions for the experimental group focused on Windows Server configuration, whereas the control group received training using Linux-based server configuration. All groups were taught the same core competencies,

the same learning objectives, and were allocated the same instructional time to ensure instructional parity, and the only variation was the server system used during the applied practical learning activities.

At the end of the teaching intervention, the same instrument that had been validated for the consistency of the measurement, was again administered as a post-test. Responses were scored with an analytic rubric that had been developed for the six dimensions of problem-solving. The collected data were subsequently scrutinized to examine both within-group improvements and between-group comparisons, as well as to assess how significantly the instructional method influenced students' problem-solving outcomes in acquiring server management competencies.

Results and Discussions

Results

Problem Solving Instrument Validity Test and Reliability Test Results

The outcomes of the validity and reliability assessment presented in Table 4 demonstrates that all instrument items fulfil the required measurement benchmarks. The Corrected Item–Total Correlation values range from 0.664 to 0.737, that exceed the r-table value of 0.179 for 120 respondents (df = 118) at the 0.05 significance level. These findings shows that all six items are valid and meet the required validity criteria. In addition, the Cronbach's Alpha if Item Deleted figures varied between 0.857 and 0.869, demonstrating strong internal consistency amongst the items. Therefore, the assessment instrument utilized within this research can be deemed both valid and reliable for data collection.

Table 4. Results of Validity Test and Reability Test

Question	Corrected Item-Total Correlation (Item Validity)	Cronbach's Alpha if Item Deleted (Item Reability)
Question 1	0.689	0.865
Question 2	0.737	0.857
Question 3	0.682	0.866
Question 4	0.703	0.863
Question 5	0.664	0.869
Question 6	0.700	0.863

Analysis Descriptive Result

The statistical overview illustrated in Figure 2 presents a comparison of learners across the experimental versus control conditions preceding and following the learning program. Regarding the experimental group, the mean value exhibited growth from 60.33 during pre-test (SD = 10.68) to 83.00 in the post-test (SD = 11.31), showing a notable progress after applying the intervention. Meanwhile, the control group also showed an increase, exhibiting a mean value rising from 50.00 in the pre-test (SD = 13.91) to 63.78 in the post-test (SD = 11.02). However, the improvement recorded among the experimental cohort reached levels considerably higher than those demonstrated by the control cohort.

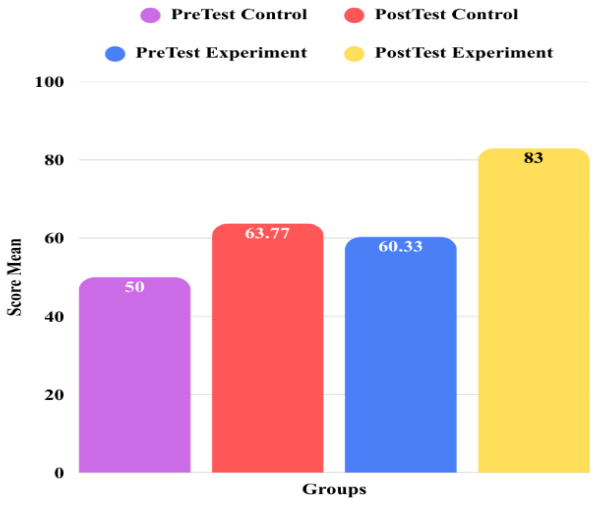


Figure 1. Descriptive Statistics

This pattern implies the instructional approach applied in the experimental class more effectively enhanced students' learning outcomes, particularly in developing their problem-solving ability. Furthermore, these findings support prior studies showing that technology-based instructional settings can significantly improve students' analytical and practical skills (Antonov et al., 2024; Aslam et al., 2024; Wang, 2024).

Normality test of students' problem-solving skills

As summarized within Table 5, the normality findings display the spread of pre-test and post-test results across each of experimental and control cohorts using Kolmogorov–Smirnov. The outcome indicated that PreTest scores in the experiment group (Statistic = 0.95, df = 60, Sig. = 0.200), PostTest scores in the experiment group (Statistic = 0.97, df = 60, Sig. = 0.200), PreTest scores in the control group (Statistic = 0.94, df = 60, Sig. = 0.200), and PostTest scores in the control cohort (Statistic = 0.99, df = 60, Sig. = 0.200) all produced ($p > 0.05$), suggesting that the dataset conforms to a normal distribution. These findings demonstrate the spread of performance scores across both groups and testing phases meets the assumption of normality. Therefore, the dataset can be considered normally distributed and appropriate for further examination through parametric statistical techniques.

Table 5. Results of normality test on problem-solving skills

Treatment	Kolmogorov-Smirnov [a]		
	Statistic	**df**	**Sig.**
PreTest (Experiment Group)	0.95	60	.200*
PostTest (Experiment Group)	0.97	60	.200*
PreTest (Control Group)	0.94	60	.200*
PostTest (Control Group)	0.99	60	.200*

Homogeneity test of students' problem-solving skills

As shown in Table 6, Levene's Test was applied to investigate the variance of homogeneity for the experimental and control cohorts. Based on the mean, the computed Levene statistic was 0.496 and significance value was 0.482. Based on the median, median with adjusted df, and trimmed mean, the significance values were 0.510 and 0.514, correspondingly. All p-values are above the common benchmark of (0.05), which suggests that no notable differences exist between the groups. Variance of the score distributions within both experimental and control groups demonstrate equivalence. Therefore, underlying premise regarding homogeneity of variance has been satisfied and the condition for subsequent inferential examination through parametric tests has been fulfilled.

Table 6. Results of homogeneity test on problem-solving skills

	Levene Statistic	**df1**	**df2**	**Sig.**
Based on Mean	.496	1	118	.482
Based on Median	.436	1	118	.510
Based on Median and with adjusted df	.436	1	118.000	.510
Based on trimmed mean	.428	1	118	.514

Results of Independent Samples T-test on students' problem-solving skills

The independent samples t-test was used to contrast students' problem-solving performance in the experimental and the control cohorts. Table 7 outlines the t-test results. With regards to the t-test findings for the equal variances assumed condition, there are 118 df, and there is a significance value of 0.000 ($p < 0.05$). For the equal variances not assumed condition, there are 117.920 df with the same significance value of 0.000 ($p < 0.05$). This test demonstrates statistically meaningful disparity across both cohorts. Furthermore, the mean difference of 19.222 suggests that the experimental cohort obtained greater average scores than the control cohort. This finding implies that the instructional intervention implemented in the experimental class contributed more effectively to the fostering of students' problem-solving competencies in contrast with the approach utilized to the control cohort.

Table 7. Independent Samples t-Test Results

	T-test for Equality of Means		
	df	**Sig. (2-tailed)**	**Mean Difference**
Equal variances assumed	118	.000	-19.222
Equal variances not assumed	117.920	.000	-19.222

Results of Paired Samples T-test on students' problem-solving skills

The change in participants' achievement levels prior to and subsequent to the instructional intervention was analyzed utilizing a Paired Samples t-test. As reported in Table 8, the examination revealed a t-value of □ 14.958 with 59 df and a significance level of 0.000 ($p < 0.05$), indicating a meaningful considerable disparity across the pre-test and post-test measurements. Furthermore, the 95% confidence interval of the mean difference ranges from □ 25.698 to □ 19.634, suggesting a substantial and consistent increase in students' scores subsequent to the implementation of the intervention. These findings indicate that the operating system utilized during the learning treatment contributed positively to improving students' problem-solving performance, as reflected in the higher achievement revealed in the post-test measured against the pre-test results.

Table 8. Results of Paired Samples T-test

Treatment	Paired Differences 95% Confidence Interval of the Difference				
	Lower	Upper	t	df	Sig.
Paired PreTest-PostTest	-25.698	-19.634	-14.958	59	.000

Discussions

The findings show Windows Server in combination with Project-Based Learning (PjBL) yielded better results in providing students with an improved environment for building skills in network administration problem-solving. As compared to the control class, the experimental class demonstrated better problem-solving skills, indicating Windows Server helped students to develop structured problem-solving skills and gain better understanding of network learning goals. Windows Server tools let students focus on the key aspects of the problem-solving process of identifying and locating configuration problems and testing possible solutions and evaluating and refining their decisions and actions through iterations. This is particularly relevant for IT vocational education as problem-solving skills flourish when students perform actionable tasks with clearly visible outcomes. This is also in line with Woolcott & Bui. (2023), who say that networking instruction is enhanced when tools that foster active learning are available, and tasks are contextualized, and Al-zubaidie et al. (2024) demonstrate that networking environments with an interface help students navigate and perform network tasks without having to deal with numerous technical issues. Similar outcomes are also given by Mwansa et al. (2024) who discovered that practice in networking combined with technology strengthens practical skills and conceptual understanding of the field, as well as professional preparedness and Noguera et al. (2024) who suggest that combining technology with integration of pedagogical strategies in vocational education is most valuable. Therefore, Windows Server treatment improved not only the results, but the students' ability to perform defined and structured problem-solving actions.

The control group using Linux Debian exhibited an improvement, although smaller than that of the experimental group. This means Debian Linux likely supported users in developing technologically related activities of a certain level that involved engagement. This is likely because interacting with Debian's command line required students to engage in a level of deep, systematic procedural work before solving tasks on the networking level. According to Yang et al. (2024), stating that command-line interaction is a necessity within Linux systems, and that the discrepancies in systems information management that need to be resolved requires high-level problem-solving skills of students. Also supporting this claim, Aliyu (2024) indicates that beginners tend to perceive CLI environments as less intuitive and more challenging to learn than interfaces. This implies that vocational students starting from the CLI will merit more time to shift from the environment on the system to a more analytic and problem-solving approach to the system. Nevertheless, this should not be interpreted as a conundrum. Debian Linux should be more pedagogically welcome, as a system based on Linux and open source, especially when properly applied to teach pedagogically, can foster problem solving, techno independence, and digital literacy. In the same regard, Tarasak et al. (2025) point to a Linux based open-source educational environment balancing the equation of problem-solving and other educational and process competencies. Debian Linux should be seen as a culturally and pedagogically challenging tool and positively introduces students to tech autonomy and problem solving.

The comparison between the two groups reinforces the main finding of this study by showing that the experimental cohort performed better than the control cohort, suggesting that Windows Server provided a more supportive context for developing problem-solving skills in network administration tasks. This also indicates that students in the experimental class were better able to analyze problems, test solutions, and improve their troubleshooting performance during project-based activities. More importantly, these findings suggest that the key issue is not whether one operating system is absolutely better than the other, but how platform characteristics interact with PjBL to shape students' problem-solving development.This interpretation is is consistent with Ahmad et al. (2023), who emphasize that appropriate technology combined with structured project-based

activities can strengthen students' problem-solving and practical technical abilities. It is further reinforced by Xiong et al. (2025), who show that vocational PjBL fosters problem-solving and innovation when involvement, teamwork, and cognitive flexibility are properly supported. A similar conclusion is offered by Tan et al. (2025), who report that PjBL in vocational education also strengthens applied ability and collaborative capability. More broadly, Sánchez-garcía & Reyes-de-cózar (2025) argue that the emphasize of PjBL is shaped by greatly through instructional structure and implementation quality. Therefore, this study suggests that Windows Server appears to be more effective for supporting early and applied problem-solving development in vocational network administration, whereas Debian Linux may be more suitable for students who are ready to engage with greater technical complexity and more independent system control.

Conclusions

This research shows that deploying Windows Server in a Project-Based Learning (PjBL) situation improves student analytical and troubleshooting skills for network administration more than the use of Debian Linux does. Windows Server and Debian Linux improved the learning outcomes of the students, however, Windows Server resulted in a greater learning outcome owing to its capacity to facilitate a more organized and systematic setting that engaged students in the practice of network configuration. The outcomes of this research reveals that choice of technology that aids the Project-Based Learning framework has a large influence in developing students' analytical and troubleshooting abilities, along with their technical abilities in the vocational information technology field.

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