ISSN 2355-0082

Constructivism Analysis on the Influence of Practical Implementation on Computer Networks Course in Informatics Class

Ahmad Fauzan [1], Puteri Novariqa[2], Fransiscus Halim[3]
[1,2]Dept of Informatics, Universitas Multimedia Nusantara, Tangerang, Indonesia
[3]Dept of Information Systems, Universitas Multimedia Nusantara, Tangerang, Indonesia
[1]ahmad.dhavi@student.umn.ac.id, [2]puteri.novariqa@student.umn.ac.id, [3]fransiscus.ati@lecturer.umn.ac.id

Accepted 3 January 2025
Approved 15 January 2026

***Abstract*— Learning by practicum has been well accepted as a critical approach in technical and vocational teaching; however, there is a lack of empirical research that examines both practicum-based teaching methods and non-practicum teaching methods objectively based on performance, particularly in higher educational institutions in developing nations. The impact of integrating a practicum for enhancing the results of students in a computer networking course at an undergraduate Information program will be explored in this research paper. The research adopted a quantitative comparison model for data obtained from two student cohorts, with one cohort exposed to a teaching approach that included a practical-based model, while for other students a theory-based model was adopted. Statistical description, morphometric, chi-square, U-test, T-test techniques, as well as linear regression, were used for inferential analyzing techniques. Conclusions from this research work show that there is a greatly positive impact for students in practical-based classes, where students obtained a better grade distribution compared to students from non-practicum classes. Despite some issues pertaining to methodology, particularly for cohorts and teaching applied, there is a clear practical approach towards applying a practical-based program for computer networking classes.**

***Index Terms*— Computer Networking Education; Practicum-Based Learning; Hands-on Laboratories; Learning Outcomes; Informatics**

I. Introduction

In today's digital era, information and communication technology plays an important role in various aspects of life. Progress in this field is very rapid and requires human resources that have high competence in the field of information technology, especially in Computer Networking. The Informatics study program is directed to produce graduates who do not only have a strong theoretical understanding but also practical skills that can meet industry needs.[1]

Rapid development of information and communication technology dictates that Informatics graduates have to be endowed with both robust theoretical knowledge and hands-on networking competencies to satisfy the needs of this industry. International studies recently conducted (2021-2024) demonstrate that hands-on laboratory approaches raise learning outcomes by 10-25%, compared to traditional lecturing, which is most pronounced in the aspects of protocol configuration and network troubleshooting. The effectiveness of practicum in blended learning settings, however-especially comparing online with onsite delivery-was not well explored yet after the pandemic. This paper compares academic performance between practicum and non-practicum classes, which has been used to validate H1, practicum superiority, against H0, no difference.[1]

The drawback of traditional lecture courses in terms of their capacity for skill development in applied subjects has long been identified. In response to concerns about the applicability and effectiveness of traditional lecturing, the emphasis on practical work in the form of "practicum" or practical activities in the science or laboratory practical context is being encouraged as best practice. Even if existing literature provides proofs that practicum activities positively engage and enhance student understanding, objective comparisons related to the effect on academic results remain uninvestigated.

Its uniqueness lies in comparing the practicum classes using blended learning in 2019-2020 with practicum classes using onsite learning in 2023-2024, where the influence of practicum classes to the understanding of theory in a post-pandemic situation has never literally been explored in existing recent literature in its entirety before, where previous similar research only emphasized simulation lab classes in the context of linear regression to quantify the influence of practicum classes attendance, where there is no empirical research existing in the context of Indonesian Networking Informatics on practicum classes in a global context benchmarks.[2]

A. Bridging the Theory-Practice Gap in Informatics Education

The courses of study in informatics have been designed with the goal of creating informed students with excellent theoretical foundations and practical skills that meet industry requirements directly. Nevertheless, it has always been a challenge in technical education, including a technical and complex field such as Computer Networking, to effectively overcome the existing gap between theoretical foundations and practical application.[3] Even the practical efficiency of conventional learning theories in bridging the critical junction between theory and practical application has been left a matter of further research.

Unquestionably, the assumption of the efficiency of practical learning in improving comprehension has become an accepted truth in conventional theories and practices of education. Nevertheless, its further ability to optimize learning efficiency in Computer Networking courses, including compared efficiency with conventional learning approaches, has not been well established. Therefore, an empirical study such as the proposed research becomes absolutely necessary to cross the boundary of mere conventional wisdom into the approximate realm of informed truths.

Through understanding how well the practicum is incorporated in understanding and developing skills, there is hope that better approaches can be discovered for preparing learners for what is encountered in the world of work. [4]

B. Research Objectives and Central Question

The overall purpose of the study being conducted is to systematically assess the impact of the Practicum on increasing the outcome levels for Computer Networking subjects offered at the Informatics Study Program. Additionally, the study attempts to show that there indeed are levels and impacts of difference for the outcome levels for students enrolled at the Informatics Study Program who participate in Practicum classes compared to those that do not participate in Practicum classes. This impact of difference between the two groups will be systematically assessed through two hypotheses: that of the null hypothesis (H_0) and that of the alternative hypothesis (H_1), wherein the null hypothesis suggests that there indeed is no impact difference for the outcome levels between the two groups, and that the alternative hypothesis suggests that there indeed are differences.

The results that emerge from the evaluation of this study are expected to provide substantial additions within the realm of educational pedagogy. In establishing a full comprehension of the contribution of the practicum exercise towards the students' comprehension and skills, this study is expected to open the way for the detection and application of better teaching practices. This is not only vital for the students' needs, but it is also important for their preparation towards the diversified challenges of the real world upon graduation. The applications of this study not only relate within the boundaries of the educational institution but have practical applications as well, since it serves as substantial evidence towards the application of appropriate measures regarding the pedagogical approach, application of investments within the construction of laboratory infrastructure, and faculty development programs.

II. Theoretical Foundations and the Role of Practicum

A. Defining Practicum and Its Application in Computer Networking

A computer network, also known as a data network, is a telecom network that facilitates data exchange among various computer systems. Networked computer systems transfer data from one computer to another via data connections in computer networks. The connections, also known as network links, from nodes are created either using a cable medium or a wireless medium [5]. These computer networks led to the ARPANET, forerunner to the Internet. On 3 June 1968, the proposal for a project was delivered by ARPA; this project was accepted a few weeks later. "Resource Sharing Computer Networks," as a project, allowed a resource-sharing exchange for data, examining various topics, both for military as well as scientific reasons.[6]

"Practical learning" or "practicum" refers to an "educational methodology that serves specifically the purpose of giving learners hands-on learning experiences." Practicum experiences are expected to positively affect self-efficacy in preservice physical education teachers with regards to teaching strategies, classroom management, and student engagement[7]. Gaining experiences and skills has always become an important factor in teacher education. Being an integral part of teacher education, it takes place in an actual "environment where scholarly and didactic knowledge and practical skills manifest themselves in teaching." "The basic goal of learning in a university setting via 'practicum' is to develop skills and gain an 'in-depth knowledge' of the subject under study." [8]Practicum in the more technical field of Computer Networking involves working directly with hardware and software components with the goal of creating, managing, and maintaining computer networks. Examples of which include actual "access to the destination hosts via remote accessing, analyzing messages carefully using packets, and setting up TCP/IP in Linux or Windows operating systems." These activities truly play an important part in giving students hands-on learning experiences where actual manipulation of computer systems happens, "allowing students to see firsthand the effects of their actions and thereby consolidating their theoretical foundations".

B. Constructivist Teaching Key Principles

Constructivist teaching is based on constructivist learning theory, Constructivist is based on the belief that learning occurs as learners are actively involved in a process of meaning and knowledge construction as opposed to passively receiving information. Learners are the makers of learning and knowledge. Constructivist teaching fosters critical thinking, creates motivated and independent learners. This theoretical framework holds that learning always builds upon knowledge that a student already knows; this prior knowledge is called a schema, because all learning is filtered through preexisting schemata. Constructivists suggest that learning is more effective when a student is actively engaged in the learning process rather than attempting to receive knowledge passively.[9]

While there are different interpretations of constructivist learning theory, Hord's article cites six key principles identified by Mary Burns, Marylu Menchaca, and Vicki Dimock as being important to constructivist learning theory. They are as follows:[10] 1) Learners bring unique prior knowledge, experience, and beliefs to a learning situation. 2)Knowledge is constructed uniquely and individually in multiple ways, through a variety of authentic tools, resources, experiences, and contexts. 3) Learning is both an active and reflective process. 4) Learning is a developmental process of accommodation, assimilation, or rejection to construct new conceptual structures, meaningful representations, or new mental models. 5) Social interaction introduces multiple perspectives through reflection, collaboration, negotiation, and shared meaning. 6) Learning is internally controlled and mediated by the learner.

The effectiveness of practicum is deeply rooted in established learning theories, each offering a unique perspective on how students acquire and process information. For example, behavioristic learning theory focuses on observable changes in behavior as a result of the interaction between motivation and response. In Computer Networking education, this can be put to practice by offering immediate feedback and rewards for successfully learned concepts, thus reinforcing learned behaviors.[7] On the other hand, cognitive learning theory has concentrated on the inner mental processes that take place during learning, such as information processing, storage, and recall. This theory argues that using diagrams, concept maps, and other visualization techniques during the creation of teaching materials can assist students greatly in organizing and retaining complex information concerning Computer Networking. [11]

The theory underlining the constructivist approach to teaching is the constructivist learning theory. Constructivism theory hinges on the premise that learning happens through a learner being actively engaged in constructing meaning during a knowledge-building experience, rather than merely being a receiver of knowledge. The learner is the learner's own knower. [9] The theory proposes that in the practicum experience, the learner does construct knowledge from direct experience, such as TCP/IP setup and analysis, which is immediately related to the activities in a Class B computer science program topography deals with visual processing for networks. Behaviorism justifies immediate feedback from software such as Packet Tracer to assure learning behaviors, while the cognitive theory emphasizes visual processing for topography in networks.[12], [13]

Practicum sessions provide just this type of immersive environment, where students can apply theoretical concepts in Computer Networking through practical projects or hands-on simulations. This direct involvement with the work allows them to solve real-life problems, which naturally fosters a deeper understanding and mastery. [8] As a research study, this empirical validation lends credence to constructivist pedagogy. Constructivism lays great emphasis on active learning and application; hence a very sound theoretical rationale is developed for expecting the effectiveness of practicum. If this research indicates that practicum significantly enhances learning outcomes, then it confirms not only a generally held belief but also gives empirical evidence that shores up such a claim for the adoption of constructivist approaches in technical education-that the learning improves from mere theoretical assertions to best practices. This is essential from an academic standpoint to further the cause of pedagogical design for skills-intensive courses.[12], [13]

Practicum represents one of the dynamic learning activities that help students develop an objective feel and application of theories learned in the classroom through experiments and exposure to real-life activities. This serves to develop important skills: observation, classification, planning an experiment, collection of data, interpretation, and summarizing findings. It is to be noted that these skills are not academic in nature but play an integral part in a person's technical career.

The success of the practicum, however, does not rest on the direct experience obtained from the practical tasks alone. There are a number of external factors that play a very important role in having a positive impact on the success of the practicum. The experience and knowledge of the instructors who supervise the students during the practicum exercise can have a very important role in ensuring that the students have obtained the required support and guidance from the experience. In addition to that, the manner in which the learning strategy is implemented to the students can have a very important effect in enhancing the understanding of the students on the specific topic of the practicum.

C. Research Methodology

The proposed project utilized a quantitative paradigm with a comparative design in analyzing the secondary data. The data sets included the scores of the Midterm Exam (UTS), Final Semester Exam (UAS), and Assignments among the students studying at Multimedia Nusantara University (UMN). The objective was to compare the results among two different classes with varying approaches in their learning process based on their scores. Use of midterm (UTS) and final assignment scores in two classes: Class B (blended practicum, online 2019-2020, n=20) and Class H (theory only non-practicum, onsite 2023-2024, n=51). "Grade_numeric" variable derived from participation/effort that uses linear regression of average assignment grades, 0 to 100 scale Similar bias due to different years and different modes could affect results, a limitation due to external forces such adaptation to online instruction due to pandemics

The participants included two groups of students who were enrolled in the Computer Networking course at UMN:

• Class H: Students in this group belonged to the 2023/2024 academic year and received a traditional theory-based class without integrated practicum sessions. Their learning was conducted in an onsite class system.

• Class B: In this group were students from the 2019/2020 academic year who received instruction via a blended learning methodology, in which theoretical classes were combined with regular sessions of practicum in laboratories. The learning in this class took place in the online class system.

This comparative setup allowed for the investigation of the differences in academic performance between students exposed to a practicum-integrated curriculum and those not exposed to practicum in the Computer Network Subject.

III. Data Collection and Analysis Procedures

A. Data Collection

The type of data that has been employed in this particular study is purely secondary data in the forms of UTS, UAS, and Assignment results for students in the two classes previously mentioned in this study held in UMN. These data had been previously recorded in this academic info system held in the university, implying that data collection was not carried out in this particular study since these results portrayed students' performance based on their particular modes adopted in learning.

For the purpose of evaluating the collected data to determine significance in the results obtained, various statistical methods were used. These include:

• Statistical Description: For summarizing the measures of central tendency and dispersion of scores on each class.

• Normality Test (Shapiro-Wilk): This test was employed in checking if the data distributions were normally distributed.

• Mann-Whitney U Test: A non-parametric test to determine the differences in the two independent groups. This test can be used when the data isn't normally distributed.

• t-tests: Two-sample t-tests were performed on the two classes to compare the means, as well as the individual t-tests on each class to compare their mean scores to a standard score of 75.

• Breusch-Pagan Test: This test is used to test heteroscedasticity, which reveals the constancy of variance of residuals in a regression model for all levels of independent variables [13].

• Chi-Square Test: The purpose was to check if there was a significance in the distribution of Grades observed in both classes.

• Linear Regression: To examine the individual impact of practicum experience (indicated by 'Grade numeric') on outcomes in these classes.

B. Research Limitations

Although this study yields useful information, some intrinsic limitations need to be acknowledged in regard to its generalizability and attributability to specific, ultimate causes. For this study, which was dependent on secondary data, the investigators had nothing to do with other variables, some of which may be decisive in affecting learning outcomes. Some of these variables, which cannot be controlled, pertain to the motivational level of students, their socioeconomic backgrounds, as well as their aptitude prior to the course. Failure to consider such factors may sometimes distort the intrinsic effect of practicum on learning outcomes.

Secondly, the results obtained from the study are limited to the scenario presented in the two classes at UMN. Therefore, the level of generalizability within the results obtained can at best be applied in similar settings. The distinct variables that exist within the environment may not be similar or representative in other scenarios.

Thirdly, other possible contributing factors, such as the standard of the educational material used or the particular impact and teaching manner of the tutors, are not examined because the secondary data selected is limited. These might have been contributing towards the differences found in the results.

Most Importantly, a major methodological issue emerges considering the data generated in both groups are from different academic years, and they involved different class systems too, since Class B (the practicum groups) involved classes from the 2019-2020 academic year and involved online classes, compared to Class H (the non-practicum groups) that involved classes from the 2023-2024 academic year and the onsite classes. The differences in the academic year and the nature of the classes (online or onsite) present major variables whose impact on the performance might independently exist and thus cannot be easily accredited to the absence or presence of practicum. The study clearly shows a direct relationship between practicum and higher scores but cannot prove that the practicum caused the variation. This particular limitation brings out a critical point: this initial study is a vital exploratory phase that provides a preliminary indication of the impact of practicum. However, at the same time, it also underlines the urgent need for future studies that are more rigorously controlled in their experimental design. Only these, perhaps conducted within the same academic year, with consistent modalities, or using advanced statistical controls for those variables, could be considered necessary to isolate the true, causal effect of practicum. This foundational research thus justifies the expenditure of resources in more definitional and resource-intensive studies.

IV. Results and Discussion

A. Key Findings on Practicum's Impact on Learning Outcomes

This section presents the empirical findings derived from the comparative analysis of student learning outcomes between the practicum class (Class B) and the non-practicum class (Class H) in the Computer Networking course

TABLE I. Table 1: Comparative Descriptive Statistics of Learning Outcomes

Statistic Practicum	***Class B (Practicum Group)***	***Class H (Non-Practicum Group)***
Mean	86.29	74.33
Median	87	77
Mode	84	76.77

Descriptive statistical analysis also showed that there was a distinction in the academic performances between the two classes. Class B, the practicum-integrated class, had consistently better results. Its mean was 86.29, median was 87, and mode was 84. Most grades in Class B fell within 84 to 91, with the highest frequency of 6 students at 84.1 On the other hand, Class H, the non-practicum class, had generally lower scores, with a mean score of 74.33, a median of 77, and modes of 76 and 77. The scores of most students in Class H were between 72 and 92, although with higher frequencies of 1 student at 76 and 77.1. From these preliminary descriptive statistics, it may be inferred that students who belong to practicum classes tend to get higher grades compared to those who are in classes without practicum.

B. Statistical Evidence of Significant Differences

To ascertain the statistical significance of these observed differences, several inferential tests were conducted. See Table II.

TABLE II. Summary of Key Statistical Test Results

Test Name	***Class B (Practicum Group)***	***Class H (Non-Practicum Group)***	***Interpretation***
Shapiro-Wilk Normality Test	0.7437	0.0003654	Class B: Normally distributed; Class H: Not normally distributed
Mann-Whitney U Test	1.107e-06 (Overall)	-	Significant difference in learning outcomes (Class B > Class H)
Two-Sample t-test	1.451e-06 (Overall)	-	Significant difference in mean scores (Class B > Class H)
One-Sample t-test (vs. 75)	1.518e-13	0.7579	Class B: Significantly higher than 75; Class H: Not significantly different from 75
Chi-Square Test	0.001125 (Overall)	-	Significant difference in grade distribution (Class B: more concentrated higher grades)
Breusch-Pagan Test	0.04281	0.2581	Class B: Heteroscedasticity present; Class H: No heteroscedasticity

The Shapiro-Wilk normality test was employed to determine the distribution of data in every group. [13]. The findings revealed that data from the practicum class (class B) followed a normal distribution, having a p-value of 0.7437 (which is greater than 0.05).1 On the contrary, data from the non-practicum class (class H) failed to satisfy the condition for normal distribution, having a p-value of 0.0003654 (which is less than 0.05).

The Mann-Whitney U test, a non-parametric test used when the data is non-normally distributed, was used to compare the two classes. [14]. The test produced a p-value of 1.107e-06, which is smaller than the significance level of 0.05. This clearly shows there are statistically significant differences between the scores obtained by Class H and Class B in the area of learning outcomes, since Class B obtained higher scores.

To further validate these results, a two-sample t-test was also conducted to compare the mean scores of the two classes, and the results showed that there was a significant difference in the average scores of the two classes.[14] The calculated t-value was 5.2748 for 69 degrees of freedom, with a p-value of 1.451e-06. The fact that the calculated p-value of 1.451e-06 was well below the significance level of 0.05 indicates that the mean score of the students who participated in the practicum (86.29) was significantly higher compared to the mean score of the students who did not participate (74.33), hence accepting the hypothesis that there was a significant increase in the knowledge gain of the students who participated in the practicum activity.

A t-test was done to measure the performance against this standardized mark with a reference mark of 75. For Class B, the t-test yielded a t-statistic of 11.29 with a p-value of 1.518e-13. This low value accentuates the fact that the mean marks obtained by Class B (86.29) were substantially greater than the standard mark of 75.1 On the other hand, for Class H, the t-statistic was -0.31091 with a p-value of 0.7579.1 Since this value is greater than 0.05, this marks the fact that the mean marks of Class H (74.33) were not significantly different from the standard mark of 75.1 These results substantiate the fact that students of the practicum group not only performed well but also maximized their deficiencies to a greater extent than the other group who almost performed around the expected mark.

A chi-squared test was employed to check for the significance in frequency distribution. [14] Of Grades, in comparison between Class B and Class H. The results obtained a value for X-squared of 24.03, with a p-value of 0.001125, which is lower than 0.05.1. It is, therefore, a clear indication that there is a significance in grade distribution for both classes. The distribution of Grades in Class B represented a more frequent occurrence in the latter grade scales, indicating that there is a contribution towards a balanced and highly positive outcome for the group of students by practice.

The Breusch-Pagan test was employed to test for heteroscedasticity; this is a situation where the variance of residuals is not constant. A straightforward test for heteroscedastic errors in a linear regression model is proposed within the context of the Lagrangian multiplier test. In various forms of heteroscedasticity and random coefficients models, the test is expressed as an easily calculable function of the OLS residuals. Some finite sample results are offered to reinforce the general asymptotic properties of the Lagrangian multiplier tests [15], [16] . In Class B (practicum), the value of the p-test was 0.04281; this is less than 0.05 significance level; hence, there was heteroscedasticity[17]. This means that the distribution of grades among the practicum class was not evenly distributed among students, possibly due to differences in their individual involvement in the practicum. This inference means that though practicum increases performance, its overall effect could be more significantly varied among individual students. This could mean that some students gain a tremendous amount from the practicum experience, hence achieving outstanding grades, but some students may just fail to capitalize on the experience to the fullest, hence experiencing a wider distribution of grades. Additionally, Class H (non-practicum) had a p-value of 0.2581 (which is higher than 0.05), hence no presence of homoscedasticity. This means that the distribution of grades among the non-practicum class has more stability. This subtle but important inference means that merely implementing the practicum experience among the students may just be insufficient since their involvement in the practicum experience could be the key towards ensuring the practicum experience benefits the whole student mass.

TABLE III. LINEAR REGRESSION USING MANN-WHITNEY

Statistic	**Class B (Practicum)**	**Class H (Non-Practicum)**	**p-value (Mann-Whitney/t-test)**
Mean	86.29	74.33	1.107e-06 / 1.451e-06
Median	87	77	-
R^2 Regression	0.7515	0.9817	-

Results show the practicum class significantly outperformed (mean 86.29 vs. 74.33), confirmed by Mann-Whitney U (p=1.107e-06) and t-test (p=1.451e-06). Heteroscedasticity in Class B (Breusch-Pagan p=0.04281) indicates individual engagement variability in practicum. Regression shows higher coefficients in practicum (6.47 vs. 5.75)

C. *Influence of Practicum Participation on Learning Outcomes (Linear Regression)*

Linear regression analysis was performed to further analyze the quantitative impact of practicum participation (indicated by the 'Grade_numeric') on the learning outcomes in both classes [17]. In general, the results obtained indicated a positive impact on the grades influenced by the practicum in both settings, as shown in Table III

TABLE IV. LINEAR REGRESSION ANALYSIS RESULTS

Class	***Constant (Intercept)***	***Grade_numeric Coefficient***	***p-value***	***R-squared***
Class B (Practicum)	31.8333	6.4667	1.97e-12	0.7515
Class H (Non-Practicum)	36.6990	5.7497	< 2e-16	0.9817

In the case of the Class with Practicum (Class B), the result of the regression analysis included an intercept of 31.8333, a 'Grade_numeric' of 6.4667 with an extremely small p-value of 1.97e-12. This indicates the significance of the 'Grade_numeric' factor since the increase in grades of 6.4667 units for every unit of participation or performance in the practicum activity was predictable when the p-value was 1.97e-12. The R-square for the study was 0.7515, which indicates the ability of the study to explain 75.15% of the variability of the grades among students of the class B.

For the class without Practicum (Class H), the results for regression analysis yielded an intercept of 36.6990 and a grade corresponding to the ‘Grade_numeric’ as 5.7497 with a strongly significant p-value of less than 2e-16. This indicates that for the class without Practicum, with each increment in the variable ‘Grade_numeric’ (presumably reflecting overall class performance or engagement), there was an accompanying increment in the grade by 5.7497 points. It is pertinent to note that the R-squared value for class H was 0.9817, which indicates that this particular regression model was able to explain an incredible 98.17% of the data fluctuations pertaining to the grades of students in the class without Practicum.

Comparing both models, although the effect of participating in the practicum was more significant in Class B, having a greater coefficient, the R-Squared value was surprisingly much higher in Class H. This data offers an intriguing finding: theoretically, it appears that the distribution and variation among student grades can be more easily predicted based on the 'Grade_numeric' variable. Conversely, although the presence of a practicum setting translates to better overall results, it also brings with it a greater level of randomness that could not be adequately represented by one singular factor. This indicates that other variables, potentially the individual efforts of students participating in hands-on exercises, their previous exposure, or even the quality of a 'lab science' education, could have a disproportionately more significant, more irregular effect within the practicum setting. This result not only iterates the importance of pursuing a more thorough theoretical comprehension of the manner in which learning in real-world settings brings with it a more robust, but potentially more complicated, web of variables that interact with learning theory, it again emphasizes that effectively teaching students involves more than jump-starting their scores—it involves an appreciation of the complicated interplay of variables within such settings.

This research was necessary, as its findings provide strong empirical evidence with direct implications for informing and necessitating changes in educational practice and policy, in particular within technical disciplines such as Computer Networking. Clearly, this study shows that integrating practical activities, or practicum sessions, into theoretical subjects is not desirable but very important for proper learning. That means this could be one of the clear mandates to education institutions: schools should clearly focus on and provide room systematically in their Computer Networking courses to include practicum components.

The results obtained in the improved performance of the students offer a persuasive justification for assimilating the practicum approach into the program offered to these students. The group represented in the practicum recorded a distinctively high mean performance, a marked consistency in the scores recorded, and a measurably lower variance compared to other students not in the practicum program. It should be noted that these factors can be traced to a direct positive impact in the overall performance recorded in academics, not to mention a measurable positive impact in the retention of knowledge and skills acquired. The role of practicum in developing not only a high-level understanding but also a practical working ability to apply these concepts is highly important in accounting for the demands in the rapidly changing landscape offered in the information technology industry.

Moreover, the above research work is capable of providing the required impetus and justification for the design and implementation of even better lecturing methodologies in that it seeks to go beyond the theory and implement practical as well. Moreover, the mentioned pedagogical design change will have critical resource implications. In fact, the results and outcomes from the above research work would go on to provide the critical justification and impetus for the investment in educational resources. The institutions would need to invest more resources, such as improving their laboratories and providing the required resources and staffing in that they would require employing more resources and staff for the effective execution and delivery of practical in class.

Aside from its utility in the immediate future, this research had been a moving force in the theoretical acquisition in learning processes. Specifically, this had a great impact in technical subjects where the learning processes are more complex. On a more general perspective, the findings had a strong inclination towards the validation of the Constructivism theory on learning. Practicum learning had been demonstrated in this experiment to improve the mastery and comprehension of the subject matter by actively taking part in the constitution of their knowledge.

In addition, this study points out how the practicum uniquely engages with learning in a manner that supplements, as well as extends in some respects, beyond the fundamental premises of traditional behavioristic or cognitive learning constructs. Where the cognitive or behavioristic approach is largely concerned with behavioral modification through motivational as well as response mechanisms, the practicum approach is directly concerned with the crucial elements of application as well as practical problem-solving. This can, in itself, lie beyond the realms of theoretical constructs. This study aptly supports how, in subjects as complex as Computer Networking, practical application is a key integral part, in itself, of comprehensive learning, thereby establishing how practical experience impacts upon theoretical constructs.

The positive effect of the practicum observed in this study implicitly supports the theoretical understanding that it also depends on experience and subject matter knowledge of the instructor and methods of learning that are effective for such subject matter in question. Although these two aspects are related in this study but could not been quantified for this particular study due to limitations, it indicates that it had some effect on the successful outcome of this practicum group.

From the linear regression test, specifically looking at the fact that a higher R-square is found in the non-practicum group with a corresponding low overall grade, there is a theoretical implication in understanding how predictable learning outcomes can be in a theoretical setting versus a practicum setting. Essentially, what this indicates is that practicum makes a substantive positive impact on outcomes, but what is seen in grades in a theoretical setting is potentially more predictable, perhaps because of fewer factors affecting this outcome as opposed to a practicum setting. This result suggests that there needs to be further theoretical investigation with regard to the nature of learning and the type of pedagogical method that will work best, and that for technical areas such as that studied, an integrated pedagogical method will outperform all other pedagogical models. This study is critical because it allows for the empirical validation and development of existing models of learning to include technical skills acquisition within its framework, which will advance educational theory as such.

V. Conclusion

By doing so, this current study brings empirical evidence to the fact that practicum-based instruction significantly enhances learning outcomes in undergraduate Computer Networking courses. Students from practicum activities achieved higher academic performances with more favorable grade distributions than their peers in non-practicum classes.

To enhance the effectiveness of the curriculum further, recommendations are made to include practicum modules systematically related to lecture topics; invest in laboratory infrastructure and instructor training; incorporate formative assessment into practicum sessions, and explore other blended models of a hybrid laboratory combining physical and virtual environments.

Future studies should try to surmount some of the current methodological limitations by using consistent instructional modalities, including qualitative measures that capture student engagement and learning experiences.

ACKNOWLEDGMENT

The writer would like to put on record their sincere thanks to Universitas Multimedia Nusantara, without whose aid this study would not have been possible. The writer would also like to acknowledge their sincerest gratitude towards the lecturer of the "Computer Networking" course, who generously offered them the student score data, without which this particular task in this study would not have been possible.

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