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Enhancing Vocational Teachers' Competence: A Cisco Packet Tracer-Based Simulation Model for Network Administration

Heriyanto[1*], Dian Wulandari[2], Lisa Chandrasari Desianti[3]
Educational Management Department, Universitas Pakuan, Bogor, West Java, Indonesia
Email: giegiez1982@gmail.com[1], dianwulandari@unpak.ac.id[2], lisachandrasari@unpak.ac.id[3]

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Abstract:

This study aims to improve teacher competence in network system administration subjects at vocational high schools by developing a Cisco Project Tracer-based simulation learning media and testing its feasibility, practicality, and effectiveness. This research employs the Research and Development method, adopting the ADDIE model. Quantitative data were analysed using a paired sample t-test and the N-Gain Score calculation. The expert validation results showed that the developed media achieved an average score of 89%, indicating "highly feasible". The effectiveness test indicated a significant increase in teacher competence, with an N-Gain Score of 0,61 (medium category). Teacher responses regarding the practicality of the media were also highly positive, with 90% agreeing that the media was easy to use and relevant to learning needs. These findings show that the developed simulation media are not only feasible but also effective and practical in enhancing teachers' pedagogical and professional competence. The study concludes that the Cisco Packet Tracer-based simulation media developed is valid, practical, and effective for improving the competence of Network System Administration teachers.

Keywords: *Teacher Competence, Vocational School, Simulation-Based Model, Cisco Packet Tracer*

Abstrak:

Penelitian ini bertujuan untuk meningkatkan kompetensi guru dalam mata pelajaran administrasi sistem jaringan di sekolah menengah kejuruan dengan mengembangkan media pembelajaran simulasi berbasis Cisco Project Tracer dan menguji kelayakan, kepraktisan, serta efektivitasnya. Penelitian ini menggunakan metode Penelitian dan Pengembangan (R&D), dengan mengadopsi model ADDIE. Data kuantitatif dianalisis menggunakan uji t sampel berpasangan dan perhitungan N-Gain Score. Hasil validasi ahli menunjukkan bahwa media yang dikembangkan mencapai skor rata-rata 89%, menunjukkan "sangat layak". Uji efektivitas menunjukkan peningkatan signifikan dalam kompetensi guru, dengan N-Gain Score 0,61 (kategori sedang). Tanggapan guru mengenai kepraktisan media juga sangat positif, dengan 90% setuju bahwa media tersebut mudah digunakan dan relevan dengan kebutuhan pembelajaran. Temuan ini menunjukkan bahwa media simulasi yang dikembangkan tidak hanya layak tetapi juga efektif dan praktis dalam meningkatkan kompetensi pedagogis dan profesional guru. Studi ini menyimpulkan bahwa media simulasi berbasis Cisco Packet Tracer yang dikembangkan valid, praktis, dan efektif untuk meningkatkan kompetensi guru Administrasi Sistem Jaringan.

Kata Kunci: *Kompetensi Guru, Sekolah Vokasi, Model Berbasis Simulasi, Cisco Packet Tracer*

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INTRODUCTION

Advancements in technology are increasingly shaping the educational landscape; technical literacy that fosters creativity is a crucial element in the learning process (Desianti et al., 2023; Hardhienata et al., 2021). Nevertheless, vocational teachers frequently lack proper training and access to useful simulation media, despite the increased focus on digital literacy. The dynamics of graduate abilities in relation to 21st-century skills require creativity, innovation, collaboration, and knowledge sharing among teachers, as continual improvement is essential for achieving learning effectiveness (Mertler et al., 2021; Teo, 2023). The integration of technology and teacher competency, along with proficient technology use and digital literacy among educators, can bolster their confidence and collaboration (Cosby et al., 2023; Nurhidayat et al., 2024). In contrast, the PISA 2022 results reveal that students engage with digital technology for educational purposes in school for less than 2 hours daily, well below the OECD average.

Vocational education (SMK) faces similar challenges in educational innovation, as its graduates are expected to develop capabilities recognized by the labour market. Conversely, evidence indicates that vocational school graduates in Indonesia possess fewer employment options than their non-vocational counterparts (Yoana et al., 2024). Data from Indonesia's Central Bureau of Statistics (BPS) show that the highest unemployment rate is among vocational high school (SMK) graduates at 9.01%, higher than among high school graduates (7.05%) and even junior high school graduates (4.11%). In various countries, the disparity between the competencies of vocational high school graduates and the requirements of internships and labour market demands is a concern for both practitioners and academics (Cecilia et al., 2025; Koca & Ortakaya, 2023; Ogawa, 2025). A primary recommendation to mitigate this gap is the implementation of practical internship activities, alongside educator support and proficiency in information technology (Chen & Ma, 2022; Pianda et al., 2025).

Proficiently teaching Network Systems Administration (NSA) is an essential competency for information technology specialists. This teaching approach requires teachers to have proficiency with technology for the lessons to be practical. Real-world practice is the most effective way of applying NSA learning, even though the required equipment is often costly. An additional option to examine is simulation; nevertheless, the accessibility of simulation resources remains constrained at present. Numerous studies have examined the Development of simulation-based learning media using Cisco Packet Tracer. The Cisco Packet Tracer application has demonstrated significant effectiveness in various industries, including transportation networks (Kabir et al., 2022; Lestari et al., 2023; Simanjuntak et al., 2024). Cisco Packet Tracer is regarded as an innovative tool for teaching communication networks in ICT education (Mwansa et al., 2024).

For NSA learning, several investigations have demonstrated that the Cisco Packet Tracer application-based learning media is both feasible and effective in enhancing student learning outcomes in network courses in vocational high schools (Azamuddin et al., 2024; Kaur et al., 2024; Sassi & Chaari Fourati, 2024). This media can enhance the interactivity of the learning process. However, studies have predominantly concentrated on students, whereas research highlighting media Development to improve instructors or teachers remains scarce. This study addresses the deficiency by creating Cisco Packet simulation-based educational resources tailored for vocational high school instructors or teachers, to enhance their professional proficiency in teaching NSA.

The problem of insufficient NSA learning simulation media requires immediate intervention through the creation of effective, user-friendly simulation methods that could significantly improve the learning experience. To address this challenge in NSA learning, video tutorial-based learning and virtual instruction were introduced (Peñate et al., 2024). Nevertheless, it was considered that using these methods did not yield the best outcomes; thus, a different approach was required (Kosasih et al., 2022). An alternative is to employ the Cisco Packet Tracer tool, which has demonstrated efficacy in facilitating learning (Ashurkulovich et al., 2024; Rakhimov & Juraev, 2024). Presently, the Development of Cisco Packet Tracer-based simulation media has predominantly centered on student interest; therefore, it is crucial to create educational media products that enhance instructor competency.

The imperative for developing this NSA learning tool stems from the persistently low competency of teachers in implementing the NSA learning process, necessitating support to help them use the NSA learning resources. It is anticipated that teachers' expertise in using simulation media in education will directly impact learning efficacy. Effective learning will empower students to attain the requisite competences, enhance their proficiency in NSA skills, and consequently possess skills that align with labour market demands.

The ADDIE methodology is considered optimal for creating NSA simulation media because it follows a methodical process from planning through testing and evaluation, ensuring the final product meets the study's goals. This study addresses the deficiency by creating Cisco Packet simulation-based educational resources tailored for vocational high school instructors or teachers, to enhance their professional proficiency in teaching NSA.

RESEARCH METHODS

The research participants are educators in Network System Administration within the Computer and Network Engineering program at SMK Insan Kreatif. This site was selected due to the six-year duration of the NSA study, which serves as a flagship program within the institution. Tracer data reveals constraints in the application of NSA abilities during job applications or post-employment, attributable to discrepancies between the NSA skills demanded and those acquired in educational settings.

The research methodology employs the ADDIE model, which stands for Analyze, Design, Develop, Implement, and Evaluate, in conjunction with

Research & Development (R&D). The R&D approach is deemed appropriate for fulfilling the research objective, as the results will be helpful as practical and simulation-based learning media. This strategy facilitates recurrent validation, yielding a comparatively effective final product (Rahmani et al., 2024; Spatioti et al., 2022). The ADDIE paradigm was selected due to its demonstrated efficacy in the Development of educational media, instructional materials, and textbooks across several subjects, including biology, Islamic studies, reinforcement videos, desktop learning, and fundamental network practicum tutorials (Adeoye et al., 2024; Pregoner, 2025).

The conceptual framework of this research posits that simulation-based learning media might enhance instructors' pedagogical and professional competencies. The ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) was chosen to develop the simulation model. The interrelationships among the components of the conceptual framework and the research flowchart are shown in Figures 1 and 2.

Figure 1. Research Conceptual Framework

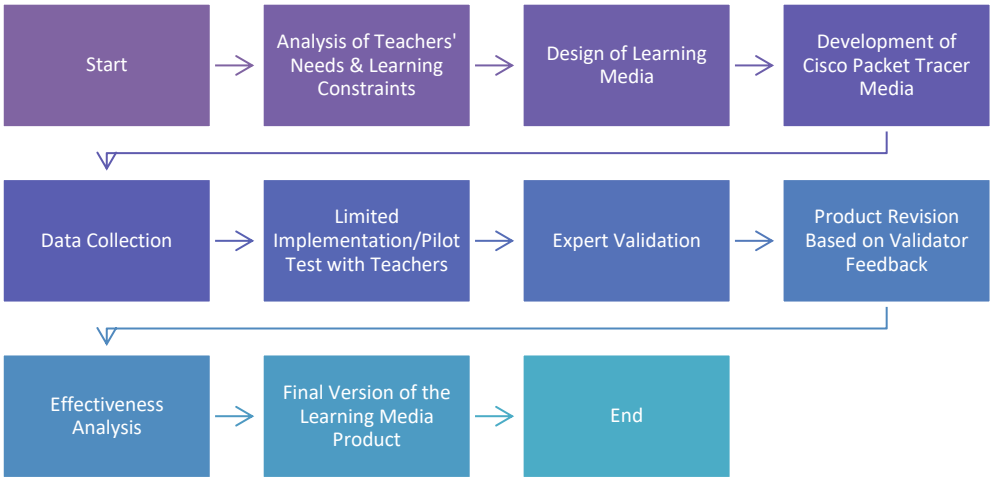

Figure 2. Research Flowchart with ADDIE Model

Quantitative data were examined by instrument validity and reliability assessments, normality testing (Shapiro-Wilk), effectiveness evaluations (t-test), and N-Gain Score calculations (Excel) to quantify the enhancement in teacher competence following media utilization. All research participants were pre-informed about the phases of the research process and its aims. The employed research instruments included: (1) Observation Sheet: to identify initial learning conditions and teacher perceptions; (2) Interview Sheet: to explore teacher needs and constraints; (3) Validation Sheet: utilized by experts in content materials, media, and language; (4) Pre-test and Post-test Questions: to evaluate the enhancement of teacher competence; and (5) Teacher Response Questionnaire: to

gauge the practicality and usefulness of the media.

Validation was conducted by three specialists in curriculum, language, and media. The curriculum validation assessed the appropriateness of the content relative to the curriculum, and a vocational school curriculum expert conducted the evaluation. It encompassed elements such as curriculum relatedness, content, support for learning effectiveness, and suitability for teachers. Media validation was conducted, covering design, visual suitability, interactivity, and ease of use. Language validation confirmed that users comprehended the instructions in the simulation model, including clarity and simplicity of terminology, interactivity, and language style accuracy.

RESULTS AND DISCUSSION

Results

Validation outcomes from material, media, and language experts indicate that the Cisco Packet Tracer-based simulation learning medium is highly feasible. The average validity score exceeds 90%. The following Table 1 displays the expert validation findings for each dimension and criterion.

Table 1. Material, Media, and Language Validation Result

Material	Score (1-4)	Media	Score (1-4)	Language	Score (1-4)
Curriculum relatedness	4	Display design	4	Clarity & simplicity	4
Content	4	Image or visual suitability	4	Communicative, interactivity	3,67
Support for learning effectiveness	4	interactivity/ simulation	3,67	Language style accuracy	4
Suitability for teachers	4	Easy to use	3,67		
Total Score	16		15,34		11,67
Max Score	16		16		12
% Validity	100		95,87		97,25
Overall Average of Expert Validity					97,7

Table 2 presents the results of the pre-test and post-test about teacher proficiency in NSA lessons and Cisco Packet Tracer. Pre-test and post-test scores indicate the number of respondents who answered correctly.

Table 2. Pre-test and Post-test Result

Competency	Pre-test	Post-test
Basic understanding of computer networks	6	10
Basic Network Configuration with Cisco Packet Tracer	3	10
Network Troubleshooting with Cisco Packet Tracer	6	8
Teaching with simulation media	5	9
Router and switch configuration in Cisco Packet Tracer	4	7

Table 2 indicates a substantial enhancement in teacher competency following the utilization of simulation media. A significant increase was observed in the items directly related to the practical implementation of the Cisco

Packet Tracer simulation in the NSA material. The N-Gain test indicated a significant improvement in teacher competence, categorizing it as high efficacy; the details are shown in Table 3.

Table 3. N-Gain Test Result

Subject	Pre-test Score	Post-test score	Gain	N- Gain
1	70	100	30	1,00
2	70	90	20	0,67
3	60	80	20	0,50
4	60	80	20	0,50
5	70	100	30	1,00
6	70	100	30	1,00
7	60	90	30	0,67
8	60	80	20	0,50
9	50	80	30	0,60
10	50	80	30	0,60
Max score	70	100	30	
Min score	50	80	20	
Average	62	88	25	
N-Gain (individual average)				70,33
N-Gain (class average)				67,67

Moreover, according to the teacher response questionnaire, this media is pragmatic and beneficial for teachers. Several teachers reported significant ease of use and heightened engagement in preparing instructional materials. Table 4 presents an overview of teacher responses regarding the use of Cisco Packet Tracer-based simulation media.

Table 4. Teachers Response to Media Simulation

Competency	
The suitability of media content with the NSA curriculum.	4,7
Media facilitates comprehension of network configuration.	4,6
The media covers important NSA topics presented clearly and understandably	4,6
The media display design is attractive and professional.	4,8
Navigation inside the media is user-friendly.	4,9
Media can run smoothly without significant technical obstacles	4,2
Cisco Packet Tracer effectively supports practical network learning.	4,3
I am much more confident teaching using this simulation media	4,6
This media helps explain the concept of networks contextually.	4,5
I can create more systematic integrated teaching modules with this media.	4,8
This media encourages me to be more active in learning.	4,3
This media can meet the needs of students.	4,6
After using the media, I have a better understanding of the technical aspects.	4,2
I am able to run network simulations independently.	4,2
This media introduces new topics such as IoT and FTTx.	4,4
This media is relevant to the current needs of the network industry.	4,2
I am very motivated to improve my digital skills.	4,2
This media facilitates the evaluation of students' learning outcomes.	4,4
I want to continue using this medium in future learning.	4,6
This media enhances my instructional and professional skills.	4,5

The questionnaire uses a scale of 1 to 5, indicating agreement, where a score of 5 is strongly agree, and a score of 1 is strongly disagree. Table 4 demonstrates that educators concur on the efficacy of simulation media and, most importantly, that their implementation in education enhances teachers' pedagogical and professional competencies. Furthermore, the utilization of simulation media provides educators with enhanced opportunities for engagement in the learning process, thereby increasing their confidence and motivation to refine their skills.

Discussion

The validation test results presented that the simulation model satisfies the specified requirements and is anticipated to be effective in application. The research demonstrates that Cisco Packet Tracer-based simulation media is highly relevant and practical for NSA learning. Areas needing improvement include the media's ability to facilitate direct, interactive feedback during setup and teachers' accessibility to independently use the media in both preparation and implementation of learning.

The main goal of the research, to improve teachers' overall competence, was considered achieved, particularly in Basic Network Configuration with Cisco Packet Tracer. The significant disparity in improvement is expected to address the constraints teachers face in enhancing students' competence in NSA. This model also improves teachers' competence in using simulations in learning. However, it is necessary to elaborate on various possible cases in the NSA so that teachers become more proficient in Network Troubleshooting with Cisco Packet Tracer.

N-Gains outcome corresponds with research indicating that social support and infrastructure influence the utilization of digital technology by vocational high school educators, and that the application of simulation media can enhance the competency and self-efficacy of these teachers. The use of relevant simulation media by teachers in instruction will enhance teachers' proficiency. The utilization of pertinent simulation media by teachers in learning will enhance teacher proficiency (Anwar et al, 2024). Previous studies indicate that the professional Development of vocational teachers should focus on enhancing specific abilities within the field (Hagedoorn et al., 2025), ensuring that educators remain current in their knowledge and competencies, particularly in digital skills. Enhancing teachers' proficiency in using Cisco Packet Tracer-based simulation tools enables the assessment of vocational school technology preparedness in urban regions, particularly those advocating the ongoing Development of innovative models for IoT readiness in educational environments (Suwastika et al, 2025).

The ADDIE model to enhance the systematic development of media. The organized validation and testing demonstrate a logical educational methodology. Simulation media plays an essential role in the realm of vocational education, particularly in scenarios with restricted physical resources (Mwansa et al., 2024; Rakhimov & Juraev, 2024). Cisco Packet Tracer enables educators to design effective, practical, and reliable experiences. Additional educational

research indicates that this form of media may improve creativity and conceptual comprehension, especially with Virtual LAN content and local network device installation.

The role of teachers in integrating simulation media is crucial. Effective implementation of digital media by teachers necessitates mastery of a synthesis of content, pedagogy, and technology, known as TPACK (Technological Pedagogical Content Knowledge) (Balakrishna, 2023; Lin et al., 2022; Runtuwene et al., 2024). This research reinforces the notion that educators engaged in media production are more qualified to utilize Cisco Packet Tracer in a professional context. The application of the ADDIE model in this research enhances the systematic Development of media. Simulation media is crucial in vocational education, particularly in scenarios with restricted physical resources. Cisco Packet Tracer enables teachers to design practical, efficient, and secure experiences (Amran & Syaharani, 2024; Malgwi et al., 2024; Patel et al., 2024). Additional educational research indicates that this form of media can enhance creativity and conceptual comprehension, particularly in Virtual LAN content and local network device installation.

The use of Cisco Packet Tracer-based simulations can significantly improve teachers' competency in teaching computer networks, particularly in basic network configuration and troubleshooting. This research provides an important contribution to the Development of simulation-based learning models that can be implemented even with limited physical resources. By integrating the ADDIE approach in media Development, this research also enriches the understanding of how simulation media can be applied systematically and effectively in the context of vocational education. The results of this research are expected to motivate the Development of innovative learning models that can optimize the potential of technology in learning and improve the quality of vocational education, which in turn will influence students' competency in facing the challenges of ever-evolving technology.

CONCLUSION

This study has generated simulation-based learning resources utilizing Cisco Packet Tracer, designed according to the ADDIE approach (Analysis, Design, Development, Implementation, Evaluation). The validation results indicate that the media falls into the very feasible category for use, with an average feasibility score of over 90%. Effectiveness assessments indicate a significant improvement in the proficiency of Network System Administration instructors at SMK, which is categorized as high according to the N-Gain Score analysis. This media was found to be practical, relevant to learning requirements, and capable of enhancing teacher engagement in the teaching and learning process, both directly and online.

Future research should focus on the following recommendations: conducting comprehensive evaluations of media efficacy across diverse vocational high schools with differing facilities and teacher qualifications; integrating additional technologies by combining Cisco Packet Tracer with other network simulators such as GNS3 or EVE-NG to enhance simulation capabilities;

linking materials to Learning Management Systems (LMS) like Moodle and Google Classroom to enable continuous access to learning; and developing a curriculum for IoT and Cloud Networking that includes educational modules on IoT topics, network security, and cloud computing, ensuring alignment with industry advancements.

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