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Cisco Packet Tracer Materials as a Virtual Networking Lab Substitute: 4D Validation and Feasibility

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ABSTRACT

Computer network learning requires repeated configuration and troubleshooting practice, but many schools have limited access to physical network laboratories, adequate network devices, and technical maintenance support. Although Cisco Packet Tracer (CPT) is widely used in networking courses, validated teaching materials that integrate CPT as a structured virtual laboratory substitute and provide classroom feasibility evidence remain limited. This study developed CPT-integrated teaching materials using the 4D model and examined their validity, feasibility, and learning effectiveness in a secondary school networking class. The study used research and development supported by a one-group pretest–posttest quasi-experimental design. The product was developed through Define, Design, Develop, and limited Disseminate stages. Product validity was assessed by two experts using a four-point validation sheet. Classroom feasibility was evaluated through student responses, teacher response, and implementation observation. Learning effectiveness was analysed using N-gain, normality testing, paired-samples t-test, and Cohen's dz. The results showed that the product was highly valid, with an expert validation score of 87.50%. Student feasibility responses reached 87.97%, teacher response reached 90.63%, and classroom implementation reached 90.00%, indicating that the materials were feasible to use. The mean score increased from 48.03 on the pretest to 75.69 on the posttest, with an N-gain of 0.553 in the moderate category. The increase was statistically significant, $t(31) = 22.542$, $p < 0.001$, with a large effect size, $dz = 3.985$. These findings indicate that CPT-integrated teaching materials can expand scenario-based network practice in schools with limited laboratories. The product contributes a validated, low-cost, and classroom-feasible model for virtual networking practice, while further studies should examine skill transfer to real network devices.

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1. INTRODUCTION

Laboratories are essential in computer network education because they provide practice-based learning experiences that help students develop procedural, diagnostic, and performance competencies beyond conceptual understanding (Romadhoni & Saifuddin, 2021; Wajdi et al., 2022). The quality of school facilities, including laboratories, contributes to educational service quality and learning outcomes (Aula et al., 2021; Iswani et al., 2024). In Indonesia, the demand for stronger alignment between education and workplace needs makes practical competence an important indicator of graduate readiness (Wajdi et al., 2022). However, laboratory access remains uneven across schools because equipment procurement, renewal, and maintenance depend on funding capacity and local resource support (Mubarak, 2023; Mustafa & Pasaribu, 2024). This inequality can reduce students' opportunities for repeated practice and widen competency gaps.

In computer networking classes, an ideal physical laboratory should provide routers, switches, servers, cables, and client devices for topology design, IP addressing, device configuration, connectivity testing, and troubleshooting. In practice, many schools face limited devices, outdated specifications, restricted laboratory schedules, and insufficient technical support (Mubarak, 2023; Sahidin, 2020). Limited funding may delay equipment procurement and maintenance, which affects the quality of practical learning and graduate competence (Aprilliantoni et al., 2024; Jasmine, 2023; Yayuk & Sugiyono, 2019). Facility management problems, including planning, inventory, maintenance, and readiness of equipment, further influence laboratory availability (Hasnadi, 2022). When teachers or technicians have limited technical support, learning may shift toward demonstrations rather than repeated hands-on practice, reducing students' opportunities to develop configuration and diagnostic skills (Ali & Nuryani, 2023; S. Kumar & Kumar, 2023; Waluyo et al., 2023).

Network simulation offers a practical response to these constraints. Cisco Packet Tracer enables students to design virtual topologies, configure devices, test connectivity, and analyse network behaviour without the risk of damaging physical devices (Asadi et al., 2024; Shambare & Simuja, 2021). Simulation-based learning can support troubleshooting because it provides system representation, hypothesis testing, feedback, and repeated practice in a controlled environment (Jonassen, 2009; Jonassen & Hung, 2006). Digital and virtual laboratories also allow more flexible access when physical laboratories are limited by schedule, location, or device availability (Dustman et al., 2021; Lima et al., 2019). However, simulations should not be understood as a total replacement for all hands-on laboratory experiences. Prior studies show that virtual laboratories can support learning outcomes under appropriate instructional conditions, but physical laboratories remain important for competencies involving real devices, cables, hardware failures, and authentic field conditions (Altmeyer et al., 2020; David et al., 2020; Shimba et al., 2016).

The effectiveness of simulation depends on the quality of the teaching materials that integrate it. Simulation activities need authentic scenarios, competency-oriented tasks, clear scaffolding, feedback, and performance assessments that measure procedural and diagnostic competence (Ariffin et al., 2022; Chen, 2025; Lima et al., 2019; Viegas et al., 2018). In research and development studies, the quality of digital teaching materials is usually demonstrated through validity, practicality or feasibility, and effectiveness evidence (Fadli et al., 2022; R.H et al., 2020; Rahayu, 2025; Wahyudin et al., 2022). Nevertheless, previous development studies often stop at expert validation or limited trials, leaving insufficient evidence about whether simulation-integrated materials are feasible in real classrooms with heterogeneous student abilities, limited infrastructure, and varying teacher competencies (Jh, 2025; Lestari & Cintamulya, 2022; Pratiwi et al., 2024; S. Kumar & Kumar, 2023).

This study addresses that gap by developing Cisco Packet Tracer-integrated teaching materials as a pedagogical substitute for selected physical network laboratory activities, especially configuration and scenario-based troubleshooting practice. The novelty of this study lies in the integration of CPT into structured teaching materials developed through the 4D model and evaluated through expert validation, classroom feasibility testing, teacher response, implementation observation, and learning effectiveness analysis. The study was guided by the following research questions: (1) How valid are the Cisco Packet Tracer-integrated teaching materials based on expert judgement? (2) How feasible are the materials for classroom implementation based on student response, teacher response, and observation? (3) To what extent do students' learning outcomes improve after using the materials? The expected contribution is a validated and classroom-feasible virtual laboratory model that can help schools with limited physical network laboratories expand students' opportunities for repeated network practice.

2. METHODS

2.1 Research Design

This study used a research and development (R&D) design based on the 4D model, supported by a one-group pretest–posttest quasi-experimental design to examine learning improvement. The 4D model consists of Define, Design, Develop, and Disseminate stages. The Define stage identified learning needs and laboratory constraints. The Design stage produced the material structure, simulation scenarios, learning activities, and assessment instruments. The Develop stage produced, validated, revised, and implemented the prototype. The Disseminate stage was conducted in a limited form through classroom implementation and peer discussion. Product quality was evaluated through validity, classroom feasibility, implementation, user response, and effectiveness indicators.

2.2 Place and Time of Research

The research was conducted at SMA Negeri 4 Surabaya in an Informatics/Computer Network class for Grade XII students. The implementation followed the school academic calendar and included preparation, product design, expert validation, revision, limited classroom implementation, and data collection.

2.3 Research Subjects

The field trial involved 32 Grade XII students selected through purposive sampling because they were studying computer networking material and had minimum device readiness to run Cisco Packet Tracer. The study also involved two validators: a subject-matter expert in computer networking and a media or learning technology expert. The subject teacher supported classroom implementation and provided product feasibility feedback.

2.4 Developed Product

The product was a text-based teaching material package on computer networking integrated with Cisco Packet Tracer simulation activities. The materials included: (1) competency maps and learning objectives, (2) explanations of core network concepts, (3) simulation activity sheets, (4) topology design tasks, (5) IP addressing and device configuration steps, (6) connectivity testing tasks, (7) troubleshooting exercises, (8) formative exercises, and (9) guidance for using Cisco Packet Tracer. The product was designed as a pedagogical substitute for configuration and troubleshooting practice when access to physical network laboratories is limited.

2.5 Development Procedure

The Define stage included needs analysis, task analysis, concept analysis, and formulation of measurable learning objectives. Needs analysis focused on limited network devices, restricted laboratory access, and the need for repeatable practice. Task analysis mapped network competencies that could be simulated using Cisco Packet Tracer. Concept analysis identified key concepts that required visualisation and procedural practice, such as topology construction, addressing, routing, connectivity testing, and troubleshooting.

The Design stage produced the teaching material format, sequence of topics, simulation scenarios, learning activities, and assessment instruments. Each simulation task was aligned with learning objectives and designed to guide students from guided practice to more independent configuration and troubleshooting tasks. The design also considered readability, navigation, visual consistency, and clarity of instructions.

The Develop stage involved producing the prototype, conducting expert validation, revising the product based on feedback, and implementing the revised version in the target class. Subject-matter validation assessed content suitability, concept accuracy, terminology, and alignment with learning objectives. Media validation assessed visual design, readability, navigation, technical feasibility, and the integration of Cisco Packet Tracer with the learning flow.

The Disseminate stage was conducted in a limited form by presenting the revised product to peers and distributing it for classroom use. Feedback from this stage was used to refine the product and identify improvements for broader implementation.

2.6 Instruments and Data Collection Techniques

Data were collected using validation sheets, student response questionnaires, teacher response questionnaires, implementation observation sheets, and pretest–posttest instruments. Expert validation sheets used a four-point Likert scale. Student feasibility questionnaires measured clarity, accessibility, usefulness, attractiveness, support for independent practice, troubleshooting support, rubric clarity, time efficiency, and overall satisfaction. Teacher response measured curriculum suitability, clarity of CPT instructions, scenario relevance, troubleshooting support, independent practice, time allocation, assessment rubric, and overall feasibility. Observation sheets documented the implementation of learning activities, student engagement, time management, teacher feedback, and technical constraints. Pretest and posttest instruments measured students' understanding of network concepts and basic procedural competence before and after using the teaching materials.

Instrument validity was addressed through expert review of content, construction, language, and relevance to the learning objectives. Item-level test data were used to examine internal consistency reliability. The pretest showed very high reliability with Cronbach's alpha of 0.966, and the posttest showed very high reliability with Cronbach's alpha of 0.965. The student feasibility questionnaire was treated as a multidimensional product-feasibility instrument; therefore, interpretation focused on aspect-level feasibility percentages and qualitative revision notes rather than relying only on a single total reliability coefficient.

Table 1. Research instrument matrix and data collection techniques

Aspects measured	Main indicators	Instruments	Respondents/ Sources	Scale	Data output
Validity of teaching materials	Suitability of content, language, presentation, and alignment with learning objectives	Subject-matter expert validation sheet	Subject-matter expert on networks	Likert scale 1–4	Average validity score
Media/design validity	Appearance, navigation, visual consistency, readability, and technical feasibility of Packet Tracer integration	Media expert validation sheet	Media/learning technology expert	Likert scale 1–4	Average validity score
Practicality/ feasibility (implementability)	Implementation of learning steps, use of teaching materials, time management, and technical constraints	Implementation observation sheet	Observer	Percentage scale	Implementa tion percentage
Practicality (teacher response)	Ease of use, clarity of instructions, material suitability, usefulness, and readiness for implementation	Teacher response questionnaire	Subject teacher	Likert scale 1–4	Average score and category

Practicality (student response)	Clarity of material, ease of following simulation steps, attractiveness, and usefulness	Student response questionnaire	Students	Likert scale 1–4	Percentage and category
Effectiveness	Improvement in understanding of network concepts and procedural skills after using teaching materials	Pretest and posttest	Students	Score 0–100	N-gain, paired t-test, and effect size
Learning engagement	Participation, perseverance, collaboration, and focus during simulation practice	Engagement observation sheet	Observer	Rubric/ checklist	Descriptive notes

2.7 Data Analysis Techniques

Quantitative data were analysed descriptively and inferentially. Expert validation scores were averaged by aspect and converted into percentages. The product was categorised as highly valid when the average validity percentage reached at least 85%. Student feasibility, teacher response, and implementation observation were analysed using percentage scores and qualitative categories.

Learning effectiveness was analysed using pretest and posttest averages, gain, N-gain, normality testing, paired-samples t-test, and effect size. N-gain was calculated using the formula (posttest − pretest)/(maximum score − pretest) and interpreted as low (<0.30), moderate (0.30–0.69), or high (≥0.70). The normality of paired difference scores was examined using the Shapiro–Wilk test. The result showed that the difference scores were normally distributed, $W = 0.978$, $p = 0.749$; therefore, a paired-samples t-test was used. Effect size was calculated using Cohen's dz by dividing the mean paired difference by the standard deviation of the paired difference.

2.8 Decision Criteria and Ethical Considerations

The product was considered suitable for use when expert validation reached the valid or highly valid category, classroom feasibility reached the feasible or highly feasible category, implementation observation reached the good or very good category, and learning outcomes showed improvement based on N-gain and inferential testing. Product revisions were made iteratively based on expert suggestions and classroom implementation findings.

Ethical considerations included obtaining school permission before data collection, explaining the learning activities and research purpose to participants, ensuring that participation did not disadvantage students academically, and using student data only for research and development purposes. Student identities were coded and kept confidential in reporting the findings.

3. FINDINGS AND DISCUSSION

This section integrates findings and discussion according to the research objectives: product validity, classroom feasibility, and learning effectiveness. Each result is interpreted in relation to the development purpose and relevant literature.

3.1 Product Validity

Table 2. Summary of Expert Validation Results (Total average = 87.50%)

No	Aspect	Average	Percentage (%)	Category
1	Alignment of materials with the curriculum	3.50	87.50	Highly valid
2	Accuracy of network concepts and terminology	3.50	87.50	Highly valid
3	Clarity of configuration steps	3.00	75.00	Valid
4	Sequence of material presentation	3.50	87.50	Highly valid
5	Quality of practice scenarios, topology, and targets	3.50	87.50	Highly valid
6	Quality of troubleshooting exercises	3.00	75.00	Valid
7	Clarity of instructions and usage guidelines	4.00	100.00	Highly valid
8	Appropriateness of performance assessment rubrics	4.00	100.00	Highly valid
9	Display/visual quality and readability	3.50	87.50	Highly valid
10	Integration of Packet Tracer with learning activities	3.50	87.50	Highly valid

The expert validation results show an average score of 87.50%, indicating that the teaching materials were highly valid. The strongest aspects were the clarity of usage guidelines and the appropriateness of performance assessment rubrics, both of which reached 100.00%. These results suggest that the product was not only technically compatible with Cisco Packet Tracer but also instructionally aligned with the target networking competencies.

The validation result supports the argument that simulation-based teaching materials require strong instructional design rather than simply adding software to classroom activities. Authentic scenarios, clear scaffolding, feedback, and performance assessment are central to effective simulation-based learning (Lima et al., 2019; Viegas et al., 2018). The high scores for curriculum alignment, concept accuracy, practice scenarios, visual quality, and CPT integration indicate that the product had a strong foundation for classroom use.

Two aspects received lower scores but remained valid: clarity of configuration steps and troubleshooting exercises. This finding is important because troubleshooting requires ill-structured problem solving, diagnostic reasoning, and flexible strategy use, not only procedural configuration steps (Jonassen, 2009). Therefore, product revision should add more explicit step numbering, screenshots of critical configuration steps, varied fault scenarios, incomplete configurations, misconfigured addressing schemes, and reflective prompts. These improvements are expected to reduce cognitive load for beginners while gradually developing diagnostic competence.

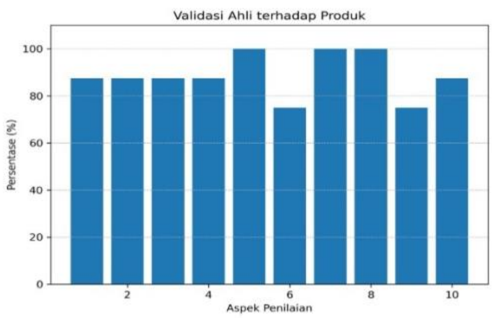

Figure 1. Percentage of Expert Validation per Aspect; the Product is in the Highly Valid Category (87.50%).

3.2 Classroom Feasibility

Table 3. Recapitulation of Classroom Feasibility by Students (Average = 87.97%)

No	Aspect	Score Obtained	Maximum Score	Percentage (%)	Category
1	Clarity of practical instructions	516	640	80.63	Feasible

2	Ease of following the configuration tutorial	583	640	90.94	Highly feasible
3	Ease of access to teaching materials and Packet Tracer files	573	640	89.53	Highly feasible
4	Alignment of scenarios with materials	514	640	80.31	Feasible
5	Attractiveness of module display	564	640	88.13	Highly feasible
6	Benefits for independent practice	599	640	93.59	Highly feasible
7	Benefits for troubleshooting	577	640	90.16	Highly feasible
8	Clarity of rubric/assessment	553	640	86.41	Highly feasible
9	Time efficiency in completing tasks	565	640	88.28	Highly feasible
10	Overall satisfaction with teaching materials	586	640	91.56	Highly feasible
	Total/Average	5630	6400	87.97	Highly feasible

The classroom feasibility score reached 87.97%, indicating that the materials were highly feasible for implementation. Students gave particularly strong responses to the benefits of independent practice, overall satisfaction, ease of following configuration tutorials, and usefulness for troubleshooting. Teacher response also reached 90.63%, while implementation observation reached 90.00%, showing that the product was feasible not only from the student perspective but also from the teacher and classroom implementation perspectives.

The feasibility result is consistent with studies showing that virtual laboratories and digital simulations can reduce logistical burdens while maintaining meaningful practice opportunities under suitable instructional conditions (David et al., 2020; Dustman et al., 2021; Shambare & Simuja, 2021). The highest student response was found in the benefit for independent practice. This result indicates that the CPT-integrated materials helped students repeat configuration and troubleshooting activities without depending fully on physical device availability. This finding is relevant for schools where practice time is constrained by laboratory schedules, maintenance costs, or limited technical assistance (Aprilliantoni et al., 2024; Jasmine, 2023; S. Kumar & Kumar, 2023).

The lowest feasibility scores were found in the clarity of practical instructions and the alignment of scenarios with materials. Although both indicators remained feasible, they show that students still needed clearer step-by-step guidance and a more gradual progression from basic to complex tasks. This finding supports the need for balanced scaffolding. Beginners need structured guidance to build procedural knowledge, but excessive guidance may limit exploration and adaptive diagnostic reasoning (Dustman et al., 2021; Jonassen & Hung, 2006). Therefore, future revisions should provide tiered activities: guided configuration, partially guided troubleshooting, and open-ended diagnostic challenges.

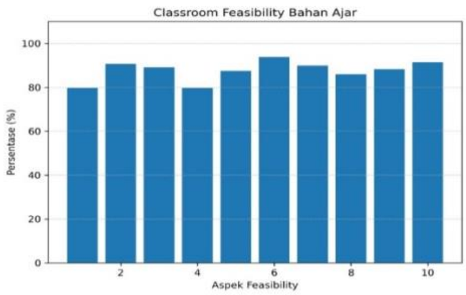

Figure 2. Percentage of Classroom Feasibility per Aspect; Teaching Materials are Highly Feasible to Use (87.97%)

3.3 Learning Effectiveness

Table 4. Summary of Pretest–Posttest, N-gain, and Inferential Statistics

Indicator	N	Pretest average	Posttest average	Gain average	N-gain average	Category	Paired t-test	Effect size
Learning outcomes	32	48.03	75.69	27.66	0.553	Moderate	t(31) = 22.542; p < 0.001	Cohen's dz = 3.985

The mean learning score increased from 48.03 on the pretest to 75.69 on the posttest, with an average gain of 27.66 points. The mean N-gain was 0.553, which falls in the moderate category. In addition, 23 of 32 students reached the mastery criterion after using the materials. The Shapiro–Wilk test showed that the paired difference scores were normally distributed, $W = 0.978$, $p = 0.749$. The paired-samples t-test indicated a statistically significant increase from pretest to posttest, $t(31) = 22.542$, $p < 0.001$. The effect size was very large, with Cohen's $dz = 3.985$.

The moderate N-gain can be interpreted in two ways. First, the improvement shows that the materials supported students in understanding basic network concepts and performing configuration procedures. This aligns with simulation learning theory, which emphasises the role of system representation, repeated practice, and feedback in building procedural and strategic knowledge (Jonassen, 2009; Jonassen & Hung, 2006). Second, the moderate gain indicates that the product has not yet produced high learning gains for all students, especially for more complex troubleshooting competence. Troubleshooting requires learners to identify symptoms, generate hypotheses, test possible causes, evaluate feedback, and revise strategies. These skills usually develop gradually and require repeated exposure to varied and ill-structured problems.

The statistical significance and large effect size show that the intervention produced a strong measurable difference between pretest and posttest. However, statistical significance should be interpreted together with the moderate N-gain. The large t-value reflects a consistent increase across paired student scores, whereas the N-gain category indicates that the level of normalized improvement was moderate. This means that the materials had a clear positive effect but still left room for strengthening deeper conceptual understanding, diagnostic reasoning, and transfer to real devices.

The results are consistent with literature that positions simulation as a powerful complement or partial substitute, rather than a complete replacement for physical laboratories. Simulation can strengthen conceptual understanding, topology design, configuration sequencing, and connectivity testing, but it does not fully reproduce cable handling, device failure, port damage, latency caused by physical conditions, or other field-based problems (Altmeyer et al., 2020; Shimba et al., 2016). Therefore, the phrase "virtual network laboratory substitute" in this study should be understood as a pedagogical substitute for scenario-based configuration and diagnosis practice, not as a total replacement for all real-device laboratory experiences.

From a transfer of learning perspective, CPT-based activities are most likely to transfer to real laboratory contexts when the scenarios, task goals, feedback, and assessment rubrics resemble authentic network work. Prior studies emphasise that authentic and competency-based scenarios increase the possibility of transferring skills to professional contexts (Ariffin et al., 2022; Lima et al., 2019; Viegas et al., 2018). In this study, the high validation and feasibility scores suggest that the product has a strong foundation for transfer. However, transfer to real devices was not directly measured. Therefore, the next stage should compare students' performance in CPT with their performance on physical routers, switches, cabling, and real-device troubleshooting tasks.

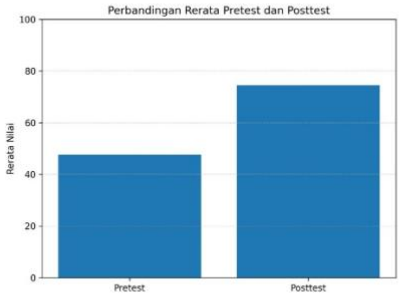

Figure 3. Comparison of the Pretest and Posttest Averages Shows an Increase in Learning Outcomes.
Theoretical and Practical Implications

Theoretically, this study supports the view that simulation-based learning is most effective when embedded in well-designed teaching materials. The findings show that CPT can function as a structured learning environment for system representation, procedural practice, and guided troubleshooting when it is supported by clear instructions, authentic scenarios, and assessment rubrics. The results also support the role of self-efficacy in simulation-based learning. When students perceive the tool as useful and manageable, they are more likely to repeat tasks, correct errors, and continue practising (Asadi et al., 2024). Feedback and self-reflection are also important because they help students connect configuration results with concepts and performance criteria (Achenbach & Schäfer, 2022).

Practically, the product provides a low-cost strategy for schools with limited network laboratory facilities. Schools can use CPT-integrated materials to increase practice frequency, reduce dependence on physical device availability, and support independent learning. This is important in contexts where funding, infrastructure, and resource management influence the quality of learning processes and graduate competence (Mubarak, 2023; Aprilliantoni et al., 2024; Yayuk & Sugiyono, 2019). The product can also support more adaptive school management by allowing teachers to combine virtual practice with limited physical laboratory sessions (Hasnadi, 2022; Waluyo et al., 2023). A hybrid model is recommended: CPT is used for concept formation, configuration rehearsal, and initial troubleshooting, while physical laboratories are used to validate skill transfer and expose students to real-device constraints.

3.4 Limitations and Future Development

This study has several limitations. First, implementation was conducted in a single school and one classroom context, so generalisation to other schools should be made cautiously. Infrastructure quality, organisational support, teacher competence, and student readiness may affect the feasibility of simulation-based learning (S. Kumar & Kumar, 2023; Waluyo et al., 2023). Second, the sample size was limited to 32 students, which reduces the strength of broader generalisation. Third, although the effectiveness analysis included N-gain, normality testing, paired-samples t-test, and effect size, the design did not include a control group. Fourth, transfer to real network devices was not formally evaluated, even though real-device validation is essential to confirm whether virtual practice produces practical laboratory competence (A. Kumar et al., 2019; Shimba et al., 2016). Fifth, the troubleshooting tasks still need greater complexity to represent ill-structured real-world network problems.

Future research should test the product in multiple schools with different infrastructure conditions, larger sample sizes, and varied teacher competencies. Further studies should use comparison groups or mixed-method designs, evaluate student performance using configuration and troubleshooting rubrics, and measure transfer from CPT-based practice to real network devices. Product development should also add more complex fault scenarios, adaptive feedback, and project-based tasks aligned with curriculum and industry needs (Chen, 2025; Safitri et al., 2024).

4. CONCLUSION

This study developed Cisco Packet Tracer-integrated teaching materials as a virtual network laboratory substitute using the 4D development model. The product was highly valid, with an average expert validation score of 87.50%. This result indicates that the materials were appropriate in terms of curriculum alignment, concept accuracy, usage guidelines, assessment rubrics, and integration with Cisco Packet Tracer. The product was also highly feasible for classroom implementation. Student feasibility responses reached 87.97%, teacher responses reached 90.63%, and implementation observation reached 90.00%. These findings show that the materials were accessible, useful for independent practice, and supportive of scenario-based troubleshooting in a classroom with limited access to physical networking equipment. Learning outcomes improved from a pretest average of 48.03 to a posttest average of 75.69, with an N-gain of 0.553 in the moderate category. The paired-samples t-test showed a significant improvement, $t(31) = 22.542$, $p < 0.001$, with a very large effect size, $dz = 3.985$. These results indicate that the materials produced a meaningful improvement in students' network learning outcomes.

The main contribution of this study is a validated and classroom-feasible model of simulation-integrated teaching materials for schools with limited physical network laboratories. Practically, the product can expand students' opportunities for repeated configuration and troubleshooting practice at a lower cost. Theoretically, the study supports the importance of structured scenarios, scaffolding, feedback, and assessment rubrics in simulation-based network learning. The study is limited by its single-site implementation, limited sample size, absence of a control group, and lack of real-device skill transfer validation. Future research should conduct multi-site testing, involve larger samples, include comparative experimental designs, and measure whether students can transfer CPT-based configuration and troubleshooting skills to physical network devices.

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Conflicts of Interest: The authors declare no conflict of interest.

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