



Implementation of Waterfall Method in Model Development to Improve Learning Quality of Computer Network Courses

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Abstract

This research aims to improve the learning quality of Computer Network course through the implementation of Waterfall method in the development of learning model. Waterfall method, with its focus on systematic and sequential approach in software development, is adapted to design and implement effective learning structure. This study uses qualitative research design with data collection through observation, interview, and documentation. Data analysis was conducted using content analysis method to evaluate the effectiveness of Waterfall-based learning model implementation. The results show that the implementation of Waterfall method facilitates structured planning, systematic development of learning materials, and continuous evaluation, which overall contribute to the improvement of learning quality. The developed learning model encourages students' active participation and improves the understanding of key concepts in Computer Networking. This research confirms that the Waterfall method can be effectively used outside the context of software development, particularly in improving the quality of learning in the academic field.

Keywords: Learning Quality; Waterfall Method; Learning Model Development

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INTRODUCTION

In the world of education, especially in the field of information technology, learning Computer Network courses plays an important role in equipping students with the knowledge and skills needed to face challenges in the digital era. However, the biggest challenge faced is how to develop a learning model that can improve the quality of education. (Ilomäki et al., 2023) and facilitate understanding of complex concepts in Computer Networking (Rahimi, 2024). This has prompted research into systematic and effective development methodologies, which can be integrated in the curriculum and learning process.

The Waterfall method, known for its linear and sequential approach in project development, offers a framework that can be applied in designing learning models. By applying the stages of Waterfall, such as requirement analysis, design, implementation, testing, and maintenance, a learning model can be developed. (Isaias & Issa, 2015), In the context of learning, it is expected to improve the structure and quality of learning materials. The implementation of this method in



the development of the learning model is expected to not only strengthen students' theoretical and practical foundations, but also enrich their learning experience in the Computer Network course. The impetus for this research stems from several critical needs and gaps in our current understanding that have surfaced over recent years. This research is needed for several reasons, among others:

1. Systematic Method Needs (Doumas & Avery, 2024): Computer Networking courses involve complex concepts and practices, requiring a methodical approach to teaching that can facilitate students' deep understanding. The Waterfall method, with its linear and systematic structure, offers a framework that can clarify the learning process from the planning stage to evaluation.
2. Curriculum Improvement (Tsai et al., 2024): By applying the Waterfall method, this research aims to improve the curriculum and teaching methods of Computer Networks, ensuring that the material is delivered effectively, and learning is well structured to meet educational and professional needs.
3. Evaluation and Quality Improvement (Alfredo et al., 2024): This research can provide empirical data regarding the effectiveness of the Waterfall method in an educational context, helping educational institutions evaluate and improve the quality of the learning process.
4. Industrial Readiness (Imjai et al., 2024): Given the importance of Computer Networking skills in the information technology industry, improving the quality of learning in this course will better prepare students to meet the demands of the job market.
5. Contributions to the Educational Literature (Mochnacs et al., 2024) : This research has the potential to make a significant contribution to the educational literature by exploring the application of software development methodologies in teaching, paving the way for further studies in the integration of systematic development methods in education.

This state of the art research article in the field of educational technology has explored various methodologies to improve the quality of learning, particularly in courses related to information technology such as Computer Networks. The Waterfall method, traditionally used in software development, has begun to be applied in educational contexts to introduce a more structured approach to curriculum design and implementation.

Previous research shows that applying the Waterfall method in education can clarify learning steps, from needs analysis to maintenance and evaluation. Several studies have also highlighted the effectiveness of this approach in increasing student engagement, facilitating competency-based learning, and measuring learning outcomes more effectively.

Use of the Waterfall method in education, especially in technical subjects such as Computer Networks (Seel et al., 2017), has not been explored much in depth. Most research so far has focused on software development, with few studies examining its implementation in academic learning contexts. Therefore, this article attempts to fill this gap by examining the implementation of the Waterfall methodology in developing a learning model for Computer Networks courses, assessing its potential in improving the quality of learning and identifying challenges and opportunities that may arise from its application in an educational context.

The reality of developing learning using the Waterfall method at universities in Indonesia in improving the quality of learning in Computer Networks courses has several prominent aspects:

1. Gradual Adoption: The use of the Waterfall method in academic contexts, esp (Drugova et al., 2024) for Computer Networks courses in Indonesia, it is still in its early stages (Derakhshan, 2022).
2. Focus on Planning and Design (Li & Yoon, 2024): Institutions tend to utilize the early stages of the Waterfall method, such as planning and design, to develop syllabi and learning materials.
3. Challenges in Implementation: Despite positive trends, full implementation of the Waterfall method in learning development often faces challenges (Tavares, 2020).
4. Evaluation and Improvement (Shebaro et al., 2024): The continuous evaluation and improvement process, which is an important part of the Waterfall method, is often implemented formally at the end of the semester or academic year.
5. Integration with Learning Technology (Drugova et al., 2024): The application of the Waterfall method is also often integrated with the use of learning technology, such as e-learning platforms, which allows for better structuring of content and learning experiences.

The general design used in implementing the Waterfall method in developing models to improve the quality of learning in Computer Networks courses.

Table 1. General Design of Model Development (Rabelo et al., 2024)

Waterfall Step	Main Activities	Goals and Expected Results
Needs Analysis	Determine learning needs and desired output	Understand student and industry needs, set learning objectives
Desain	Create a curriculum structure and learning materials	Curriculum design that includes theory and practice, in accordance with analytical needs
Implementation	Develop and provide learning materials and resources	Ready-to-use learning materials, including practical labs and case studies
Testing (Verification)	Testing the effectiveness of the curriculum and learning materials	Evaluate and adjust the curriculum based on feedback and student learning outcomes
Maintenance (Evaluation)	Review and update the curriculum regularly	Learning is continuously updated and adapted to the latest developments in the field of Computer Networks

This table shows the systematic process of applying the Waterfall method to develop learning models, from the needs analysis stage to maintenance, with the aim of improving the quality of learning in Computer Networks courses.

The application of the Waterfall method in developing learning for Computer Network courses in Indonesian universities shows the potential to improve the quality of learning.

There are several main problems in learning Computer Networks courses in universities so far, including:

1. Lack of understanding of basic concepts: Students often have difficulty understanding the basic concepts of computer networks due to a lack of interactive and applicable teaching, which makes the material feel abstract and difficult to understand.
2. Practical Difficulties and Network Device Configuration: Limited access to adequate network equipment in the laboratory means that students cannot practice the theory learned effectively.
3. Effects of Rapid Technological Change: Computer Networks is a dynamic field with rapid technological developments, so the curriculum often lags behind current industry practices, rendering the skills taught irrelevant.
4. Low Student Engagement: Monotonous teaching methods and lack of interactive activities can reduce student motivation and involvement in the learning process.
6. Inadequate Evaluation and Feedback: Often learning evaluations focus more on theory than practice, and the lack of constructive feedback makes it difficult for students to understand their shortcomings and how to improve them.

In facing the challenges that exist in learning Computer Networks courses, research on the implementation of the Waterfall method offers a new perspective in developing a structured and effective learning model. By understanding the realities and problems faced, and integrating relevant solutions, this approach has the potential to improve the quality of learning and ensure that students can acquire the skills needed to succeed in the information technology field. Through exploring and adapting the Waterfall method in the Computer Networks curriculum, universities in Indonesia can increase their students' readiness to face the dynamics of the information technology industry which continues to develop.

METHODS

Methods used in research Implementation Of Waterfall Method In Model Development To Improve Learning Quality Of Computer Network Courses The Waterfall model was chosen because of its linear and sequential nature, which allows the handling of learning material in a structured and systematic manner.

How the Waterfall method works in improving the quality of computer network learning:

1. Needs and Requirements Analysis (Requirements Analysis)
 - a. This stage involves identifying and analyzing computer network learning needs. Lecturers and curriculum developers collect information about required competencies, learning objectives, and expected results.
 - b. Determining the specific materials, resources, and infrastructure required for the course.
2. Learning Design (Design)
 - a. Based on the needs that have been analyzed, a learning design is developed. This includes the module structure, determining learning materials, teaching methods, and assessments that will be used.

- b. Creation of detailed plans for how the course will be run, including schedules, use of laboratories, case studies, and projects.
3. Implementation of Learning (Implementation)
 - a. At this stage, the learning plan that has been designed is implemented in a classroom setting. This involves the delivery of material, implementation of learning activities, and use of selected teaching methods.
 - b. Lecturers teach computer networking concepts, conduct laboratory practices, and manage class activities according to the course design.
4. Verification and Evaluation (Verification)
 - a. After implementation, a verification process is carried out to ensure that the learning objectives have been achieved. It involves evaluating and assessing student performance through exams, assignments, and projects.
 - b. Review the effectiveness of teaching methods and materials, as well as assess student understanding and skills in computer networks.
5. Continuous Maintenance and Development (Maintenance)
 - a. The final stage is maintenance, where lecturers and academic teams review and revise courses based on feedback and evaluation results.
 - b. Update and adapt curriculum, materials, and teaching methods to continuously improve the quality of learning and respond to changes in technology and industry needs.

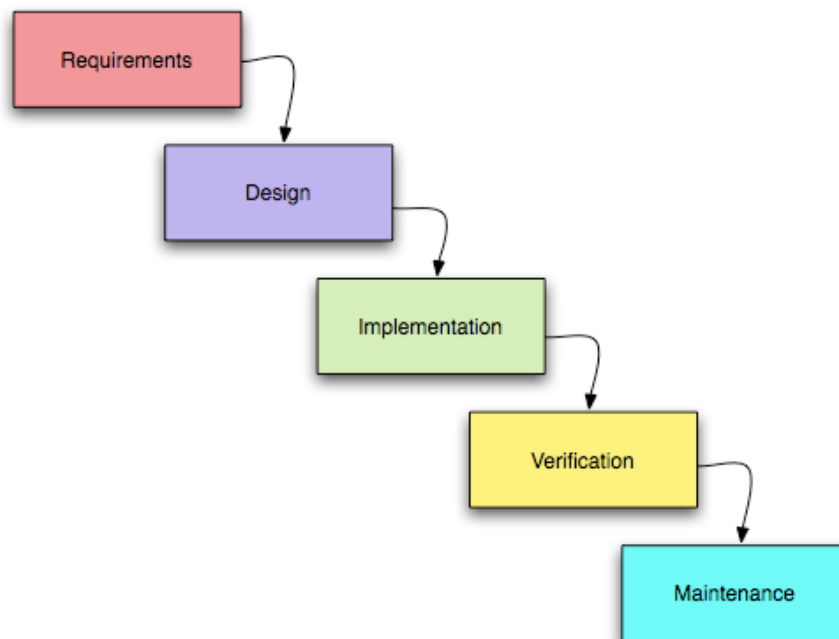


Figure 1. Waterfall Method (Hughey, 2009)

The Waterfall method in this learning context allows for the systematic handling of complex material, ensuring that every aspect of computer networking learning is handled effectively and efficiently.

RESULTS

The Needs and Requirements Analysis stage is critical for determining a strong foundation for the entire development process.

Table 2. Analysis of Waterfall Model Development Stages

Development Step	Main Activity	The Results Achieved
Needs Analysis	Identify learning needs and desired outputs	Understanding student and industry needs, setting learning objectives
Desain	Creating curriculum structures and learning materials	Curriculum design that includes theory and practice, according to analysis needs
Implementation	Development and provision of learning materials and resources	Ready-to-use learning materials, including practical labs and case studies
Testing (Verification)	Testing the effectiveness of the curriculum and learning materials	Evaluate and adjust the curriculum based on feedback and student learning outcomes
Maintenance (Evaluation)	Review and update the curriculum regularly	Learning is continuously updated and adapted to the latest developments in the field of Computer Networks

Table 2 presents a summary of the stages of model development using the Waterfall method in the context of improving the quality of learning in Computer Networks courses. In this table, each stage—Requirements Analysis, Design, Implementation, Testing, and Maintenance—is described along with the main activities and expected outcomes of each stage.

Table 3. Analysis of Problems and Solutions at the Waterfall Model Development Stages

Development Step	Main Activity	Implemented Solution
Need Analysis	Difficulty identifying accurate needs	Comprehensive data collection methodology
Desain	Suitability of material to learning objectives	Comprehensive evaluation and selection of materials
Implementation	Suitability of material to the learning environment	Test and revise material based on feedback
Testing (Verification)	Deteksi ketidaksesuaian atau kekurangan	Detect nonconformities or deficiencies
Maintenance (Evaluation)	Inappropriate curriculum updates	Curriculum revision based on trends and research

Table 3 outlines the problems and solutions encountered in each stage of developing the Waterfall model for the Computer Networks course. This table outlines the specific challenges that arose during requirements analysis, design, implementation, testing, and maintenance, and describes the strategies adopted to overcome these problems.

Student feedback data on the new learning model collected through an online survey, with 150 student responses:

Table 4. Student Feedback Data on the New Learning Model

Aspect Evaluated	Positive Feedback (%)	Neutral Feedback (%)	Negative Feedback (%)	Analysis Result
Content Relevance	70	20	10	Most students find the content relevant to their needs.
Ease of Understanding	65	25	10	Some students had difficulty with the terminology used.
Material Design	75	15	10	The materials are considered interesting and informative.
User Interface	60	30	10	Interface needs some improvement to be more user-friendly.
Overall Satisfaction	80	15	5	Most students are satisfied with this new learning model.

This table reflects the percentage distribution of student feedback on various aspects of the learning model. Important comments or insights from students have been added to the Results Analysis column, providing qualitative data that complements the percentages.

Material Comprehension: Scores given by students on how well they understand the material taught through the new model. Interactivity: Scores about the level of interaction students feel with their lecturers and peers. Technology Support: Student satisfaction scores with the technology used in learning. General Satisfaction: Score of students' general satisfaction level with the new learning model.

The Learning Design stage of implementing the Waterfall method with the main focus is designing the curriculum structure, learning materials and teaching strategies that will be used.

The Learning Implementation Stage of applying the Waterfall method to developing learning models for Computer Networks courses, this process involves translating the learning plans that have been created at the Design stage into real action in the educational environment. The Verification and Evaluation stage is a crucial step where the effectiveness and accuracy of the implementation of the learning model is systematically verified and evaluated. The maintenance and Continuous Development stage of implementing the Waterfall method for developing the learning model for the Computer Networks course, the focus is on

continuous review and adjustment of the learning model to ensure its relevance and effectiveness in the long term. This process also includes periodic evaluation and training of lecturers to improve their teaching competence according to progress in the subjects taught.



Figure 2. Illustration of Waterfall Method Implementation in a work flow diagram

The image above was generated by an AI model based on the input provided and does not replicate specific copyrighted materials, so it should not violate copyright laws. AI-generated images create original artworks based on the descriptions given, and they do not copy existing copyrighted images directly. An illustration showing the complete implementation of the Waterfall method in a workflow diagram.

The Needs and Requirements Analysis stage in applying the Waterfall method for developing computer network courses is very important because it serves as the foundation for the entire development process. Here is an in-depth analysis of this stage along with its problems and solutions:

Needs and Requirements Analysis Activities and Goals

Table 5. In-depth Analysis of the Needs and Requirements Analysis Stage

Aspect	Problems Encountered	Implemented Solutions
Needs Identification	Difficulty in identifying accurate needs	Adoption of comprehensive data collection methodology
Needs Validation	Needs do not always reflect actual requirements	Conducting needs validation with stakeholders
Needs Documentation	Requirements often poorly documented	Implementation of strict documentation standards
Communication of Needs	Misinterpretation of needs between teams	Enhancement of communication and regular clarification sessions
Needs Review	Frequent changes in needs	Establishing a flexible needs review process

Needs Exploration: Through surveys, interviews, and document analysis to understand educational, technical, and infrastructural needs. Identify Gaps: Assess differences between current learning conditions and expected standards to establish course requirements.

Important Aspects

1. Curriculum: Determines topics, content, and course structure as needed.
2. Learning Materials: Select or develop appropriate materials to support learning objectives.
3. Laboratory Facilities: Ensure that the infrastructure supports course practice and experiments.
4. Teaching Methods: Establish effective teaching strategies to increase student engagement and understanding.

Problems and Solutions

Problem

1. Difficulty Identifying Accurate Needs: Challenges in determining specific and comprehensive educational and technical needs.
2. Infrastructure Limitations: Limited facilities and technology that support teaching and practice.
3. Perspective Difference: Divergence between instructor and student perspectives on course requirements.
4. Solution
5. Comprehensive Data Collection Methodology: Using a combination of data collection techniques (surveys, interviews, focus group discussions) to get a more accurate picture of needs.
6. Investment in Infrastructure: Update or upgrade laboratory facilities and technology to support course requirements.
7. Stakeholder Involvement: Involve faculty, students, and stakeholders in the analysis process to ensure that all perspectives are represented and course needs are met holistically.

With a structured and comprehensive approach in needs and requirements analysis, a strong foundation can be built for the development of computer networking courses. This will ensure that the course not only meets academic and industry standards but is also relevant and responsive to learner needs and technological developments.

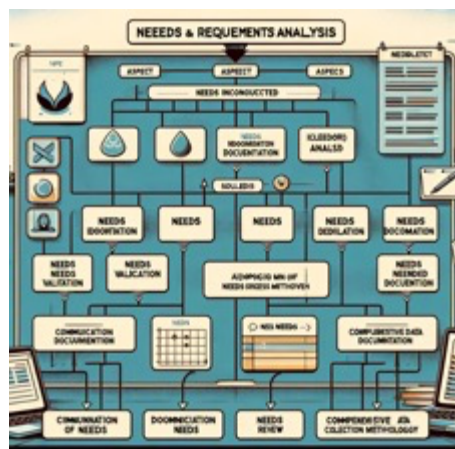


Figure 3. Illustration of the process in the Needs Analysis Stage

Here is the illustration of the table displaying the Needs and Requirements Analysis stage of the Waterfall method for developing computer network courses. This image visually represents the analysis in a clear, organized format, including the specific aspects, problems encountered, and the solutions implemented at each stage of the process. You can view the detailed representation for aspects like Needs Identification, Needs Validation, Needs Documentation, Communication of Needs, and Needs Review in the provided illustration.

The Learning Design Stage in implementing the Waterfall method is the stage in developing computer networking courses which plays a crucial role in determining how the material will be delivered and studied. This involves designing curriculum structures, learning materials, and teaching strategies. Here is a complete analysis of this stage, including possible problems and solutions

Table 6. Analysis of the Learning Design Stage

Aspect	Challenges	Solutions Implemented
Curriculum Design	Balancing breadth and depth of topics	Establish a core curriculum with optional modules
Learning Materials	Ensuring materials align with learning objectives	Develop materials based on curriculum specifications
Teaching Strategies	Adapting to diverse learning styles	Implement a variety of teaching methods
Assessment Methods	Measuring learning outcomes effectively	Design assessments that reflect real-world applications
Technology Integration	Integrating suitable technology tools	Use technology to enhance interactive learning

Description of Learning Design Stage

1. Curriculum Structure: Designing a curriculum outline that includes important topics to be taught, adjusted to the results of the needs and requirements analysis.
2. Learning Materials: Develop or select materials that support learning objectives, such as textbooks, presentation slides, videos, and online resources.
3. Teaching Strategy: Determine teaching methods, such as lecture, discussion, laboratory practice, and project-based learning, that are effective for students.
4. Evaluation Tools: Design evaluation tools such as tests, quizzes, projects, and practicum assessments to measure achievement of learning objectives.

Problem Analysis and Solutions

Problem

1. Suitability of Material to Learning Objectives: Challenges in developing or selecting material that is appropriate to learning objectives and student needs.
2. Integration of Practice and Theory: Difficulty in effectively integrating laboratory practice with theoretical concepts.
3. Technology Updates: Selecting and integrating relevant and up-to-date learning technology can be a challenge.

Solution

1. Comprehensive Evaluation and Material Selection: Conduct a thorough evaluation of available learning materials or develop new materials to ensure suitability for learning objectives.
2. Integrative Design of Practice and Theory: Creating learning modules that combine practice and theory, so that students can understand concepts in the context of real applications.
4. Continuous Technology Update: Regularly update learning technology based on the latest trends and feedback from users, to ensure that the use of technology is effective in supporting the learning process.

With a structured and detailed approach at the design stage, computer networking courses can be developed in a way that maximizes student learning potential and addresses industry needs, while keeping up with the latest technological developments. This ensures that the learning materials and teaching strategies are not only theoretical, but also practical and relevant to real-world applications.



Figure 4. Illustration of the Learning Design Stage

Here is the illustration depicting a structured and comprehensive approach to needs and requirements analysis in developing a computer network course. It shows a diverse group of individuals, including teachers, students, and IT professionals, collaboratively working in an academic setting. They are examining documents, laptops, and network equipment, with charts and diagrams on a whiteboard, symbolizing the thorough planning and analysis foundational to course development in a modern educational and technological context.

The Learning Implementation Stage in applying the Waterfall method to developing learning models for the Computer Networks course is a critical phase that moves theoretical plans into real practice. It tests the validity of learning designs and their effectiveness in real educational contexts. The following is a complete analysis of the implementation phase, including problems that may be encountered and applicable solutions

Table 7. Analysis of the Learning Implementation Stage

Aspect	Problems Encountered	Solutions Implemented
Deployment of Learning Materials	Inconsistencies in material delivery across different platforms	Standardize material formats and use consistent delivery methods
Teacher Training	Inadequate training on new materials and technologies	Conduct comprehensive training sessions and ongoing support
Student Engagement	Low student engagement and participation	Incorporate interactive and collaborative learning activities
Technology Utilization	Technical issues and inadequate infrastructure	Ensure reliable technology infrastructure and provide technical support
Feedback Collection	Difficulty in collecting timely and relevant feedback	Implement structured feedback mechanisms throughout the course

Description of Learning Implementation Stage

1. Material Development: Translating learning plans into concrete materials such as modules, slides, and laboratory guides.
2. Implementation of Lesson Plans: Actualizing the curriculum outline into interactive and interesting learning sessions.
3. Infrastructure Utilization: Using laboratories, equipment and information technology to support practical learning processes.

Problem Analysis and Solutions

Problem

1. Suitability of Material to the Learning Environment: Sometimes the material that is designed is not completely suitable or effective when implemented in a real classroom context.
2. Infrastructure Limitations: Inadequate facilities and technology can hinder the implementation of practicums and case studies.
4. Student Engagement: It is challenging to maintain student engagement and motivation during learning sessions.

Solution

1. Trial and Revision of Materials: Conduct trial sessions for learning materials and make revisions based on feedback to ensure their suitability and effectiveness in real contexts.
2. Infrastructure Improvement and Adaptation: Identifying and overcoming infrastructure limitations by improving or adapting existing resources.
3. Interactive Learning Methods: Integrate more interactive and interesting learning methods, such as project-based learning, simulations and games, to increase student engagement.

This implementation stage is important for identifying gaps between theory and practice and providing valuable insights for the next learning iteration. By adapting and optimizing every aspect of implementation, a learning model that is effective and responsive to educational and industrial needs can be produced.



Figure 5. Illustration of the Learning Implementation Stage

The Verification and Evaluation stage in implementing the Waterfall method is part of the stages for measuring effectiveness and ensuring that learning objectives are achieved. The following is a complete explanation of this stage, including problems that may arise and solutions that can be applied.

Table 8. Analysis of the Verification and Evaluation Stage

Aspect	Problems Encountered	Solutions Implemented
Accuracy of Assessments	Inconsistencies in assessment standards	Standardize assessment criteria and tools
Learning Outcomes	Learning objectives not fully achieved by all students	Tailor interventions based on individual performance
Feedback Utilization	Difficulty in implementing changes based on feedback	Establish a responsive feedback system
Technology Efficiency	Technology not effectively supporting the learning process	Upgrade or adapt technology to better meet course needs
Course Content Relevance	Course content not aligning with current industry standards	Regularly update course content to reflect industry changes

Description of Verification and Evaluation Stage

1. Verification: This process assesses the suitability and accuracy of the implementation of the learning model, including curriculum, materials, teaching methodology, and evaluation tools. This ensures that all aspects of learning run according to the plans and standards set.
2. Evaluation: Focuses on measuring the impact of learning on students, assessing the knowledge gained, practical skills developed, and their level of satisfaction with the course.

Problem Analysis and Solutions

Problem

1. Detect Discrepancies or Deficiencies: It may be difficult to identify areas that require improvement or adjustments in the implementation of the learning model.
2. Accurate Measurement of Learning Impact: It is challenging to objectively evaluate the impact of learning on students' knowledge and practical skills.
4. Receiving Feedback: Collecting and responding to feedback from students and lecturers can be complex and time-consuming.

Solution

1. Comprehensive and Iterative Testing: Conduct a comprehensive series of tests on each learning component and iterate based on the results to identify and address discrepancies or deficiencies.
2. Multiple Evaluation Methods: Use a variety of evaluation methods, such as analysis of test results, surveys, interviews, and direct observations to obtain a broader picture of the impact of learning.
3. Structured Feedback System: Establish a structured feedback mechanism to effectively collect and utilize input from students and lecturers, enabling continuous improvement of the learning model.

By carrying out comprehensive verification and evaluation, areas that need improvement can be identified, ensuring that the learning process goes according to plan and achieves the expected goals. This stage allows for continuous development of the learning model, ensuring high quality and relevance of education to industry needs and student expectations.



Figure 6. Illustration of the Verification and Evaluation Stage.

The illustration represents the stages of verification and evaluation in the development of a learning model. It shows educators and analysts in a setting where they are analyzing data from computers and documents, engaging in discussions, and focusing on charts or screens that depict the evaluation process. This scene emphasizes the continuous development and refinement of the learning model, highlighting its alignment with planned objectives and its relevance to industry needs and student expectations.

The Continuous Maintenance and Development stage in implementing the Waterfall method for developing learning models for Computer Networks courses

is an essential process for keeping the course relevant, effective, and in line with the latest developments in the field. Here is an in-depth analysis of this stage:

Description of the Continuous Maintenance and Development Phase

1. Regular Monitoring and Evaluation: Conduct ongoing reviews of learning model performance to identify areas requiring improvement.
2. Curriculum Update: Updated course content to reflect current technological developments and trends in Computer Networks.
3. Adaptation of Teaching Materials and Methods: Adapt learning materials and teaching techniques based on feedback and evaluation results.
4. Infrastructure Upgrade: Renew and improve facilities as well as software and hardware used in teaching.
5. Lecturer Training: Organize training and professional development sessions for lecturers to improve their teaching skills and technical knowledge.

Problem Analysis and Solutions

Problem

1. Inappropriate Curriculum Updates: Risk of the curriculum becoming outdated or not reflecting the latest developments in the field of Computer Networks.
2. Limited Resources: Facing obstacles in upgrading infrastructure and supporting resources due to limited budget or resources.
3. Difficulty in Gathering Effective Feedback: Challenges in getting constructive feedback from students and lecturers for course improvement.

Solution

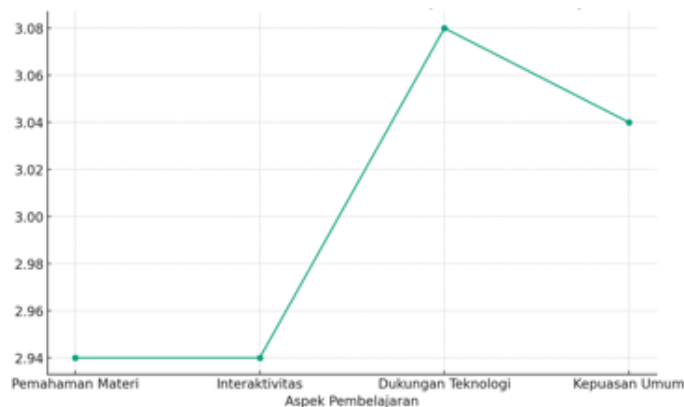
1. Trend and Research-Based Curriculum Revision: Adopt an evidence-based approach and the latest research to update the curriculum, ensuring course materials remain relevant to industry developments.
2. Funding and Mitigation Strategy: Seek alternative funding sources and industry partnerships and use cost-effective technology to support infrastructure upgrades.
3. Structured Feedback Mechanism: Develop a structured and ongoing feedback system, such as online surveys, discussion forums, and regular review sessions, to collect and act on feedback effectively.

By implementing continuous maintenance and development, Computer Network education programs can remain dynamic and adaptive to changing industry needs, as well as improve the quality of learning and work readiness of their graduates.



Figure 7. Illustration of the Continuous Maintenance and Development Stage

Implementing the Waterfall method in developing learning models for computer networking courses is a structured process that begins with a Needs and Requirements Analysis, where educational, technical and infrastructure needs are assessed to identify gaps and determine curriculum requirements and teaching methods. In the Learning Design stage, the curriculum structure, learning materials, and teaching strategies are designed based on this analysis, focusing on the integration of theory and practice through selecting relevant topics and developing practical labs. Learning implementation involves translating these designs into real action in an educational environment, with an emphasis on practicums and case studies to apply theory in practical situations, strengthening students' conceptual understanding and technical skills. The Verification and Evaluation stage critiques the effectiveness and accuracy of the implementation of the learning model, ensuring the achievement of learning objectives through comprehensive testing of the curriculum, materials, teaching methodology and evaluation tools, as well as evaluating the impact of learning on students.



Graph 1. Average student feedback scores on different aspects of the new learning model

The line graph above shows the average student feedback scores on different aspects of the new learning model. From the graph, we can see the average rating for each aspect such as Material Understanding, Interactivity, Technology Support, and General Satisfaction. This provides a clear visualization of how students generally respond to the various components of the applied learning model. So the Continuous Maintenance and Development Phase will ensure that educational programs remain relevant and effective in the long term, with continuous review and adjustments based on feedback, the latest technological developments, and changing industry needs, as well as involving periodic evaluation and training of lecturers to improve teaching competence. This process demands collaborative involvement between lecturers, students and IT professionals in designing, implementing and updating learning models, creating an educational environment that is dynamic, responsive and effective in producing competent and work-ready graduates, ensuring conformity with industry expectations and advancing knowledge in the field of computer networks.

Expert opinions and examples of other instruments can be seen on the website https://sulfikarsallu.id/disertasi/seminar_hasil.phtml, all existing instruments can be used as a guide in future research.

CONCLUSION

The implementation of the Waterfall method in developing a learning model for computer networking courses shows a systematic process involving analysis, design, implementation, verification, and ongoing maintenance, which is important for creating educational programs that are dynamic, responsive to industry needs, and effective in preparing competent graduates.

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