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Development and Implementation of a Web-Based Management Information System for Enhancing Computer Programming Training in Education

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ABSTRACT

In the current era of information technology, web-based training systems are critical for enhancing the efficiency of training processes. This study focuses on the development of a Management Information System (MIS) tailored for computer programming training, utilizing a web-based training (WBT) platform. The primary objective is to introduce a framework for a web-based MIS that optimizes the management and delivery of computer programming courses. Computer programming education presents unique challenges, such as real-time participant tracking and dynamic content management, which are addressed by this MIS. The system was developed using the waterfall model, with data collected through interviews, observations, and requirements analysis. Key features include training schedule management, participant tracking, material organization, session management, evaluation tools, and reporting capabilities. Real-time feedback enhances participant engagement, while session management improves the overall learning experience. The web-based platform offers flexible access and simplifies the management of training processes, enabling users to track schedules, access materials, and monitor progress. Validation results show a high validity score (V = 0.883), exceeding the required threshold, and the materials received a validity score of 0.864, confirming their suitability for basic programming competency training at Medan State University. These results demonstrate the system's effectiveness and potential for wider application, making it a valuable tool for improving the management and delivery of programming courses across various educational contexts.

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1. INTRODUCTION

The growing demand for skilled computer programmers highlights the need for effective training systems to meet this demand (Alwy & Baso, 2022). Given the central role of information technology in various aspects of life and business, computer programming training is crucial for human resource development. To address the challenges in managing, implementing, and evaluating computer programming training, a Training Management Information System (TMIS) offers an effective solution. TMIS is specifically designed to streamline and optimize this process, with features that include training

schedule management, participant tracking, and performance evaluation, thereby facilitating administration and enhancing training quality.

As information technology continues to evolve, it has significantly transformed how participants access and receive training. In this context, Web-Based Training (WBT) platforms have emerged as a highly relevant solution, enabling accessible and flexible training from anywhere. Consequently, the development of a web-based TMIS for computer programming training integrates the benefits of WBT, further enhancing the efficiency, effectiveness, and quality of training (Sitio et al., 2023). This integration not only addresses the need for effective training systems but also leverages the latest advancements in technology to improve the overall training experience.

Previous studies have highlighted the success of web-based TMIS in various training areas, including computer programming. For instance, the effectiveness of online-based learning in improving student achievement, particularly in Java programming, has been shown to surpass traditional classroom learning (Nordin, 2021). Additionally, research indicates that web technology can deliver training content quickly and effectively (Haleem et al., 2022). However, it is important to critically assess the existing literature. While these studies demonstrate the advantages of web-based TMIS, they also reveal limitations. For example, some systems may lack the flexibility to adapt to different learning styles or fail to provide adequate real-time feedback. Our study addresses these gaps by focusing on the development of a web-based TMIS that not only incorporates features such as enhanced participant tracking and performance evaluation but also aims to overcome the limitations identified in current systems. This approach underscores the potential for developing a more effective and adaptable web-based TMIS for computer programming training.

Department of Electrical Engineering, State University of Medan, emphasizes programming skill development. One of the program's goals is to prepare graduates for professional employment in computer technology, particularly in computer programming. To achieve this, students must be proficient in various programming domains, including computer programming, object-oriented programming, web programming, algorithms and data structures, and mobile programming. Proficiency in multiple programming languages is a prerequisite for students pursuing careers in information technology and computer science. In the Age of Revolution 4.0, graduates with computer programming skills meet the growing demand for skilled human resources (Dalimunthe & Syahputra, 2023).

The Fourth Industrial Revolution has profoundly transformed human lifestyles through advancements in computer and machine technologies, leading to a significant shift towards digitalization (Harahap & Rafika, 2020). This era, often referred to as "Industrial Revolution 4.0," has heightened the demand for skilled human resources proficient in programming to effectively implement technologies such as the Internet of Things (IoT) and other smart systems (Fairuzzabadi et al., 2021).

In response to this increasing demand for programming skills, developing a web-based Training Management Information System (TMIS) becomes crucial. A web-based TMIS can provide a scalable and adaptable solution for training programs, ensuring that individuals acquire the necessary skills efficiently and effectively in alignment with the rapidly evolving technological landscape. This approach not only addresses the growing need for programming expertise but also leverages the benefits of digitalization to enhance training delivery and management.

Graduates of the Department of Electrical Engineering at the State University of Medan are expected to have strong competencies in computer programming. To develop these competencies, various initiatives have been undertaken, including offering additional training outside regular lecture hours. This training is designed to be conducted interactively over the internet, known as web-based training. This approach not only facilitates the delivery of training materials but also supports practical training activities. Despite these efforts, there remains a gap in Training Management Information System (TMIS) solutions specifically designed for programming education.

Existing TMIS solutions often lack customization for the unique needs of computer programming training and may not fully address the practical aspects of web-based training delivery. Previous research has demonstrated the feasibility and acceptance of web-based training media (Dalimunthe & Syahputra,

2023), but there is still a need for a more specialized TMIS that can enhance the management and effectiveness of programming training. This study aims to fill this gap by developing a web-based TMIS tailored to the specific needs of programming education, thereby improving both the training process and outcomes.

Web-based training is an innovative approach to distance learning that uses Internet or intranet technologies to deliver training materials (Hefter, 2021). This approach enables the presentation of live content in a structured format that supports independent learning on various topics. Web-based training can be developed using network technologies, allowing educational content to be delivered via a web browser over the public Internet, private intranet, or extranet. This method often includes links to additional resources, such as emails, bulletin boards, and discussion groups. It may also feature facilitators who provide course guidelines, manage discussions, and deliver lectures, combining the benefits of instructor-led and computer-based training.

One of the critical components of this training model is the computer network (Ekwonwune & Edebatu, 2019). Through computer networks, it is possible to develop web-based e-learning platforms, particularly web-based training systems. This approach enables the real-time, interactive delivery of training information and provides activities similar to those found in traditional training settings. Building on previous efforts to advance web-based training media, this research focuses on creating a Training Management Information System (TMIS) utilizing a web-based training platform.

The developed system aims to establish a structured training process specifically designed to produce competent computer programmers. The primary objectives of this research are to design, implement, and evaluate the TMIS's feasibility and effectiveness within the context of computer programming training. By addressing the gaps found in existing TMIS solutions for programming education, this study seeks to contribute to the field by enhancing the management and quality of web-based programming training.

2. METHODS

The waterfall development method is used to create a web-based training management information system (TMIS) for computer programming in this study. This approach enables a structured, sequential, and measurable development process (Herawati et al., 2021; Sastradipraja et al., 2020). The waterfall method consists of clear steps from planning to implementation, allowing developers to thoroughly understand system requirements and ensure that the system functions according to specifications before deployment (Tjahjanto et al., 2022). Consequently, this method can produce more reliable development outcomes and effectively meet the needs of computer programming training.

2.1. System Development Stage

The waterfall method involves a series of sequential steps in software development: analysis, design, code implementation, testing, and maintenance. The development process in this study can be summarized as follows:

2.1.1 Requirement Analysis

In the analysis stage, the goal is to understand both the system's limitations and user expectations. The collected information is examined to gather the data required for system development (Azmi et al., 2023). For developing a training management system, the needs analysis can be described as follows: The learning process has a short duration; theory and practice are condensed into just two credits, which may not be enough for comprehensive learning. Student competency reveals that basic programming concepts have not yet fully met the desired outcomes. Additionally, there are limitations in facilities and infrastructure, including restricted access to supporting devices (computers) in practical laboratories.

2.1.2 System and Software Design

After the needs analysis is carried out, the next step is to create a conceptual design of the training management system, which will be based on previously defined specifications. In the context of software, a comprehensive system design will be prepared, covering key aspects such as system architecture, intuitive user interface, efficient database structure, and optimal workflow. With this mature design, developers will have a strong foundation to start the implementation phase and produce a web-based training management system that suits computer programming needs. Additionally, this stage serves as the design phase, where the needs from the previous stage are defined. Figure 1 below shows the use case diagram included in this design system.

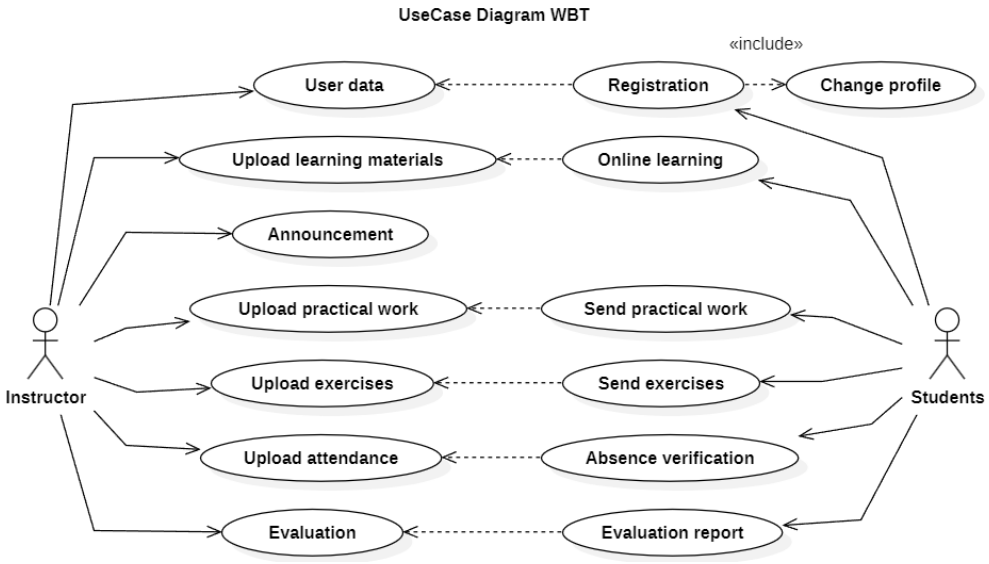

Figure 1. Usecase Diagram

2.1.3 Implementation and Unit Testing

At this point, the process of creating a web-based training management information system using a web programming language is underway. Every developed system component must be put into practice in accordance with its guidelines before moving on to the testing phase. During the system testing phase, the black box testing approach is used. Because it places less emphasis on the application's core logic structure (code), the Black Box Testing testing method was used (Mahendra & Asmarajaya, 2022). This phase of testing is carried out by the developer in addition to user testing.

2.1.4 Integration & System Testing

This crucial phase of the software development cycle involves the integration and extensive testing of the system's separate parts to guarantee that it operates in accordance with the goals and specifications set out. This phase is often completed prior to system implementation and subsequent unit testing.

2.1.5 Maintenance and Operations

The completed program will be used and kept up-to-date. Maintenance includes making corrections for mistakes that were missed in earlier stages. Enhancing system services and unit implementation in response to new requirements is a critical component of the software life cycle, which aims to maintain the system's optimal performance and ability to satisfy user needs. Updating software, applying security patches, and enhancing functionality are additional examples of maintenance that keeps a system competitive and relevant in a constantly evolving environment.

2.2. Sample and Population

This research was conducted at the Electrical Engineering Department, State University of Medan, from January to September 2023. Data were collected by selecting samples from the population using simple random sampling techniques. This method involved randomly choosing a number of students to ensure each participant had an equal chance of being included. The sample size of approximately 30 students was determined based on statistical considerations, including the need for adequate statistical power and confidence in the results. The chosen sample size was calculated to balance the trade-off between precision and feasibility, ensuring that the sample is representative of the population while providing sufficient data to assess the effectiveness of the TMIS. This approach helps ensure that the findings are statistically significant and relevant for evaluating the training management system.

2.3. Data Collection Techniques

In researching the training management system for students in the Department of Electrical Engineering, various data collection techniques can be utilized to gather the necessary information. One technique is the questionnaire, which involves creating a set of structured or open-ended questions to be distributed to students. This method helps collect data on students' preferences, needs, opinions, and satisfaction levels with their study program.

Another approach is the interview, where researchers engage in direct, one-on-one interactions with students to gain in-depth insights into their experiences, challenges, and suggestions. Observation is also used, which involves direct monitoring of student behavior and activity environments, which may reveal patterns or trends not captured through other methods. Additionally, document analysis involves reviewing relevant documents such as curricula, syllabi, academic records, and evaluation reports to obtain data about the study program's structure, policies, and historical developments. The selection of data collection techniques should align with the research objectives, questions, and available resources (Paradis et al., 2016).

2.4. Instruments

The main instruments used in this research were questionnaires in the form of validation sheets filled out by validators, as well as questionnaires regarding product practicality filled out by instructors and training participants. The questionnaire's preparation was adjusted to the needs and objectives of research data collection. The questionnaire results, which were received as qualitative data, were then converted into quantitative data using a Likert scale(Halevi Hochwald et al., 2023; Sözen & Güven, 2019), as shown in Table 1 below:

Table 1. Assessment of the questionnaire using a Likert scale

No.	Response Categories	Numerical Value
1	Strongly Agree	5
2	Agree	4
3	Neither/Nor Agree	3
4	Disagree	2
5	Strongly Disagree	1

The respondents' scores serve as preliminary data, which is analyzed to assess the viability and utility of the product under development.

2.5. Data Analysis

In this research on the training management system for students of the Electrical Engineering Study Program at the State University of Medan, the method used to analyze the data is descriptive analysis. This analysis provides an overview of the data gathered. Descriptive statistics like mean (average),

median, mode, standard deviation, and percentiles can be employed to summarize the collected data(Cooksey, 2020). Three assessment components comprise the validation instrument for the web-based training platform and training management information system utilized in this study: the visual communication, usability, and functionality aspects. Expert-given questionnaires (instruments) are used in data processing to analyze the validity of research products. After that, the data was examined using Aiken's V formula to get the content validity coefficient (V) (Nurjanah et al., 2023). The formula employed to calculate this data makes use of equation 1 below:

$$V = \frac{\sum S}{[n\,(c-1)]} \tag{1}$$

Where,

S = r – lo
S = Total number of validator scores
c = Highest validity value
lo = Lowest validity value
r = The value given by the validator

The V value's validity index is 0.677, which falls between 0 and 1. If the validity figure is greater than 0.677, which indicates a reasonably high coefficient, it can be considered valid. In the event that the coefficient number falls outside of this range, the product is considered void.

3. FINDINGS AND DISCUSSION

This section provides an overview of the system testing and performance analysis for the computer programming training system developed. It will detail the methodologies used, present the test results, and evaluate the system's functionality against the initial objectives. Each subsection will address specific aspects of the testing process, including system performance, validation results, and the effectiveness of training materials. The results of the system tests are linked directly to the initial study objectives, demonstrating how the successful operation of each feature supports the goals of the Training Management Information System (TMIS).

3.1. Implementation and System Test Results

The goal of system testing is to ensure that the Training Management Information System (TMIS) functions in accordance with established specifications, can be correctly utilized by instructors and trainees, and optimizes computer programming training management. Table 2 below outlines the steps for system testing, based on its implementation.

Table 2. System Testing Results for TMIS

No.	Test Type	Description	Results
1	Login Testing	Verifies the correct operation of login functionality, ensuring secure access, proper user authentication, role-based access control, session management, and secure logout processes.	All functionalities were tested successfully; users authenticated correctly; secure sessions were maintained, and the logout process was secure and reliable.
2	Schedule Management Testing	Ensures accurate creation, updating, viewing, and deletion of training schedules, proper handling of time and date, and management of notifications and schedule conflicts.	Schedules managed accurately; no overlaps detected; notifications sent successfully; system handled time/date correctly.

3	Testing Participant Registration	Confirms that participants can register correctly, validates input data, manages participant details and course registrations, and sends confirmation notifications.	Registration process smooth; input data validation successful; participant details managed correctly; confirmation notifications sent as expected.
4	Testing Management of Training Materials	Tests the system's ability to manage training materials, including uploading, updating, viewing, and organizing resources for instructors and trainees.	Training materials uploaded, updated, and organized without issues; resources accessible to authorized users.
5	Practical Testing	Evaluates the system's support for practical training sessions, including tracking participant progress, managing practical exercises, and providing feedback.	Practical sessions tracked accurately; participant progress monitored; feedback provided effectively; no issues encountered.
6	Reporting Testing Display	Assesses the accuracy and clarity of generated reports, including participant performance, attendance, and training outcomes.	Reports generated accurately; data displayed clearly; performance and attendance reports matched with system records.
7	Security and Error Testing	Ensures the system's security measures are robust, including data encryption, protection against unauthorized access, and proper error handling and logging mechanisms.	Security measures confirmed robust; data encryption functioning properly; unauthorized access prevented; error handling and logging effective.

Based on the system testing results summarized in Table 2, the TMIS for computer programming training operates in accordance with the established requirements and objectives. The system allows both instructors and trainees to efficiently use its features, thereby optimizing training session management. These functionalities' success supports the system's primary goal of improving the efficiency and effectiveness of programming training while streamlining administrative processes. This discussion focuses on how the tested features meet the expectations and needs outlined in the research.

However, a number of issues with the continuous use of manual assessments were discovered during the testing of the system's practical session assistance. Manual assessments provide a number of challenges, despite the fact that the system efficiently keeps track of participant progress and monitors practical sessions. First, biased assessments of participant performance may result from instructors using different assessment criteria. Second, the manual evaluation method takes a long time because teachers have to take the time to personally review and document each participant's development, which slows down the process and delays feedback. The manual method is also susceptible to human error in the form of computation or record-keeping faults.

The implementation of an automated assessment module has effectively addressed these challenges. Moreover, artificial intelligence is employed in various educational tools such as intelligent tutoring systems, automated assessments, personalized learning, and teacher-student collaboration (Kamalov et al., 2023). This approach enhances evaluation consistency by objectively measuring participant performance based on predefined criteria. Additionally, the system offers an instant feedback mechanism, allowing participants to receive their assessments immediately after completing a practical session, thus eliminating delays associated with manual grading. Teachers can easily track participant progress without the concern of inaccurate documentation, as all progress is automatically recorded in the database. TMIS has optimized practical sessions by providing more efficient, reliable, and consistent evaluations while expediting the delivery of participant feedback.

3.2. Validation Results for the Web-Based TMIS

To verify the validity of the website that has been created and will be used for basic programming instruction, the training management information system using a web-based training platform must be validated. Validators, consisting of 5-7 professionals in media engineering, IT, and electrical engineering, completed a questionnaire as part of the validation testing process. On a Likert scale from 1 to 5, experts used quantitative methodology to assess the validation questionnaire. Response options included strongly agree, agree, somewhat agree, disagree, and strongly disagree. Table 3 below shows the results of the web-based learning media validity test, as well as the Aiken's V values:

Table 2. The Training Management Information System's Validity Test Results with the Web-Based Training Platform

No.	Assessment Aspects	Average Aiken's V
1	Usability	0.877
2	Functionality	0.885
3	Visual Communication	0.888
	Total Average	**0.883**

The online training platform's validity value (Aiken's V) was determined to be 0.883, above the 0.677 criterion, meaning that it is legitimate for use (Ahmad et al., 2024). A greater validity value attests to the platform's compliance with all requirements and norms, guaranteeing its efficacy in providing training materials. This validation demonstrates how well the platform can deliver a dependable and effective learning environment that supports the effective execution of training initiatives and is in line with educational goals.

The outcomes also showed that the web-based training platform performed better than the minimal requirements in a number of important domains. The system is quite user-friendly, for example, as demonstrated by the usability score of 0.877, which is crucial for instructors and trainees to quickly become accustomed to the platform. By lowering technical obstacles and encouraging higher levels of engagement, this simplicity of use improves the learning process.

A functioning score of 0.885 indicated that every system feature performed as intended and satisfied the required training. This illustrates the system's great accuracy and dependability in handling crucial operations, including scheduling, arranging training materials, and participant assessment. The high functionality score underscores the platform’s capacity to support a smooth training process.

The user interface design's efficiency and clarity were emphasized by the visual communication score of 0.888. In order to keep users interested and make sure that content is presented both attractively and intuitively, effective visual communication is essential. An interface with good design reduces user errors and confusion, making learning more effective.

With an overall Aiken’s V average of 0.883, the web-based training platform demonstrated consistent and high performance across all evaluated aspects. A deeper analysis of these Aiken’s V scores provides insights into areas of strength as well as opportunities for improvement, such as enhancing usability through interactive guides or contextual help features (Nurjanah et al., 2023). By continuously incorporating user feedback, the platform will stay aligned with evolving training needs, further optimizing the user experience and supporting the broader goals of the Training Management System.

3.3. Results of the Validation of Training Material Needs

Based on evaluations from specialists in computer programming material and the Aiken's V value, the training material needs validity test results are shown in Tabel 3 below. Based on expert assessments and the computed validity measure, this table presents an overview of the training materials'

compliance with the specified standards. As indicated in Table 3 below, the Aiken's V value contributes to the assessment of how legitimate and suitable the content is for usage in training programs.

Table 3. Validity Test Results for Training Material Requirements

No.	Competency Elements	Average Aiken's V
1	Create a programming logic flow	0.840
2	Uses data types and the basic structures of structured programming languages	0.860
3	Create simple programmes and compile them	0.892
4	Create programs using modular programming principles	0.867
5	Apply basic general algorithm techniques to array elements	0.858
	Total Average	**0.864**

The produced training materials meet the essential validity criteria, as evidenced by the average Aiken's V value of 0.864 in the validity test results for training material needs, which is above the threshold of 0.677 (Ahmad et al., 2024). The unique quality of the training materials is shown in the Aiken's V values for each competency element. With a score of 0.840, the "Creating Programming Logic Flow" material was found to have very good validity and to be extremely successful in teaching the fundamentals of programming design. Despite not receiving the maximum rating, it is nonetheless essential when compared to real-world uses.

The "Using Data Types and Basic Structures of Structured Programming Languages" material received a score of 0.860, indicating that it was successful in imparting the fundamental concepts of programming—namely, the usage of data types and basic structures. This rating indicates that while the content is useful, it can be simpler than other courses that have immediate applicability in the real world. Next, with the highest score of 0.892, "Creating Simple Programs and Compiling Them" demonstrated that making and compiling programs is seen as very legitimate and efficient. This is due to the fact that the material gives students the direct, practical experience they need to implement the concepts they have learned in real-world situations. The highest rating indicates how important this content is for improving real-world programming abilities.

The "Creating Programs Using Modular Programming Principles" item scored 0.867, indicating that it is also very effective at teaching students the principles of modular programming, which aid in the creation of well-structured programs. Modular programming is significant, but it might require a deeper comprehension of earlier principles, which is why it didn't get the best grade. Ultimately, "Applying Basic General Algorithm Techniques to Array Elements" received a score of 0.858, which suggests that the candidate has a solid grasp of the fundamental methods for array elements. Even though it's important, once students understand the fundamentals of programming, this topic can be viewed as advanced, which could result in a somewhat lower grade than in more basic materials.

The training materials exhibit exceptional quality and conform to the set training criteria, as evidenced by their average score of 0.864. The content on designing and assembling basic programs received the highest grade, highlighting the significance of real-world experience in training and giving students invaluable insight into the working world.

3.4. Results of Students Acceptability

A thorough survey was done to gauge student acceptability of the Web-Based Management Information System (MIS) for Computer Programming Training. Important elements such as system performance, functionality, user interface design, simplicity of use, and overall satisfaction were all covered in the assessment (Alqurni, 2023). A summary of the student input and how well the system suited their needs can be found in Table 4.

Table 4. Results of Students' Acceptability

No.	Aspect	Rating (1-5)	Percentage (%)
1	Ease of Use	4.2	84
2	User Interface Design	4.5	90
3	System Performance	4.0	80
4	Functionality	4.3	86
5	Overall Satisfaction	4.4	88
	Total Average	**4.28**	**85.6**

According to the survey results, the Web-Based MIS for Computer Programming Training is well liked by students. With a score of 90%, the user interface design was rated top, indicating both strong appeal and high efficacy. As many as 88% of respondents said they were generally satisfied with the system's functionality and performance. With an ease of use score of 84%, the platform is deemed to be user-friendly, yet with potential for enhancement. Although functionality was scored at 86%, indicating that the system adequately fulfills its intended functions, system performance was given a lower rating of 80%, emphasizing possible opportunities for optimization. With an overall average rating of 85.6%, the system was generally regarded as satisfactory.

Significant advancements have been made in the effectiveness and efficiency of the training process thanks to the Web-Based Training (WBT) platform. It satisfies requirements and has passed all syntax and functionality tests. Important system functions, including scheduling, evaluations, reporting, participant registration, and training material management, have all been extensively tested and are operating as intended. Additionally, system security has received a lot of attention. Testing has confirmed resistance against possible cyberattacks and data breaches, guaranteeing the privacy of trainees' personal information.

Favorable ratings from both students and instructors for the user interface underscore its usability. The intuitive layout and simple navigation make it easy for users to access training materials, stay on track with schedules, and monitor progress. Performance testing shows that the system remains responsive and effective under heavy load, demonstrating good scalability, even with multiple participants and extensive materials.

As a result, the assessment concludes that the web-based MIS is reliable and efficient, making a substantial contribution to educational technology. Even if the system has excellent usability and functionality, improving performance will be essential to enhancing the user experience even more. Examining the reasons behind the system's lower rating could yield useful information for enhancements, including better server resource optimization, more effective database queries, and the use of sophisticated load-balancing strategies. In order to further improve system performance and overall efficacy, future research may further examine advanced instructional technologies. Furthermore, evaluating the system's long-term effects on students' programming abilities may provide insightful information for continued improvement.

4. CONCLUSION

According to Aiken's validity criteria, the development of an online training platform and management information system for computer programming teaching has been confirmed as very effective. The technology can be used to improve computer programming training at Medan State University and possibly other human resource development-related institutions, as this validation attests to. With a validity value (V) of 0.883—well above the 0.677 threshold—the web-based training medium demonstrated its effectiveness and robustness. Comparably, the training materials surpass the necessary threshold, proving their quality and applicability for basic programming competency training, with a validity test value (Aiken's V) of 0.864. These findings underline the system’s capacity to improve training management and delivery. The broader implications of this research suggest

significant benefits for educational institutions and organizations, enhancing the efficiency and effectiveness of programming education. Overall, this study provides a valuable contribution to the field by demonstrating a practical, validated approach to web-based training and management with the potential to positively impact human resource development in programming.

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