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Design and Development of a Web-Based User Interface for High School Mathematics Learning

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ABSTRACT

In the digital era, computers play a crucial role in various fields, including education, business, and entertainment. Mathematics serves as a foundation for computer science, significantly contributing to programming and technological advancements. However, many students struggle to use digital resources effectively for learning. To address this issue, this study aims to develop a web-based mathematics learning platform to enhance students' understanding and engagement. The platform is designed using Visual Studio Code, PHP as the programming language, and a MySQL database. The web-based learning system is structured to provide an interactive and adaptable learning experience tailored to students' needs. This approach allows learners to access materials conveniently, reinforcing their understanding of mathematical concepts through digital resources. The results indicate that web-based learning enhances students' comprehension and interest in mathematics by providing a structured and accessible learning environment. The platform enables independent learning, allowing students to study at their own pace and revisit topics as needed. The findings suggest that integrating technology into mathematics education can improve learning outcomes and engagement. This study concludes that a well-designed web-based learning module can serve as an effective alternative resource to support traditional classroom teaching. By leveraging digital tools, students can enhance their mathematical skills and overall academic performance.

Keywords: information technology; website; instructional media; e-learning

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INTRODUCTION

In today's digital age, computers play a fundamental role in various aspects of human life, including education, business, and entertainment. As machines designed to process instructions, computers rely on programming to perform tasks and solve problems efficiently. The field of computer science encompasses a wide range of topics, from abstract algorithm analysis to more tangible subjects such as programming languages, software development, and hardware design. While computer science primarily focuses on programming and software engineering, computer engineering is more concerned with hardware components (Amiyani, 2011).

The development of computer technology is inseparable from mathematics, as mathematics serves as a fundamental discipline underlying modern technological advancements. As a structured and universal science, mathematics fosters critical thinking, objectivity, and logical reasoning, all of which are essential for students navigating a rapidly evolving technological landscape. The integration of mathematical concepts into education helps students develop analytical and problem-solving skills, which are crucial in scientific and technological fields (Nazwita & Ramadhani, 2017).

Given its significance, mathematics education must be introduced from an early stage to equip students with logical, systematic, and creative thinking abilities. These skills enable students to acquire, process, and apply knowledge in dynamic, uncertain, and competitive environments (Magdalena *et al.*, 2020). However, many students struggle with mathematical concepts due to various challenges, including difficulties in understanding abstract principles, interpreting mathematical symbols, and applying problem-solving procedures effectively. This lack of foundational knowledge can impede their ability to grasp more advanced mathematical concepts (Sandi, 2018).

The integration of educational technology presents a promising solution to these learning challenges. Educational technology combines concepts from multiple disciplines to create innovative learning tools that enhance student engagement and comprehension. Mathematics, often perceived as one of the most challenging subjects, requires interactive and visually appealing instructional methods. The incorporation of multimedia elements, such as animations, simulations, and audio-visual aids, can improve student motivation and facilitate deeper understanding (Munir, 2010).

Traditional teaching methods, which often rely on passive learning through lectures and note-taking, may not be sufficient to address students' learning needs. Effective learning requires active participation, critical thinking, and problem-solving exercises. Technology-driven learning approaches, particularly web-based learning platforms, offer a more interactive and engaging alternative. These platforms allow students to explore mathematical concepts through structured digital content, improving their ability to learn independently and retain information (Puspitasari, 2016).

With the increasing use of digital devices, especially smartphones, web-based learning tools can serve as effective educational resources. Compared to traditional printed textbooks, which may seem rigid and monotonous, interactive digital learning platforms provide a dynamic and engaging experience. The accessibility of online learning resources allows students to review and practice mathematical concepts anytime and anywhere, making learning more flexible and self-paced (Ridwan *et al.*, 2018).

To ensure the effectiveness of digital learning media, it is essential to align them with students' psychological, social, and cognitive needs. Web-based learning tools can integrate various media elements, including text, images, audio, video, and interactive simulations, to enhance learning outcomes. By utilizing technology effectively, educators can create an engaging and adaptable learning environment that meets students' individual needs and preferences (Yuhendra, 2014).

This research focuses on the design and development of a web-based mathematics learning module aimed at improving students' understanding and interest in the subject. By leveraging web technology, this platform provides an alternative learning resource that supports self-directed learning and enhances mathematical problem-solving skills. Through an interactive and structured digital learning environment, students are expected to gain a deeper understanding of mathematical concepts and develop a more positive attitude toward learning mathematics.

LITERATURE REVIEW

The Role of Mathematics in Computer Science

Mathematics serves as the foundation of various fields, including computer science. The development of computational algorithms, programming logic, and problem-solving

techniques in informatics heavily relies on mathematical principles (Amiyani, 2011). Concepts such as discrete mathematics, linear algebra, and probability play a crucial role in shaping modern computational methods, including artificial intelligence, cryptography, and software engineering (Nazwita & Ramadhani, 2017).

Mathematical principles also support the advancement of educational technology by structuring data, enhancing simulations, and optimizing algorithms. These contributions are essential for improving the accuracy and efficiency of web-based learning tools (Sandi, 2018). Furthermore, incorporating mathematics into digital learning environments enhances students' understanding of computational processes, making learning more systematic and effective (Munir, 2010).

Educational Technology and Digital Learning Media

The integration of technology into education has led to the emergence of digital learning media. These tools combine text, graphics, videos, animations, and interactive elements to create an engaging and dynamic learning experience. Research suggests that multimedia-based learning enhances students' motivation and comprehension, particularly in subjects that require problem-solving skills, such as mathematics (Puspitasari, 2016).

Web-Based Education (WBE) is a widely adopted learning approach that leverages internet technologies to deliver instructional content. Unlike traditional classroom settings, WBE allows students to access learning materials at their convenience, promoting self-paced and independent learning (Ridwan *et al.*, 2018). Additionally, web-based learning platforms offer adaptive learning features that cater to individual student needs, improving retention and academic performance (Yuhendra, 2014).

Challenges in Mathematics Education

Despite the availability of digital learning tools, students continue to face difficulties in understanding mathematical concepts. Some of the most common challenges include struggling with abstract reasoning, misinterpreting mathematical symbols, and lacking the ability to apply theoretical principles in problem-solving contexts (Magdalena, 2018). Research highlights that conventional teaching methods, which primarily rely on rote memorization, do not adequately support students in developing critical thinking skills (Sandi, 2018).

To address these challenges, educators are encouraged to adopt interactive and technology-driven learning methods. Studies suggest that integrating digital resources into mathematics

instruction improves students' engagement and enhances their ability to grasp complex concepts through visual and interactive representations (Puspitasari, 2016).

Web-Based Learning for Mathematics Education

Recent studies have emphasized the effectiveness of web-based learning platforms in improving students' mathematical proficiency. Digital learning environments provide students with access to structured learning materials, interactive problem-solving exercises, and real-time feedback (Nazwita & Ramadhani, 2017). Moreover, the flexibility of web-based learning enables students to review content as needed, reinforcing their understanding of mathematical concepts (Puspitasari, 2016).

Web-based mathematics learning tools also integrate multimedia elements, making learning more engaging and accessible. Studies indicate that students who use web-based platforms show higher motivation and improved performance in mathematics compared to those who rely solely on traditional textbooks (Ridwan *et al.*, 2018). Additionally, e-learning systems facilitate collaborative learning through discussion forums, quizzes, and simulations, further enhancing the overall educational experience (Yuhendra, 2014).

Previous studies have demonstrated that digital technology can enhance students' understanding of mathematics. For instance, Puspitasari (2016) found that incorporating interactive multimedia in mathematics learning could boost student motivation. However, this research primarily focused on desktop-based learning applications, overlooking the flexibility of web-based platforms that can be accessed across multiple devices.

Additionally, a study by Ridwan et al. (2018) highlighted the effectiveness of web-based learning systems in improving accessibility to educational materials. Nevertheless, it did not explore in depth how student engagement and user interface design elements influence the overall learning experience. Furthermore, research by Nazwita and Ramadhani (2017) examined the integration of technology in mathematics education, emphasizing data security and system efficiency. However, this study lacked a discussion on how interactive features in web-based systems could enhance students' conceptual understanding of mathematics.

Despite these findings, there remains a gap in the integration of web technology for a more adaptive and interactive mathematics learning experience. Therefore, this study aims to develop a web-based learning platform that not only ensures high accessibility but also enhances student engagement through an intuitive and interactive user interface design.

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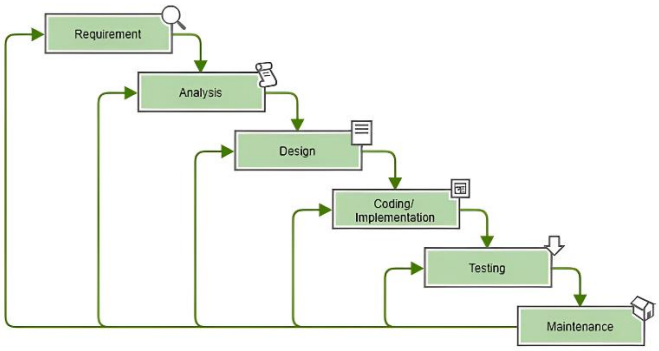
METHOD

This study employs the Waterfall Model as the development methodology, following a sequential approach that includes Requirement Analysis, Design, Implementation, Testing, and Maintenance. This model ensures a structured and systematic process in creating a web-based mathematics learning platform that meets the needs of high school students.



Source: Widiaty *et al.* (2019)

Figure 1. Waterfall Method

The research begins with Requirement Analysis, where relevant mathematical learning materials are gathered and structured according to the high school curriculum. Observations are conducted to identify students' learning needs and determine the most effective way to present mathematical content in a digital format. This phase helps in ensuring that the system provides comprehensive and accessible learning resources.

Following the analysis, the Design Phase focuses on creating an intuitive and user-friendly interface. The platform is designed using Visual Studio Code (VS Code), incorporating web technologies such as HTML, CSS, JavaScript, and PHP to build an interactive learning environment. A MySQL database is implemented to manage user data, learning materials, and system interactions efficiently. The design also considers usability principles to enhance students' engagement with the platform.

The development of the web-based learning platform in this study utilizes PHP as the primary programming language, MySQL as the database management system, and Visual Studio Code as the development environment. The selection of these technologies is based on several key considerations. First, PHP was chosen due to its flexibility in building web applications and its compatibility with various web servers. Additionally, PHP benefits from a large developer

community, making technical support and learning resources widely available (Welling & Thomson, 2021). Second, MySQL was selected as the database management system because of its open-source nature, high performance, and seamless integration with PHP. MySQL also offers robust security features, making it a reliable choice for storing and managing user data in web-based learning systems. Third, Visual Studio Code (VS Code) was used as the development environment due to its efficiency-enhancing features, such as debugging extensions, auto-completion, and built-in Git integration. Compared to other IDEs like NetBeans or Eclipse, VS Code is more lightweight while offering extensive support for multiple programming languages, including PHP and JavaScript. The selection of these technologies ensures that the developed system remains flexible, easy to manage, and accessible across multiple devices, making it an optimal solution for enhancing students' learning experiences in mathematics.

Once the design is completed, the Implementation Phase involves converting the design into a fully functional web application. The coding process follows best practices to ensure efficiency and maintainability. The platform is developed to support dynamic content delivery, allowing students to access materials, complete exercises, and track their progress. The use of PHP for backend processing, along with JavaScript for interactivity, ensures a smooth user experience.

After implementation, the Testing Phase is carried out to evaluate the system’s performance and usability. Functionality testing is conducted to verify that all features operate as intended, including user authentication, content navigation, and interactive exercises. User experience testing assesses the responsiveness and ease of navigation, ensuring that students can interact with the platform effectively. Performance testing is also performed to measure the system’s ability to handle multiple users and provide a seamless learning experience.

The final stage, Maintenance, ensures that the platform remains functional and relevant over time. Any bugs or errors identified during testing are addressed promptly, and system updates are implemented based on user feedback and technological advancements. Additionally, learning materials are periodically updated to align with the latest curriculum standards. Continuous monitoring and optimization ensure that the platform provides an engaging and effective learning experience for students.

By following this structured methodology, the development of the web-based mathematics learning platform is conducted in a systematic and organized manner. The integration of

technology in education through this platform is expected to enhance students' understanding of mathematical concepts, provide flexible learning opportunities, and increase engagement in the subject.

RESULT AND DISCUSSION

The development of the web-based mathematics learning platform was carried out systematically using the Waterfall methodology. The final system consists of several main components, including the homepage, registration and login pages, subject material pages, and a database management system. Each of these components plays a crucial role in ensuring that students can easily access and engage with the learning materials.

The homepage serves as the central interface for users, allowing them to navigate through the website and access various features. The homepage layout was designed to be user-friendly, providing direct links to learning modules and interactive exercises. The inclusion of a visually appealing and structured design enhances students' engagement and facilitates smoother navigation.

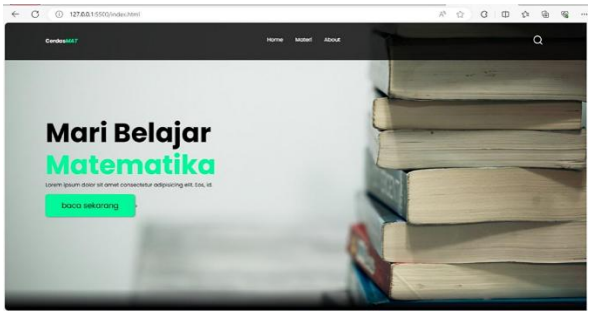


Figure 2. Screenshot of the Homepage

The registration and login pages were implemented to manage user authentication. These features ensure that only registered students and educators can access the platform's full range of learning materials. The authentication system, developed using PHP and MySQL, provides a secure login mechanism that protects user data while allowing easy access to the system.

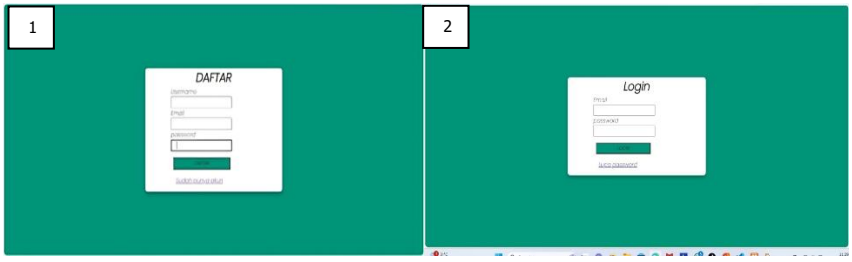


Figure 3. Screenshot of: 1.) Registration Page; 2.) Login Page

The subject material pages are the core component of the platform. The content is organized into different grade levels, enabling students to find relevant learning resources efficiently. The materials include interactive lessons, quizzes, and multimedia elements such as images and videos to enhance understanding. These features align with the principles of interactive learning, which have been proven to improve student comprehension and retention.

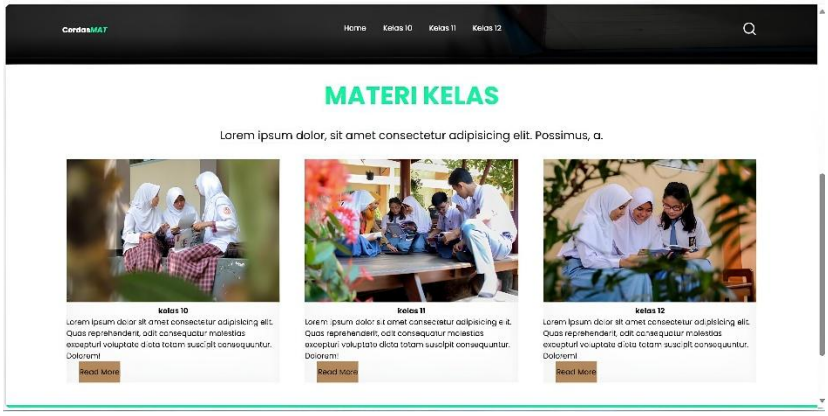


Figure 3. Screenshot of the Subject Material Selection Page

Figure 4. Screenshot of a Specific Subject Material Page

The database management system plays a crucial role in organizing and storing user data, learning progress, and assessment results. The use of MySQL ensures efficient data retrieval

and updating, enabling students to track their progress over time. Additionally, the system allows educators to monitor students' engagement and performance, providing valuable insights for instructional improvement.

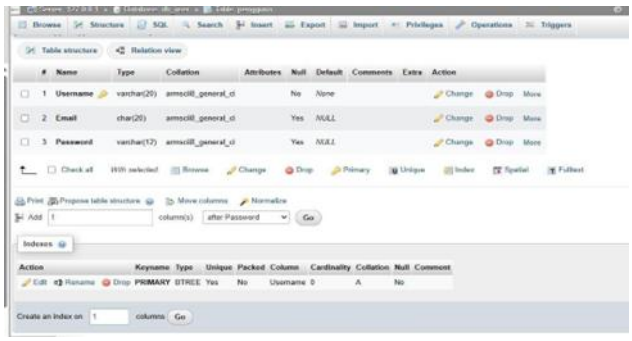


Figure 6. Screenshot of the Database Management System

Discussion

The implementation of a web-based learning platform aligns with the increasing need for digital education solutions. Traditional teaching methods often fail to fully engage students, particularly in subjects like mathematics that require problem-solving skills and conceptual understanding. By leveraging digital tools, this platform provides an alternative learning environment that is interactive and accessible.

The findings of this study support existing research on the effectiveness of technology in education. Previous studies have shown that web-based learning enhances student engagement and motivation, particularly when multimedia elements are integrated into the content. The interactive features of the developed platform, such as quizzes and video tutorials, align with these findings, demonstrating that digital tools can facilitate deeper comprehension and retention.

One of the key advantages of this system is its flexibility. Unlike traditional classroom settings, where learning is constrained by time and location, web-based platforms allow students to access materials at their own pace. This self-paced learning model accommodates different learning styles, enabling students to revisit complex topics as needed. Additionally, the incorporation of real-time feedback mechanisms allows students to identify their mistakes and improve their understanding, an aspect that is often missing in conventional learning environments.

However, some limitations were observed. The effectiveness of web-based learning depends on students' access to reliable internet connections and digital devices. In regions where

technological infrastructure is limited, students may face difficulties in utilizing the platform effectively. Additionally, while the system provides structured learning materials, it does not entirely replace the need for teacher interaction. Direct teacher guidance remains essential, especially for students who require additional support in understanding mathematical concepts.

Future improvements for this platform could include adaptive learning features, where the system customizes learning pathways based on students' performance. Implementing artificial intelligence-driven analytics could further enhance personalized learning by recommending specific exercises or lessons tailored to individual student needs. Moreover, expanding the platform to include discussion forums or virtual tutoring sessions could increase student interaction and collaborative learning.

In conclusion, the development of a web-based mathematics learning platform has demonstrated its potential to enhance student engagement and learning outcomes. The combination of interactive features, multimedia integration, and flexible access makes it a valuable educational tool. While challenges exist, further enhancements and continuous development can maximize its impact on digital learning in mathematics education.

CONCLUSION

The development of a web-based mathematics learning platform has demonstrated its potential to enhance students' engagement, accessibility, and understanding of mathematical concepts. By integrating digital learning tools, such as interactive lessons, multimedia content, and real-time assessments, the platform offers an alternative learning environment that supports self-paced and independent study. The structured design, implemented using the Waterfall methodology, ensured a systematic approach in analyzing requirements, designing, implementing, testing, and maintaining the system. Testing results indicated that the platform was functional, user-friendly, and effective in improving students' comprehension compared to conventional textbook-based learning.

Despite its advantages, this study has several limitations. The effectiveness of the platform heavily depends on students' access to stable internet connections and digital devices, which may not be available to all learners, particularly in remote areas. Additionally, while the system provides structured learning materials and interactive exercises, it does not entirely replace the need for direct teacher-student interaction. Personalized guidance and instructional

support remain crucial for students who struggle with complex mathematical concepts. Furthermore, the platform currently focuses on content delivery and self-assessment, but it lacks features for collaborative learning and peer discussion, which could enhance student engagement and knowledge-sharing.

For future research, several enhancements can be explored to improve the platform's effectiveness. First, integrating adaptive learning mechanisms powered by artificial intelligence can allow the system to personalize content recommendations based on students' learning progress and performance. Second, incorporating discussion forums and virtual tutoring features can facilitate peer collaboration and provide students with opportunities to seek guidance from educators. Additionally, expanding the platform's content to include gamification elements, such as leaderboards and achievement rewards, may further motivate students to actively engage in learning. Finally, conducting longitudinal studies to assess the long-term impact of web-based mathematics learning on student performance and retention would provide deeper insights into its effectiveness.

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