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# Interactive Educational Platform Integrating Electronic Components into Mathematics Courses for Numerical Computation

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***Abstract* – This paper proposes the development of an interactive educational platform that integrates electronic components into mathematics courses, emphasizing the use of the MATLAB software environment for numerical computation. The main objectives include investigating and selecting relevant electronic components, evaluating their characteristics, and adapting mathematics courses to parallel the learning of MATLAB. The platform will offer video tutorials, an online forum with an Artificial Intelligence (AI) - based chatbot for additional support, and a secure user authentication system. It aims to facilitate the understanding of complex mathematical concepts through an interactive and practical environment, providing practical advantages such as ease of use, accessible online lessons, and progress tracking for teachers. Users will create accounts and follow lessons in a predetermined order, with evaluations after each lesson to ensure comprehension. This educational platform represents an innovative approach to integrating electronic components into mathematics learning, offering an efficient environment for students of all knowledge levels.**

**Keywords - MATLAB; web app; mern; database; security; educational**

## I. Introduction

Integrating technology into the learning process has become a priority in modern education, significantly impacting how students learn and assimilate information. Especially in the fields of science, technology, engineering, and mathematics (STEM), the use of digital tools and software applications can enhance the understanding and application of theoretical concepts. In this light, this paper proposes the development of an interactive educational platform that integrates electronic components into mathematics courses, utilizing the MATLAB software environment for numerical computation [1].

The main objectives of this platform include the careful selection and investigation of relevant electronic components for integration into the educational context, the evaluation of their characteristics and functionalities, and the adaptation of mathematics course content to be compatible with MATLAB. Additionally, the proposal includes the development of explanatory video tutorials, the creation of an online community forum [2], and the implementation of a secure user authentication system [3].

This initiative bridges the theoretical world of mathematics and the practical world of electronics, providing students with an engaging and interactive learning environment. Through this platform, students will be able to experiment with and explore mathematical concepts in a practical manner, applying them in the context of electronic circuits and numerical problem-solving using MATLAB [4].

Thus, this paper aims to contribute to the improvement of the teaching and learning process of mathematics within STEM education by integrating technology and electronic components into an interactive and innovative educational environment.

## II. Literature Review

The integration of technology in STEM education has led to the development of various web-based learning platforms aimed at enhancing student engagement and understanding of complex subjects. This review examines the effectiveness of these platforms, particularly focusing on interactive tools, forums, AI chatbots, and virtual laboratories.

The platform discussed in the current study centers on integrating MATLAB into mathematics education, providing a hands-on approach that allows students to practically apply theoretical concepts. This approach is particularly beneficial for STEM students interested in both electronics and mathematics. Similarly, Humar [5] developed a web-based interactive learning system for engineering courses, emphasizing dynamic tools for technical engagement. However, Cheong and Koh [6] highlight the role of virtual laboratories in making abstract concepts more accessible through real-world applications, bridging the gap between theory and practice.

Forums are crucial for fostering community interaction and collaborative learning, a feature emphasized in the current platform but not fully realized in Humar's platform. Cheong and Koh [6] further support structured interaction through the Visible Thinking framework, promoting higher-order thinking and active learning.

AI chatbots, which provide real-time personalized support, are another innovation in the current platform, offering immediate feedback that enhances the learning experience. This feature, not present in Humar's platform, addresses a significant gap by ensuring continuous support for students, as underscored by Cheong and Koh [6].

In conclusion, literature underscores the importance of integrating specialized tools, community interaction, personalized support, and real-world applications in educational platforms. The current platform's focus on MATLAB integration, forums, and AI chatbots effectively addresses the specific needs of STEM students. The incorporation of virtual laboratories, as demonstrated by Cheong and Koh [6], further enhances the learning experience by making theoretical knowledge more accessible and engaging.

## III. Interactive Educational Platform

The platform represents a digital infrastructure that provides access to various learning resources and tools, allowing users to interact and explore educational content in a dynamic and adaptable manner. Through this platform, users can access online courses, video lessons, practical exercises, and other study materials, and participate in community discussions, tests, and assessments. This digital environment facilitates personalized learning and offers users the opportunity to learn at their own pace and style, representing a valuable resource in the learning and personal development process [7].

- *Structured Courses and Learning Modules*: The platform offers structured courses and learning modules covering a variety of subjects and topics, from mathematics and sciences to foreign languages or personal development. These courses are designed to be accessible and easy to follow, regardless of the user's knowledge level.
- *Varied Study Materials*: Users have access to a variety of study materials, including video lessons, explanatory texts, presentations, and practical exercises. These materials are designed to support active learning and allow users to explore topics in depth.
- *Interaction and Feedback*: The platform facilitates interaction between users and instructors or tutors through discussion forums, live chats, and Q&A sessions. Users also receive real-time feedback on their progress and the results of their tests and exercises.
- *Ease of Use and Accessibility*: The platform's interface is designed to be intuitive and easy to navigate, allowing users to access the available resources and tools quickly and efficiently.

### *A. Technical Content Of The Platform*

The technical content comprises lessons on essential components in the field of electronics and tests formulated for each lesson.

**Definition and Types of Electronic Components**

- An overview of electronic components and their role in constructing electrical circuits.
- Types of electronic components, including resistors, capacitors, coils, transistors, diodes, etc. (see Fig. 1).

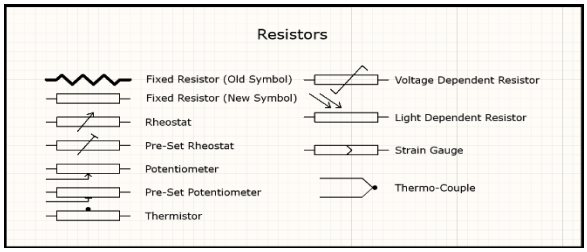


*Fig. 1. Example of resistors.*

**Characteristics and Functionalities of Electronic Components**

- Description of the main characteristics of electronic components, such as resistance value, capacitance, inductance, etc.
- Explanations on how these characteristics influence the behavior of components within circuits.

**Mathematical Concepts and Physical Formulas for Electronic Components**

- Detailed presentation of essential mathematical concepts associated with each electronic component, such as Ohm's Law, Kirchhoff's Laws, Faraday's Law, charging and discharging of capacitors, and the flow characteristic of diodes (see Fig. 2).
- Exploration of physical formulas used for calculating key parameters of electronic components, such as resistance, capacitance, inductance, and the switching characteristics of transistors.
- Integration of these concepts and formulas into the mathematics lessons on the educational platform, facilitating both theoretical and practical understanding of the behavior of electronic components within circuits.
- Practical examples and exercises to apply mathematical concepts and physical formulas in solving problems related to electronic components, thereby reinforcing students' learning and comprehension.

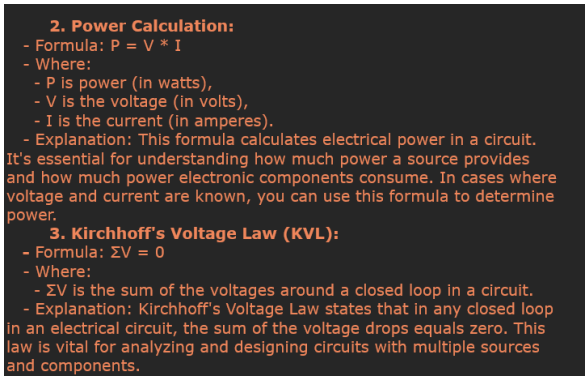


*Fig. 2. Example of Content that is on the platform.*

## *B. Social Interaction Within The Platform*

This subsection examines the role and impact of social interaction and community within the educational platform, highlighting the ways in which users can connect, collaborate, and interact to enhance the learning process.

- *Online Forum for Idea and Knowledge Exchange*: The platform hosts a dedicated online forum where users can post questions, suggestions, and educational resources. This forum serves as an interactive space where students and teachers can interact, discuss, and share ideas and knowledge in an open and collaborative manner.
- *AI Chatbot for Support and Personalized Assistance*: To provide additional support and assistance to users, the platform integrates an AI chatbot. This chatbot can answer frequently asked questions, providing information and guidance in real-time. It can also offer personalized assistance and recommendations based on individual user preferences and needs.
- *Progress Tracking and Interaction with Teachers*: The platform includes functionalities for progress tracking and direct interaction with teachers. Users can monitor their progress in real-time, viewing test results and previous evaluations. They can also communicate with teachers to receive feedback and personalized advice to improve their academic performance.
- *Study Groups and Collaboration*: Users could form and join study groups and collaborative teams. These groups enable students to work together, share resources, and solve problems in a collaborative environment. Through these groups, users can build strong relationships and connections within the educational community.
- *Extracurricular Events and Activities*: The platform will organize various extracurricular events and activities. These events can include seminars, conferences, competitions, and other social and academic activities. Participation in such events encourages engagement and social interaction within the educational community.

Through these initiatives and functionalities, the platform fosters the building of an active and engaged community where users can collaborate, interact, and learn together in a stimulating and supportive environment. This social and collaborative interaction plays a crucial role in enhancing the learning experience and promoting the academic success of users.

## *C. Available Tests*

Tests play a crucial role in the learning and evaluation process of knowledge and skills. They are an effective way to measure the level of understanding of the studied subjects and the ability to apply them in different contexts. Through tests, students can check their progress, identify weaknesses, and consolidate their knowledge. Tests can also serve as feedback tools for teachers, allowing them to evaluate the effectiveness of teaching methods and adapt learning strategies according to the needs and progress of students. Through their diversity and relevance, tests contribute to improving the educational process and stimulating academic performance [8].

**Types of Tests**

1. *Mathematics Knowledge Evaluation Tests* – These tests are designed to assess the level of knowledge and understanding of mathematical concepts by users. They can include multiple-choice questions, problem-solving exercises, and practical

exercises to evaluate competence in a variety of mathematical subjects.

2. *MATLAB Proficiency Tests* – These tests aim to evaluate users' proficiency in using the MATLAB software environment for numerical computation and data analysis. They can include questions related to syntax, functionalities, practical applications of MATLAB, as well as programming and data analysis exercises.

3. *Electronics Knowledge Evaluation Tests* – These tests are intended to assess users' knowledge in the field of electronics, covering basic and advanced concepts in applied electronics. They can include questions related to electronic circuits, electronic components, measurement techniques, and practical applications of electronic concepts in various fields [9].

4. *Content Understanding and Problem-Solving Tests* – These tests involve presenting practical scenarios or problems to solve, to evaluate users' ability to apply theoretical knowledge in practical situations. They can include open-ended questions, problem-solving exercises, and case studies to assess users' understanding and practical skills. Test Formats:

a*) Multiple-Choice Tests*: Users select the correct answers from a list of options.

b) *Question-Answer Tests*: Users must respond to short-answer or true/false questions.

c) *Problem-Solving Tests*: Users solve practical problems or calculation exercises.

d) *Fill-in-the-Blank Tests*: Users complete the blanks in each statement or problem.

## IV. USED TECHNOLOGIES

The relevant scientific context for this topic is provided by the technological and educational advancements in the field of electronics and numerical computation, as well as previous research in integrating technology into the learning process.

### Technological Context

In terms of technology, advancements in electronic components have led to the development of smaller, more powerful, and energy-efficient components, opening new possibilities for their integration into the learning process. Additionally, software development environments like MATLAB have become increasingly popular and accessible, facilitating the realization of simulations and practical experiments in electronics and numerical computation [10].

### Educational Context

In the educational domain, there is a growing interest in using technology in the learning process, with a focus on creating interactive and personalized learning environments. Online educational platforms have become increasingly popular, and various tools and resources have been developed to support the learning process and improve user experience [11].

Previous research has demonstrated the benefits of integrating technology in education, including improved student engagement and motivation, increased academic performance, and the development of practical and problem-solving skills [11].

In this context, this paper aims to explore the possibilities and benefits of integrating electronic components and the MATLAB environment into mathematics courses, using an interactive educational platform, contributing to the development of innovative methods for teaching and learning mathematical and electronic concepts.

### MERN Stack

The MERN Stack is a set of technologies used in full-stack web application development, consisting of four main components: MongoDB, Express.js, React, and Node.js. This stack provides an efficient and scalable environment for the rapid development of modern web applications.

- *MongoDB*: A NoSQL, document-oriented database that offers flexibility in data modeling and horizontal scalability. MongoDB stores data in JSON-like documents, facilitating integration with JavaScript [12].
- *Express.js*: A web application framework for JavaScript, built on Node.js. Express.js simplifies route management, handling HTTP requests and responses, and allows for the creation of robust and efficient web servers.
- *React*: A UI (User Interface) library for building interactive and reusable user interfaces. React uses a declarative, component-based programming model, making web application development and maintenance easier and more efficient.
- Node.js: A JavaScript runtime built on Chrome's V8 JavaScript engine. Node.js enables the execution of JavaScript code on the server and handles asynchronous I/O operations, facilitating the development of scalable and efficient web applications.

The MERN Stack combines MongoDB, Express.js, React, and Node.js to provide a complete environment for full-stack web application development. Each component brings its own benefits: MongoDB offers a flexible database, Express.js simplifies server development, React facilitates dynamic user interface creation, and Node.js allows for server-side JavaScript execution [13].

The MERN Stack became popular around 2013, coinciding with the rapid rise of Node.js and MongoDB. The integration of React solidified the stack as a powerful solution for modern web application development, thanks to the benefits offered by the component technologies and the declarative

programming model. Since then, the MERN Stack has become one of the most popular stacks used by web developers [13].

## V. Architecture And Design Of The Educational Platform

The educational platform is designed and developed with a solid architecture and intuitive design to provide an optimal user experience. The key aspects of the platform's architecture and design highlight how technologies and functionalities are integrated to offer efficient learning experience.

💻 *Platform Architecture*: The platform's architecture is based on a client-server model, where the client represents the user interface accessed by students and teachers via a web browser, and the server manages the logic and the database. This architecture allows for efficient task distribution and easy scalability.

💻 *UI Design*: The user interface is designed to be simple and easy to navigate. Users have quick access to the platform's content and functionalities, and the design is adaptable to fit different devices and screen sizes (see Fig. 3).

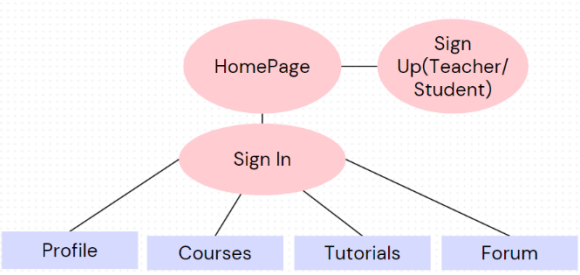


*Fig. 3. Sitemap.*

💻 *Security Aspects*: Security is essential for protecting user data and ensuring a safe online educational environment. The platform uses advanced authentication technologies such as OAuth and JWT (JSON Web Token) to validate and manage user access to resources. Secure authentication is achieved through HTTPS and SSL/TLS protocols, ensuring data encryption during transmission between the user and the server. Robust authorization and session management mechanisms prevent unauthorized access to sensitive information. Using cloud security services like AWS Identity and Access Management (IAM) and key management services ensure user data is protected against cyber-attacks and potential threats. Continuous monitoring and auditing of activities and systems are standard practices for identifying and quickly remedying any security vulnerabilities or incidents. These measures ensure that users benefit from a secure and trustworthy online educational environment [14].

💻 *Scalability and Performance*: The platform's architecture is designed to be scalable and performant, capable of handling many users and concurrent tasks. The technologies and infrastructure used are optimized to ensure a fast and seamless user experience [14].

💻 *Technological Integration*: The platform integrates various technologies and services to offer advanced functionalities and enhanced user experience. These technologies include programming languages, frameworks, databases, cloud services, and external APIs (Application Programming Interface) [15].

💻 *Extensibility Considerations*: Extensibility considerations are crucial to ensuring the platform's ability to adapt to future needs and requirements. The platform uses a modular and flexible architecture based on microservices and containerization to allow easy integration of new functionalities and modules. The use of modern technologies like Kubernetes facilitates scalability and efficient infrastructure management. Special attention is given to code standardization and API documentation, allowing third-party developers to create and integrate external applications easily. By adopting an extensibility and interoperability-oriented approach, the platform can continuously evolve and adapt to changes in education and technology, ensuring that users always benefit from the latest and most innovative functionalities and services.

## VI. Case Study

The case study explores the use of information from a mathematical analysis course to work in MATLAB and highlights how the educational platform facilitates this integration through a video tutorial.

📖 *Applying Mathematical Analysis Concepts in MATLAB*: The case study demonstrates how students can apply the concepts and theories of mathematical analysis in practice using the MATLAB development environment. This includes solving differential equations, calculating integrals, and determining limits using the functions and tools available in MATLAB.

📖 *Demonstration through Video Tutorial*: The educational platform offers a video tutorial that illustrates step-by-step how to use mathematical analysis knowledge in MATLAB. The tutorial presents various scenarios and practical exercises, providing concrete examples and detailed solutions to guide students through the learning and application process.

📖 *Exploring MATLAB Capabilities*: The video tutorial highlights the variety of functions and tools available in MATLAB and how they can be used to solve problems in mathematical analysis. Through practical demonstrations, users can better Understand the applicability of MATLAB in the context of mathematics.

📖 *Feedback and Evaluation*: Users can utilize the video tutorial to receive feedback and evaluation on their lab activity. This can include assessing the correctness of proposed solutions and the ability to apply mathematical analysis concepts in practice. Feedback and evaluation contribute to continuous improvement in users' performance and understanding. This also includes test results and access to the next course (see Fig. 4).

📖 *Benefits of Integrating Mathematical Analysis in MATLAB*: Through this case study and the associated video tutorial, students can simultaneously develop skills in mathematical analysis and MATLAB programming. Integrating mathematical analysis knowledge in MATLAB offers valuable opportunities for practical application of theoretical concepts, stimulating interest and engagement in the learning process.


*Fig. 4. Example of Evaluations.*

This section highlights how the use of information from a mathematical analysis course in MATLAB can be facilitated and enhanced through an interactive video tutorial. By integrating the two fields, the educational platform provides students with the opportunity to experiment and apply theoretical concepts in a practical and relevant environment.

***Features of the platform***

- The platform utilizes the MERN stack (MongoDB, Express.js, React, and Node.js) to ensure a robust, scalable, and high-performance infrastructure.
- The use of MATLAB in combination with mathematics and electronics courses allows students to practically apply theoretical concepts through simulations and practical exercises.
- The platform offers a rich and diversified educational environment by including video tutorials, practical exercises, tests, and adapted course materials (see Fig.5).

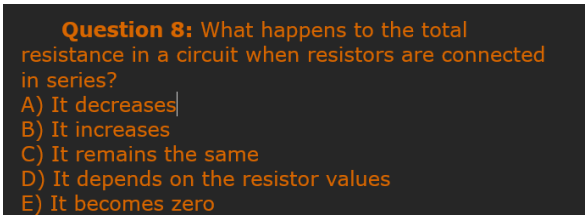


*Fig. 5. Example of question.*

- By implementing an online forum, it promotes collaboration and knowledge sharing among users, facilitating collaborative and interactive learning.
- The integration of an AI chatbot and a student progress tracking system allows for continuous monitoring and evaluation of their performance, providing instant and personalized feedback.
- Future development plans include the integration of virtual labs, interactive simulations, and real-time collaboration tools to enhance and diversify the learning experience.
- The platform is designed to be user-friendly and accessible to all users, including those without a strong foundation in physics or mathematics.
- It offers the possibility to personalize and adapt the learning experience according to individual needs and preferences.

## VII. Perspectives And Development Plans

The educational platform can be enhanced in the following ways:

- *Integration of Advanced Features*: The platform will be extended to include advanced features such as real-time collaboration tools, virtual labs, and interactive simulations. These features will enable users to actively participate in the learning process, experiment with complex concepts, and collaborate on problem-solving [16].
- *Personalization and Adaptability*: Special attention will be given to personalization and adaptability, allowing users to customize their learning experience based on their preferences and individual needs. This will include the ability to select courses and materials relevant to their fields of interest, as well as options to adjust the pace and difficulty of the content [16].
- *Performance and Scalability Optimization*: Efforts will continue to optimize the platform's performance and scalability to handle a larger number of users and provide fast experience. This will involve infrastructure improvements, code optimization, and the implementation of efficient technologies and services.
- *Integration with Emerging Technologies*: The platform will be updated to integrate emerging technologies and trends in online education. This will include incorporating tools and resources based on artificial intelligence to personalize the learning experience [17].
- *User Feedback and Collaboration*: A close relationship with the user community will be promoted through continuous collection of feedback and suggestions. User feedback will guide the direction and prioritization of future improvements. Mechanisms will be created for active collaboration between users and development teams to constantly improve the platform experience. Currently there is a contact form system in place (see Fig. 6).

These perspectives and development plans reflect the educational platform's commitment to providing a quality learning experience and staying current with the ever-changing demands and trends in online education.

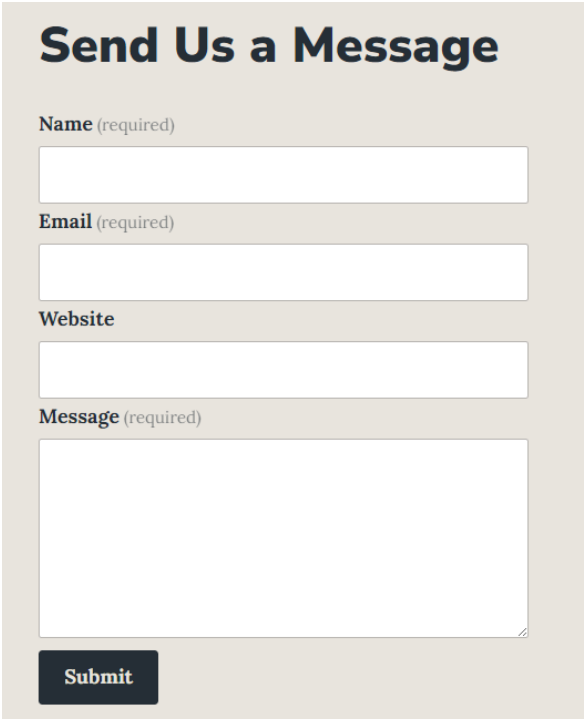


*Fig. 6. Contact form.*

## CONCLUSIONS

In conclusion, this paper explores and develops an interactive educational platform that integrates electronic components into mathematics courses, using the MATLAB software development environment for numerical computation. This platform aims to provide students with an efficient way to learn mathematics and electronics and to experience theoretical concepts in a practical and applied context.

The implementation and continuous development of this platform will contribute to creating a modern and adaptable educational environment, preparing students for the challenges and opportunities of the future. So, the next work will be focused on extending functionalities by integrating new technologies and advanced functionalities, such as artificial intelligence and augmented reality, to create an even more engaging and interactive learning experience [15]. It will be focused on continuous optimization of the platform's performance and scalability to ensure a fast and smooth experience for many simultaneous users as well.

Feedback and Adaptability by promoting a close relationship with users by continuously collecting feedback and adjusting the platform according to their needs and suggestions is a factor that will be taken into consideration.

Concluding, this paper represents a significant step towards improving the learning process in the fields of mathematics and electronics by providing an interactive and innovative educational platform that encourages experimentation and academic excellence.

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