



Received: 26-03-2023
Accepted: 06-05-2023

ISSN: 2583-049X

Creating an Innovative Mechatronics Learning Experience with Mecha-Learn: A Website-Based Platform

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Abstract

The development of mechatronics education in Indonesia as a developing country is quite rapid, this is one form of Indonesia's contribution in preparing human resources that are ready to compete in the 5.0 society. Many educational institutions in Indonesia focus on mechatronics studies, both in undergraduate, polytechnic, and vocational high school levels. The mechatronics study content consists of theory and practice. Difficulty understanding abstract, dynamic, and complex concepts is one of the problems of mechatronics learning. In addition, for practical work, the availability of practical tools or real mechatronics objects is very limited due to the need for expensive budgets, viewed from the education budget in developing countries. These problems require the right solution to implement mechatronics learning. These issues have been widely

discussed but in fact still require serious research, a solution to addressing the interests of mechatronics learning media we offer a new platform called Mechatronics Learning (Mecha-Learn) as a learning media that is not only theoretical, but practical, economical, and providing an overview of how the tool or component works approaching the original object based on website. This research aims to design and create Mecha-Learn from the system, user interface, and prototype platform. The research approach used is ADDIE. The use of Mecha-Learn as a mechatronics learning media is expected to facilitate the understanding of concepts and principles of component work, better preparation before using the actual tool, and as a solution to the imbalance in the number of components and the number of users.

Keywords: Mecha-Learn, Mechatronics, Learning Media, CodeIgniter, ADDIE

1. Introduction

The growth of mechatronics education in Indonesia is progressing quickly, this is because there is a high demand for skilled professionals in the field, which can be applied in various industries and are relevant in the fourth industrial revolution era ^[1]. Currently, there are numerous educational institutions in Indonesia that offer mechatronics courses, as reported by media, including seven universities, six polytechnics, and over sixty vocational schools spread across the country that focus on mechatronics education ^[2].

In this study the researchers designed and built a system and prototype of a learning media with a website-based animation media approach to explain the theoretical and working principles of components or tools that approach the original object related to mechatronic content. The use of this animated media approach is motivated by the limitations of presenting real objects into the learning process such as prime movers, compressors, air service units, sensors, valves, actuators, or others related to mechatronic content which results in a lack of experience in learning ^[3]. In addition, there are many uses of symbols from mechatronic components that are difficult to understand because they are abstract. Therefore, the use of this animated media will greatly help to increase effectiveness and efficiency in the mechatronics learning process, given the limitations in presenting real objects or mechatronics components which are difficult to do ^[4]. In addition, the animation approach to learning media will get closer to its concrete or original form, in this case the mechatronic components in order to increase attractiveness, motivation, and experience in learning ^[5].

This research is similar to other studies that have also designed learning media using animation. For example, one study created a pneumatic learning media for Android devices, featuring animations that demonstrate the workings of pneumatic components ^[6, 7]. Another study developed an E-Module, which is a WordPress-based learning tool, that teaches basic electrical circuits ^[8]. This research builds on previous studies by using a website-based format, allowing it to be easily accessed from anywhere, using either a smartphone or a personal computer. The content presented in this research includes not only animations of how tools work, but also brief explanations of related theory, as well as features that support the learning

process.

This study aims to design, design, and manufacture both in terms of systems, user interfaces, and prototypes of mechatronics learning websites which are named by researchers, namely Mechatronics-Learning (Mecha-Learn). The research approach used in this research is Analysis, Design, Development, Implementation, and Evaluation (ADDIE). It is hoped that in this study, the system design and Mecha-Learn website prototypes that are built are in accordance with what is expected in the process of designing requirements and the required suitability.

Mechatronics-Learning (Mecha-Learn) is a website-based interactive learning media that provides mechatronics content by presenting theoretical and animated approaches that illustrate the working principles of mechatronics tools or components close to the real thing. There are several advantages of the Mecha-Learn website, including that it can be operated by users via computers, PCs, or smartphones connected to the internet as an access link that can be accessed flexibly anywhere, anytime, and by anyone who has the motivation to study mechatronics content. In addition, there are main features to support the learning process including a dashboard feature to see how far the user is progressing in mechatronics learning, material features that can present mechatronics theory content and animations of working principles or mechatronics components approaching the real thing, training features and quizzes to measure understanding, users about the mechatronic content that has been studied, as well as the live chat feature as an interactive feature of the discussion forum between users and tutors regarding the discussion of mechatronics content. The use of the Mecha-Learn website will facilitate and answer problems related to limitations in presenting real objects or mechatronic components into the learning process and the use of the Mecha-Learn website can be applied to study groups (undergraduate, diploma, or vocational high school level) or private users (private).

In this study, the Mecha-Learn website is being created using a framework with the PHP programming language. A framework is a structure that helps developers make the website development process more efficient [9].

This research involves the development of a website called Mecha-Learn using the PHP programming language and a framework called CodeIgniter. CodeIgniter is a PHP framework that utilizes an MVC approach, which allows developers to easily create dynamic websites without having to start from scratch. It comes with comprehensive documentation and example source code, making it easy for developers to use. Additionally, it is free to use as it has an open-source Apache/BSD license, it requires less hosting space compared to other PHP frameworks, and its source code structure is simple, making it suitable for beginners. The Mecha-Learn website is developed using CodeIgniter 4, the latest version of the framework, which has several helpful features, including a CLI, a configuration file (env), and REST API support, that make the development process easier and efficient [10].

Codeigniter with the MVC approach allows the separation of the user interface and program logic which is divided into 3 main parts, namely the model, view, and controller. In the model section as a place to manage and deal directly with the database, the view is the part that presents information views to users as accessors, and the controller is the connecting part between the model and the view in every

request process from the user [11]. With this MVC concept, the designed website has separate sections and can be developed individually. For example, PHP, MySQL, Javascript, and CSS query code can be separated into separate folders so that the file size is smaller and easier to fix if errors or bugs occur.

Testing the quality of a website involves evaluating the website's design according to established standards. One commonly used standard for website quality testing is the ISO/IEC 25010 [12]. Developed by the International Organization for Standardization and International Electrotechnical Commission, this standard is an extension of previous standards such as ISO/IEC 9126. It is part of the Software Quality Assurance (SQA) and covers eight main areas of testing, including functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability [13].

2. Method

This research is a part of the design, development, and implementation stage using the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) method approach. The outcome of this research is a website-based mechatronics learning platform, which aligns with the ADDIE approach [14]. The overall aim of this research is to create a web-based interactive mechatronics learning platform that can be accessed by anyone, anytime, anywhere, as long as they have internet access. The focus of this research is on the design of the website's user interface and system design, the development of the website using the CodeIgniter framework, and the implementation stage.

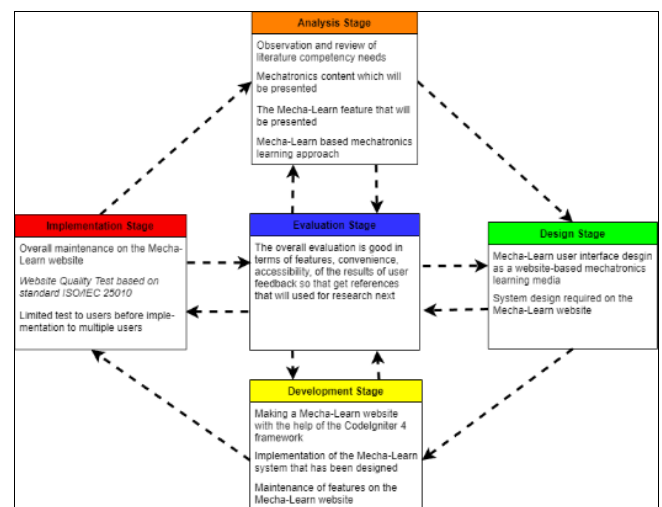


Fig 1: Addie Method

3. Result and Discussion

3.1 Mecha-Learn Website System Architecture

The Mecha-Learn website system is based on the MVC (Model View Controller) approach and has three components: networking, hardware, and software. The networking component acts as a connection to access the Mecha-Learn website, while the hardware component serves as the tool to operate the website. The software component includes the program data that makes up the user interface and the website database. The architecture of the Mecha-Learn website system can be described as having these three components working together.

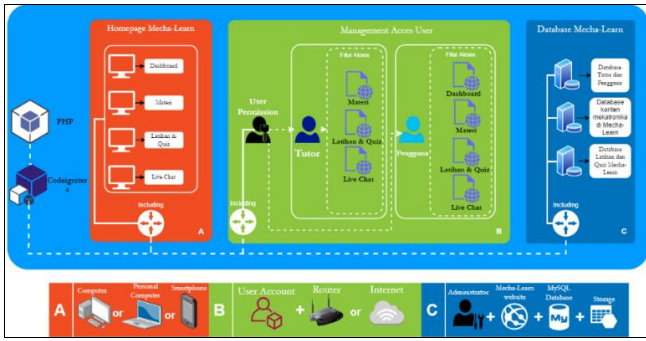


Fig 2: Architecture System Website Mecha-Learn

The Mecha-Learn website is composed using PHP programming language with the support of Codeigniter 4 framework, as shown in Fig 2. It has several main sections, including the homepage (column A) that contains the key features of the Mecha-Learn website that can be accessed using a computer, laptop, or smartphone. Column B represents the user access (tutor and user), which requires a user account created on the login page menu and an internet connection as a means of accessing the Mecha-Learn website. Column C is part of the Mecha-Learn database, which is maintained by a MySQL database, and stores crucial information such as user accounts (tutors and users), mechatronics content, and Mecha-Learn training/quiz data, which is managed exclusively by the Mecha-Learn administrator.

3.2 Mecha-Learn Website System Design

3.2.1 Use Case Diagram

The process of designing the user experience on the Mecha-Learn prototype involves the use of the Unified Modeling Language (UML) in system design modelling [15]. The system mechanism in this research prototype has been modeled using three key diagrams of the modeling language, including use case diagrams, activity diagrams, and sequence diagrams.

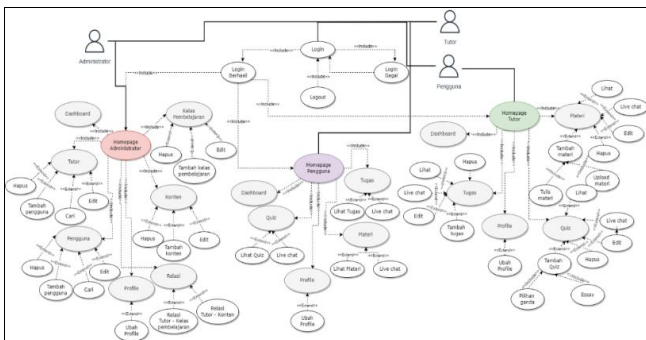


Fig 3: Use Case Diagram Mecha-Learn

The diagram shown in Fig 3 is a representation of the interaction between administrators, tutors and users with the Mecha-Learn system. This use case diagram depicts the entire process of logging in and accessing the system. To interact with the Mecha-Learn system, it is necessary to have an account, which can be created by users on the login or signup page. Access to the system is granted only after a

successful authentication process, which requires the user to enter the registered email.

3.2.2 Activity Diagram

The activity diagram is a representation of how the website interacts with the user and responds to their commands. The diagram provides an illustration of the user-system interaction, including the expected procedures [16].

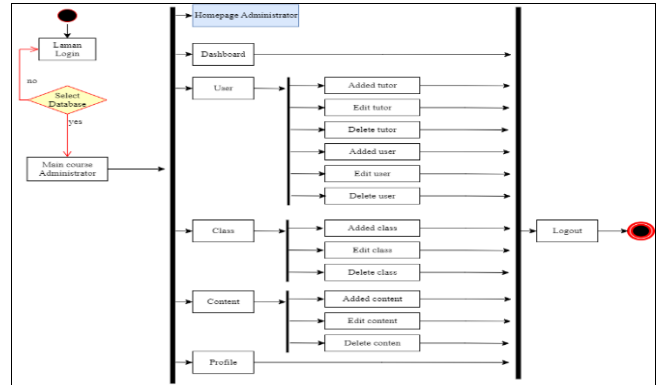


Fig 4: Activity Diagram Administrator Mecha-Learn

The Fig 4 depicts an activity diagram that shows the interaction between the Mecha-Learn administrator and the system design. The diagram has one starting point, the initial interaction between the administrator and the system, a decision node that acts as a condition for administrator activities, 6 split nodes that divide the flow into multiple streams, 21 activities that represent specific actions, and one final node, which represents the end of the administrator interaction with the system.

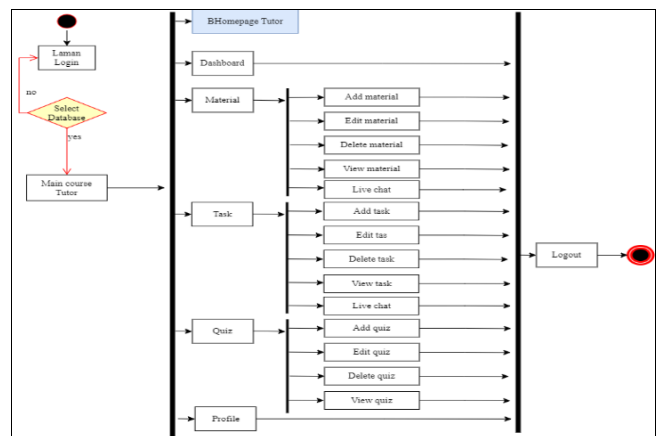


Fig 5: Activity Diagram Tutor Mecha-Learn

In Fig 5 is an activity diagram of the tutor interaction with the designed system, there is 1 initial node which is the initial process of interaction between the tutor and the designed Mecha-Learn system, 1 decision node which is a conditional activity solver in the activity tutor, 6 forks node which is a breaker for one flow diagram at a certain stage which then turns into several streams in the activity diagram tutor, 23 activities that contain each action, and 1 final node which is the end of the activity diagram tutor.

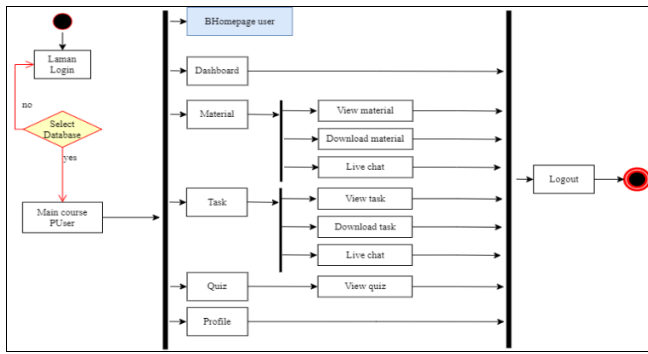


Fig 6: Activity Diagram User Mecha-Learn

In Fig 6 is an activity diagram of user interaction with the designed Mecha-Learn system, there is 1 initial node which is the initial process of interaction between the user and the system, 1 decision node which is a conditional activity breaker in user activity, 6 fork nodes which are an activity diagram flow breaker at certain stages which then turns into several activity diagram flows, 16 activities that contain each action, and 1 final node which is the end of the activity diagram from the user.

3.2.3 Sequence Diagram

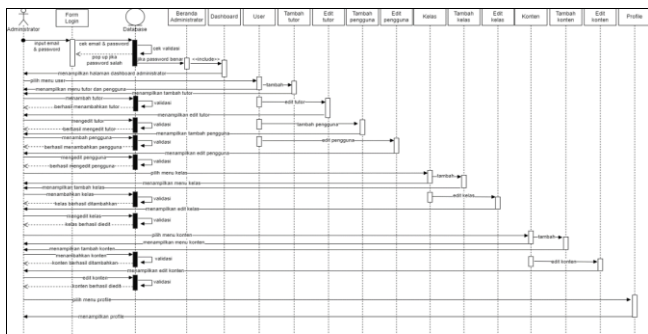


Fig 7: Sequence Diagram Administrator Mecha-Learn

In Fig 7, a sequence diagram of the interaction between actors and Mecha-Learn administrator objects is depicted. The diagram encompasses the entire system activity flow with a single system and one actor who performs the activities (administrator). The diagram consists of 16 lifeline systems that depict all system activities and 46 messages that convey information about the system activities or actions that can be performed by the actor (administrator). Additionally, there are 9 self messages indicating that an object calls itself.

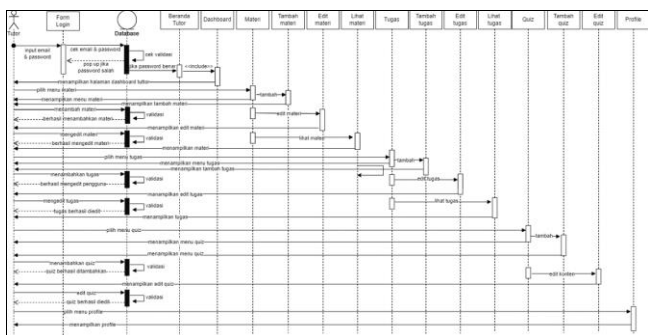


Fig 8: Sequence Diagram Tutor Mecha-Learn

The diagram in Fig 8 represents the sequential interaction between the Mecha-Learn tutor objects and the actors. The system activity flow is encompassed by a single system, with a single actor (the tutor) carrying out activities. The system activities are covered by 16 lifeline systems and the diagram includes 42 messages that convey information about the system activities that occur or that can be performed by the actor (the tutor). Additionally, there are 7 self-messages, indicating instances when an object calls itself.

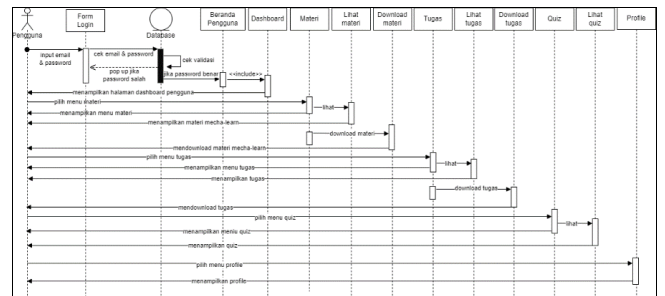


Fig 9: Sequence Diagram User Mecha-Learn

Fig 9 shows a sequential interaction diagram between the Mecha-Learn system, its users, and actors. There is one system that encompasses the entire system flow, one actor who performs the activities (the user), 13 lifeline systems that describe all system activities, 24 messages that convey information about system activities that take place or can be performed by the user actor, and 1 self message indicating that an object calls itself.

3.3 Generation Source Code

The creation of the Mecha-Learn website involved putting together the PHP programming language source code using the CodeIgniter framework. The process required 4234 files, which comprised of source code, images, and other related files, and 841 folders. The final product, a mechatronics learning website, had a total size of 62.1 megabytes [17].

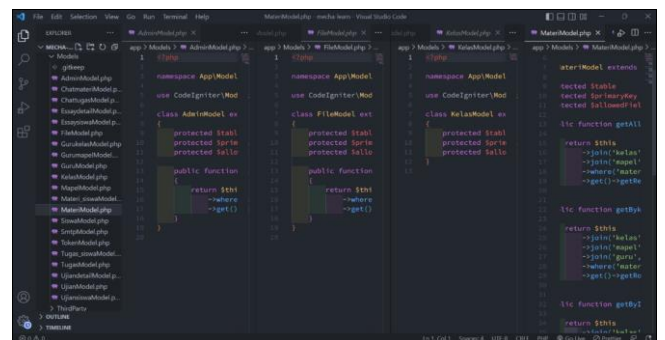


Fig 10: Routes Modelling Website Mecha-Learn

Fig 10 illustrates the modeling routes of the Mecha-Learn website implemented using the CodeIgniter framework. Within the modeling folder, there are 21 PHP files with the extension (.php) and one (.gitkeep) file. This section acts as a data management system for website applications, including user data, material data, exam data, and quiz data. The data regulations are collected and transmitted to the Mecha-Learn database.

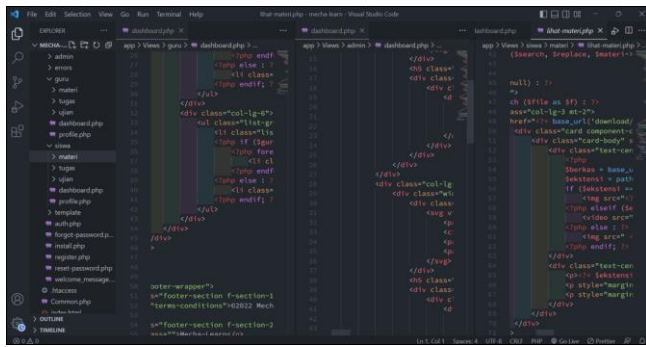


Fig 11: Routes Views Website Mecha-Learn

Fig 11 illustrates the View routes of the Mecha-Learn website. It comprises of 18 folders and 47 files consisting of extensions such as .php, .html and .htaccess. These View routes are responsible for displaying the website application to the user and creating the views that the user will access when running the application. The focus is on these routes to produce the visual representation of the website.

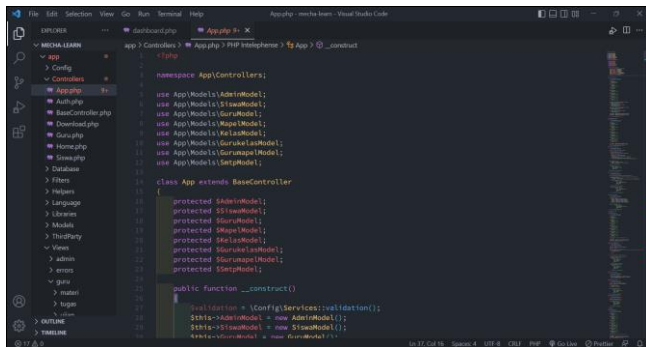


Fig 12: Routes Controllers Website Mecha-Learn

The routes for the Mecha-Learn website controllers are displayed in Fig 12, consisting of 7 files with a php extension. The purpose of these routes is to serve as a link between the modeling routes and the views routes.

3.4 User Interface Website Mecha-Learn

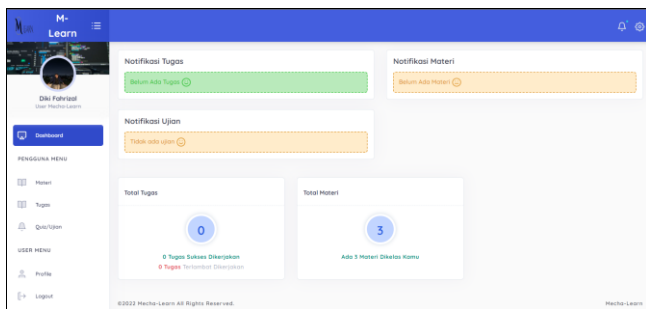


Fig 13: User Interface Dashboard Pages User Mecha-Learn

The Fig 13 displays the Mecha-Learn dashboard page for users. This page provides ease for users to monitor new notifications from tutors and keep track of their progress in mechatronics learning.

In Fig 14, the display of the material accessible by users is depicted. This material feature includes a live chat function that will be beneficial for users as it allows them to communicate with tutors directly through messaging.



Fig 14: User Interface View Material Pages Mecha-Learn

3.5 Mecha-Learn Website Testing with ISO/IEC 2510 Standard

3.5.1 Functional Suitability Aspect Testing

The functional suitability of the Mecha-Learn website is tested through a series of test cases that encompass all its functional features. The objective of these tests is to determine if the website operates correctly, as planned, and to identify any system failures [18]. The results of each feature test on the functional suitability aspect can be viewed in Table 1.

Table 1: Result of testing website on the functional suitability aspect

S. No	System Testing	Result
System Verification Integration		
1.	Create a Mecha-Learn website account	Runs optimally
2.	Reset the password of the Mecha-Learn website account	Runs optimally
3.	Login Mecha-Learn account on the login page	Runs optimally
Mecha-Learn website System Administrator Integration		
1.	View of administrator dashboard features	Runs optimally
2.	Mecha-Learn manage user menu display	Runs optimally
3.	Mecha-Learn learning class manage menu display	Runs optimally
4.	Mecha-Learn manage content menu display	Runs optimally
5.	Class relationship menu display – Mecha-Learn website content	Runs optimally
6.	Administrator profile view	Runs optimally
7.	Administrator account logout	Runs optimally
Mecha-Learn website Tutor System Integration		
1.	Tutor dashboard feature display	Runs optimally
2.	Mecha-Learn website material management menu display	Runs optimally
3.	Display of the manage tasks menu on the Mecha-Learn website	Runs optimally
4.	Display of the manage quiz menu on the Mecha-Learn website	Runs optimally
5.	Tutor profile display	Runs optimally
6.	Log out of a tutor account	Runs optimally
Mecha-Learn website User System Integration		
1.	User dashboard feature view	Runs optimally
2.	Mecha-Learn material menu display	Runs optimally
3.	Mecha-Learn task menu display	Runs optimally
4.	Mecha-Learn quiz menu display	Runs optimally
5.	Mecha-Learn user profile display	Runs optimally
6.	Mecha-Learn user account logout	Runs optimally

$$\begin{aligned}
 \text{functional suitability (\%)} &= \frac{\text{number of scores obtained}}{\text{highest number of scores}} \times 100\% \\
 &= \frac{22}{22} \times 100\% = 100\%
 \end{aligned}$$

The results obtained from the calculation are then classified into the feasibility category based on the feasibility criteria. The results of the functional suitability testing for the Mecha-Learn website are found to fall under the category of "highly feasible".

3.5.2 Compatibility Aspect Testing

Testing for compatibility of the Mecha-Learn website is conducted to determine its capability to function in a range of operating systems, devices, and web browsers. The results of the compatibility aspect tests can be seen in Table 2.

Table 2: Result of testing website on the compatibility aspect (1)

Browser/versi	Result	Noted
Google Chrome/108.0.5359.96	Optimally accessible	Succeed
Microsoft Edge/108.0.1462.42	Optimally accessible	Succeed
Mozilla Firefox/72.0.2	Optimally accessible	Succeed
Safari Browser/5.1.7	Optimally accessible	Succeed
Internet Explorer/11.0.11	Optimally accessible	Succeed

Table 3: Result of testing website on the compatibility aspect (2)

Operating System	Result	Noted
Computer or Personal Computer		
Windows 7	Optimally accessible	Succeed
Windows 8	Optimally accessible	Succeed
Windows 10	Optimally accessible	Succeed
Windows 11	Optimally accessible	Succeed
Apple MacOS	Optimally accessible	Succeed
Linux	Optimally accessible	Succeed
Smartphone		
Google Android	Optimally accessible	Succeed
Apple iOS	Optimally accessible	Succeed

3.5.3 Maintainability Aspect Testing

Assessing the quality of the Mecha-Learn website based on its maintainability aspect is crucial to ensure the optimal

operation of the website in the long term. The results of the tests on the maintainability aspect can be found in Table 3.

Table 4: Result of testing website on the maintainability aspect

#Q	Question	Score
Q1	Website documentation available and easily accessible?	4
Q2	Website documentation consist of relevant, up-to-date, and complete content?	3
Q3	Website documentation easy to understand by website develop and maintainers?	4
Q4	What time does it take long enough to fix the problem on the website?	3
Q5	The succes rate in fixing problems on website is high?	3
Q6	The website has feature that are easy to use and maintenance?	3
Q7	the website is easily integrated with other systems?	3
Total		23

$$\text{maintainability testing (\%)} = \frac{\text{number of scores obtained}}{\text{highest number of scores}} \times 100\%$$

$$= \frac{23}{35} \times 100\% = 65,7\%$$

The results of the calculations have been transformed into a category of suitability using the suitability criteria, based on the results of the Mecha-Learn website maintainability testing, which falls under the category of "easy to maintain".

3.5.4 Usability Aspect Testing

Testing of the usability aspect of the Mecha-Learn website was carried out by inviting 5 users to access the website (www.mecha-learn.com) and completing a 30-question questionnaire based on the standard USE Questionnaire [19]. The data collected from the results of the usability questionnaire will be presented as follows.

Table 5: Result of testing website on the usability aspect

Usefulness	I don't notice any inconsistencies as I use it
It helps me be more effective	Both occasional and regular users would like it
It helps me be more productive	I can recover from mistakes quickly and easily
It is useful	I can use it successfully every time
It gives me more control over the activities in my life	Ease of Learning
It makes the things I want to accomplish easier to get done	I learned to use it quickly
It saves me time when I use it	I easily remember how to use it
It meets my needs	It is easy to learn to use it
It does everything I would expect it to do	I quickly became skillful with it
Ease of Use	Satisfaction
It is easy to use	I am satisfied with it
It is simple to use	I would recommend it to a friend
It is user friendly	It is fun to use
It requires the fewest steps possible to accomplish what I want to do with it	It works the way I want it to work
It is flexible	It is wonderful
Using it is effortless	I feel I need to have it
I can use it without written instructions	It is pleasant to use

$$\text{usability testing (\%)} = \frac{\text{number of scores obtained}}{\text{highest number of scores}} \times 100\%$$

$$= \frac{685}{750} \times 100\% = 91,3\%$$

The results of the calculations have been transformed into feasibility categories based on the criteria obtained from the

usability tests of the Mecha-Learn website, which have been categorized as "very feasible".

4. Conclusion

A Mecha-Learn (Mechatronics-Learning) website has been designed and created as a means of website-based mechatronics learning media. With several features that can support mechatronics learning activities, the content

presented is in the form of a brief explanation accompanied by an animation of how objects approach the original object. The Mecha-Learn website can be used by study groups or private groups which can be accessed flexibly, practically and economically. The test parameters before the website can be implemented using the website quality standard ISO/IEC 25010, in testing the functional suitability aspect with a feasibility percentage of 100% and included in the "Very Eligible" classification, testing the compatibility aspect of the Mecha-Learn website can be run optimally on all types of websites browsers and on various devices with operating systems used, testing the maintainability aspect with a feasibility percentage of 65.7% and entering the "Easy Maintenance" classification, as well as testing the usability aspect with a feasibility percentage of 91.3% and entering the Mecha-Learn "Very Eligible".

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