

## Development of Smart Simulator for Electronic Fuel Injection (EFI) Fuel System Based on Quick Response Code (QR Code) for Learning Media

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**Abstract**—This research aims to develop learning media in the form of an intelligent fuel system simulator, namely electronic fuel injection (EFI) on motorbikes, which focuses on developing the addition of Quick Response (QR) codes as additional information from the simulator, which is connected to video on the YouTube platform. With the help of the QR code, it is scanned using a smartphone so that the QR code can be connected directly to YouTube, providing additional information about the Smart simulator EFI system on motorbikes. This research was carried out by applying the Research and Development method and following the Plomp model, which consists of the following stages: (1) preliminary investigation, (2) designing and making a prototype, and (3) assessment. The existing simulator was developed by adding a QR code, and the QR code will be connected to videos that have been uploaded on the YouTube platform. QR codes are created using the online QR code generator platform. Assessment of the smart simulator is carried out through a questionnaire filled out by media experts and subject experts, as well as through observation sheets during smart simulator testing. The research results are a smart simulator product for EFI fuel on motorbikes equipped with a QR code. Evaluation by media and material experts shows that the smart simulator is declared valid. Meanwhile, the results of observations during product testing show that the smart simulator can describe the characteristics of the EFI fuel system on a motorbike according to the actual situation.

**Keywords**—Smart; simulators; quick response code; YouTube; EFI.

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### I. INTRODUCTION

The digital era is a period where technological advances are taking place worldwide. As members of society living in this era, we should follow current technological developments [1], [2]. Using technology to overcome problems in the field of education is a smart action [3]. One way to utilize technology in education is to use computer-based video media as a learning tool in the classroom [4].

Furthermore, the media that was also developed, namely using simulators as learning media, has been developed quite a lot by previous teaching staff. Several simulators are designed to solve problems in the learning process in the form of simulators in the fuel system that use the electronic fuel injection (EFI) fuel system developed [5] on motorbikes to understand how the Honda Beat FI PGM-FI system works.

Operate and identify the components in the Honda Beat FI simulator, find out the results of welding strength calculations on the Honda Beat FI trainer frame, and assess the vibration level produced by the Honda Beat FI trainer frame. This trainer begins by designing a frame drawing using the device Inventor 2012 software [6]. Next, the steps include calculating and planning the trainer before it is made. The main goal of this process is to understand in detail the materials used and the size of the components in this trainer. It should be noted that this trainer uses original components that are commonly used in Honda spare parts. The result is that this simulator makes it relatively easy to recognize motorbike components and how they work.

Research on learning media development was carried out by [7]. The results show that learning media development is the process of planning to improve existing media or tools to improve the quality of information delivery in learning.

Learning media development generally involves three main stages: planning, production, and evaluation. Meanwhile, another study by [8] aims to develop a practical, efficient, and relevant sensor learning method in the automotive field. This will ensure that students from the automotive department can quickly understand the basic concepts of these sensors. The results of this research reflect achievements in developing a knock sensor demonstrator model, which is a crucial component in the automotive context.

The development of simulators in learning has been carried out by [9]. To reduce gaps in the learning process, there needs to be more integration between electrical theory and automotive electrical practice, which results in differences or mismatches between what students learn and the summary of lecture material. The result is that this simulator effectively overcame the problems above because it uses a simplified representation of the automotive electrical flow system, which reflects actual conditions. This simulator is a model of the real system, and when given specific input or treatment, it will show symptoms similar to those in the real car's electrical system.

On the other hand, the use of learning media in the form of simulators can increase motivation in learning [10]. This research concludes that mechanical simulator media has increased student motivation and learning achievement. And research that is in line is [11] on the development of VR media, and research results reveal that the use of VR media significantly affects their knowledge. However, it did not significantly affect their practice skills. VR is not yet able to provide an experience that is close to real-life conditions during welding, such as heat, sparks, and the sound that occurs when the electrode touches the workpiece [12].

Simulator development was also carried out by [13] and [14] in creating a simulator for learning air conditioning (AC) systems. This research aims to create a simulator for air cooling systems in motor vehicles and design a learning model focusing on environmentally friendly technology in the automotive sector. The simulator is designed according to situations appropriate to the world of work to prevent misunderstandings and incorrect practices in automotive air-cooling systems. This simulation is designed in a compact and portable format, allowing easy transportation. The results of the research show that significant progress can be seen in learning achievements in affective, cognitive, and psychomotor aspects, and also in competency development [15].

In making a simulator developed by [16] for autotronic learning, which aims to have a better understanding of sensors in terms of how they work and the working principles of sensors in cars in automotive, and creating a learning tool in the form of a simulator that focuses on automotive electronic systems and uses microcontroller to measure the output performance of existing sensors, the results from experts in media and materials show that this simulator has a very high level of validity. Meanwhile, the results of observations on product trials show that the simulator can visualize sensor characteristics in table and graph format.

A fuel system simulator that focuses more on developing practical simulation tools for the throttle position sensor and simulating problems with the ignition coil to increase understanding in diagnosing damage to the engine

management system with product feasibility test results obtaining a percentage of 90% for media experts and 96% for material experts with a very feasible category, then the Ha value will be accepted if the value in the table is smaller than the calculated value. Based on an analysis of student responses, the percentage reached 94%, which is included in the exciting category [17]. When learning is carried out using a simulator, it also increases interest in learning, as in research [18], it can be concluded that using an EMS simulator significantly increases interest in learning and the ability to repair electronic injection systems, along with an increase in the average value of class competency from 78.26 at the start to 84.09 at the end.

Making a simulator involves moving all the components in the system that will be understood in the lesson, both the fuel system and other systems, so that the information obtained is limited to the shape of the component and how the component works. This condition limits the ability to explore the elements and workings of the system more deeply in the simulator.

Furthermore, there have been many developments in learning media by making videos since COVID-19 broke out, and these learning videos were published on YouTube channels and other sites. Among them, research involving the application of the PBL model using YouTube videos as a tool has produced a presentation score of 92.14%, which shows a very high level of achievement. These results indicate that the use of the PBL learning model supported by YouTube video sources has a significant impact [19]. Using YouTube to gather information to achieve graduation for students with overall results quickly. Overall, this research aims to examine the key factors influencing how MBA program students can optimize the use of YouTube as a learning tool, impacting their academic results. A model has been proposed in this context, and several hypotheses have been tested. Educators face new challenges as they are no longer the sole source of information for their students. YouTube provides a variety of diverse sources of information. Therefore, instructors need to plan and prepare their lessons because the choice of likes or dislikes and the number of video views indicate how effective the implementation of their tasks is [20], [21].

In learning, the use of YouTube media is increasingly popular and practical. There are many choices and alternatives, which increases teaching and learning activities. There are differences in learning motivation between students who take part in learning using real media, YouTube video media, and chart media [22]. Further test results with LSD show that YouTube video media is superior to real media and graphic media in instilling learning motivation in students.

The learning process is a system consisting of several interrelated components that influence each other. Some of these components include: (1) Students, (2) Educators, (3) Learning tools, (4) Learning approaches, (5) Learning objectives, (6) Learning resources, (7) Facilities and infrastructure, (8) Environment. If one of the components in this system does not run optimally, then success in the learning process will also be affected. For example, when an educator cannot select, provide, or use practical learning tools, the information conveyed through these tools may not be well received by students. This can have a negative impact on learning outcomes and student motivation [23].

Several development studies have revealed limitations, and some simulators have become serious problems. They must be developed so that the function and role of the simulator as a medium for learning are optimal and maximal in providing information. With complete information from the simulator, the learning experience will improve and increase learning activities and competence.

One of the developments that will be carried out is combining a simulator with a Quick Response code, better known as a QR Code. This development aims to make the simulator able to provide more information about how a system works or the working principles according to the simulator. The development is combined with a QR code and will later be connected to other sources, such as explanatory videos with animation or real videos on YouTube channels. QR codes will be adjusted to the information needed so the simulator is more interactive and can respond to more detailed and complete explanations. From this basis, the development of a smart simulator was carried out, and this development has yet to be carried out, so this will provide an excellent reference for developing learning media based on ICT and 21st-century learning based on information technology.

## II. MATERIALS AND METHOD

This research was carried out using a development method based on the Plomp model, which has been simplified into three stages: the initial research stage, the prototype-making stage, and the evaluation stage. This research and development produced a smart simulator product regarding the Electronic Fuel Injection (EFI) system on motorbikes, as shown in Fig. 1.



Fig.1 Electronic Fuel Injection (EFI) fuel system simulator on a motorbike

It includes a fuel system containing several sensors and transducers and an ignition system that is equipped with a QR code and can be scanned using a QR code scanning on a smartphone so that by scanning. There will be additional information about the smart simulator and how it works or further explanation about the Electronic Fuel Injection (EFI) system in the smart simulator

### A. Initial Investigation Stage

At this stage, the initial steps of analysis are carried out, including problem identification, needs assessment, and

concept discussion [24]. During the simulator development process, relevant literature studies were also carried out. In the context of using simulators as learning aids, this stage aims to identify differences between student needs and teacher preferences [25].

A simple approach is to look for subject matter that is considered difficult and then look for ways to increase understanding through the use of learning media [26]. The concept analysis aims to find out the purpose of making this smart simulator, namely adding features to the simulator so that the smart simulator has advantages and is more interactive in providing information for learning media so that learning competencies are more easily achieved [27]. On the other hand, it will also add activity to learning because students can explore this smart simulator more deeply.

### B. Design and Realization Stage

At this stage, the process begins with manually sketching the design on paper, which involves modeling the system and converting the paper design into a framework and support structure for the simulator on the computer. The design phase is characteristic of starting from the end of the product and returning to the beginning. This means that the design provides a view that the final product will conform to the initial concept [28]. An illustration of this stage can be seen below.

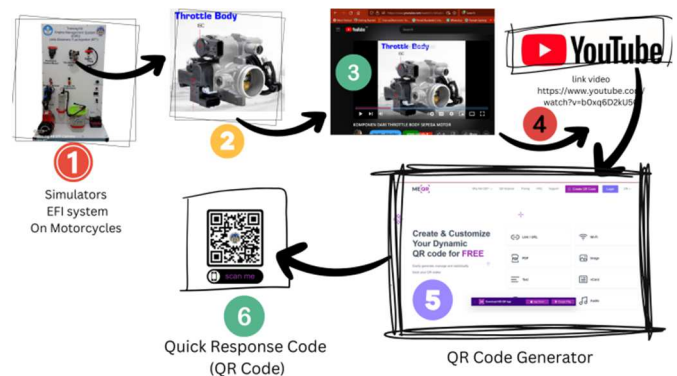


Fig. 2 Stages of the smart simulator development process

The stages of smart simulator development are:

- Simulators used in learning in general.
- Making a video that discusses complete information related to the simulator.
- Videos that have been edited are uploaded to the YouTube platform.
- After uploading, you will get a video link, and then it will be converted into a QR code with the help of a QR code generator
- The QR code that has been obtained is printed onto sticker paper
- Each QR code is affixed to the simulator

### C. Assessment phase

The evaluation phase involves formative evaluation, including self-evaluation, prototyping (including expert review, one-on-one testing, and small group testing), and field testing. During this evaluation stage, the prepared instruments validate the simulator product, including testing during component installation and how the EFI system works on the

smart simulator. Evaluation results that do not meet the objectives will require returning to the previous stage. Experts collect data using validation sheets by experts to test the designs and products made. In addition, the observation sheet is used to test how the simulator product functions in practice as intended in Table 1[29].





TABLE I  
PERCENTAGE OF SIMULATOR VALIDITY RANGE

(%)	Category
81.26 - 100	Highly valid
62,51 – 81,25	Valid
43.76 – 62,50	Less valid
25 – 43.75	Not valid

### III. RESULTS AND DISCUSSION

In the chosen method, research results are presented in a structured manner according to research steps that follow the simplified Plomp model [30], [31]. In the initial investigation stage, a needs analysis of the simulation media was carried out, and the components and materials needed to make the smart simulator were identified. The results of this need analysis indicate that the media used in learning, especially in the EFI fuel system material, are sensors and transducers found in several components. For fuel system components and ignition systems, there are components including fuel pumps, injectors, injector hoses, throttle body, Electronic Control Module (ECM), oxygen sensor, engine temperature sensor (EOT), pulser, coil, spark plugs, fuses, ignition key, drive motor, and indicator lights[32].

TABLE II  
YOUTUBE LINK AND QR CODE

Part	video link in YT	QR Code
Electronic Fuel injection (EFI) System	<a href="https://s.id/1UbNi">https://s.id/1UbNi</a>	
ECU	<a href="https://s.id/1UbN8">https://s.id/1UbN8</a>	
Throttle Body	<a href="https://s.id/1UbT5">https://s.id/1UbT5</a> <a href="https://s.id/1UbTi">https://s.id/1UbTi</a>	
O <sub>2</sub> Sensor	<a href="https://s.id/1UbTr">https://s.id/1UbTr</a>	

Part	video link in YT	QR Code
Engine Temperature Sensor (EOT)	<a href="https://s.id/1UbTO">https://s.id/1UbTO</a>	
Pulser (CKP)	<a href="https://s.id/1UbMf">https://s.id/1UbMf</a>	
Spark Plug	<a href="https://s.id/1UbNv">https://s.id/1UbNv</a>	
Coil	<a href="https://s.id/1UbSM">https://s.id/1UbSM</a>	
Fuel Pump	<a href="https://s.id/1UbUq">https://s.id/1UbUq</a>	
Fuse	<a href="https://s.id/1UbMR">https://s.id/1UbMR</a>	
Accu	<a href="https://s.id/1UbMI">https://s.id/1UbMI</a>	
Injector	<a href="https://s.id/1UbND">https://s.id/1UbND</a> <a href="https://s.id/1UbNP">https://s.id/1UbNP</a>	

After the QR code is obtained, a smart simulator will be created according to the needs that have been analyzed. The QR code will be transferred or printed onto sticker paper and attached to the smart simulator according to the position of each component[33]. The position of the components must be correct in designing a smart simulator so that the electrical system works well and according to its function. After installing the QR Code, the results will look like the image below.

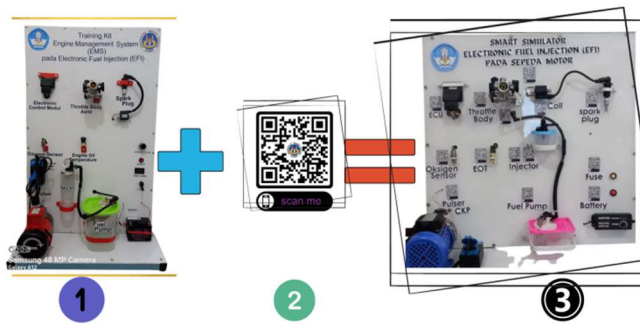


Fig. 3 Change from a regular simulator to a smart simulator

- A regular simulator that has been used
- Added QR code
- Smart simulator

You can see a very basic difference in the appearance of the simulator. The smart simulator uses a QR Code that can provide information. By using a smartphone with the QR code Reader application, the screenshot will automatically go directly to the intended YouTube link. By simply scanning the QR Code, all information about the EFI fuel system components will be revealed clearly and in detail. The steps can be seen in the image below.



Fig. 4 How to use the smart simulator

Based on this design, a smart simulator has been produced. Figure 4 depicts the resulting simulator. The best possible efforts have been made to follow the planned design. However, adjustments are still likely during manufacturing, depending on specific needs or reasons. According to Table 3, media experts scored 3 and 4 for all assessment indicators. There are no indicators that get a score of 1 or 2.

TABLE III  
MEDIA EXPERT VALIDATION RESULTS

No	Assessment indicators	Validator score
1	Appearance aspects of smart simulator design	4
2	Component layouts	4
3	Precise smart simulator dimensions	3
4	Ease of use	3
5	Video and sound on YT are clear and good	4
6	All QR codes are well connected to YT	3
7	QR code image that is easy to scan	3
Total score		24
Maximum score		28
Percentage		85.7%
Conclusion		valid

TABLE IV  
VALIDATION RESULTS BY SUBJECT EXPERTS

No	Assessment indicators	1 <sup>st</sup> validator score	2 <sup>nd</sup> qx3validator score
6	Smart Simulator complies with competencies regarding EFI fuel systems	3	4
2	The smart simulator wiring diagram is correct	4	3
3	The smart simulator components function properly	3	4
4	All QR Codes are linked to YT videos	4	4
5	The explanation of the material on YT is correct and in accordance with the theory	3	3
6	The EFI system on the smart simulator works by the system on the motorbike	4	4
7	Smart Simulator can make it easier to understand the EFI system	4	4
Total score		25	26
Total score (both)		52	
Maximum score		56	
Percentage		92.8%	
Conclusion		Very valid	

With a total score reaching 24 out of a maximum total score of 28, compared to the tool validity scale, it can be categorized as very valid. Therefore, the EFI Fuel system smart simulator on motorbikes is considered very suitable. Besides assessments, media experts provide suggestions or input to improve this smart simulator. One suggestion is to provide an APAR (Light Fire Extinguisher) for safety if a fire occurs because, in the smart simulator, there is fuel and sparks on the spark plugs.

All material experts, namely Material Experts 1 and 2, scored 3 and 4 for all assessment indicators, with most indicators getting a score of 4 (as seen in Tables 2 and 3). The percentage achieved was 92.8%, indicating that the smart simulator is highly valid. The results of the assessment involving media experts and material experts all showed a percentage above 81.26%, which suggests that the smart simulator has robust validity regarding the workings and principles of the EFI system on motorbikes.

The suggestions given by material experts can be summarized as follows: the need to improve long-duration videos, the importance of providing instrument work tables for students, the need to add modules in the descriptions, and the importance of using standard sentences. Most of these suggestions have been implemented.

#### IV. CONCLUSION

From the research results and discussions that have been carried out, conclusions can be drawn. One such conclusion is that a prototype for smart simulator learning media in the EFI fuel system on motorbikes can be combined with a QR code so that the information provided is complete and more detailed. Smart simulator testing in this learning media, which focuses on working principles, names, and functions of

components as well as how each component works, can be used with the addition of QR codes to increase independence and learning activities in 21st-century learning.

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