Interactive M-Learning Media Technology to Enhance the Learning Process of Basic Logic Gate Topics in Vocational School and Engineering Education

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Abstract - *The process of learning to use smartphones is now highly promoted. Almost everyone has a smartphone. The latest trend in learning is known as Mobile Learning (M-Learning). M-Learning can be used anywhere and anytime. Thus, we propose the use of the M-Learning application for computer system subjects in the basic logic gate topics so that students can be motivated to learn. We call this application BLG-LeMed. The focus of this research is on the process of using BLG-LeMed applications on classroom learning that is used directly by vocational high school students, then testing with alpha testing, User Acceptance Tests (UAT), usability evaluations, and knowing the effect of motivating students to use five dimensions of motivation and student learning outcomes. The development model used is Extreme Programming (XP). The design used in this study, by conducting trials in one class and observing students using the BLG-LeMed application as learning media, 38 students consisted of 26 men and 12 women involved in this study, with a duration of 135 minutes at one time of the meeting. We conclude that using the BLG-LeMed application based on M-Learning in the learning process of this basic logic gate, strongly supported by the testing team, can be accepted by users, has a usefulness as an interactive learning media, can have an effect in motivating students to learn, and provide results very satisfying learning.*

Keywords – *Alpha testing, Learning outcomes, Mobile learning, Motivation, Usability evaluation, User acceptance test.*

1. Introduction

Mobile Learning or commonly abbreviated as (M-Learning) can be defined as a learning process that is carried out anytime and anywhere using portable devices such as smartphones, Personal Digital Assistants (PDAs), tablets, and laptops. According to [1][2], mobile devices can be used to obtain all information anywhere and anytime. According to [3][4], M-Learning is a new paradigm in the world of awareness of knowledge. Learning models like this seem to keep the development of the world of information and communication technology, especially information technology and cellular communications very rapidly. Besides that, it cannot be denied at this time, cellular communication devices are one of the tools attached to the daily animation of actors such as teachers and students.

M-Learning can also be defined as a provider of education where a single or dominant technology is a handheld device [5][6]. Learning techniques such as M-Learning involve several technologies which include computer devices, PDAs, and smartphones. This technology must work together to support applications built on M-Learning [7][8].

According to [9], the advantage of M-Learning is learning that can be done remotely and does not have to be done in class. The benefits of using M-Learning in [10], are as follows: 1) Learning with mobile can happen anywhere and anytime, and learning content can be accessed anywhere; 2) Not limited to one place to carry out the mobile learning process; 3) Can increase interaction between teacher and students; 4) It is a great opportunity for teachers and students to continue learning outside of learning hours;

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5) Students can be focused and learn independently; 6) Provides great opportunities for timely training or content review; and 7) Can facilitate collaboration between teachers and students through asynchronous and synchronous communication techniques.

M-Learning offers many advantages over conventional learning approaches or others such as flexibility, mobility, and reach, and with M-Learning allows more opportunities to collaborate and interact informally among students. In our opinion, this will increase more attention to learning topic, make learning more meaningful and absorbed by students, and can encourage student motivation for lifelong learning. M-Learning, at the moment, is more innovative and student-centered.

In connection with these matters which have been described regarding M-Learning, we now associate with learning in Vocational Schools that use the 2013 curriculum, where students are required to be active or in other words learning must be student-centered. Computer system subjects, especially in basic logic gate topic, are the basic topic in tenth grade in their first semester of school, this topic must be taken as a concept in understanding computer performance and logic. In general, based on the field surveys that we conducted, we met in the implementation of learning, classical/conventional teaching still uses textbooks as the main element. However, the use of textbooks is very limited, too flat, and static. This tends to make students less motivated to learn. Though the concept of basic knowledge for logic gates is very much topics that must be remembered and understood by students, moreover there are forms of visualization of logic gates, simulations in circuits, and truth tables.

With books in our opinion, it is not efficient, because it is quite heavy to carry everywhere and also tends to be easy for students to get bored with books if they are learning to be serious. Independence of time and place is an important factor that is often emphasized, especially in the concept of M-Learning. However, in traditional E-Learning, the minimum fixed PC requirements that have the consequence that time and place independence are not fully met, we do not propose E-Learning because of that. This independence cannot yet be fulfilled by using a notebook because of the actual time and place. This means that a person can learn wherever and whenever he can access learning topic. Therefore, in the context of this new technology, it is important to develop M-Learning tools for innovation in learning media. According to [11] on its official website, that by striving to improve learning innovation in the vocational environment, this is indirectly the key to carrying out the era of the industrial revolution 4.0 to 5.0 which will now be faced.

In line with this according to research from [12], learning by utilizing technology will increase interest in learning, especially in developing M-Learning technology that indirectly has an advantage in accuracy, speed, and attractiveness without changing the essence from the learning process. The main contribution of our study which was finally reported to be this paper is to propose the use of M-Learning as a learning media, conduct testing, and find out the effects of use in the form of motivation and student learning outcomes in computer system learning on basic logic gate topic. Then prove it with the use of being tested directly in the classroom, testing the application, and knowing the effects of its use. With the use of M-Learning, this can help teachers more easily manipulate all the difficulties and problems that occur in M-Learning-based learning activities for better teaching and support for learning innovations that are very important for Vocational Schools to meet Industry 5.0 and Education 5.0. Therefore, this study will provide a very important contribution in improving learning technology in the field of vocational secondary education, especially for education in Indonesia, presenting this M-Learning application for vocational students as one of the innovations of learning media.

This paper consists of seven parts, namely in Section I containing the introduction and background problems in conducting research. Section II contains research related to the research that will be carried out. Section III contains the research methodology. Section IV describes the concepts and features that exist in the application. Section V contains an explanation of the design for implementing research that includes participants, research tools, and implementation processes. Section VI displays the results of the research in the form of images, tables, diagrams, and graphs and then conducts a discussion of the visualized results. Section VII contains conclusions from the conduct of research and recommendations for future work.

2. Related Works

As a form of an effort to improve learning technology and innovation in learning in the vocational high school environment or in this case in the area of technical education. Some researchers have tried to present and provide solutions and alternatives, especially in the scope of basic logic gate topics that are packaged in various media content applications.

First, some researchers present it on a web-based by [13], who developed a platform called DLD-VISU (Digital Logic Design-Visualization) in the form of visualization and animation of various web-based digital logic design processes, can help students practice topics that include digital logic design learning, and knowing performance feedback students based on the results of evaluations that are directly automated from the platform. From [14], produced a Web Learning development product that was assisted by Flipbook to improve logical thinking skills on the topic of logic gates.

Then the researchers who present it with game content are from research [15], designing and implementing 3D-based adventure games for technical education in digital logic design topic, they can adventure in games to study topic and complete tasks in the final stages. Research by [16], recommend the use of game-based learning for logic gate

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learning, then measure the effectiveness and student learning outcomes.

Next, those who have recommended M-Learning technology are research by [17], who develops mobile-based learning media on the subject of basic logic gates and then knows the impact of their use, the waterfall method as a software development model and tests it functionally and reports the results of evaluations from experts. From [18], that is developing and using M-Learning on basic digital electronic topic to assess students' perceptions of readiness and improve the effectiveness of learning in the classroom, but this study has not yet generated good animation from the process of making logic gates, input values, output values, as well as the truth table, this is only an image of the logic gate that is included in the M-Learning content.

Finally, some package content with other forms, but still rely on media technology/tools from research [19], studies that make modules as a medium for learning and training, can work as a simulator controlled by a Programmable Logic Controller (PLC) from logic gates, timers and other calculations, students feel very happy that they can support training and learning. Research by [20], using Arduino microcontrollers to help the learning process to understand and directly apply logic functions and Boolean algebraic gates.

The research we propose today is the use of interactive learning media based on M-Learning for computer system subjects in basic logic gate topics, where the research domain focuses on the process of use by end-users namely students, then perform alpha testing, user acceptance tests, usability evaluations, and determine the effect of their use in the form of five dimensions of student motivation and learning outcomes. The difference from our research with the same research [18] suggests that the application of M-Learning is in the fields of testing, effects, and we also add alpha testing, UAT, and usability evaluation to M-Learning, then package the content even better by adding animation and an explanation in the form of audio. Lastly evaluate the mobile-based interactive learning media that we propose, for the purpose of improvement.

3. Research Methodology

We propose a research methodology with six main stages (See Figure 1). The first stage of this methodology is the literature review and problem collection, this work aims to find various kinds of research related to the proposed research, hope we with this job can find loopholes and opportunities to fill the area of research that has not been implemented, then the problem collection here is to find the facts in the field to be resolved with the support of the results of the previous literature review. The second stage is to find solutions to solve problems based on problem collection and product development using the Extreme Programming (XP) development model (is part of agile method) that has four phases of performance according to [21][22], namely planning, design, coding, and testing. The third stage is the

implementation of research planning that aims to determine who is involved in the implementation of the research, the research tools used, and the implementation process, at this stage, is an adjustment of the title we propose, namely in the realm of application usage. The fourth stage is testing and effects, in the tests we will carry out consist of alpha testing, UAT, and usability evaluation, on the effect of use we will find out student motivation with five dimensions and student learning outcomes. The fifth stage is to report the results of the findings obtained during the study and discuss them. The last stage is to determine conclusions based on the results of existing research findings, answer the objectives and research questions, and determine future work.
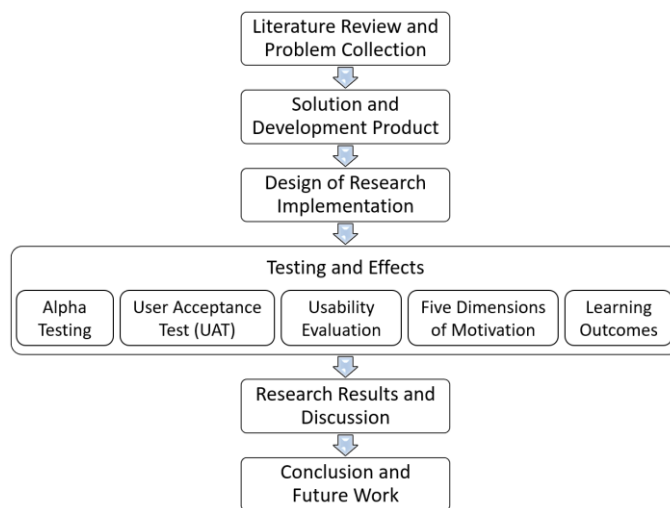

Figure 1. Proposed research methodology

Alpha testing is a test that involves content experts to show approved applications for the needs of learning related to basic logic gate topics, consisting of several questions that will be sent to content experts that we ask for examiners. User Acceptance Test (UAT) is a test performed for end users. The most important reason to use this UAT is to utilize what can be done by the system or application and these things can provide benefits to the end-user before the system or application is implemented in a larger environment in general. This UAT consists of Content, Module, Multimedia Element, Navigation, and Usefulness [23].

The concept of usability evaluation is to assess how useful an application is made to help a user's work/activity [24]. Usability evaluation is specific to the realm of measurement of M-Learning, in [25] that for evaluating usability for mobile learning requires two different criteria of use. First, based on Nielson's use criteria in physical use. Second, the use of mobile in the realm of education or pedagogical science with the following criteria: learning activities, group learning, oriented towards the objectives, application, effectiveness, and prior assessment of knowledge. The components needed for the use of new cellular learning that must be assessed during the testing

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process include presentation, activities, communications, and administration.

Of these four components are directly involved with the usability factors in the following matters, namely:

1. Adjustability: The extent to which the platform can be accepted as a learning platform by the user by emphasizing the style of interaction and the quality of the content of the learning platform.
2. Funability: The M-Learning platform and its concepts can provide users with a fun element, the application does not force users, and has little uncertainty (element of surprise).
3. Reliability: The M-Learning platform may not work in unexpected ways and must be structured.
4. Satisfaction: The user must feel that by using a mobile device he will be able to do his job by supporting any external activity.

Furthermore, for the five dimensions of motivation that are useful for knowing student motivation in using this M-Learning application, we adopted this motivational element from Glynn based on his research [26], which is a revised questionnaire for motivation consisting of twenty-five statement items motivation, which is then formulated into five dimensions of motivation, namely Intrinsic Motivation (IM), Career Motivation (CM), Self-Determination (STD), Self-Efficacy (SEF), and Motivation Grade (GM). He recommended that the full time to fill out this questionnaire should take a maximum of 15 minutes.

Student learning outcomes [27] can be known from the results of evaluations when students have gone through the learning process, then given questions about the topic he has learned, and the results of corrections from their answers, will produce values that can be measured as a result of each student's learning evaluation, to state the student's learning outcomes are good, can be obtained from the average value obtained from all students, if their average value exceeds the minimum passing criteria on the topic, then it can be stated that student learning outcomes are met well, which the value will be adjusted by the respective predicate based on the assessment rules in the relevant curriculum.

We also mapped out reasons. Why do we use M-Learning?, it is shown in Figure 2.

Figure 2. Four reasons for using M-Learning

From Figure 2, we think that indirectly many opportunities can be developed for efforts to improve learning technology based on M-Learning. Especially with point one that almost all students in Indonesia have smartphones, and even we see the facts on the ground that this smartphone looks like a good friend in their daily activities.

4. Concepts and Features of Interactive Mobile Learning Media
4.1. Media Concept

Based on previous relevant research using interactive learning media for basic logic gate topics, it is considered that students can understand and improve student learning outcomes. This would be a very good idea to improve learning technology and develop interactive mobile learning media to be a tool in supporting the learning process in computer system subjects.

In the realm of this research, interactive mobile learning media called the BLG-LeMed application has been designed and developed for beginners who just understand the concept of basic logic gates. This effort enables motivating students to learn and to change their thinking about a difficult topic into a topic that is more interesting and easy to understand. Besides, the effort to motivate students is also possible to see the learning outcomes whether in the predicate of good or bad from the use of this BLG-LeMed application. This BLG-LeMed application can be used to support students in learning and understanding topic themselves, this media focuses on content related to the concept of basic logic gates consisting of sub-topic inverter gates (NOT), AND gates, OR gates, and derivative gates includes NAND gates (NOT AND), NOR gates (NOT OR), XOR (EXCLUSIVE OR) gates, and XNOR gates (EXCLUSIVE NOT OR). The topic presented on this media content is based on the curriculum of vocational schools and computer system textbooks that are used nationally. For coverage of topics on basic logic gates shown in Figure 3.

Figure 3. Topics of basic logic gates

According to [28], logic gates are a digital circuit that has one or more inputs and only has one output. The output of this logic gate depends on the signal given to the input. We can see this in the Boole algebraic equation and the truth table that each logic gate has. Boole algebra also gives an equation for each gate and gives a symbol for the gate operation. A digital circuit can be built from a number of

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logic gates. From the equation for each gate and the truth table for each logic gate, by combining several of these gates logic operations will be obtained in accordance with the wishes and objectives expected so that a digital circuit is formed that will build the desired system. The basic logic gate is NOT, AND, and OR. While the NAND, NOR, XOR, XNOR gates are gates formed from a combination of several basic gates (See Figure 3).

The purpose of the BLG-LeMed application is to help students understand the basic concepts of basic logic gates, help students observe the form of basic logic gates based on animated offerings from BLG-LeMed applications, observe the input and output processes of basic logic gates, provide explanations in the form of audio from the instructor, and formation of truth tables which contains true Boolean values that are interpreted as values 1 and false which are interpreted to be 0. After sufficient time, the students will be presented with questions as an evaluation of basic logic gate learning using the BLG-LeMed application. Computer system subjects, especially in the basic logic gate topics as their initial concept to understand computer performance and also have a close relationship that is training their logic so that it also has relations with basic programming subjects.

4.2. Media Features

In an application especially on interactive mobile learning media, the thing that challenges us is how to make this application interesting for use by users, users in this domain are vocational high school students. According to [29], M-Learning media design must adhere to comfort, convenience in terms of interaction, and can also help in understanding learning topics more than the learning process without M-Learning (traditional learning). We try with the team to do the right design so that the fulfillment of this interest can be fulfilled. The main step is when the design process, we conduct discussions with related experts and after development through the alpha testing stage, which will be explained in the next section. The features provided in the BLG-LeMed application based on M-Learning are presented in Table 1.

Table 1. The BLG-LeMed application features

Features	Functions that must be performed
Main Menu Page (PHome)	It is the first page that is accessed by the user, on the main menu page the link buttons will go to the desired page. The available links are the link button to go to (P1) to (P10) structured arranged in a balanced system (the number of equal-left laying sequences) in the button placement. Also provided is the exit button to exit completely from the BLG-LeMed application.

Features	Functions that must be performed
Basic Logic Gate Page (P1)	This page contains the fundamental theory of the concept of logic gates and their functions in everyday life. An exit button is also provided to exit the basic logic gate page which will return to the main menu page.
NOT Gate Topic Page (P2), AND (P3), OR (P4), NAND (P5), NOR (P6), XOR (P7), and XNOR (P8)	The gate topic page is a separate page on each topic. Each page of the concerned gate contains a visualization of the theory of the gate in question, the animation of the gate formation in question, the animation of the input and output values in the truth table, and voice explanation by the instructor. An exit button is also provided to exit the respective gate topic page which will go back to the main menu page, then the play and stop button to set the flow from the logic gate animation and the truth table.
Glossary Page (P9)	This page contains terms that cover the topic of basic logic gates. An exit button is also provided to exit the glossary page which will go back to the main menu page.
Evaluation Page (P10)	When opening the evaluation page, users are asked to fill in their full name and identity number, then the play button is provided to go to the page that contains questions with multiple-choice types totaling 25 items, by pressing the options button a, b, c, d, or e. The question system here is randomized automatically, but in working on the problem, it must be sorted and cannot return to the previous question. Also provided a timer to measure and remind timings in the execution of the questions, the time provided is 35 minutes of work (countdown). When the time runs out, the question will automatically close and go directly to the score page. An exit button is also provided to exit the evaluation page which will go back to the main menu page.
Score Page (P11)	This page displays notifications in the form of feedback from student evaluations, namely the number of correct and wrong answers to evaluations and also the final value of evaluations on a scale of 0-100. Each correct question will get a value of 4 if students get the correct number of 25 questions, then 25 * 4 = 100. If students answer incorrectly, there is no reduction in value, but the blank value is considered to be 0 only. An exit button is also provided to exit the Score page which will go back to the Main Page.

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An example of the features in this BLG-LeMed application is shown in Figure 4 for the main menu page, Figure 5 for the OR and AND gate topic pages, and Figure 6 for the evaluation page.

Figure 4. Main menu page

Figure 5. Gate logic topics page
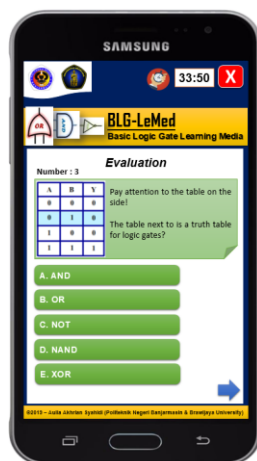
Figure 6. Evaluation page

We have done the black box testing process on all the features available in this BLG-LeMed application, we state that based on the results of the black box testing all the features in this BLG-LeMed application have functioned by stated expectations. We do not report black box testing in this paper, because automatically and also related to the title that we are proposing, an application before being used by end users, we make sure that all the features are running and functioning properly.

5. Design of Research Implementation
5.1. Participant

This research is a pilot study to simulate the improvement of learning technology and is done on students who are studying computer system subjects in basic logic gate topics. Thirty-eighth-grade students consisting of twenty-six men and twelve women. They were in the first semester of multimedia majors in vocational high schools. They were involved in using the BLG-LeMed application, after studying the topic explained by the teacher at the previous meeting. As long as they interact with the media, they can learn, understand again, and absorb knowledge by themselves.

5.2. Research Tools

Alpha testing in the form of two questions submitted to experts, this question was adapted from research [23]. Then for the UAT test statement items adapted from [23] research which consists of twenty-five points then mapped into five dimensions namely Content, Module, Multimedia Element, Navigation, and Usefulness. The questionnaire for testing UAT uses a Likert scale with six points, namely 1: Strongly Disagree, 2: Somewhat Disagree, 3: Disagree, 4: Somewhat Agree, 5: Agree, and 6: Strongly Agree. Usability evaluation in this study adapts from research [25] which also refers to usability criteria and guidelines for mobile in learning delivered by [25][30]. A questionnaire consisting of four components, namely Presentation, Activities, Communications, and Administration. In each of these components, there are four measured usability factors, namely Adjustability, Funability, Reliability, and Satisfaction and statements in the form of criteria for each usability factor. The usability evaluation questionnaire also uses a Likert scale with four pieces, namely: 1: Strongly Disagree, 2: Disagree, 3: Agree, and 4: Strongly Agree.

To find out the motivation of students using the motivation questionnaire, this motivational questionnaire was adapted from Glynn with research [26], which was related to motivation to learn science. Where the questionnaire from [26] consists of twenty-five items of motivation statements, which are then mapped into five dimensions of motivation namely Intrinsic Motivation (IM), Career Motivation (CM), Self-Determination (STD), Self-Efficacy (SEF), and Grade Motivation (GM). This questionnaire uses a Likert scale with five points, namely 1: Strongly Disagree, 2: Disagree, 3: Neutral, 4: Agree, and 5: Strongly Agree. This questionnaire aims to determine the learning motivation of students after using this BLG-LeMed application. In knowing the student learning outcomes, the final value of the evaluation that is already in the learning

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media is used, where the questions in the evaluation of the learning media have adjusted to the subject book and the basic competencies of the topic.

5.3. Implementation Process

Alpha testing was carried out by media and topic experts referred to as testers, media experts were submitted to two lecturers from the multimedia field and topic experts were presented to two lecturers in the field of vocational education/engineering education and one vocational high school teacher. For the implementation process scenario shown in Figure 7.
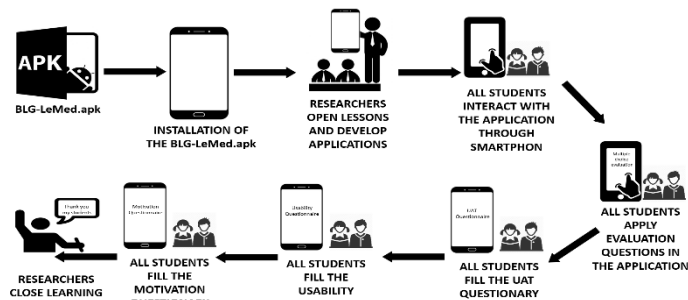
Figure 7. The scenario of the implementation process

The process of implementing the use of the BLG-LeMed application (See Figure 7) is carried out during one meeting only, the teacher who teaches computer system subjects has explained the topic about the basic logic gate at the previous meeting. When the implementation process is carried out, it is divided into several stages, namely first before the learning takes place to research and the teacher works together to distribute BLG-LeMed.apk files to each student and all students are told to install the application. Then the researcher opened the learning and introduced the BLG-LeMed application along with a concise way of using it to all students involved with time (15 minutes). The students then spend their time interacting with the BLG-LeMed application for (50 minutes). Then in the third stage, the students start working on evaluation questions which are also included in the BLG-LeMed application for (35 minutes) with a 25 choice multiple-choice questions with the system not opening the book and other sources. Then after working on the problem, the students filled out the UAT questionnaire online for (10 minutes), filled out the usability questionnaire online for (10 minutes), and at the last stage, the students were also asked to fill out the motivation questionnaire online for (10 minutes). Then (5 minutes) the researcher thanked, gave enthusiasm, and closed the lesson.

6. Research Results and Discussions

The results of alpha tests involving content experts that we call examiners, for the first and second examiners are concentrates in the multimedia field, third, and fourth examiners have a concentration on vocational education/engineering education, and the fifth examiner is a computer system subject teacher. The results show that the

application meets the needs of the learning process related to the scope of the basic logic gate topic. The content of this application is accurate, quite complete, and following the syllabus and curriculum determined by the Ministry of Education and Culture of the Republic of Indonesia for the realm of vocational learning. Questions for examiners are (i) General impressions of the BLG-LeMed application as M-Learning interactive learning media on basic logic gate topic and (ii) Do you find integration and interaction with learning styles that can facilitate students to learn basic logic gate topic using the BLG-LeMed application as M-Learning interactive learning media. After making an assessment, the final results can be concluded that the majority of testers provide very positive feedback and support this work. They like ideas and innovations towards learning media such as this application, so they can contribute to the advancement of vocational education. The results of the alpha testing feedback are presented in Table 2.

Table 2. Feedback for alpha testing

Tester	Feedback Results	
	First question (i)	**Second question (ii)**
1	Very simple and easy to understand. The application performs tasks well and the display that is made is very simple without convolution.	Yes, I found it.
2	This is a very good idea. Easy to learn and understand. I position myself as a student when testing this application, I see the interaction between applications and users is very good.	Can be found.
3	Okay, it's easy to understand and suitable for the learning process.	Yes, because it is one way to get information in the form of knowledge easily and improve the process of learning and their learning style.
4	Innovation in interactive mobile learning media that is very good. This can be recommended and becomes one of the solutions to increase learning by utilizing technology according to the development of this very dynamic era.	Yes, of course. With learning styles like this, the learning process will potentially be more interesting and students will be more open by exploring this learning style.

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Tester	Feedback Results	
	First question (i)	**Second question (ii)**
5	I, as a teacher who teaches these subjects and topics, feels very helpful and this is the best way to recommend interactive mobile learning media in the future.	This can make students find their own learning style as comfortable as possible. Opportunities to make students more active in the classroom when learning takes place.

At the implementation stage in the classroom, thirty-eight students were involved in testing the use of the BLG-LeMed application on their respective smartphones. The application that we are testing is offline in advance and students must install the application with the .apk file extension, then we ensure that the application is installed properly. Researchers introduce and demonstrate applications after they understand them, they are welcome to use the application independently. The students look very focused and seriously try the application, some even try to understand very hard the topic presented in the application, some students help other students and they interact with each other to understand the topic, teachers, and researchers only oversee their performance. Classes look very smooth and active student-centered atmosphere is also visible. This indicates that the theory conveyed, that M-Learning can make students actively involved and learning can be student-centered. After they are satisfied to interact with the application, then they work on an evaluation containing 25 questions with multiple-choice types related to the basic logic gate topic that they have learned from the application, they are seen working individually to complete the evaluation mission, they are not allowed to open anything related to the topic, and are prohibited from cheating and cooperating. The atmosphere when using BLG-LeMed applications takes place in classrooms is shown in Figure 8.

Figure 8. Implementation in the classroom

This user acceptance test is usually done by the end user. The end users of our study are vocational students. The main reason for the user acceptance test is to identify what an application will do and how it will have benefits for the end user before being implemented in the actual environment and wider scope. The researcher continued the work to find out the end user's response to this UAT to students in the real classroom environment as the first trial. Thirty-eight students were involved to use the BLG-LeMed application and provide feedback.

After they have interacted with the application to understand the topic and did an evaluation in the previous stage, students as respondents were asked to test the BLG-LeMed application, by answering the statements in the UAT questionnaire whose results are presented in Table 3. The questionnaire for testing UAT uses a Likert scale with six points: 1: Strongly Disagree (0% - 16.67%), 2: Somewhat Disagree (16.68% - 33.34%), 3: Disagree (33.35% - 50.01%), 4: Somewhat Agree (50.02% - 66.68%), 5: Agree (66.69% - 83.35%), and 6: Strongly Agree (83.36% - 100%).

Table 3. UAT questionnaire results

Five dimensions of UAT	No	Statement variable	Average
Content	1	The content of the BLG-LeMed application is clear	91.67%
	2	The content of the BLG-LeMed application is easy to understand	
	3	The content of the BLG-LeMed application is related to the basic logic gate topic	
	4	Content from the BLG-LeMed application is interesting	
Module	5	Contains an introduction or introduction to the basic logic gate topic	98.68%
	6	Contains theories to guide students	
	7	Can adjust to student learning styles	
	8	Can explore student knowledge	
	9	There is evaluation in learning	
	10	There is a summary of the terms (glossary) of the basic logic gate topic	
Multimedia Elements	11	Use the font type according to the BLG-LeMed application interface	92.69%
	12	Use the font size according to the BLG-LeMed application interface	
	13	Use of the appropriate graphics on the BLG-LeMed application interface	
	14	Use the appropriate button on the BLG-LeMed application interface	

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Five dimensions of UAT	No	Statement variable	Average
	15	Use the appropriate color combination in the BLG-LeMed application interface	
	16	Use of the appropriate animation and audio for basic logic gate topic delivery in the BLG-LeMed application	
Navigation	17	Navigation from the BLG-LeMed application is easy	94.74%
	18	Navigation from the BLG-LeMed application is concise and clear	
	19	The number of buttons and links in the BLG-LeMed application makes sense	
	20	Links on the BLG-LeMed application are consistent	
	21	Links on the BLG-LeMed application are easy to access	
Usefulness	22	Visual images, texts, animations, and audio in the BLG-LeMed application are very useful for students to understand the basic logic gate topic	92.76%
	23	The BLG-LeMed application can run well without obstacles	
Overall Average Value			94.11%

Based on the results of the Table 3, it was found that for the content dimension consisting of four statement variables, the majority of students strongly agreed with the average dimension value at 91.67%, they stated that the content of the BLG-LeMed application was indeed related to the basic logic gate topics, then the content is clear, easy to understand, and interesting. On the module dimension with the majority of students choosing very strongly agree with the average value at 98.68%, out of the six statement variables available on the module dimension, four of them are the highest values which are 100% where all students express strongly agree. For this module dimension, the students stated that the BLG-LeMed application contains an introduction or introduction (the basic concept of topic), contains topic to guide in understanding, can adjust to learning styles, can explore knowledge, has a domain for evaluating learning by raising evaluation pages, and contains a summary of the terms (glossary). Furthermore, the results obtained from the dimensions of multimedia elements containing six statement variables with an average value of 92.69% indicate that the majority of students strongly agree that the use of multimedia elements has been demonstrated

by BLG-LeMed applications with the use of font types, font sizes, graphics, buttons, color combinations, animations can adjust to the application interface, and interaction in the form of sound/audio explanatory topic from the instructor..

The navigation dimension which consists of five statement variables with dimension average values is at 94.74% which states that all very strong majority students agree that navigation in the BLG-LeMed application is easy to use, concise and clear, the number of buttons and links that make sense, consistent links, and links is easy to access. In the last dimension, usefulness contains two state variables which show a mean value of 92.76%, which also states that students strongly agree that images, text, visual animation, and audio in BLG-LeMed applications are very useful in helping to understand basic logic gate topic. They also strongly agree that the BLG-LeMed application can be run smoothly and without any obstacles. The overall average value of this UAT is in the value of 94.11% which is in a very strong position agreeing that the BLG-LeMed application can be accepted by the user, it is based on five UAT dimensions with 23 statement variables that have been assessed objective by respondents.

Then the next discussion is usability evaluation on the assessment for the M-Learning application, consists of four components, namely Presentation, Activities, Communications, and Administration. Each component has four measured usability factors, namely Adjustability, Funability, Reliability, and Satisfaction, and there are 16 criteria statements in each usability factor. The usability evaluation questionnaire also uses a Likert scale with four points consisting of: 1: Strongly Disagree (0% - 24.99%), 2: Disagree (25% - 49.99%), 3: Agree (50% - 74.99%), and 4: Strongly Agree (75% - 100%). The results of the evaluation from usability evaluation are presented in Table 4.

Table 4. The results of the usability evaluation

Components	No	Criteria for Statement	Average
Presentation	1	The BLG-LeMed application can support as learning/personalization media on the basic logic gate topic (Adjustability)	88.65%
	2	The BLG-LeMed application provides facilities and good reception tools (Funability)	
	3	The BLG-LeMed application can support communication, and technology adequacy (Reliability)	
	4	The BLG-LeMed application can perform the requested task (Satisfaction)	

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Components	No	Criteria for Statement	Average
Activities	5	The BLG-LeMed application can support students to carry out learning activities on the basic logic gate topic (Adjustability)	95.89%
	6	The BLG-LeMed application can support students to perform tasks without difficulty (Funability)	
	7	The BLG-LeMed application can support students to do their jobs safely (Reliability)	
	8	The BLG-LeMed application has been recognized as successful in carrying out its educational activities (Satisfaction)	
Communications	9	The BLG-LeMed application can support the performance of tasks related to basic communication between learners and applications (Adjustability)	84.21%
	10	The BLG-LeMed application provides facilities and acceptance of good tools in terms of communication (Funability)	
	11	The BLG-LeMed application can support communication and technology safely (Reliability)	
	12	The BLG-LeMed application has been recognized as successfully performing its duties safely in the realm of communication (Satisfaction)	
Administration	13	The BLG-LeMed application can support the requirements for successful learning of students (Adjustability)	89.14%
	14	The BLG-LeMed application can support communication and technology safely in the administrative realm (Funability)	

Components	No	Criteria for Statement	Average
	15	The BLG-LeMed application is recognized as having succeeded in carrying out its duties safely in the administrative domain (Reliability)	
	16	The BLG-LeMed application is recognized as being successful in carrying out its duties administratively (Satisfaction)	
Overall Average Value			89.47%

Based on the data presented in Table 4, that of the total 38 students who filled out the usability evaluation questionnaire were obtained for the first component, namely presentation with an average value of 88.65%, for adjustability with the highest value of 100%, meaning that all students are on these criteria very strongly agreed that the BLG-LeMed application could support as a learning/personalization media on basic logic gate topic, at the highest satisfaction value at 94.74%, 36 students stated that the BLG-LeMed application strongly agreed to be able to do the requested task, for funability factors and the reliability of the presentation components are equally at the highest value for the answer, agreeing with the numbers 78.95% and 97.37%.

Then for the second component, namely activities with the acquisition of an average value of 95.89% where adjustability and satisfaction are at a value of 100%, which means that all students strongly agree that this BLG-LeMed application can support the learning process and has succeeded in carrying out activities education, in the majority funability they agreed that the BLG-LeMed application can support learning without difficulty which means that it is worth 57.89%, and in the reliability factor, as many as 35 respondents or equivalent to 92.11% very strongly agree that BLG-LeMed applications can support learning activities with safe.

The third component is communications which are at an average value of 84.21%, where the majority of them choose answers to agree in all usability factors. Finally, for the administration component with an average value of 89.14% where the majority of them are in the agreed answer, the adjustability factor gets the highest score on the very strong answer, agreeing with the value of 92.11% where 35 respondents stated that this BLG-LeMed application can support the requirements to obtain success in basic logic gate learning. All respondents were not recorded to answer the option very strongly disagree and disagree, the assessment on this usability evaluation questionnaire was purely objective from the results of student evaluations of the BLG-LeMed applications they had used and felt their usefulness.

Evident from the final results for the average value of overall usability evaluation on the number 89.47% which is in the range of the fourth option, namely Strongly Agree (75% - 100%). We conclude that the BLG-LeMed application based on usability evaluation for M-Learning strongly agrees to have the use for end-users, namely students. This use is also felt for efforts in improving learning technology.

The next discussion is the effect of using the BLG-LeMed application on student learning motivation, the motivation here we state that there is a great interest, interest, and high curiosity from students to do something including learning activities, student motivation can be directly seen from the behavior when learning takes place using observation, but we here apply observations as well as evidence directly, where students fill in the motivation questionnaire based on what they feel, the questionnaire is adapted to the five dimensions of motivation that have been explained in the previous section.

In Table 5 contains 23 statement variables contained in the measurement of the five dimensions of student motivation that have been generated in following the learning process on basic logic gate topics using the BLG-LeMed application. This motivation questionnaire uses a Likert scale with five answer points with point 1 as the lowest value and point 5 as the highest value, which can be detailed as follows: 1: Strongly Disagree (0-1), 2: Disagree (1.01-2), 3: Neutral (2.01-3); 4: Agree (3.01-4), and 5: (4.01-5) Strongly Agree.

Table 5. Results of assessment of student motivation

Five Dimensions of Motivation	No	Statement Variable	Average
Intrinsic Motivation (IM)	1	Learning basic logic gates using the BLG-LeMed application is interesting	4.77
	2	I want to know more and learn more about basic logic gate topic using the BLG-LeMed application	
	3	The basic logic gate topic can be relevantly related to the application in everyday life	
	4	Basic logic gate topic can make my life more meaningful and motivated to learn basic logic gate topic using the BLG-LeMed application	
	5	I really enjoy basic logic gate learning using the BLG-LeMed application	
Career Motivation (CM)	6	Learning basic logic gates can support me to deal with industrial work practices	4.76
	7	Learning basic logic gates will benefit my career as a student	
	8	I will use basic logic gate science to solve problems in everyday life	
	9	Indirectly my career will be directly confronted with the concept of a basic logic gate	
Self-Determination (STD)	10	I tried hard to learn and understand the topic from the basic logic gate using the BLG-LeMed application	4.33
	11	I try to prepare myself to learn basic logic gates using the BLG-LeMed application	
	12	I put in enough effort and effort to learn to understand basic logic gate topic using the BLG-LeMed application	
	13	I spent a lot of time learning this basic logic gate using the BLG-LeMed application	
	14	I use my own strategy or method to learn basic logic gate topic using the BLG-LeMed application	
Self-Efficacy (SEF)	15	I am sure I can get the best value after learning the basic logic gate using the BLG-LeMed application	4.29
	16	I am sure I will succeed in answering the questions that exist in evaluating basic logic gate topic using the BLG-LeMed application	
	17	I am sure I will slowly master the basic concepts and skills of basic logic gate topic using the BLG-LeMed application	
	18	I am sure I can understand the basic logic gate topic using the BLG-LeMed application	
	19	I am sure I can practice the theory of basic logic gates	
Grade Motivation (GM)	20	Printing the highest score on topic evaluation is a very important hope for me	4.13
	21	Getting the best value is the most important thing for me	
	22	I think about what value I got after this evaluation	
	23	I like to do my best and compete with other students in getting the best grades	
Overall Average Value			4.46

From the data presented in Table 5, it can be seen that for the first motivation dimension, namely IM with a dimension average value of 4.77 is in the title "strongly

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agree", in each of the highest value statement variables is in the fourth statement variable number with a value of 4.95, the majority of respondents strongly agree that learning basic logic gates by using the BLG-LeMed application can make life meaningful and motivated to learn, in the IM dimension this tends to assess motivation within themselves, with the use of BLG-LeMed application can giving a feeling of being motivated from within each individual which is proven by the statement variable presented. In the CM dimension, the average score of 4.76 is obtained with the title "strongly agree", the majority of respondents also give options for points worth 5, the highest value is in the number eight statement with a value of 4.95 stated that the respondents strongly agree that they will use science basic logic gate to solve problems in everyday life, the CM tends to assess motivation in terms of career or lifespan in the future, whether this science of basic logic gates can support their lives going forward.

For the STD dimension, the average score is 4.33 which is still in the title of "strongly agree", but the majority of respondents tend to give more points 4 to the answer. The highest value is occupied by thirteen statement numbers which state that the respondents strongly agree that they have spent a lot of time learning basic logic gates using the BLG-LeMed application, this is indeed proven and according to the facts in the field, researchers witnessed that they were very focused and seriously until the time is used to interact with the application and try to learn it, thirteen statement numbers on this STD dimension are at a value of 4.63. The application of the STD dimension tends to measure the ability and self-fortune of their readiness to learn basic logic gates assisted by applications. The SEF dimension serves to measure self-confidence to get the best when learning basic logic gates using the BLG-LeMed application, the average value for SEF dimensions is 4.29 with the title "strongly agree", where the highest value is in statement number seventeen with the value 4.53 which states that they strongly agree to have confidence can slowly master the basic concepts and skills of basic logic gate topic using the BLG-LeMed application, the majority of the respondents' answers are in point 4.

Finally, the GM dimension, which measures motivation to get the best value when evaluating basic logic gate topics, the average value of this GM dimension is 4.13 with the title "strongly agree", the highest value is in the statement number twenty one with a value of 4.18 who stated that they agreed that the best value was the most important thing they had to achieve, the majority of respondents gave a score of 4, compared to the previous four-dimensional average, the GM dimension had the lowest average value, because the fact in the field that they were still visible not too brave to determine the achievement of values, but they still agree that the best value must be obtained, we assume that they are more likely to be based on prior knowledge to be improved after knowledge has been built so that values can be estimated, this is an interesting thing for us.

Furthermore for the overall average value of the measurement of the five dimensions of motivation at the value of 4.46 is at the predicate 5: (4.01-5) strongly agree. We conclude that for the highest value in the IM dimension, it is likely that motivation must be built from within each individual first, with the overall average value achieved can be stated that by using this BLG-LeMed application it is strongly agreed to be able to motivate students to learn basic logic gate in measuring five dimensions of motivation.

The next discussion is the effect of using this BLG-LeMed application is student learning outcomes. In this case, we can find out how the effect results from the final value of student evaluation. The final value of student evaluations is obtained when they have completed the evaluation stages provided by the BLG-LeMed application with a total of 25 multiple-choice types of questions, the questions raised in the evaluation do not come out of the basic logic gate discussion, referring to the teaching books and applicable curriculum, with a randomized system of questions, but they when working on evaluations are not allowed to open any tools as a reference and may not cheat and cooperate. For the weighting of the evaluation value based on the number of correct answers in each item, each correct answer will get 4 points weight (for example the number of correct answers is 25, then the number of correct answers * weighted points defined means that 25 * 4 = 100, it can be seen that the value of their final evaluation is 100 based on the final score which automatically appears applied), for the wrong answer, there is no reduction in value. The student learning outcomes from the results of evaluations that have been carried out are shown in Figure 9.
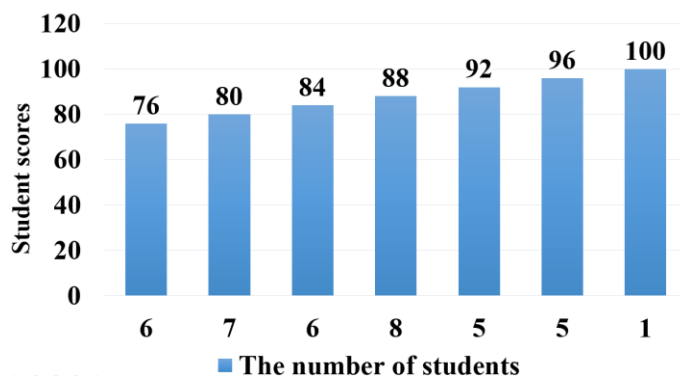

Figure 9. Graph of student learning outcomes

Based on the graph of student learning outcomes that have been presented in Figure 9, it can be seen that all 38 students succeeded in obtaining scores in the range 76 - 100, where the lowest score was 76 and the highest score was 100, which could be described as follows: 6 students scored 76, then 7 students got 80, 6 students got 84, 8 students got 88, then 5 students got 92, and 5 students got 96, the last 1 student spontaneously got a perfect score of 100. The question raised in the evaluation with the difficulty level that we stated is in the medium category, the question indeed refers to the applicable textbooks and curriculum, because it

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views that this is for the realm of tenth-grade Vocational students in their first year and semester. It is very unlikely that suddenly the question presented in the evaluation is difficult, considering this. Their final score is entirely above the minimum topic completeness criteria set by the national Vocational curriculum, ie if their final score is ≥70 then they are declared complete on the topic and if their final score is <70 then he declared incomplete. Their final score if averaged overall is at 85.89 with a "very satisfying" predicate, which is also at a position of ≥70 and it is stated that all students complete the basic logic gate topic using the BLG-LeMed application. By obtaining the average value of the overall student learning outcomes, we stated that the use of the BLG-LeMed application on basic logic gate learning also had its effect on student learning outcomes.

7. Conclusion and Future Works

The learning process by using the BLG-LeMed application based on M-Learning was carried out by involving as many as thirty-eight students with a duration of 135 minutes at one meeting. The results obtained from this study indicate that for alpha testing results, the majority of the five testers gave very positive feedback on the two questions raised related to the BLG-LeMed application. The results of the UAT indicate that the overall average value is 94.11% with the predicate "strongly agree" that the BLG-LeMed application can be accepted by the user. The results of usability evaluation are with an overall average value of 89.47% with a predicate "strongly agree" that the BLG-LeMed application has used for students. The results of students' motivational effects after using the BLG-LeMed application using the five dimensions of motivation showed that the overall average score was 4.46 with the predicate "strongly agree" that the BLG-LeMed application can motivate students. Then also affect student learning outcomes which show that all students succeeded in exceeding the minimum criteria for passing a topic with an average value of 85.89 with the predicate "very satisfying".

The future work that we recommend is that there is a need to evaluate deficiencies found in this application for future development capital, especially to enhance the features of this application, presents a practicum for simulating experiment combinations of various types of logic gates, can bring up charts for student evaluation achievement, able to know the behavior and location of students' difficulties in learning that can be detected directly by the application through the concept of artificial intelligence in engineering education.

Acknowledgments

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