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Virtual Laboratory for Line Follower Robot Competition

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ABSTRACT

Laboratory serves as an important facility for experiment and research activity. The limitation of time, equipment, and capacity in the experiment and research undertaking impede both students and college students in undertaking research for competition preparation, particularly dealing with line follower robot competition which requires a wide space of the room with various track types. Unsettled competition track influences PID control setting of line follower robot. This study aims at developing Virtual Laboratory (V-Lab) for students or college students who are preparing for line follower robot competition with unsettled and changeable tracks. This study concluded that the trial data score reached 98.5%, the material expert score obtained 89.7%, learning model expert score obtained 97.9%, and the average score of small group learning model and field of 82.4%, which the average score of the entire aspects obtained 90.8%.

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1. INTRODUCTION

On robot competition, a fine and stable Line Follower (LF) robot is required. A stability on the movement of the robot influences the accomplishment of the object taking and placing on the competition. The more stable the robot movement results in the higher possibility of accomplishment. One prevalent means to improve the stability of the robot is by using PID control [1].

Track installment for LF robot testing requires a wide space of the room. Meanwhile, the existing laboratory is not feasible to be installed various types of LF robot track. Thus, it is necessary to provide various types of virtual track in a form of virtual laboratory to obtain parameter value of PID LF robot [2].

Virtual laboratory or commonly known as V-Lab is a computer technology development as an interactive multimedia object to simulates laboratory experiment on the computer [3]. V-Lab is a computer simulation that enables an experiment function of a laboratory on a computer. Recently, a preferable virtual laboratory is an offline virtual laboratory. However, it does not offer a long-distance application at the same time [4]. In other words, the offline virtual laboratory is only limited to one particular application in one room with the initial data required to be input in each computer. Online virtual laboratory, hence, is imperative to be developed. The online virtual laboratory is a computer technology development in a form od interactive multimedia object to simulate laboratory experiment on the computer and accessible from the internet [5-6]. Learning Management System (LMS) is employed within the component of online virtual laboratory [7-8].

This study utilizes virtual laboratory (V-Lab) as a learning media of line follower robot which aims at providing the students a feasible laboratory for generating and simulating line follower robot on its track and as a learning media in resolving issues online follower robot dealing with Kp, Kd, and Ki on various competition tracks.

2. RESEARCH METHOD

This study used development learning research model in Figure 1 [9-10]. However, in this study, the stages used are only until the ninth stage. This was done with the consideration that the development of the Virtual Laboratory learning model developed only until the test prototype of the product.

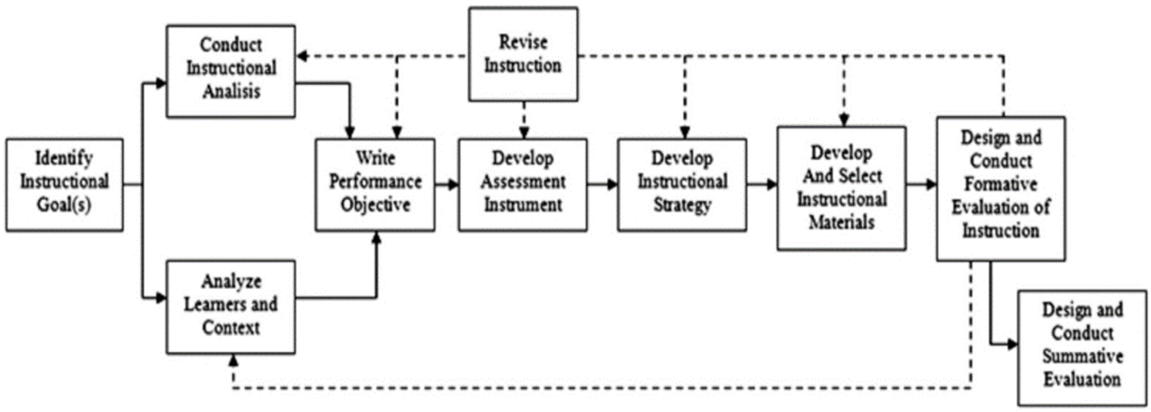

Figure 1. Learning Model Development [10]

Here, product development trials were conducted through three stages, namely individual test, small group test, and field test. The individual test phase was carried out by the learning media experts, materials experts, and learning model experts. The individual trials were conducted to determine the feasibility of teaching materials, instructional media and virtual laboratory learning model developed.

The small group trial conducted aimed at observing the feasibility of learning model design virtual laboratory, particularly the feasibility of learning media based on the web and LMS employed in line follower competition learning. Within the small group trial, the authors explored information regarding all possible obstacles faced by the students the moment they try to use the learning media based on web and LMS. In addition, the authors also tried to identify the weaknesses in LMS from varied perspectives based on the group of students.

Field trials are an advanced stage after a small group trial conducted. At this stage, the developer requested information from students that amounted to at least 20 people in one particular place simultaneously. The tested product in the field test is the product of revision at the individual (expert evaluation) and small group trial stage. This field test is conducted to determine whether or not the product has been developed.

The research instrument employed in this study is a questionnaire. Questionnaire employed in the validation process experts (material experts, media experts, and learning models Virtual Laboratory experts), and also to identify the students' response to the learning model and the developed Learning Management System. Questionnaires employed in this study was in the form of a closed questionnaire where alternative answers have been provided thus the respondents were only required to choose the answer. The calculation of the questionnaire score was calculated from the answer score for each question. The answers to the questionnaire used a Likert scale consisting of four categories of choice.

The data analysis techniques in this study were using the formula percentage, where the results of these calculations were used to see the feasibility of the aspects of learning assessed. Equation 1 is used to determine the percentage of eligibility of the assessed indicator [8]. Table 1 shows the classification is feasibility level criteria [9].

$$P = \frac{\sum x}{\sum x_i} \times 100\% \qquad (1)$$

where: P = Percentage score

$\sum x$ = Respondent amount in one item

$\sum x_i$ = total of ideal value

Table 1. Feasibility Level Criteria [9]

Percentage (%)	Qualification	Note
80-100	Valid	No Revision
60-79	Sufficiently valid	No Revision
50-59	Insufficiently Valid	Revision
0-49	Invalid	Suggested to be altered

2.1 Virtual Lab Architecture

The virtual lab was created using LMS with the support of Moodle as an interactive learning media as shown in Figure 2. Students can use Internet-connected devices to access V-Lab, then it requires a registration account as member/teacher / tutor with different features arranged by the server and stored in the database.

2.2 Virtual Lab Model

The virtual lab model is shown in Figure 3. In Moodle, there is an interaction between instructor and student by differentiating the interaction within, in which the instructor as the facilitator and provider of learning material and consultation online to the students. While the students only serve as users who are required to be registered in a virtual lab which is able to interact with both online with the instructor and offline.

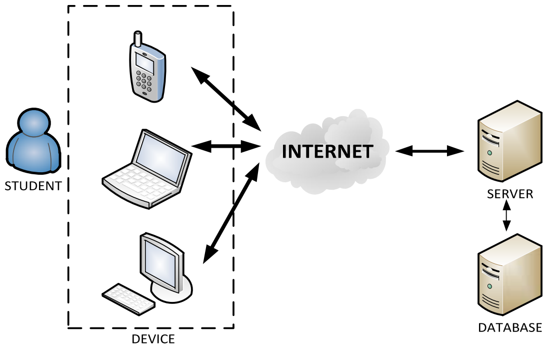

Figure 2. Virtual Lab Architecture

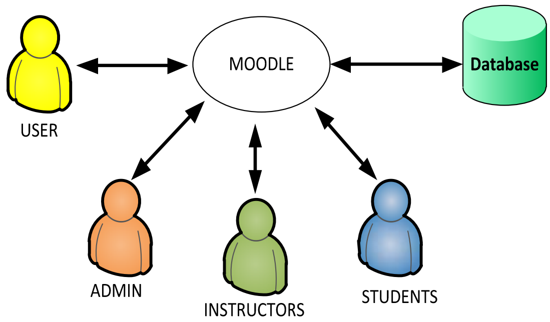

Figure 3. Virtual Lab Model

2.3 Virtual Lab Material

The material provided in VLab are:

1. Line follower robot generating
2. Line follower robot troubleshooting.
3. The determination of Kp, Ki and Kd parameters on PID control based on track level of difficulty from beginner to advanced level.
4. Questions and Answers regarding the robot line follower.

The determination of Kp, Ki and Kd parameters on the PID control of the LF robot is presented in Figure 4 based on the Ziegler-Nichols Oscillation method on the PID robotic PID LF parameter search [10-11]. This method can shorten the search time parameters for using simple formulas and process of trial and error only on the search parameters Kp [10].

In the second method of Ziegler-Nichols, the first thing to do is to generate Ti=0 and Td=0. Then, only by using proportional control action, the value is increased from zero to a critical value Kcr, here the output initially has a continuous oscillation. From oscillating outputs continuously, critical strengthening of Kcr and Pcr periods can be determined. For continuous oscillations with the Pcr period Kp, Ti, Td adjustment are delivered based on Table 2 [10-11].

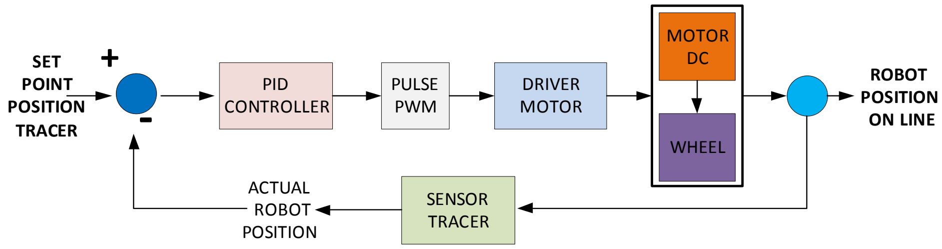

Figure 4. PID Control of LF Method By Ziegler and Nichols

Table 2. Basic Control of Ziegler-Nichols Based on Kcr and Pcr

Type of controller	Kp	Ti	Td
P	0.50 Kcr	∞	0
PI	0.45 Kcr	0.83 Pcr	0
PID	0.60 Kcr	0.50 Pcr	0.125 Pcr

3. RESULTS AND ANALYSIS

V-Lab interface is presented in Figure 5. V-Lab also provides a questionnaire for a pilot study based on Walter Dick and Lou Carey's learning development model, the questionnaires are addressed for a learning media experts enrolled in a V-Lab as a teacher, a questionnaire for a material experts enrolled in a V-Lab as a teacher, for the learning model experts enrolled in the V-Lab as teachers, questionnaires for the small groups enrolled in the V-Lab as students, and questionnaires for field trials enrolled in the V-Lab as students.

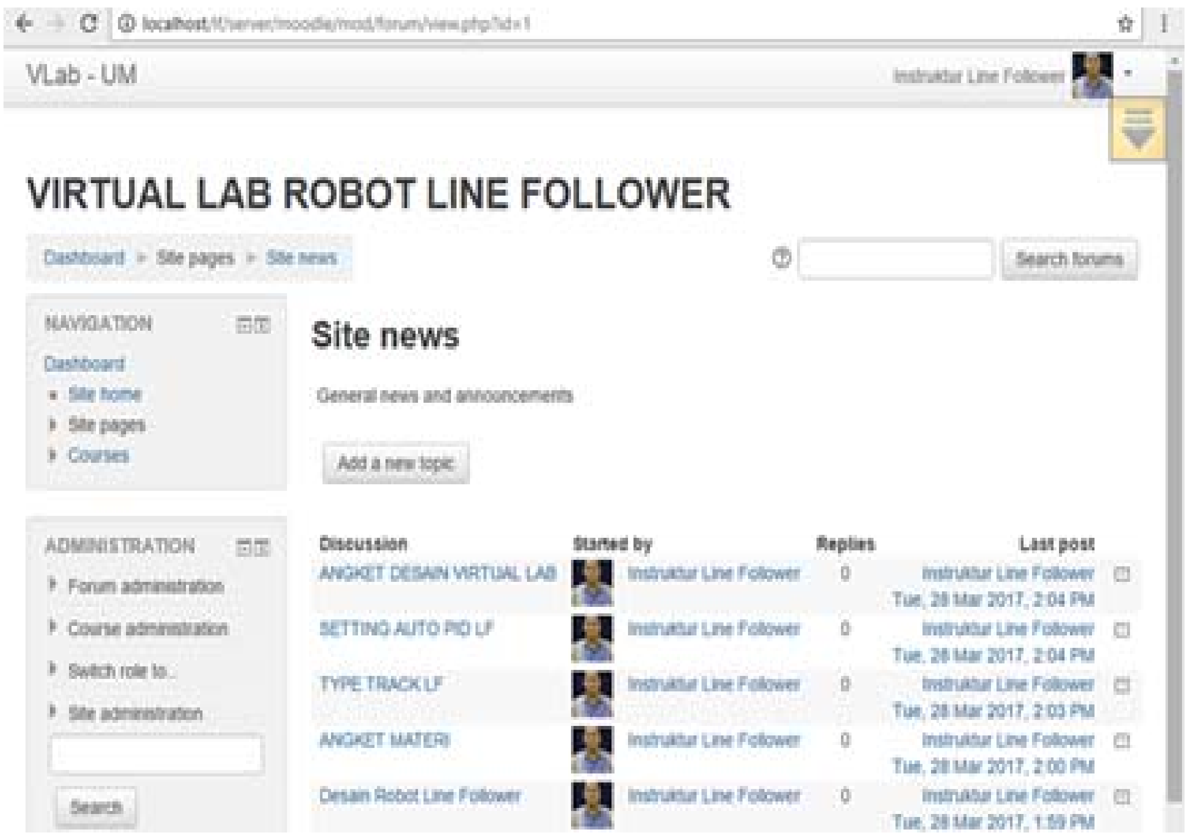

Figure 5. V-Lab Interface

Media expert validation data were obtained from the media Virtual Laboratory which was logged in as a teacher or supervisor through a web questionnaire online follower community consisted of two tutors. The validation results are shown in Table 3.

Table 3. Learning Media Experts Trials Data

No.	Assessment Aspects	Assessment Total	Average Percentage
1.	Learning media effectiveness	8 assessment aspects	100 %
2.	Learning media attractiveness	5 assessment aspects	97.5 %
3.	Learning media efficiency	4 assessment aspects	96.9 %
	Total	17 assessment aspects	98.5 %

According to Table 1 on the feasibility level criteria, the results obtained from the learning media experts as a whole stated that the learning media used in the learning is very good. The average score of the whole aspect of the assessment obtained from both media experts amounted to 98.5%. Hence, it can be said that the media used in basic dynamic web programming learning using Virtual Laboratory models are valid and do not require revision.

The validation data obtained from web media Virtual Laboratory who logged in as a teacher or supervisor of the web questionnaire online follower community as much as four teachers. According to the Table 4 which refer to the Table 1 for the criteria of feasibility, the results of both the overall material experts stated that the materials developed in the Virtual Laboratory design study model defined as excellent. The average percentage of the overall assessment aspect of both material experts obtained 89.7%. Hence, it can be said that the material on the basic line follower standard of competence developed is valid and does not require revision.

Tabel 4. Material Experts Trials Data

No.	Assessment Aspects	Total	Average Percentage
1.	Learning media material	10 Assessment aspects	83.75 %
2.	Learning media evaluation	3 Assessment aspects	91.7 %
3.	Learning media efficiency and effectiveness	7 Assessment aspects	93.75%
	Total	20 Assessment aspects	89.7 %

The expert evaluation of the learning design and model was conducted to enhance Virtual Laboratory learning model that has been developed. The expert validation data of learning model was obtained from Virtual Laboratory web in the form of a questionnaire of three teachers. According to the Table 5 referring to Table 1 on the feasibility level criteria, the results obtained from the expert of the overall learning model state that the designed Virtual Laboratory learning model meets the assessment criteria. The average percentage obtained was 94.8%. Hence, it can be said that the design of the learning model of Virtual Laboratory has been valid and require no revision. Table 6 shows the results of small group trials to UM students of Electrical Engineering Education who joined the team line follower will be described. The data were taken from 10 students.

Table 5. Validation Data Results from Learning Model Experts on Virtual Laboratoty

Assessment Aspects	Objective (%)	Content(%)	Technology (%)	Design (%)
Effectiveness	100	100	100	100
Attractiveness	75	100	100	90
Efficiency	100	100	83.3	94.3

Table 6. Small Group Trial Result Data

No.	Assessment Aspects	Total	Average Percentage
1.	LMS	13 Assessment aspects	82.3%
2.	LMS Material	5 Assessment aspects	78.5 %
	Total	18 Assessment aspects	80.4 %

Based on the result of data analysis, it is discovered that the average total score of the entire aspects of assessment obtained was 80,4% referring to Table 6 regarding validity criteria. In this small group trial, therefore, the developed LMS can be confirmed as valid.

Field trials are an advanced stage after a small group trial was conducted. In this section, the results of field trials tested to the participants of line follower competition as many as 24 students will be described. The validation results are shown in Table 7. After the improvement of the LMS, referring to the small group trial results data (Table 6), some previous aspects assessments are considered valid (range 60-79%). The field trials average percentage is presented in Table 7. The results indicated that the media is confirmed improved and it can be considered that the entire aspects of the assessment have been valid (range 80-100%).

Table 7. Field Trial Results Data

No.	Assessment Aspects	Total	Average Percentage
1.	LMS	13 assessment aspects	84.6%
2.	LMS Material	5 assessment aspects	84.2 %
	Total	18 assessment aspects	84.4 %

4. RESULTS AND DISCUSSION

The results of the material experts, media experts, model experts, small groups, and field were analyzed by comparing the data on the V-Lab pilot project [7] as follows:

1. Media Expert
   The aspect of assessment on media attractiveness obtained 97.5%. This result was obtained due to lack of animation. While the media efficiency obtained 96.9%. This number was obtained due to lack of completeness. After improvement was conducted, there is a 2.5% increase on the result.
2. Material Expert
   The aspect of assessment regarding material obtained 83.76%. This result was obtained since the language utilization on the media remains inadequate. The evaluation aspect obtained 91.7% which was obtained due to feedback process. While the efficiency aspect obtained 93.75% which was obtained due to motivation. After improvement on the media was conducted, it obtained 3% percentage increase.
3. Model Experts
   The attractiveness aspect obtained 75% due to the lackness on the objectives of the media. The efficiency aspect resulted on 83.3% since the flexibility remains insignificant. After the improvement was conducted, it increased 7%.
4. Small Group Trial
   In small group trial, LMS obtained 82.3% which was due to the availability of tutorial. While LMS Material obtained 78.5% which was due to the minor utilization of picture. After the improvement was conducted, it obtained 6% increase. The results of improvement on field trial are presented in Table 7.

In general, the experimental data validation of media experts, material experts, small group trials, and field trials as shown in Figure 6.

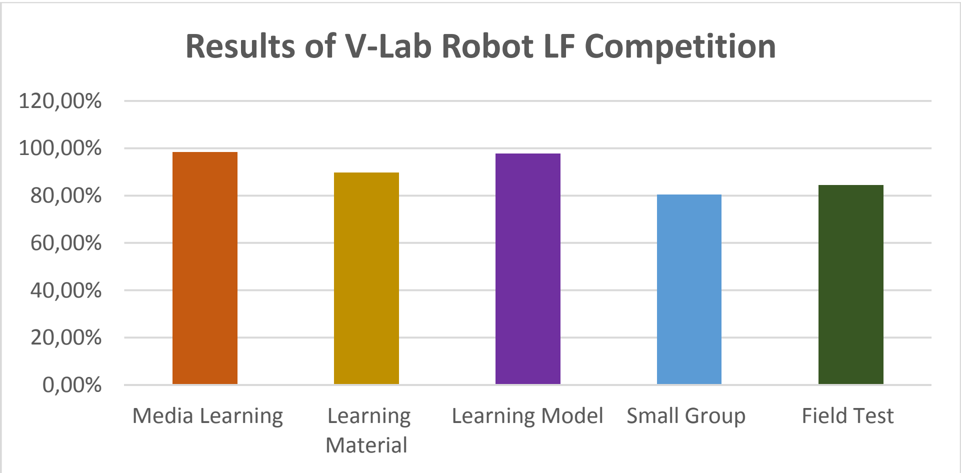

Figure 6. Trials Results Diagram

It obtained 98.5% of final data for media experts, 89.7% for material experts, 94.8 % for learning model experts, 80.4% for small group trials, and 84.4% for field trials. The average result obtained from the entire experiments performed is 90.8%. Based on Table 1 on the criteria of validity, the overall design of the learning model of Virtual Laboratory as well as the components of learning model in the form of Learning Management System and learning tools that have been developed are valid and do not require a revision.

5. CONCLUSION

Virtual Laboratory is a combination of face-to-face learning and online learning possessing diverse learning settings. The designed Virtual Laboratory refers to the learning setting that classifies into four quadrants learning settings, namely (1) Live Synchronous, (2) Virtual Synchronous, (3) Self-paced asynchronous, and (4) Collaborative asynchronous. Based on the process of development and analysis of trials result in data that has been conducted, it can be drawn that the developed Virtual Laboratory is feasible to use for simulating the line follower robot competition. However, further development, such as the control parameter could be developed for gaining more real result.

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