Problem-Based Blended Learning Models in Vocational Education: A Developmental Research

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***Abstract*—This research was motivated by two main problems: (1) the ineffectiveness of courageous learning is often caused by technical problems; and (2) the learning model used by teachers so far has not been effective, innovative, and optimal because it still uses a textual-based problem-based learning model. The purpose of this study was to develop a problem-based blended learning model for computer network engineering subjects at vocational education and to test the validity, practicality, and effectiveness. The development model applied in this study is the 4D development model, namely: (1) define, (2) design, (3) develop, and (4) disseminate. Data collection techniques were carried out through questionnaires to get validation experts, the practicality of teachers and students. Furthermore, the effectiveness of the data was done through a comparison of pretest and posttest values. The results of the calculation of the acquisition of a score reached 0.53 in the moderate category. Therefore, it can be concluded that the learning model of blended learning based on problem based learning in the subjects of computer network engineering in Vocational High Schools has a high level of validity, practicality, effectiveness.**

***Index Terms*—Developmental research, problem-based blended learning, vocational education**

I. Introduction

The problems in this research are categorized into two issues, empirical and theoretical. The empirical problems in this research were obtained based on the results of an interview with teachers at vocational schools in 2020 at school and questionnaire filling out by them. Empirically, it can be explained that there were five problems found in the application of online learning in Vocational Schools. The first problem was the difficulties of students in working on evaluations contained in the online learning system. This is due to the unavailability of material that is good enough to help students to complete the exercises given by the teacher. In addition, students' responses via electronic questionnaires showed that 22 out of 30 students (73%) stated that teachers had not provided sufficient material for online learning during Covid-19. Second, the teacher only gave a number of assignments and then students work on these assignments independently which has an impact on the quality of the assignments done. The results of the interviews showed that the average value of students' practice reached 67.5. In addition, only 27% of students complete while 73% of students have not been categorized as complete in network administration material with KKM 80. Third, a number of students tend to work together to make assignments so that cheating occurs. Furthermore, students' answers via electronic questionnaire showed that 23 out of 30 students (67%) acknowledged that while doing assignments through online learning during Covid-19 was done by rewriting from their friends' assignments. Fourth, the ineffectiveness of online learning is often caused by technical problems, such as: the inability of students to buy internet access quota, and not optimal operation of the online learning system. This is due to the different abilities of teachers in using online learning system. Furthermore, students' answers via electronic questionnaire showed 25 out of 30 students (87%) stated that students had difficulty buying internet access quota to learn via online learning during Covid-19. Fifth, the learning model used by teachers so far was not effective, innovative, and optimal because it still used a problem-based learning model that is based on textual. Furthermore, students' answers via electronic questionnaire showed 24 out of 30 students (83%) confirmed that the problem-based learning model was only textual and directly in the form of an evaluation test.

Theoretically, this study departs from research problems related to blended learning and problem-based learning models that have been carried out by previous researchers. Fundamentally there are three basic stages in the blended learning model which refers to ICT-based learning, namely: (1) seeking of information, (2) acquisition of information; and (3) synthesizing of knowledge [1–5]. In addition, research related to the existing problem-based learning model shows advantages. The advantages of the existing model syntax are: (1) the use of various model syntaxes; (2) tends to lead to the principles of 21st century learning (4C); and (3) optimizing IOT principles or using the internet as an aid to the learning process in schools [6–11]. In addition, the shortcomings and at the same time being gap and the novelty of this research include: (1) on average it is dominated by learning science subjects while this research was conducted in computer network engineering subjects; (2) the syntax that the researcher uses is more detailed and between one syntax is related to the next syntax; and (3) researchers also use additional Web-based applications that are able to accommodate students' learning needs from planning, implementing, to learning evaluation.

Some research results show that the effectiveness of learning using Information and Communication Technology (ICT) is better than traditional or conventional learning. The research findings done by Nyambane and Nzuki [12] reveal that integrating technology into classroom practice is one of the challenges faced by teachers in the 21st century.

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Professional development and accessibility of ICT resources influence teacher adaptation and integration of technology into the classroom. Furthermore, the research done by Amenyedzi and Lartey *et al.* [13] also stated that the use of media and Information Communication Technology (ICT) helps students to achieve new things such as completing assignments, solving problems, studying the history of other countries, improving typing skills, and chatting with friends. Furthermore, Yusuf and Afolabi [14] stated in their research that the performance of students using computer-assisted learning individually and cooperatively was better than their counterparts who used instructional methods in conventional classes.

Along with the rapid development of the times, the media used should also be varied. According to the findings of Siddiqui and Khatoon [15], computers in learning are more effective for increasing student achievement than traditional teaching. Then, Premalatha [16] also concluded his findings that computers in learning make the environment conducive for students at school and at home and motivate them to be involved in studies and make learning interesting [17]. In addition, Karami *et al.* [18] stated that teachers as trainees can integrate problem-based learning with ICT to solve these problems in developing more professional knowledge content and teachers are more skilled at teaching.

One form of innovative audio-visual learning media is interactive animation media. Interactive animation media is a communication tool or tool that is conveyed by more than one communication medium using a computer by combining text, graphics, animation, audio, and images that allow users to interact with the server [19]. Interactive learning media can be in the form of software and hardware that can be used as intermediaries to convey subject matter to students which can allow students to interact with the learning environment [20–23]. The use of interactive multimedia in learning mathematics is effectively used in learning mathematics [24]. The development that has been carried out has a positive impact on learning so that it can provide better learning outcomes. Therefore, the development of similar learning media must be innovative to provide more optimal benefits.

Researches have been conducted regarding the use of audio-visual media in learning, namely: Sanusi *et al.* [24] measures student learning outcomes in using computer-assisted instruction when developing their knowledge of concrete words that can be seen sense of sight. In addition, Kim and Gilman [25] from Korea did an investigation reserach related with the use of multimedia components such as visual text, spoken text, and graphics in a web-based self-teaching program to enhance students' vocabulary learning at Myungin Middle School in Seoul, South Korea.

Furthermore, Mathew and Alidmat [26] revealed that it has become a common phenomenon to integrate language textbooks with audio and video as additional resources for language learning activities in class. Then, Bello and Goni [27] found that there was a significant relationship between audio-visual media and environmental factors in the academic performance of students at senior high schools in Borno State. Shabiralyani and Hasan *et al.* [28] suggested that the results of their research explored teachers' opinions about the use of visual aids (for example, pictures, animated videos, projectors, and films) as a motivating tool in increasing students' attention in reading literary texts. Overall, from the studies that have been carried out, it can be concluded that the use of audio-visual media increases students' attention in learning.

Developmental research related to the use of animated media includes animation media developed by Zainiah and Rijanto [29] in a lesson about electricity. In addition, Fitriana [30] also developed science subjects. The results of the study show that animation-based learning media can help the learning process and it was suitable for learning. In geometry Learning using interactive media that utilizes Macromedia flash, which uses visualization, animation, and illustration in geometry gives better results on students' understanding and abilities theoretically, practically, and visually [31, 32].

The research results of Widjayanti and Musfingatin *et al.* [33] show three things, namely: (1) the validity level of animation-based interactive learning media is 89.05%; (2) the level of practicality of animation-based interactive learning media reaches 87.95%; and (3) the level of effectiveness of animation-based interactive learning media is 87.50%. Therefore, animation-based interactive learning media is appropriate to be used in learning in schools, especially in Vocational High Schools. In line with that, a research from Widjayanti and Musfingatin *et al.* [33] stated that students can understand and remember easily and quickly about maintenance that must be done on multimedia equipment, after seeing illustrations in the form of animations about multimedia equipment maintenance procedures [34].

According to Al-Madani and Allaafiajiy [35], the use of modern technological devices is not only helps improve human resources but also strengthens the country's economy to compete well in this challenging globalized world. Furthermore, Chaudhari [36] added that technology in learning is an additional instructional strategy for effective teaching. All hardware or software in the world of technology is also included as a teaching aid in every subject, including computer and basic networking subjects. The use of technology in learning can increase the learning value of students.

One learning model that can be applied through the use of technology-based media is the blended learning model. According to Driscoll [37], blended learning is learning that combines or combines various web-based technologies, to achieve educational goals. Thorne [38] defines blended learning as a mixture of e-learning and multimedia technologies, such as video streaming, virtual classes, and online text animations combined with traditional forms of classroom training. Meanwhile, Bonk and Graham [39] stated that blended learning is simply as learning that combines online learning with face-to-face (face-to-face learning).

According to Garner and Oke [40], blended learning is a learning environment designed to integrate Face-to-Face (F2F) learning with online learning that aims to improve student learning outcomes. In general, Albion [41] classifies four types of interactions that occur in online learning, including (i) student interaction with content referring to users who are bound by instructional information; (ii) student interaction with technology interfaces: the use of technology in learning

or student interaction with the technology interface can be called another type of interaction; (iii) interaction with instructors is a method or way of instructors teaching, guiding, and supporting students; (iv) And the interaction of students with students is a way for students to communicate with fellow students in the learning process.

In other words, blended learning is a learning approach that is carried out by combining two synchronous methods and an asynchronous method. Blended learning is the delivery of information, communication, education, and training on teacher material both subject matter substance and educational science online [42]. Blended learning is a learning approach that integrates traditional face-to-face learning and distance learning that uses online learning resources and a variety of communication options that can be used by teachers and students [43]. Blended learning is not entirely learning done online which replaces face-to-face learning in class, but complements and overcomes material that has not been conveyed in learning when students study in class [44, 45].

The Problem-Based Learning (PBL) model, hereinafter abbreviated as PBL, was introduced in 1969 at the medical faculty of McMaster University in Canada, then at the University of Limburg in the Netherlands, the University of Newcastle Australia, and the University of New Mexico in the United States, only then was the PBL model introduced in various disciplines. sciences such as business, dentistry, health sciences, law, engineering, and education [46]. The flow of PBL activities is as follows.

The concept of PBL learning is a learning model for finding solutions to problems as a result of the participants' thoughts and experiences and not as a result of instructor teaching [47]. The philosophical foundation of PBL is based on constructivism learning theory with contextual problem solving, namely building a problem framework based on the topic of discussion, observing, collecting data and organizing problems, compiling facts, analyzing data, compiling arguments, and solving problems [48–52].

Survey data from the Association of Indonesian Internet Service Providers (2016) shows that internet use in Indonesia reached 132.7 million people with a percentage of the male population of 52.5% and 47.5% of the female population in 2016, which means there has been an increase where in 2014 the number of internet users of 88.1 million people. The largest internet usage is on the island of Java with a total of 66.3 million users. The high number of internet access users in Indonesia also affects the number of users accessing blended learning. This can be seen from the use of Learning Management System (LMS) in the world which shows that Edmodo is one of the top 5 LMS that has many users followed by other LMS such as Moodle, Blackboard, Successfactors, and Skillsoft. Edmodo as an LMS that is used for blended learning has a total of 58 million users [53].

Learning that can maximize students' thinking processes is learning that is designed and based on problems. Learning that is focused on problems is known as problem-based learning. Problem-based learning is a learning model that requires students to learn inventions based on predetermined plans and principles and at the same time have the skills to solve problems [54]. Problems are learning stimuli as a tool for developing problem-solving and developing critical skills or critical thinking [55]. In line with the above understanding, Maulida *et al.* [56] states that the development of lifelong learning patterns is strongly supported by problem-based learning so that students can apply an open, critical, reflective mindset, and be active.

The results of research conducted by researchers have shown a positive impact on the learning process. Research conducted by Lestaringsih and Wijayatiningsih [57] concluded that the application of blended learning models and problem based learning, especially using the website, is appropriate for use in teaching tutorials in class with consideration of validation results, namely the compatibility of concept indicators, content feasibility indicators, presentation indicators, and competency indicators with the existing tutorial learning modules. Furthermore, Aeni and Prihatin *et al.* [58] concluded that the use of blended learning models at Subject Matter Knowledge (SMK) is effectively used in learning activities so that it can improve student learning outcomes.

Other relevant research related to the development of problem-based learning models shows an increase in student motivation. The results of the research conclusions of Alfi and Perdana [59] show that PBL based on blended learning is included in the very effective and practical category so that it can be categorized as feasible for use in learning. Furthermore, research conducted by Dewi [60] shows that the learning process that uses problem-based learning and blended learning can actually provide better student learning outcomes covering the cognitive, affective and psychomotor domains. In addition, the application of blended learning in PBL can also provide a positive perception.

II. Methodology

This research is a type of research and development research. The development model applied in this study is the 4D development model. This model consists of four main steps, namely: (1) define, (2) design, (3) development, and (4) dissemination. The development model in this study uses the existing model, theoretical model, hypothetical model, and final model stages. The conceptual model is an analytical model, which states the product components, analyzes the components in detail, and shows the linkages between the components to be developed. The cycle of development steps through the 4D model can be described as Fig. 1:

A. Define Phase

It is based on previous research reports or documentation of activity reports from individuals. The potential and problems raised in research must be demonstrated with empirical data. Problems and potentials can be proven factually, and then it is necessary to collect various information that will be used as material for planning. In this stage, interviews were conducted with educators in the field of computer studies and basic networks in the city of Padang and interviewed several students regarding learning difficulties amid the Covid-19 pandemic. Some of the interview topics include: the challenges of teaching computer studies and basic networks during the Covid-19 pandemic, the use of

technology in teaching, student engagement and participation in online learning, and strategies to improve student learning outcomes. Then, analyzing the characteristics of students, which consists of ways of learning and analyzing the teacher's ability to provide learning material seen from the list of values that have been obtained previously. All of this is done to assist researchers in developing problem-based learning-based blended learning models that will be used in learning.

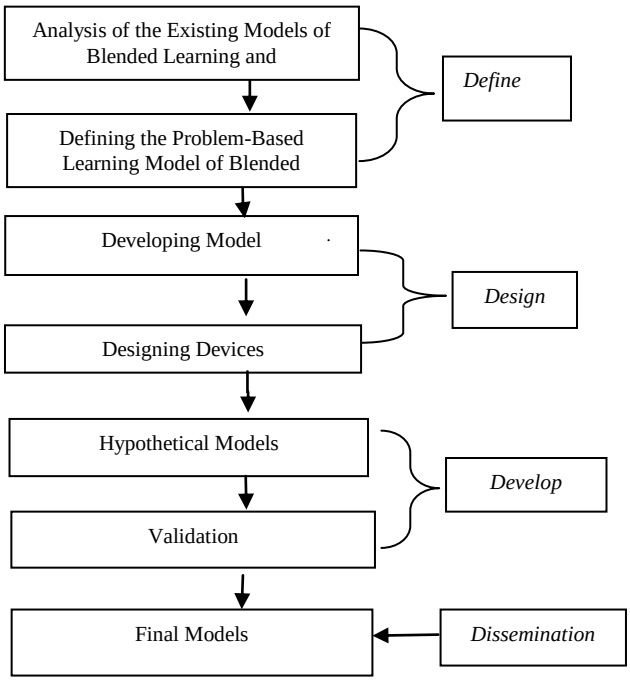

Fig. 1. The development steps through the 4D model.

B. Design Phase

Research and Development begins with identifying problems and potential for development. Problems and potential data can be the result of a series of preliminary studies, in the form of new work designs or new products. The products generated in research and development vary, and in this study, the new product developed is problem-based learning-based blended learning. This product is oriented towards creating an engaging and enjoyable learning process for students. In this stage, design validation and expert validation are conducted. Design validation is carried out by presenting the design to experts who have experience in evaluating newly designed products. Each expert evaluates the design to identify its weaknesses and strengths. Design validation can be done through discussions or Focus Group Discussions (FGD). Before the discussion, the research activities are presented until the design and its advantages are determined. In this study, design validation is carried out by experts, namely promoters, contributors, and validators. Furthermore, the prototype product from the design phase is validated by experts. The instructional tool has been designed, followed by validation activities by experts and educational practitioners in their respective fields, consisting of five expert validators. The validation results and improvement suggestions provided by validators are used to revise the learning materials, appearance and layout, as well as the systematic presentation of the developed blended learning. The validation results are categorized based on predetermined criteria.

C. Development Phase

Development is a complex activity that involves various interconnected factors such as content, materials, design, development skills, and others. The development model in this study follows the stages of the existing model, namely the conceptual model, theoretical model, hypothetical model, and final model. The conceptual model is an analytical model that states the components of the product, analyzes the components in detail, and shows the relationships between the components to be developed. The theoretical model is a model that explains the framework and is based on relevant theories supported by empirical data. The hypothetical model is a model that has received input from experts and practitioners through focus group discussions (FGD). The final model is a model that has been empirically tested. After developing the learning syntax, limited testing is carried out. In the initial stage, a simulation trial is conducted using the problem-based learning-based blended learning model. In the simulation stage, the products are introduced and displayed through a website. In the development phase, the product is revised based on the trial results. This is done to rectify and add any deficiencies or errors in the designed blended learning model. The effectiveness testing of problem-based learning-based blended learning shows that the new learning media is more effective than the previous learning media, allowing for a wider sample to be used. In this study, design revisions are made according to the assessments, criticisms, and suggestions from the validators. The design revisions for the development of instructional media are conducted through discussions with the promoters and contributors.

In the development phase, the researcher conducts tests and determines: (1) validity scores, (2) reliability, (3) calculation of question difficulty level, and (4) calculation of gain scores. Question validation is a method of item validation using the r table in the product-moment correlation test at a significance level of 5%. If the calculated r value is greater than or equal to the r table value, then the validated item is considered valid. Reliability in this study is tested using the Kuder Richardson-21 formula. Furthermore, the difficulty level of the questions in the form of objective questions given to students is calculated using the formula: p =B/Js, with criteria >0.75 considered easy, 0.25–0.75 considered moderate, and <0.25 considered difficult. Gain Score: The effectiveness of the problem-based learning-based blended learning model is determined based on the differences in student learning outcomes between the pretest and posttest. To measure the increase in student learning outcomes, the gain score formula is used. The problem-based learning-based blended learning model developed can be considered effective if the gain score is >0.30 or at least falls into the medium category.

D. Disseminate Phase

The development of the problem-based learning-based blended learning model in the subject of Basic Computer and Networking for vocational students in Indonesia is distributed to all vocational schools that implement the C-13 curriculum

and vocational schools with Computer Networking study programs. After being assigned to all vocational schools, the development of the problem-based learning-based blended learning model has been implemented in the Basic Computer and Networking subject for ideal students in vocational education.

III. Results

Testing the effectiveness of this data instrument is carried out by giving a pretest to students before being given treatment on the learning media that has been developed. Then after getting the results from the pretest students are given learning using learning media that has been developed. After that, students are given a posttest after using the learning media that has been developed. This effectiveness test looks at the level of effectiveness of the use of problem-based learning blended learning models, and whether they are more effective in using learning media.

The data instrument test needs questions used in this trial class to get the reliability results for this data instrument; (1) to see the reliability of the questions in the test questions that will be used in the intended research, (2) know the level of questions that are difficult to use in research needs to be used or not used, and (3) testing the differential power of the question analyst to be tested in research for development problem-based learning-based blended learning that will be developed.

A. Question Item Validation Results

Based on the table above, this test validation test can be seen in the results of the table, there are 40 questions given to students who are tested. The measurement of student understanding after being taught through the Problem-Based Blended Learning Model is conducted through testing. The aspects of ability measured to determine students' understanding of the subject matter are as follows: available services in a network, file administration in Linux, file systems and user access in Linux, concept and configuration of Dynamic Host Configuration Protocol (DHCP) server, concept and configuration of File Transfer Protocol (FTP) server, and configuration of Virtual Local Area Network (VLAN). The test conducted is based on the four highest cognitive levels established by Benjamin Bloom. These cognitive levels are as follows: (1) C3 (Application): Using the knowledge that has been understood to solve problems or apply it in real-life situations, (2) C4 (Analysis): Analyzing information into smaller components to understand the relationships and structures among them, (3) C5 (Evaluation): Evaluating, assessing, or making judgments about information, arguments, or situations based on predetermined criteria, and (4) C6 (Synthesis): Integrating information or different elements to create something new or original. Here is a Table I of the question (can be seen in the Supplementary) grid for analyzing validity:

Based on Table I presented above, it can be inferred that the given questions in the student's comprehension assessment regarding computer network techniques are formulated based on the cognitive levels or Bloom's taxonomy, commencing from C3, C4, C5, and C6. Moreover, the assessment comprises a total of 40 items designed to evaluate the students' proficiency. Subsequently, the students' responses are utilized for the purpose of determining and categorizing the validity level of the questions, which can be observed in the subsequent Table II.

TABLE I: Questions Grid

Question Indicators	Number of Questions	Cognitive Levels
Available services in a network	7	C3–C4
File administration in Linux	7	C3–C4
File systems and user access in Linux	7	C3–C4
Concept and configuration of DHCP Server	7	C4–C6
Concept and configuration of FTP Server	6	C4–C6
Configuration of VLAN	6	C4–C6
Total	**40**	

TABLE II: Classification of Valid and Invalid Questions

No.	Questions	Category
1	2, 3, 4, 5, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 26, 28, 30, 31, 32, 34, 36, 38, 40	Valid
2	1, 6, 7, 10, 23, 25, 27, 29, 33, 35, 37 and 39	Invalid

Based on the provided Table II, it can be explicated that there are 28 questions that meet the criteria of validity, whereas 12 questions are categorized as invalid. Based on the analysis results, the valid questions identified include the numbered questions: 2, 3, 4, 5, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 26, 28, 30, 31, 32, 34, 36, 38, 40 and invalid questions include: 1, 6, 7, 10, 23, 25, 27, 29, 33, 35, 37 and 39.

B. Test Reliability Testing

This test is a measuring tool that is used to determine whether the test item is valid or invalid and can be trusted. Testing the reliability of the test is by using the Microsoft Excel 2013 application program. Testing the reliability of the test to find the results obtained is 0.81. From the r-table, for N=30 while the significance rate is 0.05 at the r-table value is 0.361. So it can be calculated that r-count>r-table is 0.92>0.361. So it can be said testing high-reliability tests.

C. Test the Difficulty Level of Questions

The level of difficulty of this question is tested to see which questions fall into the category of difficult, moderate, and even easy questions. The difficulty level of the questions is need to be tested.

TABLE III: Difficulty Level of Questions

No.	Questions	Category
1	2	Easy
2	1, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25, 26, 27, 28, 29, 30, 31, 33, 34, 35, 36, 37, 38, 39, and 40	Medium
3	4, 23, and 32	Difficult

Based on the Table III the questions will be tested, then analyzed so that the questions will fall into which category. This level of difficulty is analyzed for the difficulty level of the problem. Three categories are grouped in analyzing the questions. There is one question, namely question number 2 which is included in the category of easy questions, there are

thirty-six questions of which are: questions 1, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25, 26, 27, 28, 29, 30, 31, 33, 34, 35, 36, 37, 38, 39, and 40 falls into the category of questions that medium, while three of them, questions 4, 23, and 32 are in the category of difficult. These questions are questions that fall into the category of difficult questions. All questions are still in a normal state because there is a balance of easy, medium, and difficult questions.

D. Data Testing of Different Power Problems

Differential power calculation is the ability of a test to differentiate between high and low ability test takers based on the test items' learning outcomes. The different power (P) of an item is calculated using the formula for discriminatory power. It is the value of the proportion of the upper group of testees minus the value of the proportion of the lower group of testees. Furthermore, the classification of the interpretive standards for item discriminatory power can be observed based on four criteria as follows: if P value is >0,70, the item is interpreted as *excellent*; if P value is >0,40-0,70, the item is interpreted as *good*; if P value is >0,20-0,40, the item is interpreted as *moderate*; and if P value is 0-0,20, the item is interpreted as *not good*.

Data on item different power are obtained through four steps. Firstly, the design and development of 40 multiple-choice questions are carried out, aligning them with the intended learning objectives and content to be assessed. Secondly, the constructed questions are administered to a sample of 30 students. Thirdly, after the respondents answer all the questions, the response data is collected. Lastly, the data is analyzed to obtain information about the item different power by calculating the correlation between the correct answers to an item and the respondents' total scores on the overall test. The results of the item different power calculation are then utilized to evaluate the quality of the items. Items with good item different power demonstrate the ability to differentiate between higher- and lower-performing respondents in the tested domain. The categorization of item different power levels can be observed in the following table.

TABLE IV: DIFFERENT POWER OF QUESTIONS

No.	Questions	Category
1	5, 9, 10, 11, 13, 16, 17, 19, 24, 26, 31, 34, 35, 36, and 37	Good
2	2, 3, 8, 12, 14, 18, 25, 28, 30, 33, 38, and 40	Moderate
3	1, 4, 6, 7, 15, 20, 23, 27, 29, 32, and 39	Not Good

Based on the Table IV the questions will be tested, then analyzed so that the questions will fall into which category. Testing Questions tested for analysis of questions that are in the good category include questions 5, 9, 10, 11, 13, 16, 17, 19, 24, 26, 31, 34, 35, 36, and 37. Furthermore, the questions are in the moderate category including questions 2, 3, 8, 12, 14, 18, 25, 28, 30, 33, 38, and 40. In addition, the categories of questions are not good, including 1, 4, 6, 7, 15, 20, 23, 27, 29, 32, and 39. Therefore, it can be understood that there are 29 questions in the good and moderate categories while 11 questions are in a bad category.

E. Testing the Effectiveness of Student Learning Outcomes

Testing the effectiveness of student learning outcomes is done by giving a Pretest and Posttest which will be tested for the effectiveness of student learning outcomes. In this study, testing of student learning outcomes was carried out using the tests given. This test is carried out before using the learning media that has been developed, namely on the pretest, and will be tested when after using the developed website-based learning media, namely on the posttest. The results of the pretest and posttest have been carried out in the first stage and are showed in Table IV.

TABLE IV: PRETEST AND POSTTEST RESULTS

Testing	Total Student	Learning Outcomes		Percentage Score	
		Total Passed	Total Not Passed	Pass	Not Passed
Pretest	30	2	28	7%	93%
Posttest	30	23	7	77%	23%

Based on the Table IV, the pretest results were given to students out of a total of 30 students. The total number of students who passed was tow students with a percentage score of 7%, while 28 students who did not pass had percentage score were 93% who took the pretest. While the posttest was given to students who had used the website-based learning media, students passed were 23 students with a percentage score of 77%, while students who did not pass were seven students with a percentage score of 23%. Students who use media that have been developed will be able to improve student learning outcomes. Testing the effectiveness of learning outcomes can be calculated using the gain score method to be able to see the results of the pretest and posttest that will be given to students or students. Based on the data, it can be explained that the average value of student learning outcomes at the pretest reached 44.42, and at the posttest reached 80.00. Furthermore, the results of calculating the minimum gain score reach 0.29 and the maximum gain score reaches 0.76. Therefore, it can be seen that the average gain score reaches 0.53 in the moderate category.

IV. DISCUSSION

Students who use media that have been developed will be able to improve student learning outcomes. Testing the effectiveness of learning outcomes can be calculated using the gain score method to be able to see the results of the pretest and posttest that will be given to students or students. The average score of student learning outcomes at the pretest reached 44.42, and at the posttest reached 80.00. Furthermore, the results of calculating the minimum gain score reach 0.29 and the maximum gain score reaches 0.76. Therefore, it can be seen that the average gain score reaches 0.53 in the moderate category.

This addresses the research findings of Al-Madani and Allaafiajiy [35], which stated that the use of modern technological devices can improve human resources and strengthen the country's economy to compete in the challenging globalized world. Technology is a valuable additional instructional strategy for effective teaching. It can be utilized as a teaching aid in every subject, including computer network engineering, and has the potential to

increase the learning value of students. Therefore, it is important to integrate technology into the learning process to enhance the educational experience and improve academic outcomes [36].

This supports the statement and research results from Drisscoll which states that one learning model that can be applied through the use of technology-based media is the blended learning model [37]. Blended learning refers to an educational approach that combines different teaching methods and technologies to create a more flexible and personalized learning experience. In this approach, both face-to-face and online teaching methods are used, and various web-based technologies are integrated to achieve educational goals. Blended learning typically involves a combination of in-person lectures or discussions, online modules, virtual simulations, and other interactive media. The approach is often tailored to meet the needs of individual students or groups, allowing them to learn at their own pace and in their own preferred learning style [38].

The use of web-based technologies in blended learning provides many benefits for both students and teachers. For students, it allows them to access educational materials from anywhere at any time, to engage in self-directed learning, and to collaborate with peers and instructors remotely. For teachers, it offers a more flexible approach to teaching, enabling them to reach more students and to customize their instructional methods to meet the needs of individual learners. Overall, blended learning is an innovative and effective approach to education that combines the benefits of traditional classroom teaching with the advantages of online learning technologies. This supports the statement and research results from Bonk and Graham which states that it offers a more dynamic and engaging learning experience, and has the potential to improve educational outcomes for students of all ages and backgrounds [39].

The results of the hypothetical model development of PB-blended provide several advantages for vocational learning, such as: which states that the advantages of blended learning are as follows: (1) students are free to study subject matter independently by utilizing materials available online; (2) students can hold discussions with teachers or other students outside of face-to-face hours; (3) learning activities carried out by students outside face-to-face hours can be managed and controlled properly by the teacher; (4) teachers can add enrichment materials through internet facilities; (5) the teacher can ask students to read the material or take tests before learning; (6) teachers can organize quizzes, provide feedback and make effective use of test results; (7) students can share files with other students; (8) there are many other advantages by utilizing the advantages of internet-based learning [61].

Blended learning is a teaching approach that combines face-to-face instruction with online learning. This approach is designed to provide students with a more flexible and personalized learning experience that can improve their learning outcomes. This supports the statement and research results from Garner and Oke which states that blended learning allows students to benefit from the strengths of both F2F and online learning [40]. F2F instruction provides students with direct access to teachers and allows for hands-on learning experiences. Online learning provides students with access to a wider range of educational resources, including videos, interactive modules, and online discussions. The combination of both forms of instruction can help students to stay more engaged and motivated, while also providing opportunities for more individualized learning [41].

One of the main advantages of blended learning is that it can be tailored to meet the needs of individual learners. Students can work at their own pace, review materials as needed, and receive immediate feedback on their progress. Teachers can use a variety of tools and techniques to create engaging learning experiences, such as gamification and multimedia resources. Blended learning can also be more cost-effective than traditional classroom teaching. By using online resources, teachers can reduce the need for expensive textbooks and other materials, while also reducing the need for classroom space and other resources. Overall, blended learning is a promising approach to education that combines the strengths of F2F and online learning. It provides students with a more flexible and engaging learning experience, while also allowing for more individualized instruction and improved learning outcomes [62–66].

Practically, the development of this model has implications for three things. First, it can be used as a useful medium in facilitating the evaluation process through online learning. Second, it can provide motivation and interest in understanding computer science concepts and basic networks as an integral part of learning in the Computer Network Engineering major. In addition, it can make it easier for students to improve their understanding of the concepts contained in network computer engineering subjects. In addition, the development of a Problem Based Learning Blended Learning model can assist teachers in creating an effective, efficient, fun, and innovative learning process. Third, it can be used as a consideration and reference in shaping students' positive behavior and creating a school academic atmosphere that is oriented towards 21st century learning and the industrial revolution 4.0.

V. Conclusion

Based on the results of the analysis and discussion, it can be concluded that the learning model of Blended Learning Based on Problem-Based Learning in computer network engineering subjects in Vocational High Schools has high effectiveness. Furthermore, the products produced in the development of the Problem-Based Blended Learning model for network computer engineering subjects, namely: (1) a platform in the form of a blended learning web that contains teaching material content about network computer engineering, (2) problem-based learning regarding content of teaching material for network computer engineering, (3) evaluation in the form of problem-based learning regarding network computer techniques, (4) student handbook modules, (5) teacher handout modules, (6) user manual books for problem-based web based learning (asynchronous), and (7) a user manual book on implementing virtual online (synchronous).

Theoretically, the development of this model has implications for the development of science in the world of education, especially in implementing the learning process in the form of developing a Problem Based Learning Blended Learning model in Vocational High School education units. This learning model aims to encourage students to learn through real problems in everyday life, or problems related to the knowledge they have learned or will learn. The problems posed in the PBL model are not "ordinary" problems or not just "practice" given after the sample questions presented by the teacher. Problems in PBL demand an explanation of a phenomenon. The focus is on how students identify learning issues and then look for alternative solutions. In this lesson, students are trained to be skilled at solving problems.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

The authors' contributions to this research can be described as follows. Ferdiansyah was responsible for the conceptualization of the study and data collection. Hasan Maksum was responsible for the literature review, data interpretation, and visualization. Fahmi Rizal was responsible for the methodology and data analysis. Ridha Hasnul Ulya contributed to the writing, reviewing, and editing of the article as well as data interpretation. All authors had approved the final version.

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REFERENCES

[1] G. Ramsay, "Teaching and learning with information and communication technology: Success through a whole school approach," ERIC Number: ED462943, 2001.

[2] C. R. Graham and C. J. Bonk, "The handbook of blended learning," *Bloom. Indiana Univ.*, 2005.

[3] J. Tao, C. Fore, and W. Forbes, "Seven best face-to-face teaching practices in a blended learning environment," *J. Appl. Learn. Technol.*, vol. 1, no. 3, 2011.

[4] M. Eryilmaz, "The effectiveness of blended learning environments," *Contemp. Issues Educ. Res.*, vol. 8, no. 4, pp. 251–256, 2015.

[5] R. Budiharti, E. Y. Ekawati, and D. Wahyuningsih, "Penggunaan blended learning dengan media moodle untuk meningkatkan kemampuan kognitif siswa SMP," *J. Cakrawala Pendidik.*, vol. 34, no. 1, 2015.

[6] R. Ibrahim and N. Syaodih, "Teaching planning," *Jakarta: Rineka Cipta*, 2003. (in Indonesian)

[7] L. K.-N. Wee, M. Alexandria, Y.-C. Kek, and C. A. Kelley, "Transforming the marketing curriculum using problem-based learning: A case study," *J. Mark. Educ.*, vol. 25, no. 2, pp. 150–162, 2003, doi: 10.1177/0273475303254016.

[8] P. Kingpum, C. Ruangsuwan, and S. Chaicharoen, "A development of a collaborative blended learning model to enhance learning achievement and thinking ability of undergraduate students at the institute of physical education," *Educ. Res. Rev.*, vol. 10, no. 15, pp. 2168–2177, 2015.

[9] E. dan Kauchak, "Learning strategies and models teaching content and thinking skills," *Diterjemahkan Wahono. Jakarta Indeks*, 2012. (in Indonesian)

[10] S. Ramalingam, M. M. Yunus, and H. Hashim, "Exploring ESL Learners' Blended Learning Experiences and Its Effectiveness through Web-Based Technologies," *Int. J. Eval. Res. Educ.*, vol. 10, no. 4, pp. 1436–1445, 2021.

[11] K. Suma, I. N. P. Suwindra, and R. Sujanem, "The effectiveness of blended learning in increasing prospective physics teacher students' learning motivation and problem-solving ability," *JPI (Jurnal Pendidik. Indones.*, vol. 9, no. 3, pp. 436–445, 2020.

[12] C. O. Nyambane and D. Nzuki, "Factors influencing ICT integration in teaching—A literature review," *Int. J. Educ. Res.*, vol. 2, no. 3, pp. 1–17, 2014.

[13] F. W. K. Amenyedzi, M. N. Lartey, and B. M. Dzomeku, "The use of computers and internet as supplementary source of educational material: A case study of the senior high schools in the Tema metropolis in Ghana," *Contemp. Educ. Technol.*, vol. 2, no. 2, pp. 151–162, 2011.

[14] M. O. Yusuf and A. O. Afolabi, "Effects of Computer Assisted Instruction (CAI) on secondary school students' performance in biology," *Turkish Online J. Educ. Technol.*, vol. 9, no. 1, pp. 62–69, 2010.

[15] U. Siddiqui and T. Khatoon, "Teaching physical science: Should we implement teacher-centered CAI or student-centered CAI at secondary school level in India?" *Eur. Sci. J.*, vol. 9, no. 10, 2013.

[16] U. M. Premalatha, "An empirical study on the attitude of high school students towards computer-assisted instruction with respect to their study practices," *IUP J. Soft Ski.*, vol. 6, no. 2, 2012.

[17] R. H. Ulya, R. Syahrul, and N. Juita, "Peningkatan keterampilan menulis tulisan argumentasi siswa kelas x. 3 SMA negeri 2 kota Sungai Penuh berbantuan media peta pikiran," *Bahasa, Sastra, dan Pembelajaran*, vol. 1, no. 1, 2013.

[18] M. Karami, Z. Karami, and M. Attaran, "Integrating problem-based learning with ICT for developing student-teachers' content knowledge and teaching skill," *Int. J. Educ. Dev. using ICT*, vol. 9, no. 1, pp. 36–49, 2013.

[19] A. Arsyad, *Media Pembelajaran*, Jakarta: Rajawali Pers, 2014.

[20] T. Sutarti and E. Irawan, "Tips for success in obtaining research and development grants," *Deepublish*, 2017. (in Indonesian)

[21] R. H. Ulya, "Social order dimension in superstition pregnant woman for Kubuang Tigo Baleh society," *TELL-US J.*, vol. 8, no. 1, pp. 38–49, 2022.

[22] E. Erni and R. H. Ulya, "The softskill and hardskill forms of Tunjuk Ajar Melayu in Nyanyi Panjang Bujang Si Undang Palalawan society of Riau Province," *AL-ISHLAH J. Pendidik.*, vol. 13, no. 3, pp. 1688–1695, 2021.

[23] R. H. Ulya, E. Gani, and E. Noveria, "Ethnolinguistic perspective: Correlational superstition and Sumbang Duo Baleh Minangkabau society," in *Proc. 5th International Conference on Language, Literature, and Education (ICLLE-5 2022)*, 2022, pp. 157–167.

[24] S. Sanusi, E. Suprapto, and D. Apriandi, "Development of interactive multimedia as learning media on the subject of three dimensions in senior high schools," *JIPM (Jurnal Ilm. Pendidik. Mat.*, vol. 3, no. 2, 2015. (in Indonesian)

[25] D. Kim and D. A. Gilman, "Effects of text, audio, and graphic aids in multimedia instruction for vocabulary learning," *J. Educ. Technol. Soc.*, vol. 11, no. 3, pp. 114–126, 2008.

[26] N. G. Mathew and A. O. H. Alidmat, "A study on the usefulness of audio-visual aids in EFL classroom: Implications for effective instruction," *Int. J. High. Educ.*, vol. 2, no. 2, pp. 86–92, 2013.

[27] S. Bello and U. Goni, "Relationship between audio-visual materials and environmental factors on students academic performance in senior secondary schools in borno state: implications for counselling," *J. Educ. Pract.*, vol. 7, no. 24, pp. 173–177, 2016.

[28] G. Shabiralyani, K. S. Hasan, N. Hamad, and N. Iqbal, "Impact of visual aids in enhancing the learning process case research: District Dera Ghazi Khan.," *J. Educ. Pract.*, vol. 6, no. 19, pp. 226–233, 2015.

[29] R. Zainiah and T. Rijanto, "Development of animation and simulation-based learning media to improve student learning outcomes in the electric lighting installation subject at SMKN 1 Sidoarjo," *J. Pendidik. Tek. Elektro*, vol. 5, no. 2, 2016. (in Indonesian)

[30] D. Fitriana, "Development of interactive animation-based learning media on the material of the human circulatory system at MI Raudlatul Ulum Ngijo Karangploso Malang," Universitas Islam Negeri Maulana Malik Ibrahim, 2014.

[31] M. Milovanovic, J. Obradovic, and A. Milajic, "Application of interactive multimedia tools in teaching mathematics—Examples of lessons from geometry," *Turkish Online J. Educ. Technol.*, vol. 12, no. 1, pp. 19–31, 2013.

[32] K. Altıparmak, "Impact of computer animations in cognitive learning: Differentiation," *Int. J. Math. Educ. Sci. Technol.*, vol. 45, no. 8, pp. 1146–1166, 2014.

[33] W. R. Widjayanti, T. Masfingatin, and R. K. Setyansah, "Animation-based interactive learning media on statistics material for grade 7 junior high school students," *J. Pendidik. Mat.*, vol. 13, no. 1, pp. 101–112, 2018. (in Indonesian)

[34] F. Ferdiansyah and D. Irfan, "Interactive learning media based on website in vocational school," *AL-ISHLAH J. Pendidik.*, vol. 13, no. 1, pp. 755–762, 2021.

[35] F. M. Al-Madani and I. A. Allaafiajiy, "Teachers' professional development on ICT use: A Saudi sustainable development model," *J. Mod. Educ. Rev.*, vol. 4, no. 6, pp. 448–456, 2014.

[36] P. Chaudhari, "Computer Assisted Instruction (CAI): Development of instructional strategy for biology teaching," *Educ. Confab*, vol. 2, no. 1, pp. 106–116, 2013.

[37] M. Driscoll, "Blended learning: Let's get beyond the hype," *E-Learning*, vol. 1, no. 4, pp. 1–4, 2002.

[38] K. Thorne, *Blended Learning: How to Integrate Online & Traditional Learning*, Kogan Page Publishers, 2003.

[39] C. J. Bonk and C. R. Graham, "The handbook of blended learning: Global perspectives," *Local Des.*, p. 5, 2006.

[40] B. Garner and L. Oke, "Blended learning: Theoretical foundation. Indiana Wesleyan University," The Brief Report Series from the Center for Learning and Innovation, pp. 1–32 2015.

[41] P. R. Albion, "Web 2.0 in teacher education: Two imperatives for action," *Comput. Sch.*, vol. 25, no. 3–4, pp. 181–198, 2008.

[42] S. Bibi, "The Effectiveness of the application of blended learning on the level of understanding of students in algorithms and programming courses," *J. Pendidik. Inform. dan Sains*, vol. 4, no. 2, pp. 274–286, 2015. (in Indonesian)

[43] D. N. Wardani, A. J. E. Toenlioe, and A. Wedi, "The allure of learning in the 21st era with blended learning," *JKTP J. Kaji. Teknol. Pendidik.*, vol. 1, no. 1, pp. 13–18, 2018. (in Indonesian)

[44] R. Saekawati and H. Nasrudin, "Effectiveness of guided inquiry-based on blended learning in improving critical thinking skills," *J. Penelit. Ilmu Pendidik.*, vol. 14, no. 1, pp. 53–68, 2021.

[45] J. W. Hur, Y. W. Shen, U. Kale, and T. A. Cullen, "An exploration of pre-service teachers' intention to use mobile devices for teaching," *Int. J. Mob. Blended Learn.*, vol. 7, no. 3, pp. 1–17, 2015.

[46] B. R. Belland, "Technology applications to support teachers' design and facilitation of, and students' participation in PBL," in *The Wiley Handbook of Problem-Based Learning*, M. Moallem, W. Hung, and N. Dabbagh, Eds, 2019.

[47] N. Pratiwi and J. Januardi, "Improving students' rational thinking skills through blended learning with moderating independent learning variables," *J. Neraca J. Pendidik. dan Ilmu Ekon. Akunt.*, vol. 2, no. 2, pp. 23–39, 2019. (in Indonesian)

[48] A. Shishigu, "Supplemental blended learning model as an approach towards the enhancement of competency based education: An experience from a pedagogical intervention," *J. Educ. Technol. Syst.*, vol. 51, no. 2, pp. 202–214, 2022.

[49] G. P. Widyaiswara, D. P. Parmiti, and I. M. Suarjana, "Pengaruh model pembelajaran contextual teaching and learning terhadap Hasil Belajar IPA," *Int. J. Elem. Educ.*, vol. 3, no. 4, pp. 389–395, 2019.

[50] R. Jacobsen *et al.*, "Online and blended learning courses for healthcare professionals and policymakers on patients' perspectives on medicine: A project report," *Pharmacy*, vol. 10, no. 2, p. 39, 2022.

[51] N. Davidson and C. H. Major, "Boundary crossings: Cooperative learning, collaborative learning, and problem-based learning," *J. Excell. Coll. Teach.*, vol. 25, 2014.

[52] D. A. Back, N. Haberstroh, A. Antolic, K. Sostmann, G. Schmidmaier, and E. Hoff, "Blended learning approach improves teaching in a problem-based learning environment in orthopedics—a pilot study," *BMC Med. Educ.*, vol. 14, no. 1, pp. 1–8, 2014.

[53] L. M. Carter, B. Beattie, W. Caswell, S. Fitzgerald, and B. Nowrouzi, "An examination of interprofessional team functioning in a BScN blended learning program: Implications for accessible distance-based nursing education programs," *Can. J. Univ. Contin. Educ.*, vol. 41, no. 1, 2016.

[54] Murniati and Hermawan, "E-Problem based learning (E-Pbl) in management accounting courses as an alternative to innovative learning," *Jurnal Ilmiah Bisnis dan Ekonomi Asia*, vol. 11, no. 1, pp 1–10, 2017. (in Indonesian)

[55] G. Cheng and J. Chau, "Exploring the relationships between learning styles, online participation, learning achievement and course satisfaction: An empirical study of a blended learning course," *Br. J. Educ. Technol.*, vol. 47, no. 2, pp. 257–278, 2016.

[56] Y. N. Maulida, K. I. Eka, and C. Wiarsih, "Application of problem based learning models to improve critical thinking skills and cooperative attitudes in elementary schools," *MUKADIMAH J. Pendidikan, Sejarah, dan Ilmu-ilmu Sos.*, vol. 4, no. 1, pp. 16–21, 2020. (in Indonesian)

[57] E. D. Lestaringsih and T. D. Wijayatiningsih, "Pengembangan model problem based learning dan blended learning dalam Pembelajaran Pemantapan Kemampuan Profesional Mahasiswa," *LITE J. Bahasa, Sastra, dan Budaya*, vol. 13, no. 2, pp. 105–121, 2017.

[58] N. Aeni, T. Prihatin, and Y. Utanto, "Development of problem-based blended learning models in computer systems subjects," *Innov. J. Curric. Educ. Technol.*, vol. 6, no. 2, pp. 27–38, 2017. (in Indonesian)

[59] C. Alfi and K. R. Perdana, "Development of blended-based learning model for PGSD UNU blitar students," *Urnal Ris. Dan Konseptual J*, vol. 4, 2017. (in Indonesian)

[60] C. A. Dewi, "The effect of blended learning in Problem-Based Learning (PBL) on the learning outcomes of IKIP Mataram students on environmental pollution material," *Prism. Sains J. Pengkaj. Ilmu dan Pembelajaran Mat. dan IPA IKIP Mataram*, vol. 1, no. 1, pp. 1–11, 2013. (in Indonesian)

[61] M. Afshari, K. Abu Bakar, S. C. Wong, and M. Afshari, "Principals' level of computer use and some contributing factors," *Int. J. Educ. Inf. Technol.*, vol. 4, no. 2, pp. 121–128, 2010.

[62] H. Husamah, "Blended learning," *Res. Rep.*, 2014. (in Indonesian)

[63] Q. Li, Q. Jiang, J.-C. Liang, X. Pan, and W. Zhao, "The influence of teaching motivations on student engagement in an online learning environment in China," *Australas. J. Educ. Technol.*, vol. 38, no. 6, pp. 1–20, 2022.

[64] T. BAŞÖZ, "The effectiveness of computer-assisted ınstruction on vocabulary achievement," DEÜ Eğitim Bilimleri Enstitüsü, 2013.

[65] A. Bell, K. Bartimote, N. Dempsey, L. Mercer-Mapstone, G. Moran, and J. Tognolini, "Student and educator perspectives on equity and online work integrated learning," *Australas. J. Educ. Technol.*, vol. 38, no. 6, pp. 185–200, 2022.

[66] N. T. T. Ho, H.-H. Pham, S. Sivapalan, and V.-H. Dinh, "The adoption of blended learning using Coursera MOOCs: A case study in a Vietnamese higher education institution," *Australas. J. Educ. Technol.*, vol. 38, no. 6, pp. 121–138, 2022.

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