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Research Article

The effectiveness of blended learning model based on inquiry collaborative tutorial toward students' problem-solving skills in physics

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Abstract

In this study, a collaborative inquiry-based blended learning model (a system of learning used as an example to follow or imitate) was developed. The purpose of this study was to examine the effectiveness of the model to practice problem-solving skills for physics students. The development model used the 4-D model (define, design, develop, and disseminate). The product (blended learning model based on inquiry collaborative tutorial) was validated by expert and instruments were validated by Pearson product-moment correlation. There were 17 valid instrument items based on the results of the validity test, and these 17 question items were used to examine students' problem-solving skills. Data collection was also performed using observation sheets and student response questionnaires. The testing phase using the effectiveness test was carried out in one shot case study pre-post test design on three classes of pre-service physics teachers at a private university in Mataram. The data analysis technique used was one-way ANOVA, n-gain test and classical completeness analysis for the implementation of developed product-based learning. The results showed that the inquiry collaborative tutorial-based blended learning model was effective in improving problem-solving skills. Students' problem-solving skills at the visualization step and describing the problem is high category, while the next stage is still in the medium category. Students also gave positive responses to learning physics using this model.

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Introduction

Physics learning innovations need to be continuously developed and implemented to prepare prospective teachers in placing themselves as educators and ready to face the challenges of the 21st century. Innovations in the field of learning need to be continuously carried out and adapted to the demands of learning which at present have gone through integrated and well-structured activities to foster a high academic and quality culture. According to Kennedy et al. (2016), the basic skills needed by educators are related to these skills: critical thinking, problem-solving, collaborative learning, student-centered teaching, and the ability to use technology. Technological advancements offer a variety of facilities to get information quickly. The application of media is necessary to visualize abstract concepts that are supported by many learning resources that can be accessed independently by students (Husein et al. 2019). This condition requires innovation to integrate conventional models through face to face with online learning that students can do on their own via the internet.

Lecturers generally provide conventional lectures through direct face-to-face methods and discussions. It is necessary to think of solutions to the application of all existing facilities, especially computer networks that already

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exist in most universities to support the learning process. A combination of e-learning with face-to-face learning which is commonly known as the blended learning model is highly requested by students. In recent years, many researchers found that students' problem-solving skills can be trained and facilitated through the integration of problem-solving strategies and computer technology (Ramadhani et al. 2019; Gunawan et al. 2018; Kim & Hannafin, 2011).

The importance of problem-solving skills in learning physics at the college level is based on the characteristics of the complex nature of the physics concepts. Students are not only expected to understand the concepts but also to apply the concepts the understood in solving problems. This shows that even though students have problem-solving ability (Ersoy & Guner, 2015), there is evidence that their basic concepts understanding is still very weak (Docktor, Strand, Mestre & Ross, 2015). Students with good problem-solving skills can apply the knowledge they have in the context of the problems faced. One of the goals of learning physics is to increase students' skills in solving complex problems by applying their knowledge and understanding of everyday situations (Walsh, Howard & Bowe, 2007).

Each student has different problem-solving skills. This depends on the students' thinking level. Students at the level of formal thinking can plan problem-solving by connecting information obtained with other information logically. Those at the transitional thinking level can visualize the problem logically when the context of the problem is closely related to the experience they have. Students need problem-solving skills to be able to compete globally, helping them make decisions that are appropriate, careful, systematic, logical and consider issues from various perspectives (Aydogdu, Guven, & Aka, 2012; Temel, 2015). Problem-solving skills must be built by students through active involvement in learning. At the concrete thinking level, students can only plan problem-solving when the problem can be immediately and easily analyzed (Rahman & Ahmar, 2016).

The current physics learning reality shows that many physics students could not solve basic problems in physics. Although students have the required mathematical skills, this does not guarantee that they are capable of solving the problems. This is shown, among others, by the low average score on student problem-solving abilities. Students are quite capable of identifying problems, only difficulties in continuing to the next problem-solving phase (Gunawan et al. 2018). Students' answer sheets show that in general, they use mathematical equations directly without doing the analysis first by guessing the formula used and memorizing the example questions that have been done to work on other questions (Gok & Silay, 2010). Students often use the same approach and rely on memory in solving physics questions (Walsh et al. 2007; Brad, 2011).

Some factors that cause low problem-solving skills in students are related to the model or learning approach used, students' mathematical abilities, students' prior knowledge, as well as the availability of experimental equipment. Students cannot solve the problems due to the lack of sufficient lab work in the laboratory, confusion of unit conversions, lack of physics books used as references (Ogunleye, 2009); lack of problem-solving skills, weak understanding of principles and laws of physics, shortcomings in understanding questions, and low student initiation and persistence (Gok & Silay, 2010). The physics learning process will be more meaningful and enjoyable if it is done through scientific methods accompanied by cognitive reasoning for the data obtained as well as observed natural symptoms (Gok & Silay, 2010; Wilhelm, Thacker & Wilhelm, 2007).

Blended learning is a mixture of conventional face-to-face learning and online learning, adopted to foster active learning, interactivity, and collaborative learning experiences. Learners try to understand, develop knowledge, and creativity in the learning process. The use of blended learning is considered effective and efficient because both models face to face or online learning have their advantages. Learning with a combination model such as blended learning requires educators to be skilled in using online systems. Educators need to prepare and manage time well so that the concepts of face-to-face learning and online can be well integrated. Several other studies revealed that the application of blended learning in the millennial generation did not fully obtain satisfactory results. Millennials that have high technological capabilities negatively affect blended learning. Moreover, their level of satisfaction with learning tends to be lower (Dziuban et al. 2005).

The blended learning model is a model that allows the delivery of teaching materials to students via internet network media accompanied by a face-to-face process. According to Garnham (2002), in blended learning, the face-to-face time is usually reduced, but not omitted. Shibley, Amaral, Shank & Shibley (2011) define blended learning as "the thoughtful fusion of face-to-face and online learning" namely combining the best characteristics of classroom learning (face to face) and the best characteristics of online learning to improve active self-learning by students and reducing the amount of face-to-face time in class.

The blended learning model product is expected to have positive implications for students' problem-solving skills. The model developed in this study adopts the inquiry model and collaborative principles that are integrated into learning activities using internet-connected Moodle applications to support student independence and activities during the learning process. Many experts agree that inquiry and collaborative learning can train students' thinking skills (Arends, 2012). The principle emphasized in the model developed is in line with the opinion of Voughan (2010) which states that the key to successful learning in a community is collaboration or collaboration.

Another learning model designed to meet the needs and challenges faced by 21st-century students is the inquiry model (Barron & Hammond 2008; Friesen & Scott, 2013). The inquiry learning model trains students to be actively involved in problem-solving by conducting a series of activities that emphasize critical and analytical thinking processes. The inquiry model can develop mastery of concepts, problem-solving skills and student science processes (Tatar, 2006; Pedaste, Maeots, Siiman & de Jong, 2015; Duran, 2014; Hermansyah et al. 2019). Through the process of investigation and discovery, students can collaborate to build knowledge, to be creative, independent, and analyze opinions. Inquiry learning can develop students' ability to formulate explanations based on data/evidence, evaluate scientific explanations, and communicate scientific explanations (Wu & Krajcik, 2006; Wenning, 2010).

The inquiry model is shown to be a superior model for learning in some research. However, the results of other studies show that laboratory inquiry is still limited to improving non-verbal communication skills (McNeill, Pimentel, & Strauss, 2011), while the skills for exchanging opinions are still in the low category (Gormally, Brickman, Hallar, & Armstrong, 2009; Duran, 2014) Moreover, it takes a lot of time for activities to observe, draw and write (Ayse & Sertac, 2011; Duran, 2014). Students must be placed as subjects who study, while the role of the tutor functions as a guide and facilitator. The task of the tutor is to choose the problems that need to be delivered in the class to be solved, but it is also possible that the problem to be solved is chosen by the students themselves. The task of the next tutor is to provide learning resources for students to solve problems (Byun & Lee, 2014).

Working in groups can also solve complex problems more effectively. Problem-solving skills can be developed through appropriate learning strategies. The results of the Gok & Gok (2016) study revealed that teaching with peer instruction has a more positive effect on problem-solving performance than teaching with conventional teaching. The use of appropriate computer-based learning media can also encourage students to improve their thinking skills. The use of computer technology as a learning medium is proven to be able to enhance the creativity of learners (Gunawan et al. 2019), critical thinking skills and dispositions (Gunawan et al. 2019; Mashami & Gunawan, 2018), and professional competence (Sumarni et al. 2019). The format can be made for ease of delivering information in the form of material online in the learning management system format (Herayanti et al. 2017) and interactive physics e-book format (Adawiyah et al. 2019).

Problem of Study

Based on the previous studies related to e-learning with the blended learning process, the main issue in this study was "Are collaborative inquiry-based blended learning models effective in higher education learning towards students' physics problem solving skills?". In practice, the main problem answers were divided into two sub-problems. Firstly, do collaborative inquiry-based blended learning models have sufficient validity to be applied in learning? and secondly, is there an increase in problem solving skills after the application of collaborative inquiry-based blended learning models?

Methodology

Research Design

This research was educational research and development. The development model used was the 4-D model developed by Thiagarajan (1974). The 4-D development model consists of 4 main stages: define, design, development, and disseminate (spread). In this study, several types of data are needed. This article focuses on the development stage, the final product draft was tested in the learning environment. The effectiveness test was carried out in one shot case study pre-post test design in three classes.

Participants

The validator team consists of experts and practitioners. Experts consist of four lecturers who have expertise in the field of science education and experience in research related to the application of technology in learning. The subject of this research was a collaborative inquiry-based blended learning model that is applied to students of physics education in a private university in Mataram, Indonesia. The model implementation test was carried out on pre-service physics teachers at the same university. The collaborative inquiry-based blended learning model was conducted in three classes: Class A (30 students), B (29 students), and C (29 students), consisting of a total of 88 students as research participants.

Table 1.
Structures of Participants

No	Participants	Participants	Research Steps
1	Validator Team	4 Validators	Product Development
2	Students (Class A, Class B, and Class C)	88 Students, Class A (30 students), B (29 students), and C (29 students)	Testing the effectiveness of the product on problem solving skills

Data Collection
The data collection procedure is as follows: (1) Researchers measured problem-solving skills using problem-solving instruments. Tests were used to measure or recognize an increase in problem-solving skills. The test is carried out in two stages, the pretest and posttest according to the indicators and objectives developed by the researcher, and (2) The researchers and other observers observed the implementation of student learning and activities. This was done to assess the feasibility of learning, student activities, as well as obstacles/obstacles during learning. Seeing the many aspects observed, observations were carried out by three observers. Previous instruments have been tested both in terms of validity and reliability using Pearson product-moment correlation for validity and Cronbach-Alpha for reliability. There were 17 valid instrument items based on the results of the validity test, and these 17 question items were used to test students' problem-solving skills. based on the reliability test using Cronbach-Alpha (Table 2) the coefficient is 0.677 higher than the standard 0.6 so that the instrument was declared reliable.

Tabel 2.
Reliability Statistics

Cronbach's Alpha	N of Items
0,677	17

Questions consisting of 17 essay items were developed based on indicators of problem solving skills in kinematics. For example, item number 1 asked students to solve a problem that involves a rabbit jumping under certain conditions and students are asked to find the direction and speed. Each question must be done in accordance with the steps of problem solving, namely visualizing the problem, describing the problem, plan the solution, execute the plan, then check and evaluate. Each student was assessed in each process and the final score was the cumulation of each stage in each question.

Data Analysis
The validity of the model is the quality of the content and construction of the learning model assessed by validators based on aspects such as supporting theory, syntax, social systems, the roles of lecturers and students, support systems, instructional impacts, and the accompanying impacts, and the implementation of learning. The instrument validity sheet was prepared in accordance with the opinion of Nieveen & Plomp (2007) that the validity that needs to be assessed was the content validity and the construct of the developed model. This validation sheet took the form of tables and columns containing aspects to be observed. This instrument was useful to support information from experts about the components of the model, namely: 1) supporting theory, 2) syntax, 3) social systems, 4) the role of lecturers and students, 5) support systems, and 6) instructional impacts and accompaniment impacts. Descriptive analysis was used to describe the acquired data, both quantitatively and qualitatively. Data analysis of problem-solving skills was based on scores obtained by students before and after learning using the collaborative inquiry-based blended learning model. The data in this study were normally distributed, so to find out if there are changes/improvements in students' problem-solving skills based on pre-test and post-test, one-way ANOVA test was conducted. The effectiveness was determined based on normalized average gain scores. *N-gain* was obtained using the equation by Meltzer (2005):

$$N_{gain} = \frac{S_{posttest} - S_{pretest}}{S_{max} - S_{pretest}} \times 100\%$$

N-gain is a normalized gain, S_{max} is the maximum score (ideal) from the initial test and the final test, $S_{posttest}$ is the final test score, while $S_{pretest}$ is the initial test score. The *N-gain* scores can be classified as follows: (1) if g> 70, then the *N-gain* is in the high category, (2) if 30 ≤ g ≤ 70, then the *N-gain* is in the medium category, and (3) if g <30, then the *N-gain* is in a low category.

Results and Discussion

The collaborative inquiry-based blended learning model is supported by several theoretical support such as the ARCS theory (Keller, 1984), Gagne theory (Moreno, 2010), Scaffolding (Santrock, 2011), Constructivist theory (Arends, 2012), Top-down theory (Nur, 2008), Vygotsky's theory and Information Processing (Slavin, 2009), Piaget's theory (Moreno, 2010) and Self-regulated learning theory (Moreno, 2010; Slavin, 2009). Some models that have been used to teach problem-solving skills in previous research are also used as a basis in developing collaborative inquiry-based blended learning models such as one proposed by Garrison et al. (2001). The syntax of the collaborative inquiry-based blended learning model tutorial is based on theoretical support of learning in training problem-solving skills. Moreover, the weaknesses of the learning model by Garrison et al. (2001) are also taken into account.

The syntax of the product model has 6 stages: 1) Orientation phase (face to face), 2) Interpretation phase (online), 3) Planning phase (online), 4) Exploration phase (face to face), 5) explanation phase (face to face and online) and 6) Reflection phase (face to face and online) based on Garrison et al. (2001). The learning process in the blended learning model is a mixture of elements of the learning environment that is online and face-to-face as a combination of the characteristics of traditional learning and the electronic learning environment (Jin & Shang, 2019). In the orientation phase, lecturers and students meet in class, this stage serves as an introduction to learning and direction towards the e-learning sites that have been developed. Phase 2 and phase 3 student activities focus on online e-learning exploration. Phase 4 The lecturer guides the students to carry out problem-solving activities through experimental activities and gives questions to find out the extent of student understanding of the material that has been delivered. Phases 5 and 6 are more directed towards students' presentations on problems that have been resolved and responses from lecturers.

The collaborative inquiry-based blended learning model was conducted in three classes: Class A, B, and C. In general, the aspects of orientation, interpretation, planning, exploration, explanation, and reflection increased in all classes. This can be seen from the acquisition of the percentage of the implementation of good learning conducted at the first meeting until the last meeting. The learning process in each phase that has been planned in the SAP can be carried out by lecturers and students. The implementation of learning using the blended learning model based on inquiry collaborative tutorials shows the level of achievement of stages in SAP conducted by lecturers during the learning process. The development of phases in the inquiry collaborative tutorial blended learning model was designed to improve problem-solving skills for students. The implementation of learning consistently increases relatively stable. Figure 1 shows the achievement of learning implementation in each class.

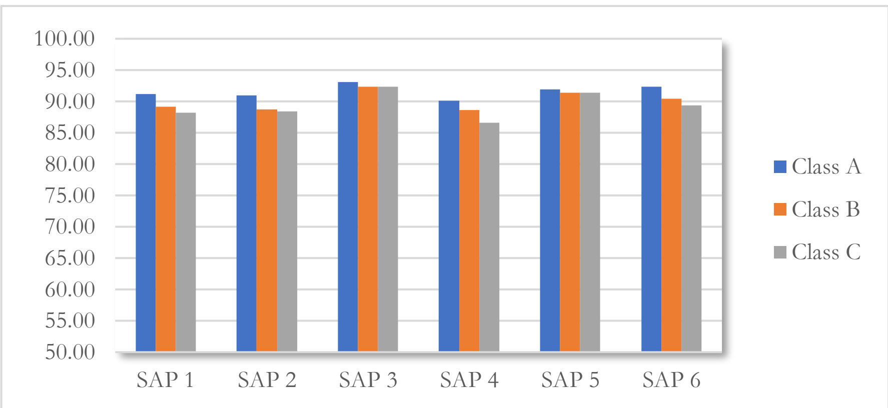

Figure 1.
Percentage of Learning Implementation on Class A, B, and C

Table 3 shows the results of statistical analysis using the one-way ANOVA test was conducted. This statistical test aimed to determine the differences in problem-solving skills based on pre-test and post-test.

Table 3.
ANOVA Test Result

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	10654.398	1	10654.398	153.332	0.000
Within Groups	1945.606	28	69.486		
Total	12600.003	29			

Table 3 shows the significance value of 0.000, meaning that the value is smaller than 0.05. It can be understood that after applying collaborative inquiry-based blended learning models there were significant differences in the problem-solving skills of research participants.

Figure 1 shows that Class C has a lower initial knowledge compared to the other two classes. However, after learning using the inquiry collaborative tutorial-based blended learning model the problem-solving skill is increased. This increase is influenced by a well-implemented learning process. This shows that students have succeeded in understanding the initial information, methods of implementing learning, and the use of e-learning in learning. The average score of the pre-test and post-test, the indicator completion, and the N-gain score from the increase in each indicator of problem-solving can be seen in Figure 2.

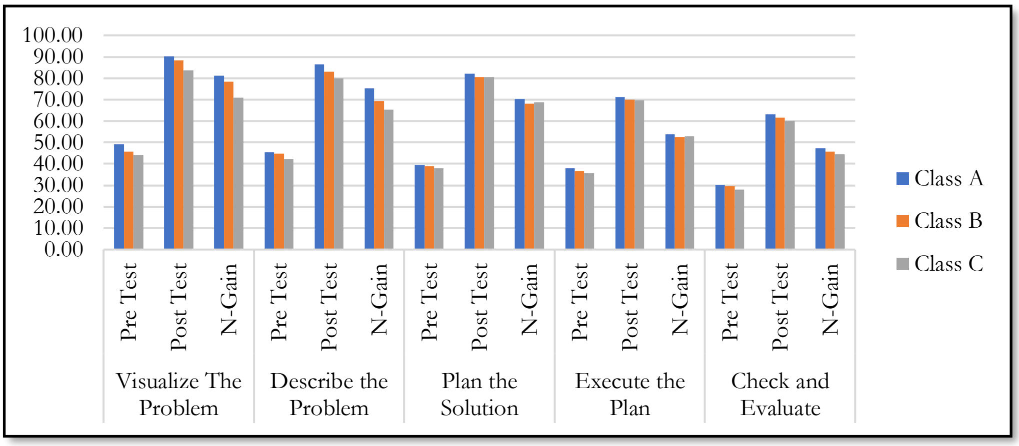

Figure 2.
Average Score Diagram for Problems Solving Skills in Each Indicator

Figure 2 shows that the difference in pre-test scores on each indicator is not significant. Therefore, the students' initial ability to identify problems, set goals, provide solutions and take action, and give conclusions are the same before the treatment. Improvement in the ability of students in visualization and describing problems is high, while in other aspects are in the medium category.

Discussion and Conclusion

The main objective of collaborative inquiry-based blended learning is to provide opportunities for various characteristics of students so that independent, sustainable and lifelong learning takes place so that learning will be more effective, more efficient and more interesting. A collaborative inquiry-based blended learning tutorial that requires internet-based learning, of course, provides an opportunity for students to explore their ability to find and solve their problems (Owston et al. 2019).

The results of the development of inquiry collaborative inquiry-based blended learning models are based on the needs of 21st-century skills that students must have, namely problem-solving skills. In the new era of information technology, the ability to think and solve problems is very important for students to master the knowledge and contribute to the development of modern society. Thinking skills and problem-solving are combined in learning outcomes to enable students to solve simple problems, make decisions and express themselves creatively (Ngang et al. 2014).

Blended learning collaborative inquiry-based tutorial is a combination of traditional and online learning. Web-based learning and classroom teaching provide practical and realistic opportunities for students to be actively involved in problem-solving activities (Balram, 2019). Besides, writing a group discussion report during the group discussion can help students think more about the problem-solving process and achieve higher scores on learning outcomes. The ability to solve problems in physics can be trained by conducting investigative activities through scientific methods (Etkina et al. 2006).

The results of the average data analysis of student activity scores at each meeting in class A, B, and C, can be seen that the first activity is to explain the problem (describe the problem) has the highest percentage and reliability. Class A obtained a percentage score of 88.70%, class B obtained the same score of 88.70% and class C obtained a score of 88.33%. Students become very capable in describing existing problems because learning uses the collaborative inquiry-based blended learning model tutorial. Students are asked to explore every form of abstract concepts in physics through online media and theoretically able to analyze these problems well.

Observations made by observers in each meeting were calculated from how many students did well in carrying out the five activities. The number of students who carry out well will be given a range of scores of one to four which finally gets a total score in each activity that exists. Class A is the class that gets the best score most in its learning activities. This can be seen from the reliability and the calculation of the score of each observer. Class B and Class C also have fairly good reliability in every activity that exists.

The practicality of collaborative inquiry-based blended learning models can be seen from the observation of the model's syntactic implementation of the implementation of designed learning. The elements seen at the observation of the learning of blended learning models based on collaborative inquiry tutorials are learning syntax, social systems, and reaction principles. The implementation of inquiry collaborative tutorial blended learning model is implemented in six phases, namely: orientation phase, interpretation phase, planning phase, exploration phase, explanation phase and reflection phase.

The first meeting of the results of the implementation of collaborative inquiry-based blended learning models can be described as follows. The lecturer provides an overview of the implementation and assessment of learning using the collaborative inquiry-based blended learning model tutorial. The lecturer then asks students to open the e-learning address: http://lovyherayanti.ikip-mataram.ac.id/, guiding students to fill in their email addresses and passwords and lecturers explaining information on using Moodle e-learning in learning. Furthermore, students are faced with authentic problems with kinematic material but have not been able to generate student initiation.

At the beginning of the meeting, lecturers were still dominant enough to assist students in opening e-learning addresses given because there were still frequent mistakes when filling out email addresses and passwords that caused errors in the system which affected the time allocation in the learning process. Activities where learning requires face to face, some students are not skilled in using practical tools in learning so that they can interfere with practical activities. Students besides that are also still not familiar with the problem-solving activities carried out, even some of them require special attention during the learning process. Some students are passive and not focused on learning activities. In the initial meeting, the lecturer facilitated the student group to do the presentation and discussion according to the group that had been prepared for the announcement through e-learning. Arrangements between groups of presenters and groups of participants were not too good, only a small group of students were actively involved in presentations and discussions. Students rely more on their friends to present and answer discussion participants' questions.

The arrangement between groups of presenters and groups of participants is not too good. Questions that are difficult for the presenter to answer, are facilitated by the lecturer to direct the appropriate questions and answers. The lecturer facilitates students to make summaries and conclusions from the results of investigations and discussions. At the beginning of this meeting, lecturers were more dominant in explaining what would be summarized and how to make conclusions while students seemed more passive and waiting for lecturers' direction.

The second, third and so on the meeting, the results of the implementation of collaborative inquiry-based blended learning models can be described as follows. Students are skilled and use computers and skilled in opening e-learning addresses that have been provided so that online-based learning can run smoothly. Most groups of students can conduct independent investigations. At this meeting, lecturers were only facilitators for students. When face-to-face meetings, lecturers facilitate student groups to make presentations and discussions. At this meeting, the arrangement between groups of presenters and groups of participants was good. Almost all student groups are actively involved in presentations and discussions. Students can share roles with their friends to present and answer discussion participants' questions. The lecturer only functions as a facilitator and directs the presentation and discussion. The lecturer facilitates students to make summaries and conclusions and the results of investigations and discussions. At this meeting, the lecturers only functioned as facilitators to reinforce while students seemed very active in making summaries and conclusions.

The syntactic implementation model of inquiry collaborative tutorial-based blended learning model shows that the syntactic implementation of each phase in the collaborative inquiry-based blended learning model at the meeting was well categorized. But in meetings II to VI the syntactic performance of each phase of the model was very good and the ability of students to do the tasks given was very good.

Online and face to face learning activities are specially designed learning activities that can change student behaviour from the teacher centre to the student centre to improve student teaching and learning activities (Häkkinen et al. 2017). In online learning, lecturers act as facilitators, motivators, and mediators for students. In implementing this collaborative inquiry-based blended learning model this tutorial is practically used, but there are still some obstacles when this model is implemented in students.

The application of information technology in the field of education has a positive influence on problem-solving skills. The use of collaborative inquiry-based blended learning models in everyday life has a close relationship with problem-solving skills. According to Yen & Lee (2011), web-based learning and classroom teaching provide practical and realistic opportunities for students to be actively involved in problem-solving activities. Problem-solving skills are the ability of students to solve a problem and then find the right solution. Kashefi, Ismail & Yusof (2012) revealed that blended learning is a learning environment to support student thinking and creative problem-solving. In addition, the results of Stockwell's research, Stockwell, Cennamo & Jiang (2015) concluded that blended learning in science education was able to improve students' problem-solving skills test results. The use of more active collaborative inquiry tutorials will improve problem-solving skills (Hämäläinen et al. 2015). This software provides a structure for students to work together in simulating real-world problems that require the application of mathematical reasoning.

In general, it can be seen that before given learning using inquiry collaborative blended learning tutorials, students have tried to identify and define problems, which is indicated by the acquisition of the highest pre-test score in indicator one. After being given learning using collaborative inquiry-based blended learning tutorials, students become more able to recognize each concept in a given problem and succeed in defining each existing variable by placing the value of the physical quantity that is appropriate for each answer. Also, the ability of students to identify and define problems increases very high after learning to use the collaborative inquiry-based blended learning model tutorial. This is indicated by the N-gain score obtained by indicator 1 of 81.06% for class A, 78.26% for class B, and 71.03% for class C which is a score in high criteria. Students succeed in getting to know the problem given and succeed in determining the parts of each problem-solving.

The second indicator, which is to Describe the problem, has increased significantly. This statement is shown by a higher post-test score than the pre-test score with a considerable difference of 41.17 in class A, 38.38 in Class B, and 37.63 in class C. This shows that after using blended learning based collaborative inquiry tutorial, students become more capable in determining the goals of the problems given, and can determine every aspect that can achieve these goals. Increasing the ability of students in defining their goals and objectivity in solving problems is at high criteria. The N-gain score obtained for indicator 2 is 75.33% for class A, 69.45 class B, and 65.20 in class C shows this.

The increase in the third indicator, Plan the Solution, is also at high criteria with a score of 70.39% in class A, 68.16 class B, and 68.65 in class C. This N-gain score shows that students are very capable of generalizing solutions to problems that given. After being able to define the problem by giving important points of the questions provided and defining the objectives, students must be able to provide solutions based on these indicators. After learning to use inquiry collaborative blended learning tutorials, students managed to assemble simple solutions to the problems given. They can form a solution based on the variables provided by the learning media. This result was also strengthened by a higher post-test score compared to the pre-test score with a difference of 42.44 in class A, 41.69 in Class B, and 42.65 in class C.

After being able to provide a solution, students must be able to make a plan and further action on the solution. This stage is the fourth indicator of the problem-solving process. In this indicator, students' abilities are seen to increase from before being given treatment. This statement is shown from the higher post-test score compared to the pre-test. In addition, the acquisition of an N-gain score on the 4 (Execute the Plan) indicator is in the medium criteria with a score of 53.71% in class A, 52.73% in class B, and 53.01% in class C. These results identify the ability of students to make plans and taking action on existing solutions increases after learning to use collaborative inquiry-based blended learning tutorials. The score is in the medium criteria which means that the ability of students for the fourth indicator is good enough and can be improved again. The last indicator, namely the fifth indicator (Check and Evaluate) shows the least score compared to the other four indicators. However, the scores obtained in the three classes A, B, and C were 47.33%, 45.72% and 44.61% respectively which were scores with moderate criteria.

These results indicate that students can carry out planning and provide appropriate conclusions on the solutions they have given in the previous stage. By learning to use collaborative inquiry-based blended learning tutorials, students succeed in arranging solutions, making plans, taking actions, and concluding the results they provide. Problem identification skills and goal setting help students recognize problems, categorize, and define solution plans.

Students who use software are rated higher in solving problems in problem-solving planning skills (Chu et al. 2011). The findings of the development of inquiry collaborative tutorial-based blended learning models are supported by Alammary, Sheard & Carbone (2014) which states that blended learning is an effective approach through combining online teaching resources. This is widely applied to support face to face learning and responding to user needs (Al-Azawei, Parslow & Lundqvist, 2017). Blended learning offers opportunities for students to connect flexibly with the community of students anytime and anywhere.

Problem-solving skills are one of the 21st-century skills that must be developed in addition to critical thinking, communication, and collaboration. Problem-solving skills are the ability to find or find new solutions or apply new ways to learn. Problem-solving skills include: focusing problems, outlining in physical concepts, planning solutions, implementing the problem-solving plans, and evaluating answers. (Huffman, 1997). According to Kennedy et al. (2016) basic skills needed by educators regarding these skills, namely: critical thinking, problem-solving, collaborative learning, student-centered teaching and the ability to use technology. Frensch & Funke (2014) revealed that not all of the tasks we face lead to solving complex problems. Complex problem-solving must have an element of novelty, complex, changing dynamically over time, and not transparent.

Improving student problem-solving skills can be seen from the results of N-gain problem-solving skills in kinematics material through the calculation of test scores tested to students before and after learning by applying the collaborative inquiry-based blended learning model tutorial. Learning on kinematics material using inquiry collaborative tutorial-based blended learning model, students have good problem-solving skills with n-gain of 81.06% for visualizing the problem, 75.33% for describing the problem, 70.39% for plan the Solution, 53.71% to execute the plan and 47.33% to check and evaluate. These results indicate that there is an impact of learning using a collaborative inquiry-based blended learning model tutorial on improving physics problem-solving skills. The improvement of problem-solving skills following the problem-solving skills indicators using inquiry collaborative tutorial-based blended learning models is due to several things including students being trained and directed towards achieving indicators of problem-solving skills (Bradford, 2015), using learning tools in the form of student teaching materials, sheets student work, a supportive learning environment that has a good effect on students in enhancing increased autonomic learning, critical thinking, assisting in key applications and recall skills (Chakravarthi & Haleagrahara, 2010; Efendioglu, 2015). Explanation of natural symptoms based on data obtained through the investigation process is a very decisive factor in the success of physics practicum learning (Godwin, Adrian & Johnbull, 2015).

After following the learning with the collaborative inquiry-based blended learning model, each student was asked to fill out a questionnaire response to the learning model. The results of the analysis of student responses showed that in general students gave a positive response to the model. It can be seen from the average response of students who are in the agreed category (43.67%) and strongly agree (56.32%) to the application of the model. If seen from each item question answered by the students, it can be seen that according to students (82.76% strongly agree; 17.24% agree) that this model provides an opportunity for students to actively participate. The same number of respondents also stated that they were happy and satisfied following a series of learning activities.

The average positive student response to the blended learning model based on the Inquiry Collaborative Tutorial. The model applied is considered to provide opportunities for students to actively participate. This model can be used to change perceptions about physics, so students are more motivated and interested in learning physics both individually and in group learning. The practice and feedback provided also make students feel confident and more valued. Challenges during the practicum according to students also provide a fun challenge. This model encourages curiosity in students so that they are happy and satisfied following the whole series of learning activities.

Based on the analysis of data related to the average completeness score and N-gain of each problem-solving indicator using the collaborative inquiry-based blended learning model the tutorial developed shows that the score obtained has increased for each indicator. This means that the model developed meets effective criteria because it can train problem-solving skills in solving physics problems because the n gain test can be used to test the effectiveness (Kinoshita et al. 2017). The training or assignment given can clarify the material so that it can be understood by students. The opportunity to ask both directly and online helps students to more easily understand the material being studied. Likewise, with the existence of simulations and enrichment in e-learning which is very helpful for students in learning physics concepts. Students become happy with the support of computer and internet media in learning. Learning becomes more interesting and fun. This is also the case with media support and worksheets that support efforts to understand the important concepts planned. They are free to create and express opinions/ideas. According to students, this model is interesting and relatively new, including the worksheets used. Available material can be accessed wherever and whenever. This is certainly very helpful for students in learning physics concepts.

The obstacles encountered with the blended learning model based on collaborative inquiry tutorials on online learning include: lecturers as tutors have not been accustomed to using inquiry collaborative inquiry-based blended learning models so that they have not focused on implementing activities based on model books; students are not accustomed to learning by using e-learning so that when opening email address errors often occur that cause errors in the system; mistakes often occur when filling out an e-mail address and passwords that have been given affect the time allocation in the learning process; some students cannot download material that has been prepared at the web address because of slow access or internet network, and some students only download the material and do not directly do the assignments given.

Face-to-face learning, there are still many students who are less skilled in the use of practical tools can be overcome by training the use of tools that are not yet known by students; there is a practical tool that is easily damaged so it interferes with practical activities, and students are not familiar with the problem-solving activities carried out during learning, even some students need special attention. This is following the results of Jahanpour's research, Azodi, Azodi & Khansir (2016) which states that the skill of using laboratory equipment and step-by-step problem-solving skills is easier to do if students actively practice / try and understand the problem properly.

A good learning model must have specific characteristics and goals and meet aspects of validity, practicality, and effectiveness. Honebein & Honebein (2015) states that learning effectiveness can be obtained if the learning process is designed based on the core principles of learning planning theory. Effective learning can be achieved if the lecturer has the right strategy in conveying knowledge to students in a structured manner, and can increase student involvement in the learning process (Kaya, Akaydin & Demir, 2015). Learning is said to be effective if the level of knowledge and understanding of lecturers on learning is good, students play an active role in learning, the availability of infrastructure in the form of computer labs and physics labs, there is an increase in student learning outcomes, and student responses to learning are quite good (Kanadli & Saglam, 2016). Effectiveness can be measured based on the increase in learning outcomes and student responses to learning (Feng & Ha, 2016).

Improving the results of problem-solving skills using inquiry collaborative tutorial-based blended learning models is also supported by several research results. inquiry-based blended learning collaborative tutorials are widely applied to support face to face learning and respond to user needs (Al-Azawei et al. 2017). Blended learning, educators can improve communication between lecturers and students (Cheung & Hew, 2011). The effectiveness of learning can be determined based on the quality of teaching, availability of facilities and infrastructure, student responses, and improvement in student learning outcomes and achievements (Feng & Ha, 2016). One of the advantages of blended learning is allowing flexible learning, students can freely manage their time to access learning material (Stebbings et al. 2012). Effective lecturers know how to assist students in conducting investigations by using knowledge, curriculum and learning in stages to overcome the complexity they face in class (Simone, 2014). People who have good problem-solving skills can have a better life because they are more successful in finding the best solutions (Coşkun et al. 2014). At last but not least, Gunawan et al. (2020) provided research results, which showed that learning supported by computer-based content was able to improve students' problem-solving skills, regardless of their gender.

The results of this study are also supported by several learning theories related to problem-solving skills in collaborative inquiry-based blended learning models, including ARCS theory (Attention, Relevance, Confidence, and Satisfaction), which states that students will be motivated if what presented by the lecturer can attract the attention of students (Keller, 1987); the top-down process states that students start with complex problems to solve and then find the basic skills needed (Moreno, 2010); the cognitive apprenticeship theory states that students gradually acquire knowledge and expertise through better interaction with teachers or peers (Slavin, 2009); Analysis theory states that one method of creative problem-solving that is often suggested is to analyze and list the main characteristics of the elements of a problem (Moreno, 2010).

The collaborative inquiry-based blended learning model can be effective if it is supported by learning tools, the environment, and the completeness of the facilities used. An environment that provides a conducive atmosphere for teaching and learning activities will improve good instructional delivery and better learning outcomes (Ajayi, 2011; Liu, Lin, Jian & Liou, 2012). The inquiry collaborative tutorial-based blended learning model meets the effective criteria, namely the implementation of inquiry collaborative tutorial-based blended learning models can train problem-solving skills related to physics questions, and inquiry collaborative tutorial-based blended learning models are included in interesting criteria based on student positive responses. The implementation of the collaborative inquiry-based blended learning model can provide a negative effect on students.

Based on the formulation of research questions, the results of research and discussions, it can be concluded that the collaborative inquiry-based blended learning model is effective learning models. Based on the results of data analysis there are significant differences in students' problem-solving skills before and after the implementation of collaborative inquiry-based blended learning models. There is an increase in problem-solving skills in students who study with the model developed. Students' problem-solving skills at the visualization step and describing the problem was high, while the other phases are still in the medium category. Students give a positive response to learning using blended learning models based on inquiry collaborative tutorials and instruments.

Recommendations

The authors provide suggestions for further research that can apply interactive learning media to examine other thinking skills. Interactive multimedia must be adapted to the skills that will be developed. The potential of interactive multimedia on students' skills development has been proven theoretically and empirically, but more data are still needed for media specifications that are relevant to student learning needs. Finally, the authors also suggest further research to develop interactive media combined with other learning methods, to obtain more in-depth and broader data.

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