The Effect of Using Physics Education Technology (PhET) Simulation Media to Enhance Students' Motivation and Problem-Solving Skills in Learning Physics

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Abstract: One of the demands of 21st-century skills is problem-solving skills, to have good solving skills, one must have good learning success factors, such as learning motivation. In fact, from the results of observations and interviews conducted at SMA Negeri 2 Darul Makmur, it was found that the motivation and problem-solving skills of students were still low. The purpose of this research is for investigating the effect of using Physics Education Technology (PhET) simulation media to enhance students' motivation and problem-solving skills in learning physic. This research used a quasi-experiment quantitative approach with Non-Equivalent Control Group Design. The population of this research was students of Grade XII MIA as many as 57 students. There were 50 students taken by random sampling. The instrument was questioned in the form of an essay and questionnaire by the Likert scale. The data of this research was analyzed by average test, N-gain, and independent-sample t-test. The result showed that the average score of motivation study in experiment class is in the high categorize and in the control class is in the low categorize, while N-gain score problem-solving skill for experiment class is in the high categorize and in control class is in the medium categorize. Moreover, based on an independent sample test is obtained that there is a significant difference between for problem-solving motivation and skill, this is strengthened by the positive response of students using media simulation PhET in learning. It can be concluded conveyed that media simulation of Physics Education and Technology (PhET) in learning physic can enhance students' motivation and problem-solving skills.

Keywords: Media Simulation PhET; Students's motivation; Problem-solving skills

Introduction

Education is one of the important things in life and becomes an asset for human resource development in a country. Education is like a light that leads humans to undergo the life well (Setiawan et al., 2021). One of the main focuses of 2013 curriculum education is related to problem-solving skill, where the 2013 curriculum learning process encourages students to be able to solve the problem, finds thing for themselves and works hard to realize the students' ideas (Permendikbud, 2013). In

addition, recently teachers are demanded to be able to develop skills in students to be able to answer various challenges of the times (Sa'pang & Purbojo, 2020).

Skill is significantly important in students' life for facing the problem which cannot be separated and becomes part of daily life (Fadhil & Kuntjoro, 2021).. Based on 21st-century education demand, several skill competencies must be had by students, such as problem-solving, critical thinking, cooperation, communication, creation, updating, technology and information literation, contextual study, information, and media literation especially in learning (Nurpitriani, 2021).

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Related to the several skill demands, accordingly critical-thinking and problem-solving skills is the most demared skill demandedly because both become the goal of teaching today (Monica, 2021).

Problem-solving is a skill which must have by person to make the person able to put the basic scientific thinking skill which the person has (Agustyaningrum et al., 2018; Buyung et al., 2020; Heryaningsih et al., 2018). Problem-solving also becomes the most important thing which must be had by students in learning Physics, since it is one of goals in learning (Lestari et al., 2021). Through problem-solving skill and ability, students are able to have positive attitude towards the learning (Weaver et al., 2018), can solve the problem which students face effectively and flexibly (Chen et al., 2016), can create an effective learning atmosphere and provide a working memory stimulus by seeking information to answer the problem encountered (Chamïdy et al., 2020), can understand and implement the concept, and can find a solution especially in learning Physics (Ozus et al., 2018). A person who wants to have good problem-solving skills, so the understanding of concept must be good, where by good understanding concept so the problem-solving skills are good too, this is because the understanding concept significantly affects in problem-solving skill (Zuhriyah & Nurimani 2021).

There are many kinds of strategies of problem-solving related to steps in solving the problem such as visualize the problem, describing the problem in physics description, plan the solution executingute the plan, and check evaluating (Heller et al., 1992). These steps are highly required by students in finishing the real problem in learning process and can help students to train the problem-solving skill so that the learning objective can be achieved maximally. The achievement of objectives and the success of students' learning is not also separated from several factors in other learning such as in physic learning is affected by factors as follows early ability, intelligence level, learning motivation, learning interest, and other (Maulidina & Bhakti, 2020).

Motivation becomes one of the most important factors in learning (Davoudi & Parpaouchi, 2016). Students which are motivated in learning will affect the learning outcomes, because the understanding concept will be better (Khairunnisak, 2018). The better learning motivation of students, the better understanding concept of students (Sihombing et al., 2021). Where motivation and understanding of concept is a thing which can influence learning outcomes which are obtained from students' problem-solving outcome. If learning motivation of the students is high, so the problem-solving abilities will high too, if learning motivation of the students is medium so the problem-solving abilities of the students is medium too, while if learning motivation is low so the problem-solving ability is low too (Agsya et al., 2019). Students with high

learning motivation, the students' problem-solving abilities will be better (Harefa, 2018).

Based on observation result in *SMA Negeri 2 Darul Makmur* has obtained information that in the school still utilize conventional learning so that teacher is difficult to enhance motivation in order that the students' understanding concept becomes good which will affect problem-solving skill especially in Direct Current Electric Circuit (DC). The Researchers also see that the school does not yet have complete physics laboratory equipment, so that teacher must think how to make students understand the concept which is abstract and must be built the experiment directly in laboratory, so that the students can absorb all information which that taught by teacher for solving the problem found in learning, consequently the students do not depend on the teacher anymore and able to solve the problem for finding new concept independently based on motivation which the students have. Furthermore, the students' physics learning outcomes is still low in *SMA Negeri Darul Makmur*. Based on *Puspendik* data in 2015 from until 2019, it was gained in 2015 the final score of student learning outcomes was 58.66, in 2016 it was 54.78, in 2017 it was 0.00, in 2018 it was 31.25, and in 2019 it was 30.56 (Puspendik). Based on these data, it can be observed that the learning outcome of students each year are low below the KKM score of 75.

The Physic problem-solving ability of students tend to be low (Masita et al., 2020). The lack of this ability because currently learning physic in Indonesia is more emphasize how to enhance cognitive knowledge of the students than how to help students find the concept independently so tharning physic has not been capable to create students active and involved directly in learning process (Istyowati et al., 2017). Based on PISA data showed that students' problem-solving ability in Indonesia is highly low, far below Malaysia, Thailand, and Philippines (Permanasari, 2016). This is because Indonesian children are not capable in connecting between knowledge with several phenomena that occurs, moreover there are still students with low learning motivation in learning process (Shidik, 2020).

The problem above showed that the lack of problem-solving and learning motivation ability of students in Physic learning, as well as it is still found school which has not had Physic laboratory, where it is not easy to learn Physic because there are various concepts is abstract and must be tested experimentally (Klein et al., 2021). Consequently, for overcoming this thing, it is required an alternative media technology which can explathat the abstract concept in Physic learning especially in Direct Current Electric Circuit (DC) so that the problem-solving which is faced by students can be finished. The media application in learning process by students will make learning process undergo easily and effectively (Rahayu et al., 2019).

Where education today and future requires new innovation on innovations and information to be able to assist education in students' learning process (Allo, 2020; Purwanto el al., 2020).

Learning media that can be utilized is PhET simulation media, this is because PhET simulation media is not only providing concepts but also inviting the students to find the concept in reality (Mariko, 2021). Motivation and understanding concept can be enhanced by using PhET stimulation media (Khairunnisak, 2018). PhET media is a medthatic improves the students' concept mastery in Physic learning (Yunita el al., 2019). Furthermore, the students' problem-solving can be enhanced by using PhET simulation media (Daret el al., 2017).

Based on description above, the researcher observed that there is a necessity related to technology media usage which can help students conducting experimenting witharning process, and the lack of motivation as well as problem-solving ability especially in physic learning so the researcher uses PhET simulation media which is considered suitable used as alternative in this research. Consequently, the objective of this research is for investigating the implication of using physics education technology (PhET) simulation media to enhance students' motivation and problem-solving skills in learning physics.

Method

The researcher and this research used a quantitative approach with the type of quasi-experimental research (quasi-experimental). The research design used in this study is the Non-Equivalent Control Group Design. This study used two classes, namely the experimental class and the control class. The experimental class is the class that gets the implementation of treatment with PhET simulation media and learns using the PBL Model with problem-solving skill steps, while the control class is a comparison class that only uses conventional methods in learning such as lectures and also explanations explained on the blackboard. The experimental class and the control class in this study were given a pretest and also a posttest to be able to see the differences in problem solving skills and motivation of the two classes. Where to be more clear and complete can be seen based on the research flow chart in Figure 1.

The Non-Equivalent Control Group Design in this study can be seen in Table 1 below.

Tabel 1. Research design Non-Equivalent Control Group Desaign

Class	Pretest	Treatment	Posttest
Experiments	O_1	X	O_2
Control	O_1	-	O_2

(Sugiyono, 2018; Yusuf, 2017)

The population used in this research was students in grade XII/MIA as many as 57 students. The sample of this research was taken by random sampling and counted using solving formula, where based on the calculation there were 50 people as samples in this research. The sample of this research was divided into two groups, where 25 students were in experimental class and 25 students is in control class.
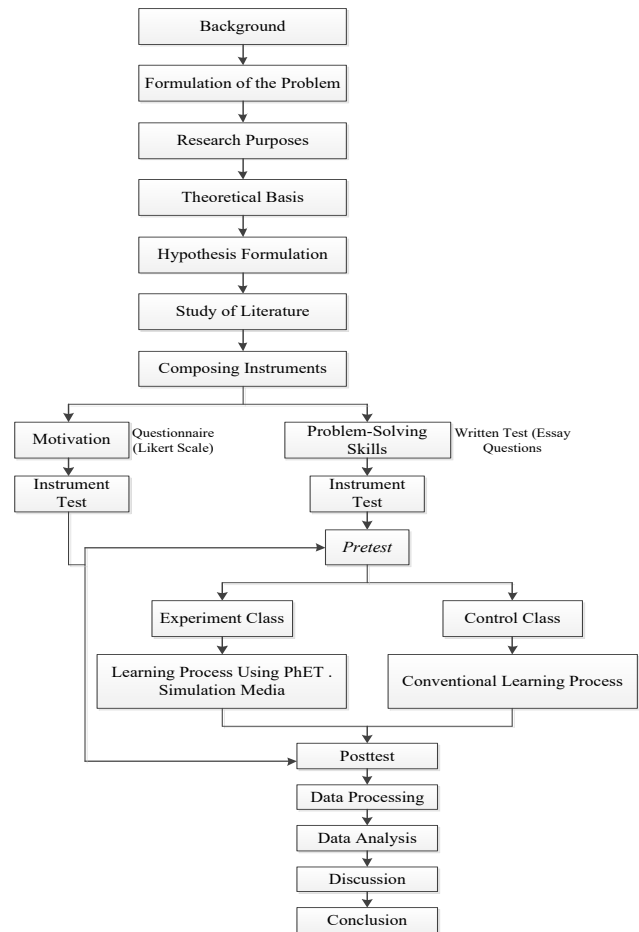
Figure 1. Research Flow Chart

The instrument used in this research consisted of questionnaire on Likert scale used to measure students' learning motivation, essay test question was used to measure students' problem-solving skills and the responsed of questionnair on in the Likert scale was used to invest how students' responto on learning process by using PhET stimulation media assistance.

This research was begun by providing pretest to the students for observing how motivation and problem-solving skills which was had before being provided treatment by using PhET. After conducting pretest, the next would be conducted learning process by using PhET stimulation assistance. Then after learning finished, the last research would be conducted posttest for observing how students' motivation and problem-solving skill after being provided treatment. Pretest and

posttest data which had been obtained was analyzed by using percentage average test for learning motivation and N-gain test for investigating the improvement of problem-solving skill, moreover the data obtained was also conducted hypothesis test by using independent sample t-test.

Analysis of the data that has been obtained in this study the decision was taken based on several classifications for both learning motivation and problem-solving skills. Motivation to learn in this study the decision was taken based on the average value obtained by students with data interpretation can be seen in Table 2 below.

Tabel 2. Interpretation of Learning Motivation

Category	Index
Very high	87.76 – 108
High	67.6 0– 87.75
Low	46.26 – 67.50
Very low	25.00 – 47.25

(Yusrizal, 2016)

The increase that occurs in the problem-solving skill variable in this study using N-gain with the gain index classification used can be seen in Table 2 below.

Tabel 2. Klasifikasi Indeks *Gain*

Gain	Criteria
(g) > 0.70	Medium
0.30 < (g) < 0.70	Height
(g) < 0.30	Low

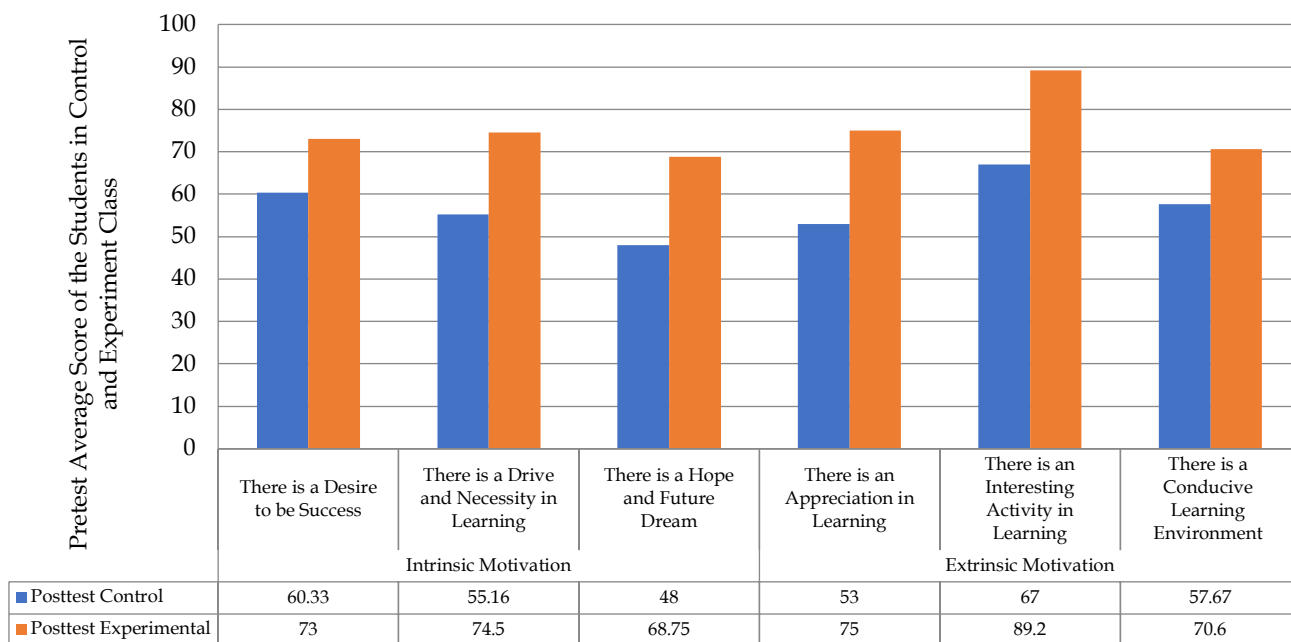(Meltzer, 2002)

Result and Discussion

Learning Motivation

Based on the results obtained from the pretest and posttest scores, it was found that the learning motivation of students in the control class increased from very low to low category, while in the experimental class students' learning motivation also increased from very low to high category which can be seen from the score. The average percentage of students' learning motivation in the control class and experimental class is calculated based on the average value of each indicator of students' learning motivation in Table 3.

The values in Table 3 show the overall average value of all learning motivation indicators used in this study, while the average value of the learning motivation indicators used in this study with six indicators has an average value in the experimental class and the control class. can be seen in Figure 2.

Table 3. Analyses Data of Enhancement Students' Problem-Solving Skill

Class	Average Score of Learning Motivation	Average Score of Learning Motivation
	Pretest	Posttest
Experimental	45.04	75.18
Control	45.26	56.86

	There is a Desire to be Success	There is a Drive and Necessity in Learning	There is a Hope and Future Dream	There is an Appreciation in Learning	There is an Interesting Activity in Learning	There is a Conducive Learning Environment
■ Posttest Control	60.33	55.16	48	53	67	57.67
■ Posttest Experimental	73	74.5	68.75	75	89.2	70.6

(Intrinsic Motivation — first three columns; Extrinsic Motivation — last three columns)

Figure 2. The Percentage *Posttest* Average Score Graph of Students' Learning Motivation in Experimental and Control Classextensive citations and discussion of published literature.

Based on the results obtained for every learning motivation indicator Picture 1 above showed that the indicators which have the highest posttest score is indicators with interesting activities in learning, where for experimental class the average score is 75.18 and for control class is 67. Although the indicators of both classes have higher average score than others, however in experimental class the average score is higher, 75.18, this is because in experimental class the learning process is conducted by using PhET simulation media so that the students' learning motivation from the first is very low becomes relatively high. It is since PhET simulation media can create learning process becomes exciting and greatly difference from what students previously got from teacher at *SMA Negeri 2 Darul Makmur*.

The high enhancement of the indicators is there is interesting activities in learning process of experimental class, since PhET simulation media can engage students to be more enthusiastic in learning process. The high enhancement of the indicators is there is interesting activities in learning process is also caused the PhET simulation media becomes an alternative media which presents interesting pictures in learning process. Consequently, the students are interested in following learning (Diraya el al., 2021). Where by the presence of interesting activities which is offered by PhET stimulation media, both in the term of appearance and contextual assessment related to daily phenomena, will make emergence interesting activities and different from previous learning for the students so that indicator of the presence of interesting activities in learning process will relatively high enhancement compared to the others.

Based on the average score of learning motivation which is obtained by students showed that the indicator of the hope and future goals have average score as many as 68.75, this score is less than other indicators. It is caused because the students of *SMA Negeri 2 Darul Makmur* basically less of responsibility in doing assignment which can be seen from the score of control class which is also low. The low of indicators score is also caused the students of *SMA Negeri 2 Darul Makmur* tent to not understand the basic concept about Direct Current Electric Circuit (DC) and enable related concept which they have with daily phenomena. Although tends to be lower however the indicator enhancement is also in high categorize after conducting treatment by using PhET simulation media assistance.

The high score obtained for the indicator of future hopes and aspirations is due to the fact that the learning is conducting using PhET simulation media which can make students interested and enthusiastic in the learning process and can provide students with an understanding of abstract concepts. The large value of this indicator is also due to the fact that students who learn to use PhET simulation media can find their own

phenomena that can raise their level of learning creativity (Marlinda et al., 2016).

The PhET simulation media emphasizes the relationship between real-life phenomena and the underlying science, supports an interactive and constructivist approach, provides feedback and provides a creative workplace (Rizaldi el al., 2020). Consequently, it can make students responsible for the tasks provided by the teacher, because students feel understand and can do the task. One of the causes of someone's laziness in doing assignments and taking notes is the lack of enthusiasm for learning in students (Rosmawati et al., 2021). There is good enthusiasm in learning with PhET simulation media, it will affect students' learning motivation. Students who have learning motivation will make students experience an increase in learning outcomes obtained, this is supported Herpratiwi (2022) who says that motivation is from learning and is very important in achieving learning achievement, this is also supported Ahmad et al. (2021) who say that using interactive computers and simulations can improve students' ability in electrochemical achievement test scores and their level of motivation compared to students who follow ordinary classroom teaching. The application of PhET simulation media in learning also has a very significant effect as seen from the sig value of 0.002 < 0.05. Therefore, learning with PhET simulation media has a significant effect on students' learning motivation.

Problem-Solving Skill

Based on the results of the research showed that the average score of pretest-posttest is obtained posttest score in experiment class is higher than control class and there is an enhancement of students' problem-solving skill can be seen from N-gain score of experiment and control class. The score of analysis result which is obtained related to the enhancement of students' problem-solving skill can be seen completely or succinctly in this Table 4 below.

Table 4. Analysis Data of Students' Problem-Solving Skill Enhancement
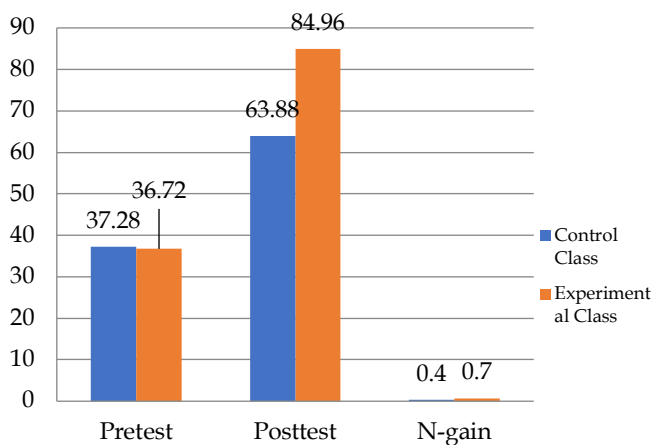
Class	The Average Score of Students' Problem-Solving Skill		N-gain
	Pretest	Posttest	
Experiment	36.72	84.96	0.76
Control	37.28	63.88	0.43

The finding of students' problem-solving skill is observed from pretest and posttest score as well as N-gain score. Table 4 showed that pretest score both class is relatively similar and low. This showed that students' understanding related Direct Current Electric Circuit material is very low, where for experiment class pretest average score is 36.72 and control class is 37.28. Whereas the posttest average score for experiment class is 84.96

higher than control class, 63.88. This result showed that there is an enhancement students' problem-solving on Direct Current Electric Circuit (DC).

The large average score of the experimental class is due to the fact that learning is conducted using PhET simulation media as an alternative learning and problem-solving step in learning, while in the control class only uses conventional learning based on the learning that is indeed used by Physics subject teachers in *SMA Negeri 2 Darul Makmur*. The learning process of the two classes both conducted experiments with different treatments in order to strengthen students' understanding of the concept of Direct Current Electric Circuits (DC), so that it would affect their learning outcomes. Student learning outcomes using PhET simulation media will be better than using conventional methods (Saputra el al., 2017).

The difference score of problem-solving skill is significantly difference which is gained by control class when posttest with average score is 63.52 whereas experimental class is 81.28. The score showed that there is difference the average score significantly of students' problem-solving skill based on independent sample t-test is obtained significance score 0.014 < 0.05, so that can be concluded there is significantly difference toward students' problem-solving skill for control and experimental class, where learning process of experimental class is conducted by PhET simulation media assistance. Although there is a difference however the enhancement of students' problem-solving clearly is seen on Figure 3.

Figure 3. Graph of the Average Score of Pretest-posttest and N-gain of Students' Problem-Solving Skills

Ficture 3 showed that there is difference of the pretest-posttest average score in experimental and control class with N-gain score each class, where in control class the average score of pretests is 36.04 while the posttest is 63.52 with enhancement score based on N-gain score, 0.40 in medium categorize, while in the experimental class the average score of pretests is 63.52 and posttest is 81.28 with N-gain score, 0.70 in high

categorize. Based on N-gain can be concluded that there is enhancement of students' problem-solving skill of experimental and control class, where in experimental class the enhancement of score is higher than control class. This is because the learning of experimental class uses learning alternative by PhET simulation media assistance.

The more specific explanation related to the analyses of the result enhancement pretest-posttest average score in control and experimental class can be investigated based on N-gain score every indicator of problem-solving skill which becomes a reference in determining overall average score pretest-posttest of control and experimental class, where N-gain score every indicator of problem-solving skill can be seed below Table 5.

Table 5. N-gain Score of Problem-Solving Skill every Indicator

Indicator	N-gain Score of Problem-Solving Skill	
	Control Class	Experimental Class
Focusing Problem	0.48	0.74
Situation Description of Physics	0.28	0.71
Planning Solution	0.47	0.75
Executing the Plan	0.49	0.82
Answer Evaluation	0.39	0.78

Based on the N-gain score, Table 5 for the control class and experimental class showed that overall, there is an increase of problem-solving skills in the high category in the experimental class, where the overall N-gain score in the experimental class is in the high category. The highest N-gain value from other indicators lies in the indicator of implementing the plan. This increase occurs, because students basically already have several skills related to the indicator steps of problem-solving skills, where before the PhET simulation media was applied, students tended to solve problems only to the stage of implementing the plan, but for indicators describing the physics situation and evaluation of answers was rarely done. which can be seen from the N-gain score of the control class.

The enhancement of problem-solving skills occurs when the learning process is conducted using PhET simulation media as seen from the N-gain score of the experimental class, where for indicators that are initially low and medium tend to experience an increase in the score of problem-solving skills, especially those most visible in the indicators describing the physics situation which initially the N-gain score is only 0.28 for the control class in the low category to the high category in the experimental class with an N-gain score is 0.71.

Based on the N-gain score of the five problem skills indicators, there are two indicators that have the

smallest score compared to others even though they are both in the high category, namely the indicator describing the physics situation and focusing on the problem. The small score for this indicator is because students at SMA Negeri 2 Darul Makmur initially found it difficult to understand the problems in the questions due to a lack of conceptual understanding, the in frequentness of students at the school in carrying out these indicator steps to solve the problem and the in frequentness of students in conducting experiments. The low score of the problem-focusing indicator step is caused because students never visualize the problem-focusing stage in words and rarely apply this indicator step in problem solving (Halim et al., 2016). The low score on the indicator describing the physics situation is caused because students are rarely taught to solve problems with this indicator step.

Although the value of the focusing indicator is low, in the experiment there is still a high increase in this indicator, which according to Melawati et al. (2022) is because students have worked on the problem-solving stage to the problem-focusing stage. Meanwhile, to describe the physics situation, students have also taken this step when going through learning, so they are used to doing it, besides that learning is carried out using PhET simulation media which makes participants have an interest in learning and are able to follow the steps of problem-solving skills when learning using PhET simulation media.

Problem solving is a major factor in science and technology education (Ceberio et al., 2016). Students who solve problems, they will develop a model or step of thinking to be able to solve problems (Khasanah et al., 2016). The implementation of this step will be their benchmark in understanding the concepts related to the learning provided by the teacher at school. The way students think in understanding concepts can be done by confronting students with phenomena or problems that provide freedom in finding the concept independently, so that students can understand the concept directly. The situation is directly related to the material concept, one of which is very easy to reach with PhET simulation media. where according to Prihatiningtyas et al. (2013) said that the PhET simulation media can complete all student learning, help students understand learning and can improve scientific skills and scientific characteristics. So, it is not surprising that with the PhET simulation media students' problem-solving skills have increased.

The presence of learning using PhET simulation media, makes students at SMA Negeri 2 Darul Makmur enhance in all steps of problem-solving skills indicators, in addition to the use and giving examples of questions using problem-solving skills steps in the learning process makes students accustomed to using these steps in solving the problems provided to him, where the use

of PhET simulation media and problem-solving skills steps create students more focused, interesting, directed in learning. Consequently, students can make better understanding of concepts that affect their problem-solving skills.

Students' Respond

Based on result analyses which has been done, it showed that students provide positive attitude on learning by using PhET simulation media of Physic material, Direct Current Electric Circuit (DC). This thing can be seen from the average score of the respond which is obtained of 86.2 showed highly positive attitude. It showed on Table 6 below.

Table 6. Students' Respond Related to PhET Simulation Media Usage in Learning

Indicator	Score	Category
Easiness	85.37	Very Positive Attitude
Interest	89.14	Very Positive Attitude
Clarity	86.33	Very Positive Attitude
Linkages	83.25	Very Positive Attitude
Average	86.02	Very Positive Attitude

Table 6 above showed that Physic learning on Direct Current Electric Circuit (DC) by using PhET simulation media can improve learning motivation and problem-solving of the students. This also can be investigated when learning process, where students are highly enthusiastic in conducting practice by using PhET simulation media. Moreover, the students' opinion toward PhET simulation media in learning process for some indicators such as easiness, interest, clarity, and linkages showed very positive respond. It means that students have good impression when leaning uses PhET simulation.

Based on result analyses of the research, there is an enhancement of motivation and problem-solving skill by using PhET simulation. PhET simulation provides students easiness in understanding the material, emergence of interest, clarity of provided concept, and have linkages among concept which is learnt. PhET simulation media has interesting and exciting display as well as capable to grow learning interest of the students becomes higher (Verdian et al., 2021). Virtual media, PhET simulation, is able to enhance learning outcomes and enhance responds' result of the students in learning process (Laila, 2021).

Based on the explanation related to the above discussion, it can be concluded that learning by using PhET simulation can increase students' learning motivation and problem-solving skills, this is because the PhET simulation media is very easy to apply, has an attractive appearance, can explain the concept of the material clearly and is able to provide information. a concrete understanding of the material concept of Direct Current (DC) Electric Circuits taught at SMA Negeri 2 Darul Makmur.

Conclusion

Based on the objective and analyses of the result research can be concluded that there is an enhancement of learning motivation, especially the highest indicator namely there is interesting activities in learning process. The enhancement of learning motivation occurs significantly with average score of control class is low categorize and experimental class is high categorize. Furthermore, the students' problem-solving skill also faces significantly enhance, especially the highest indicator steps, namely conducting solution, where this enhancement can be seen based on N-gain average score of students in experimental class with high categorize and control class with medium categorize. The high enhancement of experimental class is caused on the class the learning process is conducted by using PhET simulation media assistance and uses the problem-solving steps. Moreover, the implementation of PhET simulation media in learning process has positive respond by students so that with positive respond this is strengthened that PhET stimulation media is exactly used to enhance motivation and problem-solving skill especially in Physics learning.

Acknowledgements

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