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Development of Problem Based Learning Collaborative (PBL-C) Physics E-Worksheet to Improve Student Problem Solving and Collaboration Skills

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Abstract: Problem-solving skills are needed in the 21st century because, in life, humans will always be faced with problems. One way to solve the problem is through collaboration. This research was done with the purpose of improving students' problem-solving and collaboration skills through problem-based learning e-worksheets. This method in research was research and development through the model by ADDIE (analysis, design, development, implementation, and evaluation). The analysis carried out on development is one of validity and practicality. At the implementation stage, problem-based learning e-worksheets were tested in schools to determine the e-worksheets effectiveness. The design in research used was the one-group pretest-posttest design. The research results obtained were: 1) PBL-C physics e-worksheets that were developed fall into the category of valid and practical; 2) PBL-C physics e-worksheets are effective for use in learning to increase problem-solving skills and collaboration of students.

Keywords: Collaborative skills; E-worksheets; Problem based learning collaborative; Problem solving skills

Introduction

Learning in the 21st century demand students build a variety of skills to be able to deal with the problems they encounter. Students are demanded to have skills of problem-solving so they can deal with any conditions, anytime, and anywhere (Bariyyah, 2021). One of the skills that can help students fix problems is the ability to collaborate. Different abilities of students in finish problems can affect the results of solving problems (Afiyati et al., 2020). Collaboration skills can support students solve the problems they face together (Chang et al., 2017). Students' collaboration skills can be trained through physics learning carried out in schools.

Physics learning is a part of subjects studied by students at school. Physics learning studies all phenomena that occur in the environment of students (Octaviana et al., 2022). The objectives of learning physics include developing students' knowledge, understanding, and analytical skills of the environment and surroundings (Azizah et al., 2015). In other words, the ultimate goal of learning physics is to make is easier for humans to solve physics problems consist of the knowledge, understanding, and abilities they have.

In fact, the conditions that occur in the field shown that skills of problem-solving by students in physics learning was still lack (Ma'ruf et al., 2020). This is marked by the difficulties of students in solving problems given by the teacher in learning physics (Batlolona et al., 2018). The collaboration student skills in physics learning are also still lack (Octaviana et al., 2022). This condition is also got helped by the observations results at Senior High School at Yogyakarta. The results of observations of students learning physics show a lack of collaborative activities carried out by students. Learners tend to be passive in

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the process of learning. We can look that is when learning is carried out in groups; in one group, often only a few students are active in conducted activities of learning and the others are passive (Balqist et al., 2019). This can be caused by many factors that occur during learning in the classroom.

The results obtained from the identification of these problems found that one of the something that makes students lack the skill to finish problems and collaborate is that the teaching materials used by teachers do not have syntax that directs students to collaborate to solve problems. The material of teaching used in schools are in the shape of printed books. Printed materials of teaching tend give information but less interesting because they cannot use sound, video, animation, or visualization that can support concept explanations (Irwansyah et al., 2017). This makes students less enthusiastic about learning. Another factor that was found was that the learning applied by the teacher did not accustom students to actively collaborating to solve problems; learning was only dominated by the teacher (Ivánková et al., 2022). Therefore, teaching materials are needed that can instruct students to collaborate to solve problems using model of learning that make students active when learning physics.

Materials of teaching are one of the most a crucial part of learning. In the current era of technological development, many teaching materials have been developed using technology (Rusman, 2018). The use of smartphones in all activities is the most common thing done by everyone in this era. Smartphones can also be used to facilitate learning. The part materials of teaching that can be accessed using a smartphone is an e-worksheet (Setiati et al., 2023). E-worksheets are student worksheets packaged in electronic form, accessible anytime and anywhere via a smartphone.

An e-worksheet is a teaching material that contains instructions or steps to complete a task based on a basic competency to be achieved (Soenarko et al., 2022). In this e-worksheet, there is a material description, assignments, and exercises have correlation to the material to be given to students (Muthoharoh et al., 2017). E-worksheets contain interesting pictures, practice questions to improve critical thinking and communication skills, content summaries, work instructions, or simulations, and can be easily used without any time limits (Nasrullah et al., 2018). E-worksheets developed must be structured with syntax that directs students to collaborate be active in learning. So, an appropriate model of learning is needed to increase students' collaboration skills through the use of the e-worksheet.

The part models of learning that can be used to make students active is problem-based learning or PBL (Saputra et al., 2019). PBL is a model for fix a problem. Students can collaborate in solving the problems presented (Saadah et al., 2019). Solving problems together can provide more optimal results in less time. So, the model of PBL-C can be used by teachers to increase students' collaboration skills in solve problem.

The PBL-C approach stresses problem-solving abilities through student participation in learning. This model includes markers for problem-solving and cooperation abilities. Understanding the problem, planning to solve the problem, solving the problem, and re-examining the consequences of the settlement are all indicators of problem solving skills (Young et al., 2016). Meanwhile, Hermawan et al. (2017) define collaboration abilities as contribution, time management, issue solving, working with others, and investigative tactics. The PBL-C approach is intended to help students improve their problem-solving and collaboration skills.

This learning model has a syntax consisting of apperception, orientation, coordinating students, group investigations, the results of proving investigations, developing and presentation for work results, analysis and evaluation of process for problem-solving. These stages are integrated in physics e-worksheet so that the learning carried out by students is directed to solving problems in collaboration. The stages that make students collaborate are when students investigate problems in groups, find evidence and present findings and evaluate what they get themselves as answers to the problems presented.

This research has advantages and differences from previous research, namely that the developed physics e-worksheet is adapted to the model of problem-based learning, which is integrated although indicators of problem solving and collaboration skills, so that the model used for the e-worksheet development in research is problem-based collaborative learning. Based on the explanation that has been given, the research purpose to develop physics e-worksheets based PBL-C to increase students' problem solving and collaboration skills.

Method

The research was done including research and development research. The ADDIE model is used as the research model development research. The ADDIE model is used as the research model. There are 5 phases in this research, namely: analysis, design, development, implementation, and evaluation (Dick et al., 1996). This method and model were chosen because they aim to produce PBL-C physics e-worksheet. The research purpose is to increase students' problem-solving and skills of collaboration in physics learning through the

use of PBL-C physics e-worksheets. The design of research used in the limited trial was the one-group pretest-posttest design (Creswell, 2017).

Research starts with the analysis stage. Analysis was conducted to collect information in the shape of student analysis, concept analysis, and curriculum analysis. The design is carried out to make a draft e-worksheet that will be developed and also includes the preparation of the instrument. The development was carried out to test its validity by two lecturers majoring in physics and one physics teacher at a high school in Yogyakarta. Implementation was tested to reveal the practicality and effectiveness of electronic worksheets for class XI MIPA students as participants in a limited trial. While the evaluation provides an assessment and analysis of the data obtained from the trial phase.

This development given qualitative and quantitative data. The validator's comments and suggestions for improvement on the product provide qualitative information. Quantitative information was obtained for evaluating each criterion point in each opinion using instruments that had been validated beforehand. The score for each criterion uses a scale of Likert. The scale of Likert with strongly agree has a score of 4, agree has a score of 3, disagree has a score of 2, and strongly disagree has a score of 1. The validity and usefulness of PBL-C-based worksheets are assessed using quantitative analysis. Research data analysis was carried out through formula below.

Data Analysis

Validity analysis

Validation data is calculated using Aiken's V validity through the following formula (Aiken, 1985):

$$V = \frac{\sum s}{n(c-1)} \quad (1)$$

Information:

V = Factor of Content Quality
s = r-l_0
l_0 = Smallest rating value
c = Biggest qualification value
r = The validator provided a value
n = Validator total

Table 1. V Aiken Interpretation Results (Istiyono, 2020)

Average Result	Classification
V ≥ 0.80	Very valid
0.40 < V < 0.80	Valid
V ≤ 0.40	Not valid

The PBL-C physics e-worksheet is used if it meets the valid criteria and will be revised again if there are still suggestions from the validator.

Practicality Analysis

A practicality analysis was conducted to see the practicality of the e-worksheet-based PBL-C. A practicality analysis was conducted using quantitative equations (Sudjana, 2005), whose results are categorized via the categories adapted from Riduwan (2015) in Table 2.

Table 2. Practicality Analysis Category

Average Result	Classification
0-20	Very Impractical
21-40	Impractical
41-60	Pretty Practical
61-80	Practical
81-100	Very Practical

Effectiveness Analysis

Cognitive pretest-posttest results and SPS data were analysis quantitatively using the test of normality (Test of Shapiro-Wilk) to test whether the data obtained were normal or abnormal. The paired sample t-test was done to test the differences in the pretest and posttest average scores of students. An analysis of N-gain was performed to reveal the improve in problem-solving abilities based on the pretest-posttest. Calculations were done with of SPSS version 25 support. N-gain is calculated using the following formula (Hake, 2002):

$$\text{N-Gain} = \frac{\bar{X}posttest - \bar{X}pretest}{\bar{X}\,\max - \bar{X}pretest} \quad (2)$$

Information:

$\bar{X}posttest$= Average value after test
$\bar{X}pretest$ = Average value for the pre-test
$\bar{X}max$= Maximum value

The interpretation of the N-gain value into the effectiveness category is shown in Table 3.

Table 3. N-gain Criteria (Sundayana, 2016)

N-Gain value	Categories
< g < 0.30	Low
0.30 < g < 0.70	Medium
0.70 < g < 1.00	high

Data analysis from the collaboration ability questionnaire was carried out using quantitative analysis techniques (Sudjana, 2005). Interpretation of data using the proposed categories (Riduwan, 2015).

Result and Discussion

Research on the development of PBL-C physics e-worksheet to increase students' problem-solving and collaboration abilities using the ADDIE model in line with research conducted by Haerani et al. (2023).

Research starts with the analysis phase. In the analysis phase, material analysis, curriculum analysis, and needs analysis were carried out. This stage was conducted although interview the physics teacher and distributing questionnaires for pre-research to 30 students of class XI MIPA at MAN 2 Yogyakarta. The material chosen is the material used in optical devices. The material was chosen because the questionnaire results stated that students found it difficult to understand the concept of forming shadows on the eyes correctly and to distinguish the application on the eyes with maximum accommodation and not accommodation (Parno et al., 2019). This difficulty may be due to the characteristics of the material that require conceptual understanding, which must be sought through observation, conjecture or hypothesis, data analysis, discussion, and conclusions (Rohmah et al., 2019).

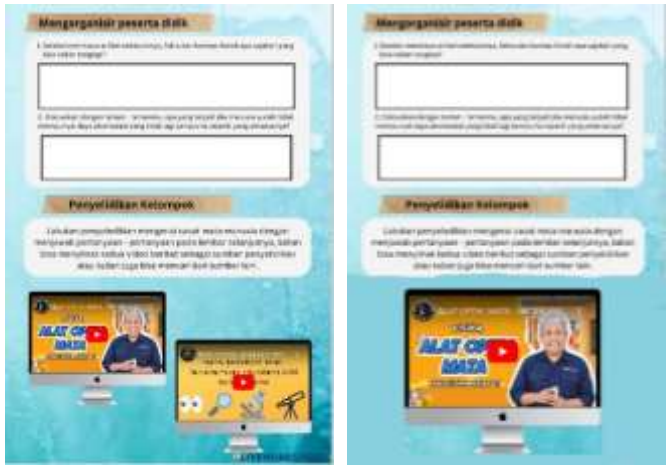
The curriculum implemented by the school is the revised 2013 curriculum. An analysis is conducted on basic competencies that are appropriate to the material to determine indicators and objectives of learning that must be achieved from students. The analysis results of the need for information obtained consist of: 1) students find it difficult to solve problems in learning physics; 2) students tend to be passive in learning; 3) teachers still often use conventional methods or focus on the teacher; 4) the media of learning used have limitation to printed books and worksheets from schools; 5) teachers have not tried using electronic learning media.

Based on these problems, the solution given is to develop an e-worksheet using a problem based learning model. Previous research conducted by Melawati et al. (2022) showed that the results of using e-worksheets had a positive influence on problem solving and student learning outcomes. E-worksheets with a PBL model can be used to help students actively discover physics concepts (Fuadi et al., 2022).

The design stage consists of designing an e-worksheet and compiling an assessment instrument. Making a PBL-C physics e-worksheet design adjusted to the analysis phase results of the e-worksheet is designed using a model of PBL-C based on the material of optical devices. The e-worksheet contains indicators of problem-solving and collaboration skills. The indicator Problem solving include understanding of issue, make a plan for problem solving, finish problems, and re-examining the results of the solution (Young et al., 2016). While the indicators of collaboration skills according to Hermawan et al. (2017) include contributions, time set, problem solving, working with others, and inquiry techniques, After the product is ready to be designed, proceed with the development stage.

The next stage, development stage consist of activities to design products (Sugiyono, 2019). The development phase is to produce tools in learning that support the process of learning. The resulting product was in the shape of an electronic PBL-C-based worksheet. The research purpose is to produce tools that are feasible and effective in increasing research variables.

Validation activities are carried out by expert validators and practicing validators to improve product quality. The validation activities carried out by the validator obtained suggestions and input which were taken into consideration for revising the product. One of the suggestions given by the validator is on the media aspect. The validator suggests that in displaying videos, only 1 video in one slide is because students use smartphones to use e-worksheets. The results of the improvements made can be seen in Figure 1.



Pre-revision Post-revision

Figure 1. Product revision

The validation results conducted by the validator through analysis using V'aiken obtained the results for the validation assessment on the material aspect of 0.846 in the category was very valid. In the media assessment aspect, a value in average of 0.924 is obtained in the category was very valid. The research results are similar with the research was done by Rahmawati et al. (2022) and Lisanti et al. (2022) where the e-worksheet developed on elasticity material was obtained in the very valid validity category in similar validity aspect. Thus, we got conclusion that the PBL-C physics e-worksheet media is very valid in material terms and media aspects, so that we may be used for learning about optical subject.

Product practicality assessment is carried out on aspects of language, appearance, ease of operation, and reliability. The results of the practicality assessment given by students were obtained for the language aspect of 90% in the very practical category, the display aspect of 87% in the very practical category, the ease of operation aspect of 82% in the very practical category,

and the reliability aspect of 79% in the practical category. The average value of e-worksheet-based practicality PBL-C was obtained at 84.5% in the very practical category. The results obtained are in line with the research done by Fatimah et al. (2022), in which the research results got positive responses from students, namely above the value of 90% in the very practical category. Andayani (2020) states that teaching materials that have been assessed as practical can be used in classroom learning. Therefore, the developed e-physics worksheet in this research is stated to be practical for use for learning, especially in the material of optical instruments.

After the product was declared valid and practical, the research continued with trials in schools, namely at MAN 2 Yogyakarta. The field test process carried out at school shown in Figure 2.

Figure 2. Field test of PBL-C physics e-worksheet in school

The product effectiveness analysis results for the normality test obtained results as shown in Table 4.

Table 4. Problem Solving Ability Normality Test Results

	Shapiro-Wilk		
	Statistics	df	Sig.
Pretest PSS	.94	30	.097
Posttest PSS	.95	30	.169

Based on Table 4, we can see that a significance value of 0.097 and 0.169 was obtained. This indicates that the value achieved is better than 0.05, which states that the data in normal distributed. Furthermore, the paired sample t-test obtained results as shown in Table 5.

Table 5. The Paired Sample T-Test Problem Solving Ability Results

	t	df	Sig. (2-Tailed)
Pretest PSS -PSS Posttest	-41.35	29	.00

According on the data in Table 5, the sig. (2-tailed) problem solving ability of 0.00 means that there was a result with difference in the average cognitive pretest-posttest score and SPS because of the sig. (2-tail) 0.05. Thus, an N-Gain analysis was performed based on the analysis by Hake (2002). The N-Gain value obtained for PSS is 0.77 in the high category. So, problem-based learning and collaborative e-worksheets may be stated to be effective. The N-gain value for each PSS indicator which consists of understanding the problem (PSS1), making plans (PSS2), solving problems (PSS3) and evaluating (PSS4) is presented in Figure 3.

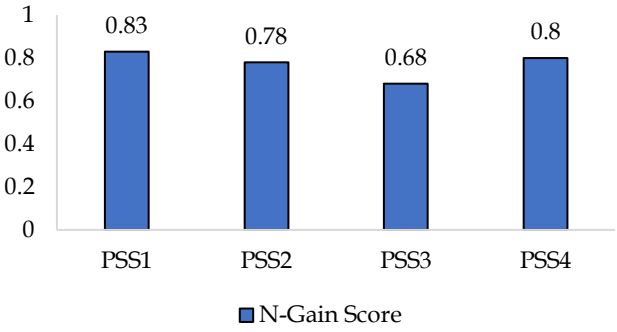


Figure 3. N-Gain value for each PSS indicator

The N-Gain value data in Figure 3 displays the N-Gain value for each PSS indicator in the high category. This result was obtained because the PBL-C physics e-worksheet was compiled using the PBL-C syntax, which guided students to solve problems by collaborating. According to the e-worksheet, it is developed according to the development of students through the integration of videos and sample questions that are according to their level of development. This helps students solve problems. so that students have interesting in learning to solve the problems presented (Nurahman et al., 2019). The results of this research are in line with research by Wahyuni et al. (2020), PBL-based e-worksheets can be effective in helping students solve problems in physics.

Assessment of collaboration skills obtained through scores at the pretest and posttest obtained assessment results based on collaboration ability indicators which include contribution (CS1), time management (CS2), problem solving (CS3), working with others (CS4), investigative techniques (CS5). The results of the collaboration ability assessment are shown in Figure 4.

According on data in Figure 4, we can see that the values obtained for each indicator of collaboration ability before using the e-worksheet based PBL-C obtained a value in average of 56.4% in the sufficient category. This is due to the fact that the media of learning used by the teacher are less attractive and do not guide students to collaborate in physics learning (Balta et al., 2017). In addition, another factor that makes students

less collaborative is the way the teacher teaches without involving students (Mufit et al., 2022). According to Rott (2020), to understand the complete concept, students must be involved in concept discovery. Therefore, a PBL-C physics e-worksheet was developed in this study.

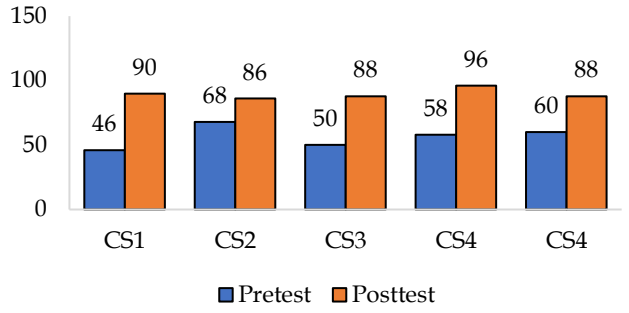


Figure 3. Collaboration skill assessment results for each indicator

The results obtained after implementing learning using PBL-C physics e-worksheet on collaboration skills showed an increase in students' collaboration abilities to 89.6% in the very good category. This is due to the integrated e-worksheet stages of problem-based learning. PBL research can demand students accustomed to solving problems (Dewi et al., 2023). Through collaborative learning, students will become active so that their abilities and skills can increase (Sumadi et al., 2017). This is because collaboration can help solve problems better (Yanti et al., 2023). According research results that has been done, it can be stated that PBL-C physics e-worksheet are effective in increasing students' problem-solving and collaboration skills.

Conclusion

The research results were obtained that the validation and practicality tests results of PBL-C physics e-worksheet are in the category of valid and practical. The PBL-C physics e-worksheet trials results in the field showed that the PBL-C physics e-worksheet were effective in increasing students' problem-solving abilities and the collaborative skills of high school students for material of optical devices. With regard to the suggestions that the researchers gave, known as considering that the developed PBL-C physics e-worksheet provides benefits to students' problem-solving abilities and collaboration, teachers or other researchers are expected to also develop e-worksheets through the PBL-C model on other physics subject for support the physics learning process.

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Conflicts of Interest
The authors declare no conflict of interest.

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