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Developing Physics E-Scaffolding Teaching Media to Increase the Eleventh-Grade Students’ Problem Solving Ability and Scientific Attitude

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ABSTRACT

This research aims at revealing (1) the suitability of physics e-scaffolding teaching media with mathematical and image/diagrammatic representation, as well as (2) the effectiveness of the e-scaffolding teaching media with mathematical and image/diagrammatic representation to improve students’ problem solving ability and scientific attitude. It is a research and development adapting Borg and Gall model which consists of five stages: (1) preliminary study; (2) planning; (3) product development (production, validation & revision); (4) limited trial and product revision, field testing and product revision; and (5) dissemination. The instruments applied in this research comprise validation form, lesson plan implementation observation form, students’ response questionnaire, teacher interview form, problem solving ability test, and scientific attitude observation form. The subject of this research is the eleventh grade students of SMA Negeri 2 Wonosari. The respondents of this research consisted of six validators, 24 students for thelimited test, and 48 students for field testing. This research produced physics e-scaffolding teaching media equipped with lesson plans, students worksheets, problem solving ability test, and scientific attitude observation form. The result of the validation shows that physics e-scaffolding teaching media developed in this research issuitable to be implemented and categorized as “very good.”The result of the test shows that this teaching media fulfills the criteria of effectiveness. Based on the MANOVA test, it can be concluded that there is a difference between problem solving ability and scientific attitude in the experiment class and the control group. Thus, it can be concluded that there is a significant difference in the gain of problem solving ability and scientific attitude among the students who participated in the learning process using physics e-scaffolding media and other media developed in accordance with the devices used by the teachers.

KEYWORDS
e-scaffolding, problem solving ability, scientific attitude, mathematical representation, image/diagrammatic representation

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Introduction

Education plays an important role in providing the Indonesian students with various necessary competences for their career and future life (The Regulation of the

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Minister of Education and Culture No. 69, 2013). The competences include the problem solving ability and scientific attitude. The 2013 curriculum places the competence of formulating problems into the core competences which include the aspects of attitude, knowledge, and skills. The core competences are used as the restrictions to determine the standard for passing grade criteria in accordance with the demand of the 21st century learning outcomes.

The competences based on the 21st century learning paradigm include (1) learning and innovation skills, (2) information media and technology skills,and (3) life and career skills (Partnership for 21st Century, 2008).The domain of learning and innovation skillsinclude critical thinking ability, problem solving ability, communication and collaboration ability. The information media and technology skills domain is related with the ability in ICT literacy. Finally, in the domain of life and career skills, flexibility, adaptation, responsibility, leadership, and high initiative are required.

In accordance with the demand of the 21st century learning outcomes, the competences required are also stated in the Indonesian National Qualifications Framework (*Kerangka Kualifikasi Nasional Indonesia – KKNI*). The qualifications for the 2nd level are a number of qualifications required for a high school graduates, in which among others arebasic operational knowledge and factual knowledge of specific areas of work; hence, students are expected to develop an ability to solve problems related to their professions. Each qualification level includes the process of developing students' affection so that they are able to collaborate with others, and have sensitivity as well as high social concerns toward the society and their surroundings (Presidential Decree No. 8, 2012).

Physics is a school subject that plays an important role in life. Physics is important because it is the basic science for the development of many study fields such as mechanical engineering, electronics, nuclear sciences, and digital information system. Physics presents various problems, from the simplest to the complex ones, as well as from the macro to the micro ones. Physics attempts to find the solutions to solve those problems.

Education system is developed not only to establish scientists but also to create a generation capable to understand and implement scientific facts in delivering the principles of their opinions and choices (Benjamin & Florencia, 2012). Thus, physics learning is responsible to prepare the students to gain problem solving ability and high scientific attitude. The ability to solve physics problems is required not only by students in schools, but also in various professions (Heller & Heller, 2010. Scientific attitude needs to be developed in physics learning. This will be the ground for the graduates to integrate their knowledge with social aspects (Sekar & Mani, 2013).

Programe for International Student Assessment (PISA) research result in 2012 shows that scientific literacy among Indonesian students is low. Based on the survey conducted by *Programe for International Student Assessment (PISA) Organization Economic Cooperation and Development (OECD)* in 2012, it mentioned that Indonesian students' scientific ability reached the score of 382. The maximum score is 580 (OECD, 2014). The problem solving ability is a component contained in the scientific literacy (Yilmas, 2012). The low score of scientific literacy among Indonesian students as indicated in the PISA research implies that the ability to solve physics problems is also low.

Finding problems in physics learning tends to be the process of learning emphasizing on the mastery of concepts, rather than problem solving ability (Hoellwarth, Moelter, & Knight, 2005). Students are able to solve simple quantitative problems, but fail to solve more complex ones (Redish, 2004). Some researches show that physics is considered a difficult subject because it requires complex mathematical skill(Nashon&Nielsen, 2007); high metacognition (Anderson & Nashon, 2006); and high occurrence of misconception(Alwan, 2011; Halim, Young, & Meerah, 2014; Von Aufschnaiter & Rogge, 2010). Students' negative assumption that physics is a difficult subject has caused them to have a negative attitude toward physics. This assumption could lower students' curiosity and enthusiasm in their learning process in class.

One of the physics teaching materials that the students assume to be difficult is balance and rotational dynamics. Rosengrant, Heuvelen, & Etkina (2009) state that to solve problems of dynamics, the ability to analyze the forces in an object and to describe it in form of free body diagram. Students who commonly solve the problem using mathematical equations will encounter a problem to master the concept. One of the appropriate ways is using multi representation.

The use of representation implemented in various ways or representation modes to discover the concept and solve problems is called multi representations (Kohl & Finkelstein 2008). Some experts indicate that mathematical representation is an important approach to understand physics (Albe, Venturini,& Lascours, 2001; Sherin, 2001). Meanwhile, to obtain qualitative understanding toward physics, image/diagrammatic representation can be applied. Diagram representation is used to describe forces condition on a system in Physics. Pictures can help visualize an abstract object.

Physics learning can take place effectively when students learn to complete tasks they have never learned, but still within their capacity. Z*one of proximal development* (ZPD) is a level of development which is slightly above one's present level of development (Vygotsky, 1978). Difficult tasks far beyond students' ZPD have caused difficulties in solving the problems. The lower limit of ZPD means the limit of skill level in which students can achieve independently. The upper limit of ZPD is the skill level that students can achieve with the help of teachers/more competent students (Santrock, 2011). To improve the ability of problem solving and understanding the concept of physics, students need to get cognitive help which is commonly called scaffolding (Santrock, 2011).

Scaffolding is a technique of changing the support level along the process of learning given by a teacher or more competent fellow students by adjusting the assistance given to students' performance (Santrock, 2011). Scaffolding involves a process of observing students' ZPD and making it a priority in determining the learning process (Hughes & Diane, 2010). Scaffolding is proven effective to be implemented in a learning process with various students, to achieve various objectives, and in various environments as in the study of language (Mirahmadi & Alavi, 2016),mathematics(Amiripour, *et al.*, 2012), and science (Raes, Schellens, Wever, & Vanderhoven 2012).

Scaffolding has been widely implemented in physics learning. The benefit of using scaffolding is to provide help to achieve the objectives of learning that cover the domains of attitude, process, and the content of physics (Podolefsky, Moore, & Perkins, 2013). Scaffolding adapted for physics through e-learning can improve students' performance and motivation (Ching Hue Chen, 2014). In the cognitive domain, scaffolding improves the effectiveness of the use of students' abstract representation (Podolefsky & Finkelstein, 2007) so that they can produce a new structure of knowledge organization(Podolefsky & Finkelstein, 2007). A stronger and integrated structure of knowledge organization is a useful ability to solve physics problems. Jonassen (2011) and Ringenberg & Van Lehn (2006) state that the implementation of scaffolding in physics learning can improve students' ability to solve problems.

Along with the development of technology, the implementation of ICT in education is inevitable. ICT can be used innovatively in every teaching and learning activity to develop scientific processes as well as conceptual understanding, to assist problem solving, and to instill positive attitude toward science (Suartama & Tastra, 2014; Sari & Sugiyarto, 2015). One of the application of ICT is e-learning system.

The management of e-learning requires a set of media so that an appropriate outcome can be expected. *Learning Management System* (LMS) is a software application to be used by teachers as internet-based online learning media (Amiroh, 2012). LMS shows some excellence in which it is a unit of comprehensive software integrated at various features to send and manage learning (Riad & El-Ghareeb, 2008). LMS automatically handles the features of course catalogues, course delivery, marking and quizzes. Schoology is one of LMS facilities that enable teachers and students to interact with each other in a learning environment through online social network.

Scaffolding has been implemented extensively in ICT learning processes (Ching Huei Chen, 2014; Azevedo, Cromley*,* Moos, Greene, & Winters, 2011;Chang, Sung, & Chen, 2001). ICT-based scaffolding can give sufficient help that enable students to succeed in solving problems and doing complex tasks, as well as broadening the range of experiences from what they have learned (Davis & Linn, 2000).

The development of computer-based scaffolding as online learning media can be implemented as a solution to improve students' ability to solve problems and students' scientific attitude toward physics learning. Physics scaffolding teaching media are developed with multi representations based on the characteristics of physics teaching materials, such as 1) mathematical representations and 2) image/diagrammatic representations. As proper teaching media, physics scaffolding teaching media have to cover the aspects of materials, presentation/appearance, pedagogy, and physics e-scaffolding components.

The application of physics e-scaffolding media in classes has to be integrated in the lesson plans so that the media can be optimally used. The detailed activities in students' worksheets must also be integrated with physics e-scaffolding teaching media in order to direct the students to more focused activities. Thus, physics e-scaffolding teaching media developed in class must be equipped with lesson plans, students' worksheets, the result of problem solving ability test, and students' scientific attitude observation form.

Methodology

Type of the Research

This is a research and development (R&D) development model proposed byBorg& Gall that consists of 10 steps. Borg & Gall (1983)suggest 10 steps in conducting an R&D research. They are (1) gathering information (including review of literature, class observation, and research framework); (2) planning (formulating research objectives, estimating time allotment as well as funds, and research procedure); (3) developing prototypes (developing Preliminary Form of Product); (4) preliminary field testing; (5)main product revision; (6) main field testing; (7) revision of product; (8) operationalfield testing; (9) the final productrevision; and (10) product dissemination.

Development Procedure

The development procedure in this research includes preliminary study, planning, development, and testing. Preliminary study was conducted to obtain information on field preliminary needs that will become the base of product development. The preliminary study consists of literature review and field study. Literature review covers collecting information related to literature that supports physics e-scaffolding media product development. The field study is an activity conducted to discover problems related to physics learning in schools, the practice of physics learning, and the need for physics learning media. The field study is done by conducting learning observation, distributing questionnaire on needs analysis to the students, and interviewing the physics teachers.

At the step of planning, analysis on the curriculum and learning objectives is conducted. The curriculum analysis covers the activity of core competences analysis, basic competences, indicators of competence achievement, the form of marking, and the materials. At the end of this stage the map of material concepts is obtained and will be presented in forms of products and learning.

The step of product development consists of initial product development and validation. The stages in product development include (1) designing product format; (2) establishing product assessment instruments; and (3) developing a product by referring to the analysis result in the stage of planning. The final result of product development is product assessment instruments and the first draft of the product. The validation covers product assessment instrument validation and product validation.

The stage of product testing is done through two steps, i.e.limited trial and comprehensive testing. The limited trial is conducted by implementing the teaching process in one class. The experiment group was tested using comprehensive testing, while the control group wastested using quasi-experimental method with a Nonequivalent Control-Group PretestPosttest Design.

Subject of the research

The research subject to test the developed product in this research was the eleventh grade high school students during the first semester of the academic year of 2015/2016. The subject for the limited trial was a class consisting of 24 students. The subject for comprehensive testing was the eleventh grade students of SMA Negeri 2 Wonosari (Wonosari Public High School 2).

Data analysis techniques

Feasibility analysis

Data analysis techniques toward e-scaffolding evaluation begins with the tabulation of all data obtained for each aspect and criteria provided in the evaluation items in the evaluating instruments. The average score for each aspect of each validator is calculated using the following formula:

$$X_n = \frac{Score\ number\ of\ each\ aspect}{Item\ number\ of\ each\ aspect} \quad (1)$$

X_n = Validator number $-n$
and n = 1, 2, 3, 4, 5, and 6.

Further, the average score of each aspect marked by the validator applies the following formula:

$$\bar{X} = \frac{\sum X_n}{6} \quad (2)$$

Notes :
$\bar{X}$ = average score of each aspect

$\sum X_n$ = average score number of each aspect by each validator with n = 1, 2, 3, 4, 5, and 6.

The average score of each aspect is modified into feasibility categories with a five-scale marking standard. The reference of score modification into a scale five marking standard is (Azwar, 2011: 163) as seen in Table 1.

Table1. Marking score conversion ofe-scaffoldingby the validator

Interval	Category
$X > 4$	Very good
$3.3 < X \leq 4$	Good
$2.7 < X \leq 3.3$	Average
$2 < X \leq 2.7$	Poor
$X \leq 2$	Very poor

The product feasibility is determined based on the category in the five-scale marking standard out of the average score of all aspects in the evaluation instruments using the following formula:

$$p_n = \frac{\sum Score\ of\ all\ aspects}{\sum aspects} \tag{3}$$

p_n = Product assessment score with n = physics *e-scaffolding*, lesson plans, students' worksheets, problem solving ability test, scientific attitude observation form, and students' response questionnaire.

The validity of product assessment instruments is determined using validity coefficient developed by Aiken (1985: 133) as seen in the following formula:

$$V = \frac{S}{[n\,(c-1)]} \tag{4}$$

with $S = \sum n_i\,(r - l_0)$ (5)

Notes: V is Aiken's validity coefficient, n_i is number of raterschoosing the criteria, c is number of category/criteria, r is criteria no.i, l_0 is the lowest category, and n is total number of raters.

In this research, the number of raters used is 6 persons with a range of values between 1-5. Therefore, Aiken's coefficient must be ≥ 0.79 (Aiken, 1985: 134).

The agreement percentage from the assessors is calculated using the following equation (Borich, 1994).

$$R = \left(1 - \frac{A-B}{A+B}\right) \times 100\% \tag{6}$$

Notes: $R$is assessor's agreement percentage, A is high scores given by assessors, and B is low scores given by assessors.

Borich (1994) also explains that the value of R is bigger than or equal to75% (≥ 75%) for good instruments.

In this research the minimum score for product feasibilityis in good category. This means that the product developed is feasible to be implemented as teaching media according to the validator.

Analysis of Lesson Plan Implementation

The analysis of lesson plans implementation is done by summing up the number of "YES" and "NO" answers on each component in the teaching performance form, which then is calculated into percentages. The observation of physics teaching performance is focused on the steps stated in the lesson plan. The percentage of the implementation of the lesson plan is calculated by using the following formula:

$$P = \frac{\sum X}{n} \times 100\% \tag{7}$$

Notes: P is percentage of the implementation of lesson plans, $\sum X$ is total number of "YES", and N is number of components of lesson plan implementation.

Analysis of the scientific attitude observation form

The analysis of the scientific attitude observation form is conducted by calculating the average of the total score of students' scientific attitude and then converting it into a categorization. The conversion of scientific attitude score uses a 4-scale marking standard according to Mardapi (2008:123) as presented in the following table 2.

Table 2. Modification ofscore and conversion

Interval	Category
X ≥ 3.1	Very good
3.1 > X ≥ 2.5	Good
2.5 > X ≥ 1.9	Poor
X < 1.9	Very poor

Analysis of students' response questionnaire

The analysis of students' response questionnaire is conducted to obtain data on students' response toward physics e-scaffolding media and students' worksheets. The score obtained from the students' response questionnaire is calculated using the following formula:

$$A = \frac{\sum x}{n} \tag{8}$$

Notes: A is response questionnaire score, Σx is total score, and n is number of statement items in the questionnaire.

The students' response questionnaire uses the 5-scale scoringcriteria for each item can be seen in Table 1.

Analysis of the differences in scientific attitude and problem solving ability

The analysis on the improvement of students' problem solving ability and scientific attitude uses the method of normalized gain. The formula to calculate gain according to Hakes (1999) is as follows:

$$\langle g \rangle = \frac{(\text{\%posttest -\% pretest})}{(100\text{-\%pretest})} \tag{9}$$

$\langle g \rangle$is the normalized gain score, % posttest is the percentage of average posttest, and % pretest is the percentage of average pretest. Hake (1999:1) divides the normalized gain score into three categories as presented in Table 3.

The improvement on problem solving ability and scientific attitude in the experiment class and the control group is tested using multivariate testing. The required prerequisite testing before conducting multivariate testing is normality test and homogeneity test.

Table 3. The category of normalized gain score

Interval	Category
$\langle g \rangle \geq$ **0.7**	High
0.7 $> \langle g \rangle \geq$ **0.3**	Moderate
$\langle g \rangle <$ **0.3**	Low

Normality test on data distribution

The normality test is used to find out whether or not the data originate from the normally distributed group. The normality test is done on the data gain on problem solving ability and scientific attitude in the experiment class and the control group. The calculation of the normality test is conducted by using the statistics of *Kolmogorov-Smirnov*testing with the level of 5%. *Kolmogorov-Smirnov*testing is done using the SPSS 21 for Windows program. The criteria for decision making is accepting Ho if the significance is bigger than 0.05. Meanwhile, the hypothesis for the normality test is as follows:
Ho: Data originated from normally distributed population
Ha: data originated from not normally distributed population

Homogeneity test

Homogeneity test aims at finding out whether or not the data obtained from the experiment class and the control group have the same variance. This testing is done on the gain of the students' problem solving ability and scientific attitude from the experiment class and the control group. The calculation of homogeneity test is done using *Levene* homogeneity model with the significance level 5%. Levene testing is done using SPSS 21 for Windows program. The hypothesis proposed to measure homogeneity is as Ho is data variance are the same (homogeneous) and Ha is data variance are different (heterogeneous). The criteria used to determine the variance homogeneity is accepting H_o if the significance score is (2-tailed) >αas determined, that is, 0.05.

Variance/covariance matrixhomogeneity test

The assumption to be fulfilled in MANOVA is the similarity of variance/covariance matrix between the groups on dependent variables. To test this requirement Box's M testing on SPSS can be applied. Ho is variance/covariance matrix from the same dependent variable and Ha is variance/covariance matrix from different dependent variable. The criteria used to determine the homogeneity of variance/covariance matrix is accepting Ho if the significance score is (2-tailed) >αas determined, that is, 0.05.
Hypothesis testing

After the fulfillment of prerequisite testing, the data of problem solving ability and scientific attitude are analyzed using MANOVA with the help of SPSS 21 for Windows. Statistical hypothesis tested in this research includes

Ho: There is no significant differences in effectiveness in problem solving ability (Y_1) and scientific attitude (Y_2)between the students taught using physic e-scaffolding media and the students taught using the teaching media provided by the teacher.

Ha: There is a significant difference between the students taught using physic e-scaffolding media and the students taught using teaching media provided by the teacher.

The conclusion whether or not Ho is accepted is obtained by interpreting MANOVA significant score using SPSS21 for Windows. If the significant value <0.05, Ho is rejected.

Result and Discussion

The result of feasibility test

The feasibility test result consists of validation of product and assessment instrument. The validation of the product assessment instrument is done in two ways, FGD and expert validation. 2 lecturers and 18 students of physics education of Yogyakarta State University Graduate Program. Based on the result of the FGD and expert validation, all the product assessment instruments are 100% valid and applicable for the research with minor revision.

The result of product validation is done by two expert validators and four practitioners who teachphysics in high schools. Based on the validation result, all the products are categorized as very good. The result of product validation can be seen in Table 4.

Table 4. Product Validation by Experts and Practitioners

No	Product	Score	Category
1	Physics e-scaffolding	4.4	Very good
2	Lesson plans	4.4	Very good
3	Students' worksheets	4.4	Very good
4	Problem solving ability test	4.5	Very good
5	Scientific attitude observation form	4.4	Very good
6	Student's response questionnaire	4.3	Very good

The validity analysis on assessment involving six raters fulfills the category of valid with V Aiken score of $\geq$ 0.79 for all items. The reliability of the assessment instrument is categorized as reliable with (R) $\geq$ 75% based on Emmer and Millet's conformity percentage (R). Based the validity and reliability analysis on each instrument, it is found that all the items in the instruments are valid and reliable.

The result of limited trial

The implementation of lesson plans in the first up to the sixth meeting reaches $\geq$ 75%. This means that the learning process held has a good conformity rate to the developed students' worksheets. The data of the implementation of students' worksheets can be seen in Table 5.

Table 5. Data of the implementation of students' worksheets in limited trial

Meeting	Average score	Implementation (%)
1	16	100
2	16	100
3	15.5	96.88
4	15	93.73
5	16	100
6	15.5	96.88

The result of problem solving ability test in the pretest and posttest during limited trial shows that the lowest score is 25.00 on the pretest and 27.50 on the posttest. Meanwhile, the highest score is 55.00 on the pretest and 97.50 on the posttest. The average score of problem solving ability among the grade XI MIA 2 students is 38.13 on the pretest and 60.83 on the posttest. The result of the pretest and posttest in the limited trial is presented in Table 6 below.

Table 6. The result of problem solving ability in limited trial

No	Score	Highest	Lowest	Average
1	Pretest	55.00	25.00	38.13
2	Posttest	97.50	27.50	60.83
3	N-Gain	0.94	0.11	0.37

The n-gain of students' problem solving ability is divided into high category, one student, average category, 15 students, and low category, 8 students. The average gain in problem solving ability is 0.37 within the average category. The data of students' problem solving ability gain can be seen in Table 7.

Table 7. The data of students' problem solving ability gainin limited trial based on N-gain

No	Criteria	Number of students	Class average	
			n-gain	Criteria
1	High	1	0.37	Average
2	Average	15		
3	Low	8		

The observation on the students' scientific attitude during limited trial shows that there is a gain both in their curiosity and cooperation. Figure 1 shows the gain of students' scientific attitude. The measured scientific attitude forms a curve that tends to lean to the top right. This denotes that students' scientific attitude during limited trial tends to improve in every meeting.

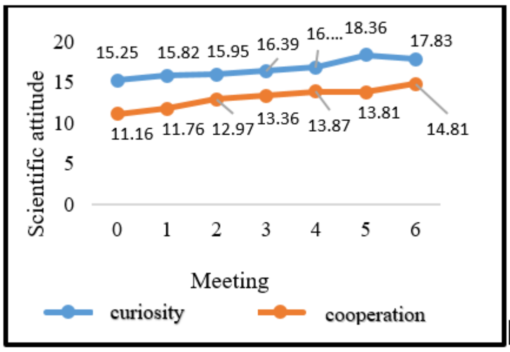

Figure 1. Graph of students' scientific attitude gain in limited trial

The n-gain of cooperation is within the average category, while the gain of curiosity is in the low category. Table 8 in general shows that the average gain of scientific attitude in the limited trial is 0.24 in the low category. This is due to the exercise which has been designed at a high level of difficulty. Thus, adjustment is done.

The revision after limited trial is done on the product especially on the level of difficulty of the exercises, the addition of more various colors, and addition of product animation.

Table 8. The gain of curiosity and cooperation in limited trial

No	Curiosity				Cooperation			
	Criteria	Number of students	Average N-gain	Average Criteria	Criteria	Number of students	Average N-gain	Average Criteria
1	High	-	0.17	Low	High	-	0.35	Average
2	Average	3			Average	17		
3	Low	21			Low	7		
Average of scientific attitude			**0.24**		**Category**		**Low**	

The questionnaire on the response toward physics e-scaffolding media and students' worksheets was distributed to 24 eleventh grade students of MIA 2, SMA N 2 Wonosari after the teaching process was completed using the designed product. The result of the students' response analysis is presented in Table 9. Students' response to the physics e-scaffolding media is good, and is very good for the students' worksheets. Based on the students' response, it can be concluded that physics e-scaffolding media and students' worksheets can be applied in the physics learning.

Table 9. Analysis result of students' response in limited trial

NO	Product	Students' response	Category
1	Physics e-scaffolding	3.92	Good
2	Students' worksheets	4.12	Very good

Field trial result

The data on the implementation of the lesson plans in limited trials is presented in Table 10. The completion of implementation of lesson plans in the first to the sixth meetings is bigger than 75%. This means that the appropriateness of the designed lesson plans and the process of learning is good.

Table 10. Data on the implementation of lesson plans in field trial

Meeting	Average score	Implementation (%)
1	16	100
2	16	100
3	16	100
4	15.5	96.88
5	15.5	96.88
6	16	100

The result of problem solving ability test shows that the lowest pretest score in experiment classis 15 and the highest score is 55, and the average is 36.56. Similar result is also found in the control group. The lowest score is 15, the highest is 55, and the average is 36.56. In experiment class, the lowest score in the posttest is 55, the highest is 100, and the average is 67.92. Meanwhile the lowest score of the posttest result in the control group is 22.50, the highest is 77.50, and the average is 56.35. Figure 1 and 3 present the n-gain histogram in both the experiment class and control group.

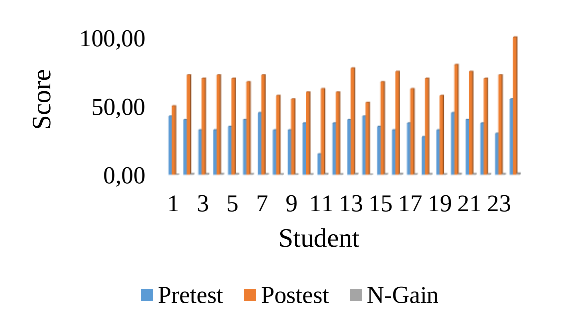

Figure 2. N-Gain Histogram on Student's problem solving ability in theexperiment class

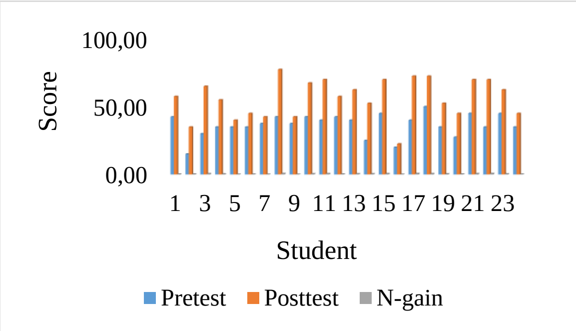

Figure 3. N-Gain Histogram on Student's problem solving ability in control group

The comparison between the number of students in the experiment class and the control group based on three-scale marking can be observed in Table 11. In the control group, thirteen students gain theirproblem solving ability at the "average" category, and 11 students at the "low" category. No student gains the problem solving ability at "high" category. The average n-gain in the control group is 0.32which is in the average category. In the experiment class, there is one student whose problem solving ability is high, 21 students are at the average category, and two student belong to low category. The average n-gain in the experiment class is 0.50 which is categorized as average.

Based on the elaboration of the field test result, it can be concluded that the gain in problem solving ability in the experiment class is higher than that in the control group. It is obtained from the ratio of the n-gain of the two groups. The result shows that the average score of n-gain in the control group is lower than that in the experiment class.

Table 11. Ratio of N-gain in experiment class and control group

Group	Criteria			N-gain score		Averagen-gain	
	High	Average	Low	The highest	The lowest	Average	Category
Control	-	13	11	0.61	0.08	0.32	Average
Experiment	1	21	2	1.00	0.13	0.50	Average

Observation of the process of learning is conducted to measure the gain in students' scientific attitude. Figure 4 shows the observation result of students' scientific attitude during the learning process both in the experiment class and the control group.

In average the students' scientific attitude gain during the process, but the one in the control group tends to remain the same.

The calculation of n-gain of the scientific attitude before the treatment and during the treatment in the experiment class and control group can be seen in Table 12. This table indicates that the gain of scientific attitude in the experiment class is higher than the one in the control group.

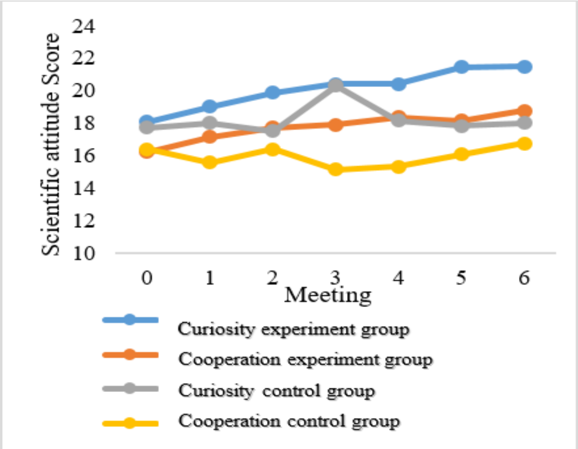

Figure 4. Chart of Scientific attitude gain in the gain scientific attitude in experiment class and control group

Tabel 12. The ratio of the n-gain of scientific attitude in experiment class and control group

Class	**Criteria**			**N-gain score**		**Average n-gain**	
	high	average	low	highest	lowest	average	category
Experiment	-	17	7	0.50	0.16	0.33	Average
Control	-	-	24	0.11	-0.11	0.01	Low

The questionnaire on students' response to the product is distributed to 24 students in the experiment class after the process of learning is completed. The result is presented in Table 13. Based on the result of the questionnaire, it can be seen that the students' response toward physics e-scaffolding media and students' worksheets is very good. Thus, it can be concluded that the product developed can be well accepted by the students.

Table 13. Analysis result of students' response in the field test

No	Product	Students' response	Category
1	Physics e-scaffolding media	4.34	Very good
2	Students' worksheets	4.32	Very good

Normality Test

The result of normality test which has been conducted using *Kolmogorov-Smirnov*test can be seen in Table 14. Based on the result, the gain significance score on the problem solving ability and scientific attitude in the experiment class and control group is > 0.05, H_0 is accepted. This shows that the gain in problem solving ability and scientific attitude is normally distributed.

Tabel 14. The result of Normality test using *Kolmogorov-Smirnov*test

Class	Variable	Kolmogorov-Smirnov
experiment	Problem solving ability	0.83
	Scientific attitude	0.200
control	Problem solving ability	0.200
	Scientific attitude	0.185

Homogeneity Test

*Levene*test is used to conduct homogeneity test with the level of 5%. The result of this test can be seen in Table 15. Based on the test result, the gain significance score of students' ability in problem solving and scientific attitude is > 0.05. So, H_0 is accepted. This shows that the gain of students' problem solving ability and scientific attitude has relatively the same variance.

Table 15. The result of *Levene's* Test

Variable	Levene's Test
Problem solving ability	0.610
Scientific attitude	0.837

Variance/covariance matrix homogeneity test

Variance /covariance homogeneity is tested using *Box Matrices*. The result of Box's M is displayed in Table 16. The result of SPSS shows that Box's M score is 1.699 and the significance is 0.655. The significance obtained is bigger than 0.05. This denotes that zero hypothesis is accepted, which means that the variance/covariance matrix of the dependent variable is homogeneous. The assumption of this test is fulfilled, so MANOVA test can be conducted.

Table 16. Variance/Covariance Matrix Homogeneity Test

Box's M	Significance
1.699	0.655

MANOVA Test

Multivariate test is done to find out the average differences on the average gain of problem solving ability and scientific attitude in the experiment class and control group. The test on gain differences on problem solving ability and scientific attitude is done using Multivariate test/Hotelling's Trace with the significance level of 5%. The result of the test can be seen in Table 17. The gain of Hotelling's Trace test result on problem solving ability and scientific attitude shows a significance score of < 0.05, so H_0 is rejected. Based on the result of the hypothesis test using Hotelling's Trace, it can be concluded that there is a significant difference in the average gain of problem solving ability and scientific attitude among those who learn using physics e-scaffolding media and using the media designed and provided by the teacher.

Table 17. The result of *Multivariate test/Hotelling's T2*on Problem solving ability and scientific attitude

Effect	Sig.
Hotelling's Trace	0.00

Conclusion and Suggestions

Based on the result of the research, it can be concluded that (1) physics e-scaffolding teaching media equipped with Lesson plans, students' worksheets, problem solving ability test, and scientific attitude observation form fulfill the feasibility criteria in accordance with the expert's (experts of materials and expert of media)and practitioners' validation and were categorized as "very good." Physics e-scaffolding teaching media gain positive responses from the students in the "very good" category; (2) Physics e-scaffolding teaching media is effective to improve students' ability in problem solving. It is shown by the significance differences of the multivariate test result toward the n-gain of the ability to solve problems, curiosity, and cooperation in the experiment class and control group. The significance score is < 0.05.

Disclosure statement

No potential conflict of interest was reported by the authors.

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