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Developing Students' Responsibility and Scientific Creativity through *Creative Responsibility Based Learning in Learning Physics*

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Abstract

Development of scientific responsibility and creativity in learning physics are included in the key competencies in the industrial era 4.0. However, both of these competencies are not used in school. Therefore, the purpose of this study is to analyze the effectiveness of Creative Responsibility Based Learning in developing students' responsibility and scientific creativity. This research is part of the research and development of the ADDIE model. Trial implementation using one group pre-test and post-test design on 27 students of Class XI-2 MAN 2 Banjarmasin. Data collection instruments consist of responsibility observation and scientific creativity tests. After being CRBL implemented, the students' responsibility increased at each meeting in good criteria. Also, the value of n-gain scientific creativity by 0.34 in moderate criteria. Thus, CRBL is effective in developing the students' responsibility and scientific creativity in learning physics.

Keywords: *CRBL, responsibility, scientific creativity*

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INTRODUCTION

Physics have cultural, intellectual, and responsibility values in printing creative products to solve the problems of people's lives and the environment (Suratno, Komaria, Yushardi, & Wicaksono, 2019; Trianggono & Yuanita, 2018). Scientific creativity becomes a source of innovation or new products as solutions to complex and diverse problems (Suacamram, 2019). However, the responsibility role is needed so that the creative product is utilized for the good of the community. Responsibility encourages individuals to try to do their best to achieve the desired goals (Blascova, 2014; Suyidno, Susilowati, Arifuddin, Misbah, Sunarti, & Dwikoranto, 2019). In other terms, the integration of responsibility and scientific creativity in learning physics can produce creative products that are beneficial to people's lives and their environment.

In the industrial era 4.0, creative products of science have influenced various fields of human life. Its activities start to wake up to sleep again without being separated from technology. However, the negative impact is the problem of life becomes increasingly complex and diverse (Suratno et al., 2019; Suyidno, Nur, Yuanita, & Salam, 2020). This can create opportunities as well as threats to human survival and career. In contrast to creative and responsible individuals, each problem can be an inspiration and imagination to try to produce useful creative products (Suyidno et al., 2019). Students are responsible for using their scientific knowledge (facts, concepts, principles, laws, theories) and process skills in developing students' scientific creativity (Rachmawati, Kirana, & Widodo, 2018; Suyidno et al., 2019; Zubaidah, 2018). Therefore, the development of responsibility and scientific creativity plays an important role in the era of the industrial revolution 4.0 even in the era of society 5.0.

The scientific creativity in learning physics has similarities with general creativity in terms of fluency, flexibility, and originality. However, scientific creativity is more emphasized on the ability to find and solve problems, science experiments, and creative science activities (Siew, Chong, & Chin, 2014). Scientific creativity facilitates unusual use, problems finding, products, improvement, scientific imagination, science problem solving, experiments, creative product design; and creative products (Suyidno et al., 2020). Scientific creativity becomes more useful when equipped with responsibilities in learning and life. Students are accustomed to participating, respecting others, cooperating, leading, and expressing opinions during the learning process (Rolina, 2014; Suyidno et al., 2019). Thus, the integration of responsibility and scientific creativity encourages students to try to become creative and useful future generations.

Suyidno et al (2019) and (Suyidno, Nur, Yuanita, Prahani, & Jatmiko, 2017) found that students only understand the responsibilities and scientific creativity still limited to knowledge, and difficulty of actualizing it in solving problems in real life. This is confirmed by the results of observations of researchers in class XI MIPA 2 MAN 2 Banjarmasin Model that the students' score in problem finding is 0.00; having scientific imagination of 39.71; creative problem solving by 34.57, and creative products design by 14.07. All of the indicators do not meet the Minimum Completeness Criteria (MCC = 75.00). Also, the results of the questionnaire students' responsibility obtained scores of participating, respecting others, cooperating, leading, and expressing their respective opinions 66.30; 72.59; 75.93; 69.26; and 66.48. Even though the score of respect for others and cooperation is above 70. In reality, some students still have difficulty actualizing it in learning. Thus, the responsibility and scientific creativity of students become major problems in learning physics.

The students' responsibility and scientific creativity can be explored properly provided that teachers can use appropriate learning models in the classroom (Suratno et al., 2019), among which are Creative Responsibility Based Learning (CRBL). The CRBL includes innovative learning that maximizes the responsibility and science process skills of students in developing their scientific creativity (Suyidno, Dewantara, Nur, & Yuanita, 2017; Suyidno et al., 2020, 2019). The main theories underlying CRBL are cognitive theory, complex cognitive processes, sociocognitive, and constructivism. This cognitive theory in addition to involving the relationship of the stimulus with the response also involves complex thinking processes. The thought process can take the form of digging information, solving scientific problems, and practicing something based on scientific methods (Siregar & Nara, 2010). The complex cognitive processes make it easy for students to apply scientific knowledge and process skills in making creative products (N. Suyidno et al., 2017). Albert Bandura who explained three factors that greatly influenced the learning process, namely: social, cognitive, and doers (Chaer, 2016). Social factors include the behavior of students to observe the concepts given by teachers in learning. The theory of constructivism gives freedom to students to find and implement their creative ideas and as an effort to provide awareness to learn to students (Suprihatiningrum & Rovik, 2016). This is reinforced by the results of previous studies including Suyidno et al (2017) found that CRBL can maximize the students' process skills in creative product design. Surif, Wulansari, & Fatmawati (2015) concluded that the activities of students during the productive learning process were in a good category. Also, Suyidno et al (2019) found that CRBL can increase the responsibility and scientific creativity of high school/MA students in the medium criteria.

Based on the descriptions above, the purpose of this study is to analyze the effectiveness of CRBL in developing students' responsibility and scientific creativity in learning physics. It's beneficial for students in dealing with various problems in their future lives.

METHOD

This research is research and development. The independent variables are CRBL tools, while the dependent variable is students' responsibility and scientific creativity. The study was conducted from September to December 2019. Subjects in this research were 27 students of Class XI-2 MAN Banjarmasin on Static Fluid material.

This research and development use the ADDIE model. In the previous stage (Analysis, Design, Develop) CRBL tool designs that included lesson plans, teaching materials, worksheets, and scientific creativity tests were produced. The tool has also been validated by three experts to obtain validity and reliability scores for lesson plan (3.11, 0.86); teaching materials (3.05, 0.87); worksheet (3.11, 0.60); responsibility questionare and scientific creativity test (3.17, 0.81). It means CRBL tools are valid and reliable as supporting devices in class trials. Next, the researcher revised the device based on suggestions from the validator.

At the Implementation and Evaluation stage, the researchers tried out the CRBL tool using one group pre-test and post-test design: O1 X O2. This research begins by asking students to do a pre-test of scientific creativity (O1), that is they do an essay test to find scientific problems, to imagine the science, solve problems creatively, and creative design products. Furthermore, the implementation of learning physics using CRBL tools for 4 meetings (X), where students are divided into 6 teams. The activities of teachers in guiding CRBL are presented in Table 1.

Table 1 Implementation of CRBL

Phase	**Meeting**			
	1	**2**	**3**	**4**
Generating creative responsibility	√	√	√	√
Organizing creative learning needs	√	√	√	√
Guiding group investigations	√	x	√	√
The actualization of creative responsibility	x	√	√	√
Evaluation and reflection	x	√	√	√

Note: √ = implemented; x = not implemented

At meeting 1, teachers can raise students' responsibility by asking them to mention the use of objects for scientific purposes (for example: writing down as much water as possible); organizing creative learning needs (forming 6 creative teams, presenting students’ worksheet and various reference sources); guiding group investigations (conducting scientific discussions to find creative solutions). However, the existence of unexpected school activities and causing the learning process must end, then at meeting 1, there was no creative responsibility phase of writing. However, it immediately ended with evaluation and reflection. Meeting 2 as a continuation of meeting 1; teachers remind students of the creative responsibilities of students and their creative learning needs. Students are allowed to actualize their creative responsibilities (presentations and discussions on the results of scientific investigations), then end with evaluation and reflection. At meetings 3 and 4, each phase was carried out in full. During the learning process, 2 observers observe the behavior of students' responsibilities in participating, respecting others, cooperating, leading, and expressing opinions. Furthermore, this study ends with asking students to do a post-test of scientific creativity (O2), while the post-test indicators are the same as pre-tests.

The score of students' responsibility is obtained from the total score given by the observer divided by the number of observers multiplied by 100. Meanwhile, the results of the pre-test and post-test scientific creativity are converted to quantitative data using the assessment rubric in Table 2.

Table 2 Rubric assessment of scientific creativity

Indicator	Dimension	Criteria
1. Problem finding	Fluency	Counting all the correct responses that have been given. Every correct response is given a score of 1.
2. Scientific imagination	Flexibility Originality	Counting the number of correct approaches given. Tabulating the frequency of all correct responses obtained. The frequency and percentage of each response are calculated and chosen one of the answers that have the smallest probability of response. If the response probability is smaller than 5%, a score of 2 is given; if a probability of 5 to 10% is given a score of 1; if the response probability is greater than 10%, a score of 0 is given.
3. Science problem solving		
4. Creatively product design	Flexibility Originality	Each function is correctly given a score of 1. Giving a score of 1 to 5 based on a holistic assessment.

(Suyidno et al., 2020)

Based on the conversion results in Table 2, the value of scientific creativity is the total score of scientific creativity obtained divided by the highest score of students in the class and multiplied by 100. Acquisition of responsibility and scientific creativity is adjusted to the criteria: 0-40 (not good); 41-55 (poor); 56-65 (enough); 66-80 (good); 81-100 (very good) (Suyidno et al., 2020). In addition, the level of improvement in students' scientific creativity was calculated using the N-gain equation (Hake, 1998) with criteria: 0.00-0.29 (low); 0.30-0.69 (moderate); 0.70-1.00 (high).

RESULT AND DISCUSSION

The effectiveness of CRBL is seen from the attainment of students' responsibility and scientific creativity. The results of the effectiveness data analysis are described below.

Responsibility

Data responsibility is obtained from observing the behavior of students during the learning process. The results of the analysis are presented in Table 3.

Table 3 Learners responsibilities per indicator

Indicator	A score of the Creative team …					
	1	2	3	4	5	6
Participation	74,46 (G)	74,21 (G)	74,96 (G)	77,25 (G)	76,13 (G)	77,17 (G)
Respect others	73,67 (G)	73,92 (G)	73,58 (G)	77,50 (G)	79,33 (G)	78,33 (G)
Cooperation	74,17 (G)	75,79 (G)	80,71 (VG)	75,50 (G)	75,42 (G)	77,08 (G)
Lead	74,58 (G)	76,38 (G)	76,13 (G)	75,54 (G)	76,71 (G)	76,67 (G)
Express an opinion	69,67 (G)	75,88 (G)	72,58 (G)	75,00 (G)	77,13 (G)	75,33 (G)

Noten: B = good; SB = very good

In the above indicators, all creative teams obtained good criteria, and even team 3 was able to work very well together. This means students have been able to take responsibility while studying physics. This supports the acquisition of responsibility scores at each meeting in Figure 1.

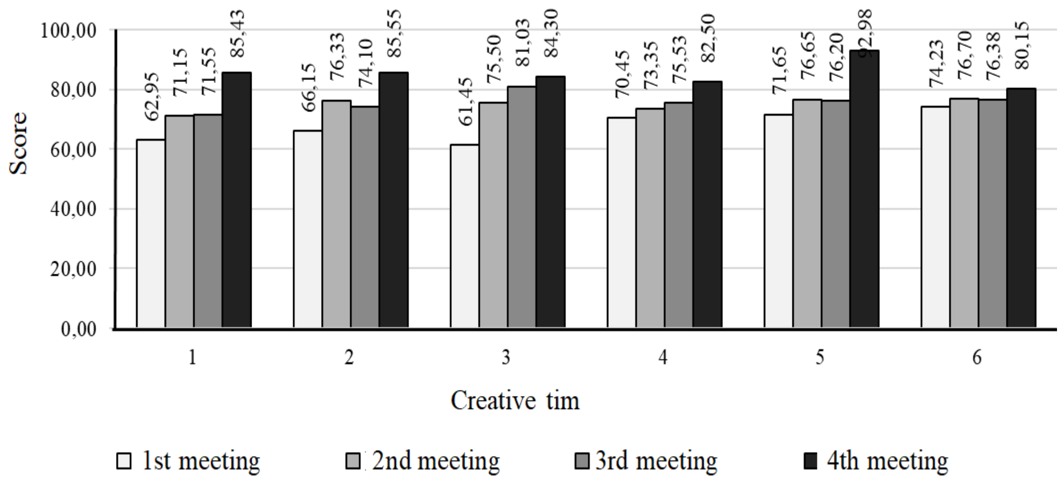

Figure 1 Learners' responsibilities at each meeting

Based on Figure 1, each team generally experienced increased responsibility at each meeting. However, there was a decrease in scores on teams 2, 5, and 6 at the third meeting. In all three teams, students are less focused on learning in class since they prepare themselves for tests on other subjects. However, at the fourth meeting, it was resolved and the score increased again.

At the first meeting, where students have just been involved in activities with

CRBL, four teams have good responsibilities, while the two teams are still quite good, namely Team 1 and 3. The ability of students (Team 1) in expressing opinions is good, not better than other teams. When discussing groups, they can express opinions to their group colleagues. However, when class discussions, only a few students who express their opinions. Teachers have asked several students to express their opinions as best they can; however, they still feel lacking confidence even some do not dare to speak. In Team 3, there are already members who lead in good criteria, however not better than other teams.

At the second meeting, the educator has overcome the problem at the first meeting by asking students to take a leadership role in the team and appointing passive students to present the results of their team's performance so that the whole team is in good criteria. All the teams in the 4th meeting were in very good criteria, except team 6 was still in good criteria. The involvement of students' responsibilities is since CRBL facilitates the role of the students' responsibilities in each phase (Suyidno et al., 2019). Responsibility as a personality trait drives students to try their best, never give up, and be useful (Rolina, 2014). The application of CRBL can explore the responsibilities of students in supporting their success in learning.

Scientific Creativity

Data on scientific creativity was obtained from the pre-test and post-test of students. The results of students' scientific creativity analysis after being applied by CRBL are presented in Table 4.

Table 4 Results of pre-test and post-test of scientific creativity

Indicator	***Pre-test***		***Post-test***		***N-Gain***	
	Score	**Criteria**	**Score**	**Criteria**	**<g>**	**Criteria**
Problem finding	0,00	Not good	35,58	Not good	0,36	Medium
Scientific Imagination	39, 71	Not good	60,87	Enough	0,35	Medium
Science problem solving	34, 57	Not good	69,96	Good	0,54	Medium
Product design	14, 07	Not good	48,20	Poor	0,40	Medium

Pre-test data show that the students' scientific creativity was initially low. Students have difficulty formulating the problem of applying Pascal's law to hydraulic pumps since they have not been trained in writing the formulation of problem. After being implemented by CRBL, it turns out there are students who still have difficulty writing the formulation of the problem since there are differences in the ability of students to formulate the problem, where there is one student who can write a problem statement with a large number of 6 problem formulations. Meanwhile, other students write less and consequently their scores are still low (the maximum score is the highest student score). Another factor is that many students have original answers with a large frequency, resulting in an originality score of 0 (zero). However, the results of the n-gain test showed that there was an increase in the ability to find scientific problems in the medium criteria.

On indicators of scientific imagination, students are asked to write down what will happen if there is a sophisticated technology similar to a submarine, however operating in the air. During the pre-test, 9 students were unable to write the answers. Even though many students have written answers, in Table 6, the average score of scientific imagination in the criteria is not good since it provides few answers (substandard), approaches that are not diverse (less flexible) and between students have the same answer (less original). On the contrary, the results of the post-test showed students were able to provide more variations of answers than during the pre-test. Students can give answers with a low frequency; however, they can think outside the box. The average class score for scientific imagination is still quite good in the criteria since there are still differences in the ability of students, one student gives a large number of answers, while most give a small number of answers. This is very influential in the smoothness score. Also, students were still found who had alternative original answers with a large frequency so that the originality score was 0 (zero). The average score of the scientific imagination of students has not yet met the MCC. However, the results of the n-gain test show there is an increase in the ability of scientific imagination in the medium criteria.

On the indicator of solving science problems creatively, students look for solutions to overcome problems on pontoon drums that are often rocky, slippery, and less safe for users. During the pre-test, eight students were unable to provide answers due to a lack of knowledge about the pontoon drum. In contrast, the results of the post-test showed students were able to provide several different alternative answers. The score of problem-solving is in good criteria. This is reinforced by the results of the n-gain calculation that there is an increase in the ability to solve problems in the medium criteria. This means that the application of CRBL influences the imagination of students in solving problems creatively.

Furthermore, when students are asked to design creative products that make it easy for humans to dive and their functions. During the pre-test, 20 students had difficulty designing the product since they were not skilled in drawing and did not understand what to draw. After a post-test, all students can provide answers. The most widely written designs are the wetsuit designs; they provide several additions to the equipment in certain parts to make it more useful. One of the unique findings is that there is a jetski design that can dive and drive freely in the sea. Unfortunately, the product design score is still in poor criteria. The factor that caused it was that there were still many students who did not write the function of the tool they were designing. However, the acquisition of n-gain scores showed an increase in the ability to design creative products within the criteria of being. This means that the application of CRBL affects the imagination of students in designing creative products.

The results of the n-gain value indicate the application of CRBL can improve indicators of scientific creativity of students within the criteria of being, however, has not yet reached the MCC. Based on the results of the researchers 'interview with teachers obtained information on various barriers to scientific creativity that interfere with them, recognizing students' creative ideas are presented in Figure 2.

Barriers to teachers in exploring scientific creativity
Teachers find it difficult to explore the scientific creativity of students since: (1) Limited time allocation of learning time so that teachers cannot provide enough information to students; (2) at the end of the meeting, teachers do not analyze what indicators are the weaknesses of students so that they can be overcome at the next meeting; (3) the lack of physical knowledge and its application makes it difficult for students to explore their creative ideas; (4) students lack the courage to give their original answers; (5) students are still not accustomed to finding problems creatively, most of them only refer to physical formulas or equations; (6) the ability to draw students is still lacking so they have difficulty in expressing creative ideas in the form of product design, and (7) there is a difference in the ability of students, where some students provide many answers, while most others give only a few answers.

Figure 2 Summary of the results of the interview about students' creativity barriers

Figure 2 shows the various barriers to scientific creativity that interfere with the ability of students to recognize their creative ideas. This finding is consistent with the findings of Suyidno et al (2019) that scientific creativity has so far been understood to be limited to knowledge, so participants are not accustomed to exploring their creative potential. The use of technology such as LCD and photocopying, on the one hand, can improve the quality of learning. However, on the other hand, it turns out that students are not accustomed to drawing so the picture quality is not good. Also, teachers need to try to maximize the creative responsibilities of students so that they are bolder and not afraid to present unique and unusual ideas. Another problem is the lack of knowledge in physics and its application, as well as current science issues making it difficult for students to explore scientific creativity. This is following the findings of Hu & Adey (2010); Siew et al (2014); Suyidno et al (2019) that scientific creativity depends on scientific knowledge and process skills of students. However, the results of the n-gain calculation of scientific creativity show an increase in scientific creativity as presented in Table 5.

Table 5 N-gain values of scientific creativity of students

$\bar{\Sigma}$ ***Pre-test***	$\bar{\Sigma}$ ***Post-test***	***N-gain***	**Criteria**
43.34	65.58	0.34	medium

Table 5 shows an increase in the pre-test and post-test scores of students' scientific creativity, where the n-gain value indicates that the level of increase in scientific creativity after applying CRBL is in the medium criteria. This is inseparable from the role of the creative responsibility of teachers who can carry out the CRBL phases well (Table 1). Teachers can explore students' abilities in finding scientific problems, imagining scientifically, solving problems, and designing products creatively within the criteria of being. This finding is by the findings of Suyidno et al (2019) that the application of CRBL can increase students' responsibility and scientific creativity.

The limitation of this research is that scientific creativity is only focused on problem finding, scientific imagination, solving scientific problems, and designing creative products. Meanwhile, other indicators such as determining the use of objects for scientific purposes, improving the quality of a product technically, creative science experiments, and creating creative products have not been trained. The learning process of only 4 meetings turned out not to be able to accustom students to become creative and responsible individuals. This can be seen from the achievement of responsibility in the medium criteria and the value of the scientific creativity post-test under the MCC. Another limitation is the implementation of teaching and learning between worship and rest activities. Therefore, teachers need more time to organize learning readiness in class. As a result, teachers lack sufficient information about scientific creativity.

The effectiveness of CRBL in this study can be seen from the increased responsibility of students at each meeting (Figure 1), and the n-gain value of scientific creativity shows there is an increase in the criteria of being (Table 5). Therefore, CRBL can be used to explore students' scientific responsibility and creativity. Also, the positive belief of teachers in their creativity and learning needs to be maintained or enhanced so that students' scientific responsibility and creativity can be explored to the fullest. This positive belief can be a motivator to try their best, dare to innovate and be creative, and take the right decision to overcome every problem it finds.

Given the responsibility and scientific creativity, including one of the competencies in the industrial era 4.0 (Suyidno et al., 2020) then the fundamental implication of this study is that CRBL can be used as an alternative to print future generations in the industrial era 4.0. The generation that can work hard to print creative products is useful for solving problems of people's lives and the surrounding environment.

CONCLUSION

The application of CRBL is effective to develop the responsibilities and scientific creativity of students in learning physics. In each learning, students can participate, respect others, work together, try to lead, and express opinions well. Also, n-gain scientific creativity is in the medium criteria. CRBL can be alternative learning in the industrial era 4.0, especially preparing future generations who are creative and responsible. Further research is needed to improve students' abilities in finding scientific problems and designing creative products, as well as improving the use of technical products, creative experiments, and creating creative products.

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