The influence of scientific creativity and critical worksheet (SCCW) on project based learning to increase cognitive ability, scientific creative skills and scientific critical skills senior high school students on sound wave problem

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Abstract. The aims of this study to determine the effect of SCCW on project based learning in improving the cognitive abilities, students’ scientific and scientific creative thinking skills on sound wave problem. The research method used is pre-experimental research with randomized control group. The research phase involves preparation, execution, and final stage. At the preparatory stage is a preliminary study, RPP preparation, and instrument validation by 4 expert validators. At the implementation stage is done in one high school in Bandung with pretest, the implementation of learning using project based learning with conventional student worksheet (CSW) and SCCW, then given the final test (posttest). The study participants were 22 students of both control class and experimental class in one of high school in Bandung. The instrument used is the instrument of cognitive ability and scientific thinking as well as scientific critical thinking skills. Implementation of SCCW on project-based learning can improve creative thinking skills and critical scientific and cognitive abilities of students with greater improvement than the application of SCW on project-based learning.

1. Introduction
Based on Permendikbud No. 22 Tahun 2016 on Standard Process of Primary and Secondary Education, that learning characteristic in each unit of Education is closely related to Graduate Competence Standard and Content Standards. In accordance with the SKL, the learning objectives cover the development of the areas of attitudes, knowledge, and skills elaborated for each educational unit. Based on Permendikbud No. 56 of 2013 on Standards The process mentioned that the learning process in the educational unit held interactively, inspirational, fun, challenging, motivate learners to participate actively, and provide sufficient space for initiative, creativity, and independence in accordance with the talents, interests and development physical and psychological learners [1]. Based on the 21st century partnership framework, there are three skills that must be possessed in the 21st century, such as (1) life and career skills, (2) learning and innovation skills, (3) information, media and technology skills [2]. Research conducted in focus on the second point is about learning and innovation skills. The learning that fits the demands of the 21st century is a 4C learning that is Critical thinking, collaboration, communication and creativity [3]. This 21st century skill should be able to be implemented in our education system. Based on the 2013 revision curriculum it is said that the learning process should be oriented to students rather than teachers. Since 21st century skills must be tailored to the demands of the
revision of the 2013 curriculum appraisal, an assessment of cognitive ability in addition to scientific and scientifically creative thinking judgments can be assessed. Cognitive abilities are measured through instruments based on Bloom's revised taxonomy. There are 4 cognitive levels used in this instrument C1 (remember), C2 (understand), C3 (apply) and C4 (Analyze) [4].

Physics learning essentially refers to the physical nature of products, processes, and attitudes so that learning in schools is expected to refer not only to students' cognitive abilities but also to students with critical and creative thinking skills, communicating, and collaborating so that students can make decisions in solve physically-related problems physically in everyday life appropriately. Creative thinking skills are the cognitive skills to come up with and develop new ideas, new ideas as the development of previously born ideas and the skills to solve problems diverging [5]. Scientific creativity is a type of creativity that is intellectual or produces a product that is original and has social value or personal value and is designed with a particular idea using existing information [6]. Creative thinking is the process of thinking in determining new relation between things, finding new solutions of a problem, finding new systems, and finding new artistic forms. Creative thinking skills require knowledge and techniques to solve a problem in order to create a new understanding and solution to the problem based on the knowledge and techniques that have been previously owned [7]. The creative thinking skills of Hu are limited by a combination of aspects that combine process (imagination, thinking), trait (fluency, flexibility, originality) and product (technical product, science knowledge, science phenomena, science problem) in the Scientific Structure Creativity Model (SSCM) [8]. White states that critical thinking skills are needed to develop an educated society in which that ability involves knowledge that is based on the ways in which thinking is used. Because critical thinking skills are indispensable not in Physics learning. Therefore, in learning ideally students can think critically so that students can process their own any information received. White, et al developed an instrument of critical thinking skills, namely Assessment of Critical Thinking Ability (ACTA). This instrument evaluates three students' thinking skills using essay-shaped questions. ACTA assesses three critical thinking skills considered critical for an evaluation of Critical thinking ability 1 (CTA-1): the ability to integrate conflicting knowledge into an integrated conclusion, Critical thinking ability 2 (CTA-2): the ability to design an experiment to answer any doubt in certain knowledge, Critical thinking ability 3 (CTA-3): is the ability to estimate other interpretations of a particular knowledge [9].

Based on the description of the scientific creative and critical thinking skills. To encourage students' ability to produce contextual work, both individuals and groups, it is advisable to use a learning approach that produces project based learning (PjBL) work. Project based learning (PjBL) is an effective educational approach that focuses on the creativity of thinking, problem solving, and interaction between students and their peers to create and use new knowledge [10]. Project-based learning (PjBL) is one of the learning approaches that teaches many strategies for success in the 21st century where students are encouraged to learn through discovery, working collaboratively for research and project-making based on their knowledge [11]. The project-based learning model is expected to improve students' cognitive abilities and can be used to improve scientific and critical scientific thinking skills by using Scientific and Scientific Critical Worksheets (SSCW).

2. Methods
The research method used in this research is pre-experimental research with quantitative approach. According to Arikunto, Experimental study is a study which aimed to know there is or not the effect of the variable studied [12]. The research design used was randomized control group Pretest-posttest design. Where in this study a number of subjects taken from a certain population in grouping into two classes, namely experimental class and control class. This design involves two groups of experimental groups that will obtain learning treatment with PBL using Scientific and Scientific Critical Worksheets (SSCW) called experimental groups, and the other group as a comparator who both received learning treatment with PBL but by using a Conventional Student Worksheet (CSW) called a control group. Both the experimental and control classes, both given the same pretest and postest [13]. Subject for this research
are 46 student second grade senior high school in Bandung city, 46 student divided two group there are 23 students in experiment group and 23 students in control group.

3. Result and Discussion

3.1 Increased cognitive abilities
Different test was done to see the significance of skill enhancement between the two groups. After the Kolomogorov-Smirnov normality test and variance test (homogeneity test) the data are stated normal and homogeneous distributed then t-test to see the difference between experimental class and control class, the result is shown at table 1:

| Gain control class | 12.919 | 0.58723 | -1.78745 |
| Gain experiment class | 15.343 | 0.69741 | -1.720 |

The results of the analysis based on Table 1 show that there is a difference in cognitive ability improvement using project-based learning between the control class using the Conventional Student Worksheet and the experimental class using the Scientific and Critical Worksheet (SSCW). The average gain of cognitive abilities of the experimental class is higher than the average gain of cognitive ability of the control class. This is because in the experimental class, project-based learning using Creative and Scientific Critical Worksheets (SSCW) makes it easier for students to think actively, creatively, and critically, thus affecting the improvement of higher cognitive abilities. While in the control class, project-based learning using Conventional Student Worksheet (CSW) is still less able to trained students to think actively, creatively, and critically so that it still less able to influence students' cognitive abilities.

3.2 Increased Scientific Creative Thinking Ability
Different test was done to see the significance of skill enhancement between the two groups. After the Kolomogorov-Smirnov normality test and variance test (homogeneity test) the data are stated normal and homogeneous distributed then t-test to see the difference between experimental class and control class, the result is shown at table 2:

| Gain control class | 13.097 | 0.59532 | -2.52241 |
| Gain experiment class | 15.077 | 0.68532 | -1.720 |

The results of the analysis based on Table 2 show that there is a difference in the improvement of scientific creative thinking skills using project-based learning between the control class using the Conventional Student Worksheet (CSW) and the experimental class using the Creative and Critical Scientific Worksheet (SSCW). The average gain of creative thinking skills of experimental class scientific experiments is higher than the average gain of creative thinking skills of scientific class control. This is because in the experimental class, project-based learning using Scientific and Scientific Critical Worksheets (SSCW) makes it easier for students to think actively, creatively, and critically so as to influence the improvement of higher scientific creative thinking skills. While in the control class, project-based learning using the Conventional Student Worksheet (LKS) is still less able to train students
to think actively, creatively, and critically so that they cannot influence the students' creative thinking skill.

There are three aspects of scientific creative thinking skills tested namely fluency, flexibility and originality. Fluency related technical product (maximum score 2 for each point) with indicator to make design variation of project to be made. While the fluency related science knowledge is described on the matter with indicators linking the design made with sound wave concept. Aspects of flexibility (maximum score 2) related to science knowledge with an indicator about proposing ideas freely. and the last is the aspect of originality (maximum score 2) related to technical product spelled out with indicators of choosing a new and unique design. Graph of improving the creative thinking skill of each aspect is presented in Figure 1 below:

**Figure 1.** Graphic number of students who answer true by score > 3 each aspect

Figure 1 show that in implementations applying project-based learning, the control class uses the conventional Student Worksheet (CSW) so that at the time of posttest, students' skills in creative scientific thinking are poorly trained, while for experimental classes, project-based learning uses Scientific and Scientific Critical Worksheets (SSCW) so that at the time of posttest, students have started many who think creatively scientifically.

Different test was done to see the significance of skill enhancement between the two groups. After the Kolomogorov-Smirnov normality test and variance test (homogeneity test) the data are stated normal and homogeneous distributed then t-test to see the difference between experimental class and control class, the result is shown at table 3:

**Table 3.** Recapitulation of result of improving scientific creative thinking skills on each aspect by using the average gain test

| Scientific creative aspect | Gain control class | Gain experiment class | tcount | ttable (n = 22; α = 0.05) |
|----------------------------|---------------------|-----------------------|--------|---------------------------|
| fluency                    | 11,758              | 14,088                | -1,79247 | -1,720                     |
| flexibility                | 16,001              | 18,418                | -2,759  | -1,720                     |
| originality                | 13,751              | 16,167                | -2,45439 | -1,720                     |

Based on the above results, $t_{count} > t_{table}$ which means the null hypothesis (no difference between the two groups) is rejected. This means that there is a difference in the improvement of scientific creative
thinking ability between the two classes. Therefore, the use of SCCW on project-based learning is more effective than the use of SCW in project-based learning in improving students' thinking skills.

### 3.3. Increased Scientific Critical Thinking Ability

Different test was done to see the significance of skill enhancement between the two groups. After the Kolomogorov-Smirnov normality test and variance test (homogeneity test) the data are stated normal and homogeneous distributed then t-test to see the difference between experimental class and control class, the result is shown at table 4:

#### Table 4. Recapitulation of result of improving scientific critical thinking skills by using the average gain test

|               | amount | Average \((\overline{x})\) | \(t_{count}\) | \(t_{table}\) \((n = 22; \alpha = 0.05)\) |
|---------------|--------|-----------------------------|--------------|----------------------------------|
| Gain control class | 13,210 | 0.690455                    | -2.23214     | -1.720                           |
| Gain experiment class | 14,133 | 0.642409                    | -2.23214     | -1.720                           |

The results of the analysis based on Table 4 show that there is a difference in the improvement of scientific critical thinking skills using project-based learning between the control class using the Conventional Student Worksheet (CSW) and the experimental class using the Creative and Critical Scientific Worksheet (SSCW). This is because in the experimental class, project-based learning using Scientific and Scientific Critical Worksheets (SSCW) makes it easier for students to think actively, creatively, and critically so as to influence the improvement of higher scientific creative thinking skills. While in the control class, project-based learning using the Conventional Student Worksheet (CSW) is still less able to train students to think actively, creatively, and critically so that they cannot influence the students' creative thinking skill.

There are three aspects of scientific critical thinking skills tested namely critical thinking ability 1 (CTA 1), critical thinking ability 2 (CTA 2), critical thinking ability 3 (CTA 3). Graph of improving the critical thinking skill of each aspect is presented in Figure 2 below:

![Figure 2. Graphic number of students who answer true by score > 3 each aspect](image-url)

Figure 2 show that in its implementations applying project-based learning, the control class uses the conventional Student Worksheet (CSW) so that at the time of posttest, students' skills in creative scientific thinking are poorly trained, while for experimental classes, project-based learning uses Scientific and Scientific Critical Worksheets (SSCW) so that at the time of posttest, students have started many who think critically scientifically.

Different test was done to see the significance of skill enhancement between the two groups. After the Kolomogorov-Smirnov normality test and variance test (homogeneity test) the data are stated normal...
and homogeneous distributed then t-test to see the difference between experimental class and control class, the result is shown at table 5:

**Table 5. Recapitulation of result of improving scientific critical thinking skills on each aspect by using the average gain test**

| Scientific critical aspect | Gain control class | Gain experiment class |  
|---------------------------|---------------------|-----------------------|
|                           | amount (X)          | tcount                |
| Gain control class CTA 1  | 13,750              | 0,6250                |
| Gain experiment class CTA 1| 15,753              | 0,7161                |
| Gain control class CTA 2  | 13,137              | 0,5971                |
| Gain experiment class CTA 2| 15,302              | 0,6956                |
| Gain control class CTA 3  | 10,744              | 0,4884                |
| Gain experiment class CTA 3| 12,028              | 0,5467                |

Based on the above results, $t_{count} > t_{table}$ which means the null hypothesis (no difference between the two groups) is rejected. This means that there is a difference in the improvement of scientific critical thinking ability between the two classes. therefore, the use of SCCW on project-based learning is more effective than the use of SCW in project-based learning in improving students' thinking skills.

4. Conclusion

Once applied to a project-based learning model that is integrated with SCCW and SCW, creative and critical thinking skills as well as students' cognitive abilities increase. Increased creative thinking skills and critical scientific and student cognitive abilities of larger groups applied by SCCW than those applied by SCW can be seen from the average of n-gain pretest-posttest of both groups and different T test to see the level of difference. SCCW is influential in improving the creative thinking skill and scientific critical as well as students' cognitive ability, it can be seen from different T-test and Mann-Whitney test result posttest of experiment and control groups.

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