

HOTS student worksheet to identification of scientific creativity skill, critical thinking skill and creative thinking skill in physics learning

S Astutik¹, I K Mahardika¹, Indrawati¹, Sudarti¹, Supeno¹

¹Departement Physics Education, University of Jember, Jember, Indonesia

Email: tika.fkip@unej.ac.id

Abstract. In the learning context of 21st century, teachers encounter many challenges in optimizing the process and the outcome of learning. Students who have higher order thinking skills will be able to think of scientific creativity, critical thinking and creative thinking. In this study, identification is done by measuring the ability of scientific creativity, critical thinking and creative thinking skills by HOTS student worksheet. The result showed that student's scientific creativity with 6 indicators need to be develop especially for physics problem solving and technical production. For critical thinking skills students obtain moderate results but have shown good results in answering physics problem. For creative thinking skills students get good results on the indicator fluency, flexibility and elaboration but for the originality still needs to be developed. Therefore, it is very important to develop a proper physics instructional design that can develop scientific creativity, critical thinking and creative thinking skills.

1. Introduction

The competence of high school graduates is desirable who can solve problems and apply in everyday life of students. To succeed in the life, students need skills that support them such as scientific creativity, critical thinking, creative thinking, collaborative problem solving, innovation, literacy, communication and collaboration [1] [2] [3] [4] [5]. The results of previous studies in scientific creativity [6] [3] suggest that as scientific creativity in learning activities are important in identifying problems, exploring different methods, and exploring alternative solutions. Scientific creativity in science education consists of several aspects including: knowledge, intellectual ability, personality and motivation, and environment [17], ability to learn scientific knowledge and scientific problem solving [18]; [16], and social or personal value [6] as well as studying the essential nature and superiority of scientific thought [19]. The result of previous studies in critical thinking [2] stated that Critical thinking skills are one of the basic modalities or intellectual models that are essential to everyone and are a fundamental part of one's maturity [7]. Meanwhile the result of previous studies in creative thinking [8] [3] stated that creative thinking deals with how people approach problems and rely on personalities and thinking styles [31].



The results of research gained related scientific creativity, critical thinking, and creative thinking in education have been reported in many studies [3] [9] [1][10] [30]. Some previous research results showed that many teachers and lecturers have limited pedagogical knowledge and skills, especially in designing effective learning activities in training the students' skills [2].

Based on interviews with senior high school physics teachers in Jember, the problems that are often faced in the learning of physics is the low learning outcomes. Based on daily test results on Newton's law material in class XI of academic year 2017/2018 shows that the highest percentage of students answered one correct item on Newton's law material that is 44,1% and lowest percentage that is 13,22%. This shows that the result of physics learning of class XI students is low [11]. One of the causes of low learning outcomes is that students have difficulty in understanding the concepts of physics. This indicates that the level of mastery of the physics concept of students is low. The results show that students' scientific creativity ability is still low [3] [26].

The importance of mastering the concept on the cognitive aspect, does not necessarily ignore the balance of affective and psychomotor aspects. Because in the learning process in accordance with the 2013 curriculum, it is also necessary to pay attention to the soft skill aspects such as collaborative ability, mutual respect, sense of belonging, and sense of responsibility [12]. Aspects of high-order thinking in accordance with the 21st century in the aspects of soft skills are the ability of scientific creativity, critical thinking skills and creative thinking skills. Aspects that are measured on learning are aspects of scientific creativity, critical thinking skills and creative thinking skills [4]. The ability of scientific creativity, critical thinking skills and creative thinking skills are essential in today's learning because students are trained in higher order thinking skills in these aspects.

According to the 21st Century Learning framework, "Learning and Innovation" includes: creativity and innovation, critical thinking and problem solving and communication and collaboration in the context of higher-order thinking [13] in this research focused on scientific creativity, critical thinking and creative thinking. Higher order thinking skills based on [20] are defined as the cognitive abilities of students who, according to Bloom's unincorporated level of cognitive, evaluation, and creative cognitive abilities [29]. High-level thinking is the embodiment of critical thinking, creative, and problem solving. Based on the results of the exploration of creativity in the literature, scientific creativity is defined as a kind of intellectual nature or ability to produce or potentially produce a specific product that is original and has social or personal value, designed with a specific purpose in mind, using certain information [8].

Torrance [6] considers fluency, flexibility and originality the main features of creativity: Fluency means the number of original ideas produced. Flexibility is the ability to be unattached to a predetermined approach after the approach can no longer be used efficiently. Originality is interpreted statistically: an answer is interpreted as a rare answer, if the answer only appears or occurs occasionally in a particular population and such answers are viewed as original [29].

Every human being can grow and develop into a critical thinker, because in reality human thinking will relate to the pattern of self-management. Critical thinking skills are very important possessed by students in Physics learning because at the time of learning Physics students are required to be able to recognize, solve problems, interfere, analyze, summarize and evaluate. The benefit of critical thinking skills for students is to enhance students' academic awards as lifelong learning [14].

Creative is a performance. Performance in realizing ideas and ideas through a series of intensive activities to produce a work of creation. Creative works can be poured in an idea, activity, artwork, to a performance that has a unique uniqueness that can attract many people. Creative children are children who will always realize creative ideas in the form of ideas in creative activities to produce the work. Creative children are children creators. Children who always struggle with activities create a masterpiece of the idea they have. The work created embodies novelty and good value based on the experience and knowledge of children in learning [15] [29].

HOT'S student worksheet is a student worksheet that contains questions about critical thinking skills, creative thinking skills and students' scientific creativity abilities. This HOTS student worksheet was

created to explore students' abilities related to high order thinking skills. Each question is compiled with regard to indicators and aspects of scientific creativity skills, critical thinking and creative thinking.

The purpose of this study are to identify the ability of scientific creativity, critical thinking skills and creative thinking ability about Newton's law on student high school in Jember by HOTS student worksheet.

2. Method

This research was conducted on high school class XI students in Jember in academic year 2018/2019. The study was conducted in class XI. Score of scientific creativity, critical thinking and creative thinking are derived from the questions given to the students. Score of scientific creativity is determined based on indicators of unusual use, technical production, hypothesis, science problem solving, science product and creative experimental. Score critical thinking skills are expressed in 5 indicators, namely: Elementary Classification (EC), Basic Support (BS), Inferency (I), Advanced Clarification (AC), and Explanation (E). While the score of creative thinking skills expressed in aspects of fluency (F), Flexibility (F), Originality (O) and Elaboration (E).

The type of this research is qualitative descriptive research conducted in high school in Jember in the academic year semester 2018/2019. The selection of the sample is done by direct determination using purposive sampling method that is in the students of class XI IPA consisting of 112 students namely: group-A, group-B and group-C.

Techniques used to retrieve data in this study is the documentation of student identity and written tests given to students. While the instrument used is a written test in the form of a description (essay) about Newton's law which consists of 6 questions of scientific creativity, 5 questions of critical thinking and 2 questions of creative thinking. The technique of data analysis to answer the first problem formulation is the assessment using the scoring rubric of scientific creativity ability about Newton's law which consist of 6 value indicator for quantitative data and using rubric scale of scientific creativity ability about Newton's law which consist of four scale ability for qualitative data. The technique of data analysis to answer the second problem formulation is the assessment using the rubric of critical thinking ability assessment in solving problem about Newton's law which consists of 5 description of value for quantitative data and using rubric scale critical thinking ability about Newton's law which consist of four scale ability for data qualitative. The technique of data analysis to answer the third problem formulation is the assessment using the rubric of creative thinking ability assessment in solving problem about Newton's law which consists of four description of value for quantitative data and using rubric scale creative thinking ability about Newton's law which consist of four scale ability for data qualitative .

Assessment on the ability of scientific creativity based on indicators of unusual use, technical production, hypothesis, science problem solving, creative experimental and science product. Indicators of scientific creativity ability can be seen in Table 1.

Table 1. Scientific creativity skills indicator [4]

Scientific Creativity Skills	Sub Skills of Scientific Creativity
Unusual Use (UU)	<ol style="list-style-type: none"> 1. Using objects for scientific purposes 2. Assessing fluency, flexibility and originality in scientific purposes
Technical Production (TP)	<ol style="list-style-type: none"> 1. Improving science technical production 2. Assessing fluency, flexibility and originality
Hypothesis (H)	<ol style="list-style-type: none"> 1. Make formulation of the problem and hypothesis 2. Assessing fluency, flexibility and originality

Science Problem Solving (SPS)	1. Make solving problems in science 2. Assessing fluency, flexibility and originality in science
Creative Experimental (CE)	1. Doing creative experiments 2. Assessing fluency, flexibility and originality in creative experiments
Science Product (SP)	1. Designing science products 2. Assessing flexibility and originality in designing science products

Assessment of critical thinking skills based on indicators elementary clarification (EC), basic support (BS), inference (I), advanced clarification (AC), explanation (E) [25] [26]. Critical thinking skills indicators can be seen in Table 2.

Table 2. Critical thinking skills indicator

Critical Thinking Skills	Sub Skills of Critical Thinking
Providing a simple explanation (Elementary clarification)	1. Focusing questions 2. Analyze the argument 3. Ask questions and answer challenging questions and clarifications
Building basic skills (Basic support)	1. Consider credibility (criteria of a source) 2. Observing and considering observation results
Summing up (Inference)	1. Make deductions and consider the results of deduction 2. Making inductions and taking into account induction 3. Make and consider the value of the decision
Make further explanation (Advanced clarification)	1. Define terms, consider definitions 2. Identify assumptions
Strategy and Tactics (explanation)	1. Decide an action 2. Interacting with others

Assessment of creative thinking skills based on indicators is expressed in terms of fluency (F), Flexibility (F), Originality (O) and Elaboration (E). Creative thinking skills indicators can be seen in Table 3.

Table 3 Aspects and Indicators of Student Creative Thinking Skills

Aspect	Description
Fluency	- Students can offer more than one answer for a problem.. - Students are fluent in their ideas.
Flexibility	- Students can provide different ways to solve a problem.
Originality	- Students can provide answers along with different solutions or new ideas with other students in solving problems.
Elaboration	- Students take steps systematically in solving problems- Students can combine elements, principles, and concepts that exist so as to become a unified whole

The identification of the scientific creativity skills, critical thinking skills and creative thinking skills was analyzed based on the assessments that was determined using observation sheets.

The data obtained from scientific creativity skills there are 6 problem with 6 data that is unusual use, technical production, hypothesis, science problem solving, creative experimental and science product. Score of Scientific creativity category expressed in four categories, namely: VH (Verry High) is the example of the value of 2.25-3.00, H (High) is high with a score of 1.50 -2.24, M (Moderate) is an moderate with a value of 0.75 - 1.49, and L (Low) is low with grades 0 -74. The ability of students' scientific creativity is derived from the average score of scientific creativity indicator that is unusual use, technical production, hypothesis, science problem solving, creative experimental and science product with VC (Verry Creative) category is the example of the value of 2.25-3.00, C (Creative) with a score of 1.50 -2.24, (LC) Least Creative with a value of 0.75 - 1.49, and NC (Not Creative) is low with grades 0 -74.

The data obtained from critical thinking skills there are 5 problem with 5 data that is indicators elementary clarification (EC), basic support (BS), inference (I), advanced clarification (AC), explanation (E). Score of critical thinking skill category expressed in four categories, namely: VH (Verry High) is the example of the value of 2.25-3.00, H (High) is high with a score of 1.50 -2.24, M (Moderate) is an moderate with a value of 0.75 - 1.49, and L (Low) is low with grades 0 -74. The ability of students' critical thinking is derived from the average score of critical thinking indicator that is indicators elementary clarification (EC), basic support (BS), inference (I), advanced clarification (AC), explanation (E) with VC (Verry Critical) category is the example of the value of 2.25-3.00, C (Critical) with a score of 1.50 -2.24, (LC) Least Critical with a value of 0.75 - 1.49, and NC (Not Critical) is low with grades 0 -74.

The data obtained from creative thinking skills there are 2 problem with 4 creative thinking skill aspect data that is fluency, flexibility, originality and elaboration. Score of creative thinking category expressed in four categories, namely: VH (Verry High) is the example of the value of 2.25-3.00, H (High) is high with a score of 1.50 -2.24, M (Moderate) is an moderate with a value of 0.75 - 1.49, and L (Low) is low with grades 0 -74. The ability of students' creative thinking is derived from the average score of creative thinking aspect that is fluency, flexibility, originality and elaboration with VC (Verry Creative) category is the example of the value of 2.25-3.00, C (Creative) with a score of 1.50 -2.24, (LC) Least Creative with a value of 0.75 - 1.49, and NC (Not Creative) is low with grades 0 -74.

3. Result and Discussion

The first objective in this study was to identify students' ability in scientific creativity in solving problems about Newton's law using a skill assessment rubric consisting of 4 description values. The first assessment is to assess the answers of students based on each problem is a unusual use, technical production, hypothesis, science problem solving, creative experimental and science product. Each student answer is grouped based on the description of the achieved value consisting of six values as shown in the Table 4. The ability of scientific creativity for all groups can be expressed as shown in Figure 1.

Tabel 4. The average score of scientific creativity skills in all groups

Indicators of Scientific Creativity	Scientific Creativity					
	Score Group - A	C	Score Group - B	C	Score Group- C	C
Unusual Use (UU)	2,4	VH	2,2	H	2,0	H
Technical Production (TP)	1,9	H	2,0	H	1,4	M
Hypothesizing (H)	2,3	VH	2,2	H	2,3	VH
Science Problem Solving (SPS)	1,1	M	1,3	M	1,4	M
Creative Experimental (CE)	2,3	VH	2,1	H	2,3	VH

Science Product (SP)	2,1	H	2,1	H	2,2	VH
Scientific Creativity	2,0	C	2,0	C	1.9	C

Note: C= Criterion, VH= Very High H= High M= Moderate L= Low

VC= Very Creative C=Creative LC= Less Creative NC= Not Creative

Table 4 shows the score of each indicator of creativity scientific in the range of 1.1 to 2.4. Highest score on unusual use (UU) indicator and lowest score on science indicators problem solving (SPS).

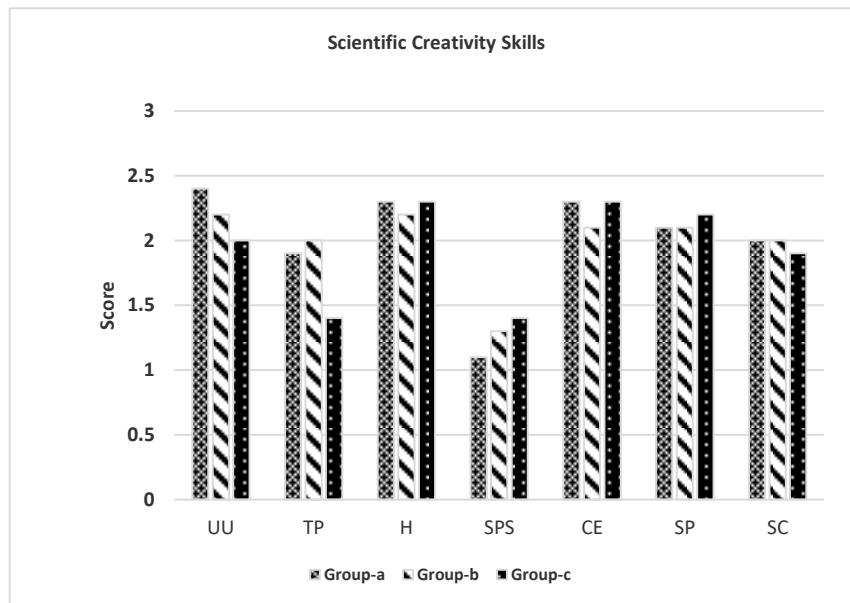


Figure 1. The average scores of scientific creativity skill, in all groups

The second objective in this study was to identify students' ability in critical thinking skill in solving problems about Newton's law using a skill assessment rubric consisting of 4 description values. The assessment is to assess the answers of students based on each problem is a Providing a simple explanation (Elementary clarification), Building basic skills (Basic support), Summing up (Inference), Make further explanation (Advanced clarification), Strategy and Tactics (explanation)[[23][28]. Each student answer is grouped based on the description of the achieved value consisting of five values as shown in the Table 5. The ability of critical thinking skills for all groups can be expressed as shown in Figure 2.

Table 5. The average score of critical thinking skills in all groups

Indicators of Critical Thinking	Critical Thinking					
	Score Group- A	C	Score Group- B	C	Score Group- C	C
Elementary clarification (EC)	2,0	H	2,0	H	2,0	H
Basic support (BS)	2,0	H	1,8	H	1,4	M
Inference (I)	1,4	M	1,5	H	1,3	M
Advanced clarification (AC)	0,6	L	0,9	M	0,4	L
Eexplanations (E)	1,4	M	1,4	M	1,3	M
Critical Thinking	1.5	C	1.5	C	1.3	LC

Note: C= Criterion, VH= Very High H= High M= Moderate L= Low

VC= Very Critical C=Critical LC= Less Critical NC= Not Critical

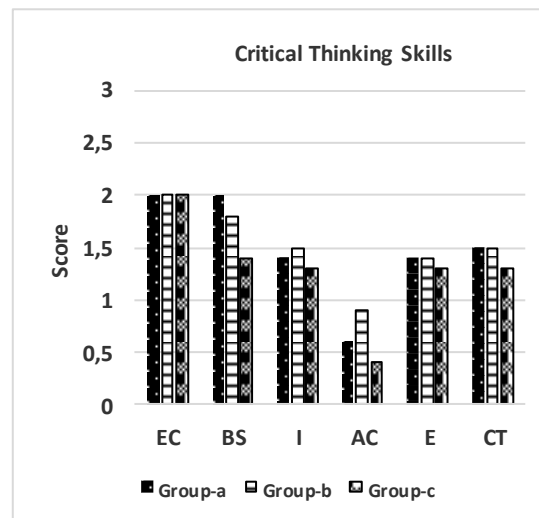


Figure 2. The average scores of critical thinking skill in all groups

The third objective in this study was to identify students' ability in creative thinking skill in solving problems about Newton's law using a skill assessment rubric consisting of four description values. The assessment is to assess the answers of students based on each problem is fluency, flexibility, originality and elaboration [25]. Each student answer is grouped based on the description of the achieved value consisting of four values as shown in the Table 6. The ability of creative thinking skills for all groups can be expressed as shown in Figure 3.

Table 6. The average score of creative thinking skill aspect in all groups

Aspect of Creative Thinking	Creative Thinking					
	Score Group- A	C	Score Group- B	C	Score Group- C	C
Fluency (F)	2,5	VH	2,4	VH	2,0	H
Flexibility (F)	2,3	VH	2,2	H	2,1	H
Originality (O)	1,1	M	1,1	M	1,3	M
Elaboration (E)	1,6	H	1,9	H	1,4	M
Creative Thinking	1.8	C	1.9	C	1.7	C

Note: C= Criterion, VH= Verry High H= High M= Moderate L= Low
 VC= Very Creative C=Creative LC= Less Creative NC= Not Creative

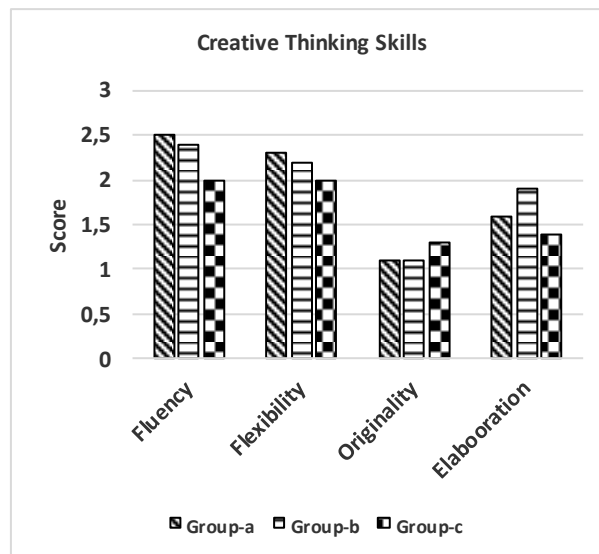


Figure 3: The average scores of creative thinking skill in all groups

The average value of each skill of scientific creativity, critical thinking skills and creative thinking skills is shown by Table 1, Table 2 and Table 3. Furthermore the results obtained on the skills of scientific creativity, critical thinking as well as creative thinking can be expressed in the graph of students' ability higher order thinking skill as shown in Figure 4.

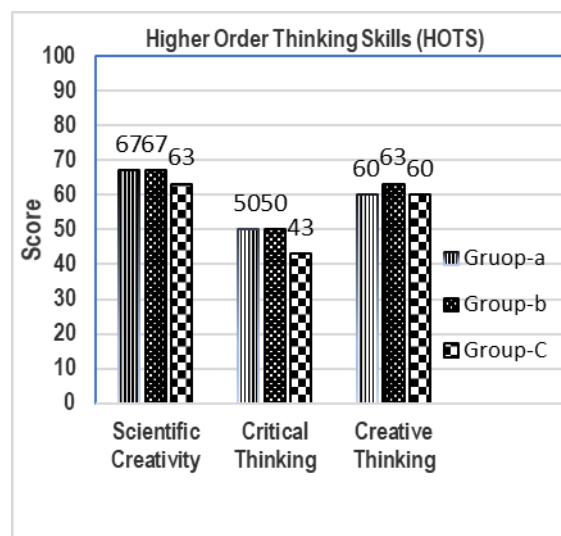


Figure 4. The average scores of scientific creativity skill, critical thinking skill and creative thinking skill in all groups.

Figure 4 shows the average score of scientific creativity skills for group-a, group-b, and group-c, are respectively 67; 67; and 63. The average score of scientific creativity skills for group-a, group-b and group-c is in the creative category. The average score of critical thinking skills for group-a, group-b, and group-c, are respectively 50; 50; and 43. The average score for group-a and group-b is in the creative category and group-c is in the less creative category. The average score of creative thinking skills for group-a and group-b and group-c are respectively 60; 63; and 60. The average score of creative thinking skills for group-a and group-b and group-c is in the creative category [22][26].

3.1 Scientific Creativity Skills

The student's ability of scientific creativity can be seen from the average score of scientific creativity indicators including unusual use, technical production, hypothesis, science problem solving, creative experimental and science product. The average score of unusual use in scientific creativity skills for all groups are respectively 2.4; 2.2; and 2.0 is in very high, high and high category the standard score (minimum score 1.00 in score range 1-3). The average score of technical production in scientific creativity skills for all groups are respectively 1.9; 2.0; and 1.4 is in high, high and moderate category. The average score of hypothesis in scientific creativity skills for all groups are respectively 2.3; 2.2; and 2.3 is in very high, high and very high category. The average score of science problem solving in scientific creativity skills for all groups are respectively 1.1; 1.3; and 1.4 is in moderate category. The average score of creative experimental in scientific creativity skills for all groups are respectively 2.3; 2.1; and 2.3 is in very high, high and very high category. The average score of science product in scientific creativity skills for all groups are respectively 2.1; 2.1; and 2.2 is in high category. Based on the results of the analysis of the 6 indicators of scientific creativity there is a low value of technical production and science problem solving in all groups. The technical production result for Group-a gets 1.9, group-b gets 2.0 and group-c gets 1.4. Result for science problem solving Group-a gets 1.1, group-b gets 1.3 and group-c gets 1.4. This is because the technical production for students is a new thing and feel the difficulty in designing a science-based product. The result of the assessment for science problem solving is the students' difficulties when solving problem-based science problems. This is supported by a questionnaire that says it is difficult 78% for technical production and 90% difficult for science problem solving. The unusual use indicator for all groups has the highest value, this is because students easily understand the characteristics of the unusual use question. If the questions given to the students in accordance with the stages of student development then obtained a good value [4][21][27]. Hypothesis, creative experimental and science product indicators get high and medium values. The value of scientific creativity ability for all groups can be seen in Figure 1.

3.2 Critical Thinking Skills

The student's ability of critical thinking can be seen from the average score of critical thinking indicators including Elementary clarification, Building basic skills (Basic support), Summing up (Inference), Make further explanation (Advanced clarification), Strategy and Tactics (explanation). The average score of Elementary clarification in critical thinking skills for all groups are respectively 2.0; 2.0; and 2.0 is in high category the standard score (minimum score 1.00 in score range 1-3). The average score of Basic support in critical thinking skills for all groups are respectively 2.0; 1.8; and 1.4 is in high, high and moderate category. The average score of Inference in critical thinking skills for all groups are respectively 1.4; 1.5; and 1.3 is in moderate, high and moderate category. The average score of Advanced clarification in critical thinking skills for all groups are respectively 0.6; 0.9; and 0.4 is in moderate category and low category. The average score of explanation in scientific creativity skills for all groups are respectively 1.4; 1.4; and 1.3 is in moderate category. Based on the results of the analysis of the 5 indicators of critical thinking there is a low value of Advanced clarification in all groups. The Advanced clarification result for Group-a gets 0.6, group-b gets 0.9 and group-c gets 0.4. The low student score on the Advanced clarification indicator is because students still have difficulty when defining terms, consider definitions and Identify assumptions. The result of the assessment for Advanced clarification is the students' difficulties when defining terms, consider definitions and Identify assumptions. The result of assessment a Providing a simple explanation (Elementary clarification), Building basic skills (Basic support), Summing up (Inference), Strategy and Tactics (explanation) is in high and moderate category. The results of the research that have been carried out show that there is a moderate increase when students are given learning by using the learning model (Jatmiko, et al., 2017) because appropriate learning can improve critical thinking skills.. Critical thinking skills are a cognitive process and a person's mental process to gain more knowledge than

others. With this critical thinking skill can help students to be more active and more critical in exploring a new science that they will learn.

3.3 Creative Thinking Skills

The student's ability of creative thinking can be seen from the average score of creative thinking aspect including fluency, flexibility, originality and elaboration. The average score of fluency in creative thinking skills for all groups are respectively 2.5; 2.4; and 2.0 is in very high and high category in the standard score (minimum score 1.00 in score range 1-3). The average score of flexibility in creative thinking skills for all groups are respectively 2.3; 2.2; and 2.1 is in very high and category. The average score of originality in creative thinking skills for all groups are respectively 1.1; 1.1; and 1.3 is in moderate category. The average score of elaboration in critical thinking skills for all groups are respectively 1.6; 1.9; and 1.4 is in high and moderate category. Based on the results of the analysis of the 4 indicators of creative thinking there is a low value of originality in all groups. The originality result for Group-a gets 1.1, group-b gets 1.1 and group-c gets 1.3. The low student score on the originality aspect is because students still have difficulty when determined the thing in originality. The result of assessment in fluency, flexibility, originality and elaboration is in high and moderate category. The results of the research that have been carried out show that there is a moderate increase when students are given learning by using the proper instructional design (Susantini, et.al., 2017).

The ability to think high-level can be obtained through the skills of scientific creativity, critical thinking skills and creative thinking skills through the indicators provide an overview of students' understanding of these three skills. Scientific creativity directs students to be able to master scientific performance through scientific processes (Aktamis, et. Al., 2008). Critical thinking skills are a cognitive process and a person's mental process to gain more knowledge than others. (Amabile, et.al., 1983). Creative thinking skills lead students to have fluency, flexibility, originality and elaboration aspects in every learning activity. When these three skills are creativity skills, critical thinking skills and creative thinking skills are already mastered by students, in essence the students already have higher order thinking skills. The success in identifying scientific creativity skills, critical thinking skills and creative thinking skills is strongly influenced by supporting instruments, namely adequate questions. Problems that match the characteristics of scientific creativity, critical thinking and creative thinking will be able to explore their higher order thinking skills.

4. Conclusion

The results of this research for all groups indicate that the ability's scientific creativity is in high category, moderate category and low category. High category for unusual use, hypothesis, creative experimental and science product. While, the technical production and science problem solving in low category. The results of the critical thinking is in moderate category and the results of the creative thinking is in high and moderate category.

The implications of this research can be an alternative to overcome the problems of 21st century education in the industrial revolution era 4.0 related to the problem of the low level scientific creativity skills, critical thinking skill and creative thinking skill on the physics learning course. Further research can be done to improve the results of this research, it is necessary to research at the elementary, middle and upper level of education, it is also need to be proven in other countries.

Acknowledgment

The author's gratitude goes to the University of Jember for funding the research (research group funding). Likewise, the author's gratitude goes to the senior high school in Jember that have provided collaborative research opportunities

References

- [1] Griffin P and Care E 2015 *Assessment and teaching of 21st century skills: Methods and approach* (New York: Springer)
- [2] Jatmiko B, Prahani, B K, Munasir, Supardi Z A I, Wicaksono I, Erlina N, Pandiangan P, Althaf R and Zainuddin 2018 The comparison of OR-IPA teaching model and problem based learning model effectiveness to improve critical thinking skills of pre-service physics teachers. *Journal of Baltic Science Education* **17** 1-22
- [3] Astutik S, Nur M, and Susantini E 2015 Development of the hypothetical model to teach the skills of scientific creativity students in learning science *AEC Conf. Proc.*
- [4] Astutik S, Sudarti, Bektiarso S, & Nuraini L 2017 Developing scientific creativity test to improve scientific creativity skills for secondary school students. *The International Journal of Social Science and Humanities Invention*. **4** 3970-3974
- [5] Wicaksono I, Wasis, and Madlazim 2017 The effectiveness of virtual science teaching model (VSTM) to improve student's scientific creativity and concept mastery on senior high school physics subject *Journal of Baltic Science Education* **16** 549-561
- [6] Hu W and Adey P 2010 *A Scientific Creativity Test For Secondary School Students, College* (London)
- [7] Putri A R, and Jatmiko B 2016 Guided Discovery Learning to Improve Creative Thinking Skill for Learning Elasticity in 10th Grade Wonoayu High School *Physics Learning Innovation Journal JIPF* **5** 26-33.
- [8] Nur M 2014 *Creative Thinking* (Surabaya: UNESA)
- [9] Huang M H, Dong H R, Chen D Z 2012 Globalization Of Collaborative Creativity Through Cross-Border Patent Activities *Journal Of Informetrics* **6** 226-236
- [10] Hesse F, Care E, Buder J, Sassenberg K, and Griffin P A 2015 *Framework for Teachable Collaborative Problem Solving Skills* (Dordrecht: Springer)
- [11] Fithriani S L, Halim A, and Khaldun I 2016 Media Simulation by Phet based on Guided Inquiry to Improve Student Creative Thinking Skill in Heat Energy at Banda Aceh 12 High School *Science Education Journal Indonesia* **4** 45-52
- [12] Suyidno N M, Yuanita L, Prahani B K, and Jatmiko B 2018 Effectiveness of creative responsibility based teaching (CRBT) model on basic physics learning to increase student's scientific creativity and responsibility *Journal of Baltic Science Education* **17** 136-151
- [13] Trilling B and Fadel C 2009 *21st Century skills: Learning for life in our times* (John Wiley & Sons)
- [14] Conklin W 2012 *Higher-Order Thinking Skills to Develop 21st Century Learners. Higher-Order Thinking Skills to Develop 21st Century Learners* (Shell Education Publishing, Inc)
- [15] Kurniawan H 2016 *Creative School* (Yogyakarta: Ar-Ruzz Media)
- [16] Hu W, Wu B, Jia X, Yi X, Duan C, Meyer W and Kaufman J C 2013 Increasing Student's Scientific Creativity: The "Learn to Think" intervention program. *The Journal of Creative Behavior* **47** 3-21.

- [17] Liu S C and Lin H S 2013 Primary teachers' beliefs about Scientific Creativity in the Classroom Context *International Journal of Science Education* **36** 1551-1567
- [18] Wang J and Yu J 2011 Scientific creativity research based on generalizability theory and BP_Adaboost RT Advanced in Control Engineering and Information Science *Procedia Engineering* **15** 4178 – 4182
- [19] Zhang J, Liu G, and Lin C 2014 An action-oriented approach to gifted education: evidence from the field of Scientific Creativity *High Ability Studies* **23** 123-125.
- [20] Krathwohl D R 2002 *A Revision of Bloom's Taxonomy: An Overview* (Ohio: Ohio State University)
- [21] Aktamis H, Pekmez E S, Can B T and Ergin O 2008 *Developing Scientific Creativity Test* (Turkey:University of Dokuz Eylul)
- [22] Aktamis H and Ergin O 2008 The effect of scientific process skills education on students' scientific creativity, science attitudes and academic achievements *Asia-Pacific Forum on Science Learning and Teaching* **9**
- [23] Amabile T M 1983 *The Social Psychology of Creativity* (New York: Springer- Verlag)
- [24] Arends R I 2012 *Learning to Teach Ninth Edition* (New York: McGraw-Hill)
- [25] Astutik S, Nur M, and Susantini E 2016 Validity of Collaborative Creativity (CC) Models *ICRIEMS Conf. Proc.* 73-78.
- [26] Astutik S 2017 Effectiveness of collaborative students worksheet to improve student's affective scientific collaborative and science process skills (SPS) *International Journal of Education and Research* **5**
- [27] Astutik S and Prahani B K 2018 The Practicality and Effectiveness of Collaborative Creativity Learning (CCL) Model by Using PhET Simulation to Increase Students' Scientific Creativity *International Journal of Instruction* **11** 409-424
- [28] Beetlestone F 2012 *Creative Learning: Imaginative Teaching* (Philadelphia, Open University Press)
- [29] Jones A, Miels D, Littleton K, and Vass E 2008 The discourse of collaborative creativity writing: peer collaboration as a context for mutual inspiration *Thinking Skill and creativity journal* **3** 92 – 202
- [30] Lin C, Hu W, Adey P and Shen J 2003 The influence of CASE on scientific creativity. *Research in Science Education* **33** 143-162
- [31] Susantini E, Isnawati, and Lisdiana L 2016 Effectiveness of genetics student worksheet to improve creative thinking skills of teacher candidate students *Journal Of Science Education* **17** 74-79