The analysis of the development of the 5E-STEAM learning model to improve critical thinking skills in natural science lesson

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Abstract. This article aims to develop 5E-STEAM learning model that is used to increase the critical thinking skill in science learning. Critical thinking is the ability to think logically, to apply these rational thoughts in order to evaluate problems, and to make good judgments and decisions. 5E-STEAM is a learning model that combines the 5E Learning cycle with the STEAM approach. This research used 4D development model that consist of four stage i.e define, design, develop and dissemination. Results of the need assessment given to 10 teachers showed that only 10% of teachers applied STEAM in the class, while others use PBL, Discovery learning, and inquiry learning. As many as 70% of teachers do not know about 5E Learning Cycle, and as many as 30% only know but they have not implemented yet in learning. In addition, as many as 70% of teachers know only the acronyms of STEAM, but do not understand how to apply STEAM in learning. Moreover, the other 30% don't know about the STEAM approach. The 5E-STEAM syntaxs are Engagement; stages provide real world problem. The second is Exploration; the stages of problem solving. The third is Explanation; students explain ideas or concepts about solutions to problems. The fourth is Elaboration; stresses collaborative teamwork. The fifth is Evaluation; teacher provides feedback and tests student's knowledge.

1. Introduction
The current period is the 21st century, where information and knowledge development is increasing. In addition to having expertise, students must have a rational attitude (critical and analytical thinking skills, creative thinking), noble values and a commendable attitude [1]. Education in the 21st century not only stresses students' goods or learning results but also recognizes the skills that students need to have in line with 21st century demands. Communication, collaboration, and critical thinking are all skills required. Higher-order thinking skills are also required to assist them in recognizing, assessing, developing and applying information related to it and working [2]. Students need skills of the 21st Century for the future and life post-graduation [3].

The learning process in the 21st century must provide students with the knowledge and skills to compete in the global economy. Therefore, there must be an increase in the quality of learning [4]. Learning in this era must be able to identify problems, work in a multidisciplinary manner, solve problems and communicate effective [5]. The government through the Ministry of Education and Culture seeks to develop a 2013 curriculum oriented towards 21st century Education which includes creative and innovative thinking, problem solving and critical thinking, communication and collaboration, technological literacy and life and career skills [6]. Teachers also have a role in designing learning activities that are oriented towards the challenges of the 21st century. Teachers must help to develop and train students so that they have skills according to the 21st century [7].
The PISA evaluation in 2018 results show that Indonesia remains below PISA's average level and occupies the place of 72 out of 77 countries taking the PISA test [8]. This gap may arise due to the lack of knowledge of students, particularly in the areas of scientific literacy, language literacy and mathematical literacy. The learning process in schools should therefore give students meaning and be able to provide skills in line with the specifications of the 21st century and the competence to work [9]. Meaningful learning is usually shown by developments and changes in cognitive structure. Knowledge learned should be relevant to previous knowledge [10]. Teachers must innovate to deal with the demands of the 21st century, one of which is to set up students with critical thinking skills.

Critical thinking is a skill used to analyze an argument about a specific subject, not to know facts, but to understand facts, and to position them in context and relationships between contexts. Critical thought is not recalling knowledge or answers from actual memorization [11]. Critical thinking is a systematic process that allows students to formulate and evaluate their own convictions. Critical thinking involves thinking reflectively and productively and analyzing facts. Critical thought requires an introspection of logic in order to enhance thought [12]. Critical thinking skills are one of the HOTS required to make purposeful, reflective and rational decisions on what to believe or realistic problems in the future. Critical thinking is also becoming very important, because the real issues of today's life have become more complicated [13]. The teacher can train and accustom students to think critically using the STEAM approach.

STEAM is defined as an approach to learning that integrates two or more components of STEAM, namely Science, Technology, Engineering, Art and Mathematics, or a combination of one component of STEAM with other scientific disciplines. The integration of art in the STEAM approach is expected to make learning more meaningful, as students are actively involved in the learning process that needs to be achieved in real terms in the form of projects [14]. The STEAM curriculum encourages students to apply their knowledge, cooperate with others, and practice independent learning skills so that they can respond quickly to the dynamic nature of the job requirements and the real challenges they face in the future [15]. STEAM encourages students to have high-level skills, including problem-solving, collaboration, research-based learning, and challenges [16]. The STEAM approach must create a transdisciplinary space that does not refer to specific categories of scientific discipline. Teachers can design assignments that involve multiple disciplines and thus enhance the ability of students to transfer learning to different disciplines [17].

The STEAM approach is not yet operational, and therefore an appropriate learning model is needed, one of which is Learning Cycle 5E. The 5E learning model is constructivism learning, each "E" is part of the process of helping students experience learning sequences by linking prior knowledge to new concepts, which consists of: engagement, exploration, explanation, elaboration and evaluation [18]. Learning Cycle 5E is a more student-oriented learning model (student-centered learning) with a series or stages of activities to enable students to master the skills that must be achieved in learning. Learning activities in the learning cycle 5E encourage students to participate directly in learning activities so that students are expected to gain a deep understanding of the concept [19].

Previous studies carried out by Siwawetkul and Koraneekij [20] have shown that the Learning Cycle 5E learning model can improve student achievement, learning outcomes and reasoning skills. This is also in line with research from Wilson and Bradbury [21] which shows that the application of the 5E model is capable of increasing students' knowledge. In addition, the integration of the STEAM approach into project-based learning can develop students' soft skills, such as cooperation, critical thinking, environmental care, responsibility, adaptation skills, creative thinking, leadership and honesty [10]. STEAM enhances scientific creativity in order to increase the national competitiveness of science through the convergence of science, technology and art, by increasing the capacity to solve creative problems [22]. The background described above is the baseline for research into the development of Learning Cycle 5E based on STEAM approach. 5E-STEAM learning model allows students to be more active in order to make the learning process more meaningful and to improve student's critical thinking skills.
2. Method
This research is a research and development study which is used to produce effective products for use in schools. The developmental design used is a 4-D developmental learning model consisting of the definition stage (Define), the design stage (Design), the development stage (Develop) and the dissemination stage (Disseminate) [23]. However, this research only reached the design stage. The first stage is define, the goal at the define stage is to define and define the learning requirements starting with the objective analysis of the material constraints the device develops. This stage includes 5 main steps, namely:

1) **Front end analysis.** Activities at this stage are analyzing the curriculum, school conditions and literature studies as the basis for developing models and developing tools used to support models developed in the implementation of limited trials. At this stage the researchers distributed questionnaires to several science subject teachers to find out which learning models had been used, to find out whether the teacher provided a stimulus or triggering event to students, trained students to make mind mapping, training in the form of experiments to students, directing students to ask questions, discuss, express opinions, and confirm in the learning process. This stage is carried out by researchers to get a picture of facts, expectations, and alternative problem solving that makes it easier to determine the learning model developed.

2) **Analysis of students.** This stage is carried out by analyzing the character of students including the academic ability of students in understanding and receiving learning through student learning outcomes in the previous material. In addition, an analysis of the critical thinking skills of students was conducted.

3) **Task analysis.** The activity at this stage is that the researcher examines the possible tasks to improve active learning that is centered on students. In developing this model, it is practicing / experimenting, discussing to do exercises, presenting discussion results and making conclusions.

4) **Concept analysis.** The concept analysis stage is carried out by identifying the main concepts to be taught, systematically arranging and detailing the relevant concepts.

5) **Formulation of learning objectives.** This stage is carried out to convert the results of the task analysis and concept analysis into the goal of developing a learning model.

The second stage is design, the goal at this stage is to design a prototype model in accordance with the learning objectives. These stages include:

1) **Constructing criterion-referenced tests.** This stage includes the preparation of tests used in the implementation of the 5E-STEAM learning model at the development stage after validation by experts. The preparation of tests is carried out based on learning objectives in accordance with KD (Basic Competence).

2) **Media selection.** Selection of the media to be used must be in accordance with the character of the material in science subjects, including the use of powerpoints, simple experimental equipment, and the use of the surrounding environment.

3) **Prototype model (Initial design).** The initial design obtained is simulated in advance on material that can be studied contextually. Before the design continues at the next stage, it is necessary to validate the resulting product (learning model).

The resulting prototype is a 5E-STEAM learning model, 5E-STEAM is a combination of the 5E Learning Cycle model with the STEAM approach. The aim of the development of the 5E-STEAM learning model is to enhance the critical thinking skills of student. The research subject is 7th grade junior high school students. This research was conducted using the interview process, with 10 teachers taking part in this study. The assessment needs to be carried out with the aim of exploring important information on the problems and needs that occur in schools. The findings of the need assessment are used as content for the development of the learning model.
3. Result

3.1 Need assessment

Some information on learning activities can be found on the basis of a questionnaire distributed to 10 teachers. The findings of the questionnaire can be found in the following table.

| No | Activity of Learning               | Percentage of Respondents (%) |
|----|-------------------------------------|-------------------------------|
| 1. | Implement Problem Based Learning   | 70%                           |
| 2. | Implement Discovery Learning       | 10%                           |
| 3. | Implement Inquiry                  | 10%                           |
| 4. | Implement STEAM                    | 10%                           |
| 5. | Know the 5E Learning Cycle         | 70%                           |
| 6. | Don't know the 5E Learning Cycle   | 30%                           |
| 7. | Know about STEAM                   | 70%                           |
| 8. | Don't know about STEAM             | 30%                           |

The following is a collection of questionnaire results distributed to teachers shown in graphs and diagrams below:

![Learning process](image1)

**Figure 1.** (a) Learning process in class (b) Learning process in class.

![5E Learning Cycle](image2)

**Figure 2.** (a) Teacher knowledge of the 5E Learning cycle (b) Teacher knowledge of the 5E Learning cycle.
Table 1 presents the findings of the questionnaire on the application of the learning model in the classroom that teachers frequently carry out and the understanding of the STEAM and the 5E learning cycle model. Based on the questionnaire, it was found that out of 10 teachers, the other 70% of teachers applied PBL, 10% applied Discovery Learning, and just 10% applied the STEAM approach. It is understood from these results that teachers still have very limited understanding and implementation of the STEAM approach. As many as 70% of teachers don’t know about the constructive learning model of 5E Learning Cycle, and as many as 30% only know, but they have not implemented yet in learning. In addition, as many as 70% of teachers know only the acronyms of STEAM, but do not understand how to apply STEAM in learning. And the other 30% don’t know about the STEAM approach. Another interesting finding was teachers still find it difficulties to train students to think critically. Some of the difficulties faced by the teacher are students fixated on the answers in the book, students are not familiar with HOTS questions, and the teacher is still difficult to make HOTS questions. Students’ critical thinking skills are still low, so teachers must prepare and adapt students to be critical when engaging with problems.

3.2 Results from the development of the learning model
This research is research development that produce the new learning model, which is 5E-STEAM learning model that is developed using 4D design. The stages of learning activity in 5E-STEAM learning model are mixing the 5E learning cycle learning model with the STEAM approach. The syntax of the 5E-STEAM learning model is:

| Table 2. The syntax of developing the 5E-STEAM learning model. |
|---|---|---|
| Syntax of learning | STEAM Principle | Learning activities |
| Engagement | Content from different STEM disciplines is aligned and connected | • The teacher explores the initial knowledge and ideas of students (apperception) | • Students relate their initial information to new information. |
| | • Students are involved in authentic problems | • Teacher integrates content from a range of disciplines (Science) | |
| | • Teacher gives students real problems | Students involved in real problems. Students listen to or
| Exploration       |  |  |
|-------------------|  |  |
| • Students are actively engaged in posing questions, planning and designing experiments. | • The teacher guides students to analyze, interpret natural phenomena or social behaviour. Students are encouraged to apply science process skills, such as observing, questioning, investigating, testing predictions, hypothesizing, and communicating, with other peers. | • Students analyze, observe natural phenomena or social behaviour.  |
|                   |  |  |
|   | • Guide students to ask questions, plan and pilot study. (Engineering, Technology) | • Students are actively involved in questioning, planning and designing experiments. (Engineering, Technology) |
|                   |  |  |
|   | • Guide students to work in teams. | • Students are working together in teams. |
| Explanation       |  |  |
| • Teachers will encourage students to clarify concepts in their own words, to obtain proof and confirmation from their explanations, and to perform discussion activities. | • Students have an interpretation of the findings of the previous discussion. |
| Elaboration       |  |  |
| • Students are actively engaged in creating some kind of artefact (e.g. robot, computer program) | • Teacher guides students to apply concepts and skills to the workplace. (Engineering, Mathematic, Art) |
| • Students work together in teams | • Students apply concepts and skills to new situations. |
| • Students are free to create and embellish works of art. | • Students are actively involved in the development of many works (Engineering, Mathematic, Art) |
| Evaluation        |  |  |
| • The teacher provides feedback and tests student's knowledge, comprehension of concepts or skills. | • Students answer questions or assessments provided by the teacher as an assessment through the learning process. |
Figure 4. Flow chart of syntax 5E-STEAM learning model.

Figure 1 shows the flow of each learning stage. 5E-STEAM stages are engagement, exploration, explanation, elaboration, and evaluation. The first stage is engagement, teacher gives student contextual problems and students must be make solutions from this problem. The second stage is exploration, students carry out science activities such as observation, investigation, or practicum. Students explore questions and seek information from various literatures. The third stage is explanation, teachers will encourage students to clarify concepts in their own words, to obtain proof and confirmation from their explanations, and to perform discussion activities. The fourth stage is elaboration, students apply the concepts that have been presented at the explanation stage to work. And the last stage is evaluation, teacher provides feedback and tests student's knowledge, comprehension of concepts or skills.
Figure 5. The relationship between teacher and student interactions.

Figure 2 shows the relationships between teachers and students in the 5E-STEAM learning model. The teacher has only a role as facilitator and companion for students, and students have a major role to play in this learning process (student centre learning). At the stage of engagement, the teacher plays a role in stimulating students by asking HOTS questions. At the stage of exploration, explanation, and elaboration students will work together and discuss in their respective groups. Each group consists of four students (may be more or less), who will discuss and find solutions to the problems of the teacher. In addition, students will be asked to make a simple design prototype of the solution. In this process, students are taught to be creative and to make those decisions they should make. In the final step, namely evaluation, the teacher provides feedback and checks on the student's comprehension, understanding of concepts or skills.

4. Discussion

4.1. Results of need assessment

Results of questionnaires given to 10 teachers showed that only 10% of teachers applied STEAM in the class, while another 70% applied problem-based learning, 10% applied Discovery Learning and 10% applied inquiry-based learning. As many as 70% of teachers do not know about the constructive learning model of 5E Learning Cycle, and as many as 30% only know, but they have not implemented yet in learning. In addition, as many as 70% of teachers know only the acronyms of STEAM, but do not understand how to apply STEAM in learning. And the other 30% don't know about the STEAM approach. In this 21st century, teachers not only transfer knowledge, but also provide 21st century skills. 21st Century skills provide the understanding and performance required by students to solve problems, analyze community activities, and succeed in work and social life [24]. Teachers can use the STEAM approach to provide 21st century skills, STEAM Education is a one-sided approach advanced skill growth and achievement in fast-growing careers in the arts and STEM fields. STEAM curriculum ensures that students have the knowledge and skills required for success on any career path, while at the same time empowering and training students for STEAM work [25].
STEAM has made a positive contribution and this program will have a positive effect on their future lives for students [26].

Some of the challenges that occur in the learning process include lack of student engagement, non-focused students, students taking significant time to solve problems, and lack of critical thinking skills. Another challenge facing the teacher is to train students to think critically, students are still not familiar with HOTS questions, students are still focused on the explanations in the book. Students need the ability to solve complex problems. In order to solve complex problems, students must connect previously learned concepts to solve them. The role of the teacher is very important for improving problem solving skills [27]. There are interesting findings based on the results obtained. First, 70% of teachers are know of the STEAM approach, but just 10% apply it to the learning process. Second, the teachers just know the acronym of STEAM without understanding its substance. It is a challenge for the government and teachers to be able to boost the quality of education in Indonesia. Teachers must constantly develop their skills and always keep up with new trends in the field of education and adopt good things to be applied to learning. In addition, the government must be in a position to provide adequate regulations and facilities for teachers to ensure optimal learning.

4.2. Learning model system of 5E-STEAM

4.2.1. Social system
The social system that refers to this model is the creation of groups of heterogeneous students. Students are encouraged to work together and to respect each other's thoughts as other friends share their opinions. Students are free to express opinions, ideas and questions in the discussion. This learning helps students to be able to work together and to rebuild the experience they have with the new knowledge they have learned and to be able to apply it in their daily lives. By cooperative learning, each student can contribute to the learning group and thus learn from each other. Through cooperative learning, interpersonal skills of students can be fostered and developed [28]

4.2.2. Reaction principle
The principle of reaction in the 5E-STEAM Learning Model is that the teacher acts as a learning facilitator, such as helping students relate concepts, implementation concepts, direct groups. Other activities of the teacher include coordinating students to discuss the results of the interaction exercises, observing students as they present the results of the discussion in front of the class, and clarifying the information presented by the community. Furthermore, teacher give feedback or evaluation in learning process, teachers motivate their students to learn by providing them with positive feedback, in order to develop competence [29].

4.2.3. Supporting system
The support system for the implementation of 5E-STEAM learning model is that teachers must have specific or actual issues, resources and materials for the development of goods. The instructor also offers detailed workbooks and student discussion papers. Students must actively seek and explore knowledge through a variety of literature.

4.2.4. Instructional impact
The instructional effect of the 5E-STEAM learning model is that students have the ability to associate information, to apply knowledge, to interact, to express their thoughts, to provide critical thinking skills and to solve problems. This can be seen from the cognitive value of students after learning.

4.2.5. Indirect impact
The impact of the 5E-STEAM learning model is that students are actively involved in the learning process in order to make learning more meaningful. Students are able to solve problems through discussion. Discussion activities will trigger a sense of cooperation and mutual respect for one another.
In addition to the practical work that will be carried out, students will be more thorough, and disciplined.

4.3. Critical thinking skill in 5E-STEAM learning model

Critical thinking skills can be developed in their learning practices in the 5E-STEAM learning model. At this point, in the first syntax that is engagement, the teacher gives students questions in the form of contextual problems. Students will be stimulated by the HOTS questions, so students will begin to think and discuss the problems. The second stage is exploration, at this phase the teacher poses more complicated problems and directs students to be able to examine and find a solution. In addition, the solution that students consider must be applied in a product or task performance. It would offer students the ability to have engineering and technological skills. Piaget stated that direct experience plays an important role in accelerating cognitive development. Efficiency of direct experience as a driving factor for cognitive speed. Through exploration activities, students can get hands-on experience which is very important for the process of knowledge reconstruction [30]. The third stage is an explanation, at this point students are prepared to be able to describe the implications of the previous discussion. In the debate events, students will share thoughts and views, which also allows students to think critically. The fourth stage is elaboration, at this stage students are applying job concepts. Elaboration exercises can activate student's skills in developing a work that includes engineering, mathematics, and art. The final stage is Evaluation, at this stage students will focus on different worksheets intended to develop students' critical thinking skills.

5. Conclusion

The 5E-STEAM learning model is the development of the learning cycle 5E and STEAM approach. The 5E-STEAM syntaxs are Engagement, Exploration, Explanation, Elaboration, Evaluation. The components of the 5E-STEAM learning model include social systems, reaction principles, support systems, instructional impacts, indirect impacts. The teacher triggers student's critical thinking skills by posing HOTS questions at the stage of engagement. The teacher also presents questions for the C4-C6 level at pre-test and post-test. This research has reached the stage of define and design, for the next, this research still needs a validation process to test the validity and effectiveness of the learning model. Also dissemination process to publish the results of product to other teachers.

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References
[1] Afandi, Sajidan, Akhyar M and Suryani N 2019 Development frameworks of the Indonesian partnership 21st century skills standards for prospective science teachers: A Delphi study Jurnal Pendidikan IPA Indonesia 8 pp 89–100
[2] Teo P 2019 Teaching for the 21st century: A case for dialogic pedagogy Learning Culture and Social Interaction 21 pp 170–178
[3] Haviz M, Karomah H, Delfita R, Umar M I A and Maris I M 2018 Revisiting generic science skills as 21st century skills on biology learning Jurnal Pendidikan IPA Indonesia 7 pp 355–363
[4] Suratno, Komaria N, Hobri, Husniah F, Novenda I L and Fahroyin M 2020 Biotechnology concept: Questioning of analysis with lesson study for learning community (LSLC) for higher ordered thinking skill on coffee area plantation Journal of Physics: Conference Series 1563(1)
[5] Suratno, Komaria N, Yushardi, Dafik and Wicaksono I 2019 The effect of using synectics model on creative thinking and metacognition skills of junior high school students International Journal of Instruction12 pp 133–150
[6] Insani K, Suratno and Farisi I 2020 ICT literacy with google suite for education (GSFE) in junior high school with different academic abilities Journal of Physics: Conference Series 1563(1)

[7] Fadilah I N, Suratno, Prastiti T D, Dafik and Hobri 2020 The metacognition of elementary students in object change learning with SQ3R (Survey, Question, Read, Recite and Review) Journal of Physics: Conference Series 1563 (1)

[8] OECD 2019 PISA 2018 Results (Volume I): What Students Know and Can Do PISA Paris: OECD Publishing

[9] Lévano M, Albornoz A 2016 Towards a framework to improve the quality of teaching and learning: consciousness and validation in computer engineering science UCT International Conferences ITS, ICEduTech and STE pp 100–106

[10] Kostiainen E, Ukskoski T, Ruohotie-lyhty M, Kauppinen M, Kainulainen J and Tommi M 2018 Meaningful learning in teacher education 71 pp 66–77

[11] Fernandi R A U ’ilm F H and Rusyati L 2017 The Profile of Students’ Critical Thinking Measured through Science Virtual Test on 9th Grade in The Theme of Living Things and Environmental Sustainability. Journal of Science Learning 1 pp 1–7

[12] Lucas K J 2019 Chinese Graduate Student Understandings and Struggles with Critical Thinking: A Narrative-Case Study Critical Thinking & International Students Participants and Setting 13 pp 1–7

[13] Mutakinati L and Anwari I 2018 Analysis of Students’ Critical Thinking Skill of Middle School through STEM Education Project-Based Learning Jurnal Pendidikan IPA Indonesia 7 pp 54–65.

[14] Rahmawati Y 2018 Peranan transformative learning dalam pendidikan kimia: pengembangan karakter, identitas budaya, dan kompetensi abad ke-21 JRPK: Jurnal Riset Pendidikan Kimia 8 pp 1-16

[15] How M L and Hung W L D 2019 Educuing AI-thinking in science , technology , engineering , arts , and mathematics (STEAM ) education Educ. Sci 9 pp 184

[16] Apriliana M R, Ridwan A, Hadinugrahaningsih T and Rahmawati Y 2018 Pengembangan soft skills peserta didik melalui integrasi pendekatan science, technology, engineering, arts, and mathematics (STEAM) dalam pembelajaran asam basa JRPK: Jurnal Riset Pendidikan Kimia 8 pp 42–51

[17] Liao C 2016 From interdisciplinary to transdisciplinary: an arts-integrated approach to steam education. Art Education 69 pp 44–49

[18] Karsli F and Ayas A 2014 Developing a laboratory activity by using 5e learning model on student learning of factors affecting the reaction rate and improving scientific process skills Procedia - Social and Behavioral Sciences 143 pp 663-8

[19] Shofiah S, Lukito A and Siswono T Y E 2018 Pembelajaran learning cycle 5e berbasis pengajuan masalah untuk meningkatkan hasil belajar siswa kelas X pada topik trigonometri. Kreano, Jurnal Matematika Kreatif-Inovatif 9 pp 54-62

[20] Siwawetkul W and Koraneekij P 2018 Effect of 5E instructional model on mobile technology to enhance reasoning ability of lower primary school students Kasetsart Journal of Social Sciences pp 1–6

[21] Wilson R E and Bradbury L U 2016 The pedagogical potential of drawing and writing in a primary science multimodal unit International Journal of Science Education pp 1–21

[22] Kim H and Chae D H 2016 The development and application of a STEAM programbased on traditional Korean culture Eurasia Journal of Mathematics Science and Technology Education 12 pp 1925–36

[23] Thiagarajan S, Semmel, D S, Semmel, M I 1974 Instructional Development for Training Teachers of Exceptional Children Indiana: Indiana University Bloomington

[24] Atalay N and Dilek B B 2019 Slowmation application in development of learning and innovation skills of students in science course. International Electronic Journal of Elementary Education, 11 pp 507–518
[25] Dell’Erba M 2019 *Preparing Students for Learning, Work and Life Through STEAM Education* pp 1–12
[26] Ozkan, G., & Topsakal, U U 2017 Examining Students’ Opinions about STEAM Activities *Journal of Education and Training Studies*, 5 pp 115
[27] Hobri, Ummah I K, Yuliati N and Dafik 2020 The effect of jumping task based on creative problem solving on students’ problem solving ability *International Journal of Instruction* 13 387–406
[28] Wang G 2020 On the Application of Cooperative Learning in College English Teaching. *International Education Studies* 13 6 pp 62
[29] Davion J 2017 The role of teachers in motivating students to learn *BU Journal of Graduate Studies in Education* 9 pp 2013–16
[30] Fitriyah M, Suratno, Prastiti T D, Dafik and Hobri 2020 The effectiveness of the combined of inquiry and experimental learning models on student cognitive learning outcomes about the properties of light *Journal of Physics: Conference Series* 1563(1)