The development of science, technology, engineering, art, and mathematics learning devices – lesson study for learning community to improve students’ creative thinking skill

M Safik¹, Hobri², N Yuiani³, W Sarjono⁴, and I A Sa’id⁵
¹²³Mathematic Education Department, University of Jember, Jember, Indonesia
³Education Department, University of Jember, Jember, Indonesia
⁴Information System Management Departement, BINUS Graduate Program – Master Of Information System, BINA NUSANTARA University, Jakarta, Indonesia 11480

Email: nanik.fkip@unej.ac.id; mohammadsafik140280@gmail.com

Abstract. This research aimed to develop learning devices based on science, technology, engineering, art, and mathematics - lessons study for the learning community to improve students’ creative thinking skills on algebraic operation material. The learning devices developed were lesson plan, students’ workbook, and learning result test. The development model used Thiagarajan’s development model that consisted of four stages: define, design, develop, and disseminate. The subjects of this research were the eighth-grade students from (Islamic Junior High School) MTs. Nurul Islam Bades Pasirian. Students' creative thinking abilities were measured using a creative thinking skill test. This research described the development process and validity, practicality, and effectiveness results. This research’s results were learning devices that met the criteria of validity, practicality, and effectiveness.

1. Introduction
Education can be done by the nation's children to develop themselves, both in thought patterns and attitudes, traits, skills, intelligence, self-control, and spiritual religion. It is in accordance with the meaning of education as stated in The Law of Republic Indonesia Number 20/2003; namely, Education is a deliberate and planned attempt to build a learning environment and the learning process so that students grow their potential actively so that they have the strength of faith, spiritual influence, self-control, personality, intellect, noble character, and skills required for themselves the community, country, and state.

Life in the 21st century demands people to acquire various skills to face and prepare for future challenges. 21st-century learning focuses on high-level abilities and innovation abilities. There are four main principles of learning, namely student-centered learning approaches, collaboration-based education, contextual learning (associated with everyday life), and schools integrated with the surrounding environment (community) [1]. Students are expected to have four key abilities from these values to live the life of the 21st century, including critical thinking, creativity, communication and teamwork. [2][3][4]. In creativity, teachers are expected to prepare creative ideas so that their creative thinking skills can generate new ideas [5]. Creativity is how students think creatively and how someone must have both aptitude traits and non-aptitude traits [6] [7].

STEAM is one of the learning methods that uses five elements of science (science, technology, engineering techniques, art, and mathematics) where all these aspects become systematic ways of thinking to be able to understand science and apply them in the daily life as a pattern of problem-solving, creative, and analytical thinking [8][9].

The STEAM learning model's final result was that children were involved in learning, got an experience, could do problem-solving, collaborated, and worked through a creative process (4C/21st century learning). STEAM was believed to be a solution in facing the revolutionary era industry 4.0.
STEAM-based learning is expected to be a product and design that supports educational activities [12]. STEAM is the incorporation of disciplines in the fields of science, technology, engineering and mathematics (STEM) into the curriculum and learning [13]. Meanwhile, according to Brown [14] STEM is a school-level meta-discipline where teachers of science, technology, engineering and mathematics teach an integrated approach and each content is viewed as a vibrant unit.

Efforts to improve creativity skills begin with the habit of the school and integrating it into the learning process. When the group does collaborative learning and community learning, learning patterns may be improved. Group learning seeks to facilitate the creation of collaborative teacher relationships to achieve collaborative learning in the classroom [15]. Community learning has a goal that no student feels overlooked in learning activities by the teacher. In addition to conveying learning, the teacher must also care for students, especially students that have difficulties, by motivating learners to learn collaboratively in which the students can learn from each other and listening to each other. There are three philosophies in the learning community: 1) public philosophy, 2) democracy philosophy, 3) superior philosophy [16]. Collaborative learning and community learning are a series of LSLC lessons. LSLC is an implementation of a lesson study to build a learning community [17].

In Indonesia, in a series of follow-up programs from the Indonesian Mathematics and Science Teaching Education Project (IMSTEP) at the end of 2004, LS was first launched by the Japan International Cooperation Agency (JICA) to enhance the quality of mathematics and science education in Indonesia.

As time goes by, lesson study has changed into a Lesson Study for Learning Community (LSLC), oriented towards students’ activities and how students learn. Teachers as models in learning and parents join the learning community and participate in restoring education together [18]. LSLC activities also include “plan”, “do” and “see” activities focused on collaborative learning carried out to build a Learning Environment through free “Open Class” classes [19].

2. Method
This research was qualitative research which aimed to develop STEAM-LSLC learning tools. This research was the development of a product-oriented learning design. The development process was explained clearly and in detail through the development stages until obtaining the development of qualified learning tools. The resulted products consisted of student worksheets, lesson plans, and tests of students’ creativity skills. Furthermore, the resulted products were distributed to the students from other schools in Lumajang Regency.

This study used the development of the 4D Model by Thiaragajan research method. Thiagarajan’s 4-D model fulfilled the development process instructions, consisting of four stages: Define, Design, Develop, and, Disseminate.

The objective analysis was limited only to the subject matter to be developed. The planning stage aimed to design learning tools to obtain prototypes (examples of learning tools). The ‘develop’ stage began after setting specific learning objectives. This stage consisted of 4 steps, namely: 1) preparation of tests, 2) media selection, 3) selection format, and 4) initial design (initial design). The ‘develop’ stage aimed to produce a draft of revised learning tools based on experts’ suggestions and data obtained from trials. Activities at the ‘develop’ stage consisted of the assessment by experts and field trials. Those activities included validation of the tools by experts with revisions and field trials with real students. This stage was the stage of using learning tools developed on a broader scale, such as in other classes, other schools, and other teachers. This stage’s purpose was to test the effectiveness of using learning tools in the teaching and learning process. The ‘Disseminate’ stage was done by applying learning tools in libraries and on the internet. Data analysis was carried out in the development of STEAM-LSLC learning tools, namely 1) data analysis towards the learning tools, 2) data analysis towards students’ activities, 3) data analysis towards teacher’s activities, 4) analysis of
students’ responses about STEAM-LSLC learning tools, 5) the analysis of students’ creativity skills. The process of development research can be seen in Figure 1.

![4-D Models](image)

Figure 1. 4-D Models

This development was carried out at Islamic Junior High School (MTs.) Nurul Islam of Pasirian, especially in class VII A that consisted of 28 students. The data of this research were collected through experts’ validation, observation, creative skill tests, and questionnaires. The data in the research can be seen in Table 1.

| Validity          | Practicality                                                   | Effectiveness                                                                 | Creative Skill Test                                                                 |
|-------------------|----------------------------------------------------------------|------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| The learning tool was said to be valid if it met the validity criteria. The validation was carried out by two lecturers of the Faculty of Mathematics and Natural Sciences, University of Jember, and a mathematics teacher at Islamic Junior High School Nurul Islam of Pasirian. | Learning tools were said to be practical if the observation sheet assessment met practical criteria. The data obtained through interviews and observation sheets were analyzed. | Learning tools were said to be effective if they fulfilled three aspects, namely cognitive seen from the test results, psychomotor seen from student observation sheets, and affective seen from student response questionnaires. | Learning tools affected students’ creative thinking if the creative ability test met the criteria for assessing the level of creative thinking. |
3. Results and Discussion

3.1 The Results of the Research

This research produced learning tools that were valid, practical, effective, and applicable to see improvements in students' creative thinking. This research's development process began with preliminary research by the researcher at Islamic Junior High School Nurul Islam of Pasirian in Lumajang regency. The observation, which was carried out in the seventh grade, became an analysis of the learning process, including student analysis, material analysis, and competency specifications. The next step was the ‘design’ stage, namely designing the learning tool's initial prototype, compiled learning plans, student worksheets, and tests of students' creativity skills. Validation and testing activities were carried out at the assessment stage. Validation aimed to assess the feasibility of the learning tools to be tested. First, the trial stage was carried out in small groups of 4 students. Furthermore, the trial in a large group was carried out at Islamic Junior High School Nurul Islam in Lumajang Regency, especially in class VIIA, consisting of 28 students.

After the activities were carried out according to the steps above, the learning tools' validation results, namely the lesson plan, student worksheets, students' creativity skill test, and research instruments, can be seen in Figure 2 and Figure 3.

![Figure 2. The result of learning tools validation](image1.png)

![Figure 3. The result of the research instruments validation](image2.png)

Figure 2 shows that the lesson plan's average score was 4.6; the students' worksheets' average score was 4.5; the average test score of 4.6. This score was included in the valid category. Figure 3 shows the observation sheet getting an average score of 4.7; the student observation sheet's average score was 4.6; the questionnaire's average score was 4.6. These scores can be included in the valid category. Therefore, the learning devices and research instruments were categorized as valid. The results of the STEAM-LSLC learning tools testing at Junior High School Nurul Islam of Pasirian in class VIIA are presented in the following figure.
The chart above shows that observations of teacher’s activities reached 79% with good criteria. At the second meeting, the teacher's activities reached 85.6% with good criteria. At the third meeting, it reached 90% with very good criteria.

Theoretically, the learning tool’s practicality could be seen in experts’ and practitioners’ assessment results who had implemented learning tools and stated that learning tools could be implemented in learning. The results of observation of teacher’s activities when teaching using STEAM-LSLC-based learning tools.

The teacher at Islamic Junior High School Nurul Islam of Pasirian has never implemented STEAM-LSLC-based learning yet. The teacher was accustomed to using the conventional learning method. Students were only allowed to listen to and note what the teacher said. Only a few students had the opportunity to develop personal abilities. A learning process like this made students passive. It was why students were not able to build mathematical knowledge or find their problem-solving solutions. If there was material that the students did not understand, they could not ask questions and could not express their thinking. To solve the problems above, the researcher and the mathematics teacher discussed STEAM-LSLC-based learning, then asked the teacher to carry out learning using STEAM-LSLC-based learning tools with a parallel class pattern instead of an experimental class. Thus, the practicality of learning tools based on observation towards the teacher’s teaching activities reached the good category.

The effectiveness of learning tools can be determined through students' activities, tests of students' creativity skills, and questionnaires. First, students' activities can be seen by observing students’ activities during learning. One of this research’s interests was group discussion. Group discussion should lead to collaboration between students, which created an exemplary learning community. The flow of students’ activities is presented as follows, each group consists of four students’[20] (using the example of one group)

In Figure 5, it can be seen that the group discussion was running quite well. There were four people in the group, namely student A, student B, student C, student D. At the first meeting, student C seemed very active because student C understood the material better and provided explanations to all group members. It showed student B’s concern for all group members. However, there were only two students
who asked questions, namely student B and student D. Student A did not understand the material, so he
did not seem active. Students who had understood the material trying to explain to student A so that
student A could understand the material. This activity showed that no student was neglected because
they had a sense of competitiveness in caring for one another. At the second meeting, the students
seemed able to collaborate well. Each student had a sense of concern for each other. It was evident from
the students swapping seats at this meeting. At this meeting, student A dared to ask questions. At this
meeting, all students seemed to collaborate in solving problems faced actively, cared for each other by
helping friends, and shared in group learning. In addition to observing students' activity, the researcher
also provided questionnaires to students regarding student worksheets scores. The results of the
questionnaires can be seen in Figure 6.

![Figure 6. The students' responses](image)

Figure 6 shows the students' responses, including 10% of students disagreed, 7% of students
disagreed, 27% of students quite agreed, and 57% agreed. The reason many students chose to agree was
that learning was carried out with much practice. It was also fun and motivated students to find new
ideas not to get bored. Student worksheets were equipped with pictures to make them more attractive.
Students gave positive responses regarding student worksheets because the language used was
understandable. Furthermore, the student creativity skills test.

Twenty-eight students in the class attended the student creativity skill test. In detail, 24 students
completed the results, and four other students did not complete them. The completeness of the scores
above the minimum passing score (KKM) reached 85.7% of the whole students in the class. Therefore,
the STEAM-LSLC based mathematics learning tool could be considered as effective. The results of the
tests conducted by students can be seen in Figure 7

![Figure 7. Graph of student score](image)

### 3.2 Discussion

The learning tools must have content validity, and the construction of the learning tools developed
must meet valid criteria. From the trial phase to determine the level of validity for pursuit development,
it was obtained that the average percentage score of the validator for the lesson plan was 92%.
Furthermore, the percentage of the average score of the student worksheet results was 91%. Then, the
percentage of the average score of the results of the students' learning tools validation. The creativity
skill test reached 93%, so that the criteria set for the lesson plan, student workbook, and the creativity
skill test fulfilled valid criteria.

Practical criteria could be seen based on extensive group tests. The practicality was seen based on
observations of teachers' activities in which the learning tools met the good category. The effective
category was seen based on the observation of students’ activities that met good criteria. The results of the completeness of teaching materials met the classical completeness criteria. Based on the results of the questionnaires, the students showed positive responses.

Many other researchers have carried out the development of LSLC-based learning tools. This research developed STEAM-LSLC-based learning tools, which contained learning designs integrated with LSLC and included STEAM elements. This device was able to improve creative thinking skills in solving problems, especially mathematics. The correlation between STEAM and LSLC to increase students' creative skills can be seen in Figure 8.

![Figure 8. The correlation between STEAM and LSLC](image)

The development of STEAM-LSLC based learning tools was beneficial because students were invited to construct solutions to problems utilizing collaborative learning groups and a caring community.

4. Conclusion

Based on the research that has been done, it can be concluded that the development of STEAM-LSLC based mathematics learning tools produced valid, effective, and practical learning tools. The process of developing learning tools was carried out through Thiagarajan's 4-D model, namely, Define, Design, Develop, and Disseminate. The development showed that it was valid with the average score of lesson plan was 4.6; the average score of the students' worksheets was 4.5; the average test score of 4.6 this score was included in the valid category. It showed that the observation sheets got an average score of 4.7; the student observation sheet's average score was 4.6; the questionnaires’ average score was 4.6. The class's completeness presented the effectiveness with 85.7% of the 28 students who completed. The practicality was shown from observations of learning implementation with a percentage of 90% in the very good category.

Based on research on the development of STEAM-LSLC based mathematics learning tools, it could be considered as can improve students' creative thinking. Other mathematics teachers can use the student workbook and learning outcomes test for daily learning. For future researchers who will conduct similar research, it is necessary to know the difficulties in developing mathematics learning tools, especially in designing lesson plans.
Acknowledgments
We are very grateful to the department of post-graduate mathematics education, Faculty of Teachers Training and Education, University of Jember. I am grateful to have received support from friends of the ImelsLC research group, FKIP Universitas Jember Indonesian of the year 2020 and supervisors who gave a lot of input on this paper.

References
[1] Zubaedah S 2016 Keterampilan Abad Ke-21: Keterampilan Yang Diajarkan Melalui Pembelajaran J. Penelit. Pendidik. 1–17
[2] Madden M E, Baxter M, Beauchamp H, Bouchard K, Habermas D, Huff M, Ladd B, Pearson J and Plague G 2013 Rethinking STEM education: An inter-disciplinary STEAM curriculum Procedia Computer Science
[3] Lee L H J and Tan S C 2020 Teacher learning in Lesson Study: Affordances, disturbances, contradictions, and implications Teach. Teach. Educ.
[4] Ariyani, B., Wasitohadi, Rahayu T S, Leikin, R., Zaskalavsky O, Anita W, Setianingsih R and Sunardi 2016 Educational Psychology Active Learning Edition vol 28
[5] Sitorus J and Masrayati 2016 Students’ creative thinking process stages: Implementation of realistic mathematics education Think. Ski. Creat.
[6] Lanudin D 2018 PENGEMBANGAN BAKAT KREATIVITAS ANAK J. Teknodik
[7] Moore T J, Stohlmann M S, Wang H H, Tank K M, Glancy A W and Roehrig G H 2014 Implementation and integration of engineering in K-12 STEM education Engineering in Pre-College Settings: Synthesizing Research, Policy, and Practices
[8] Kena G, Aud S, Johnson F, Wang X, Zhang J, Rathbun A, Wilkinson-Flicker S, Kristapovich P, Notter L, Nachazel T and Dziuba A 2014 The Condition of Education 2014 (NCES 2014-083)
[9] Siregar Y E Y, Rahmawati Y and Suyono 2020 Elementary school teacher’s perspectives towards developing mathematics literacy through a STEAM-based approach to learning J. Phys. Conf. Ser. 1460
[10] Nurhikmayati I 2019 Implementasi Steam Dalam 1 41–50
[11] Tirri K, Cho S, Ahn D and Campbell J R 2017 Education for Creativity and Talent Development in the 21st Century Educ. Res. Int.
[12] Saddhono K and Rohmadi M 2014 A sociolinguistics study on the use of the Javanese language in the learning process in primary schools in Surakarta, Central Java, Indonesia Int. Educ. Stud.
[13] Katz-Buonincontro J 2018 Gathering STE(A)M: Policy, curricular, and programmatic developments in arts-based science, technology, engineering, and mathematics education Introduction to the special issue of Arts Education Policy Review: STEAM Focus Arts Educ. Policy Rev.
[14] Brown T and Katz B 2011 Change by design J. Prod. Innov. Manag.
[15] Saito E, Murase M, Tsukui A and Yeo J 2014 Lesson Study for Learning Community
[16] Hobri 2016 Proceedings of the Madura National Seminar: University of Madura (UNIRA) (Madura: University of Madura (UNIRA))
[17] Hobri and Susanto 2016 No TitleNational Seminar Proceedings (Jember: Universitas Jember (UNEJ)
[18] Saito E and Atencio M 2015 Lesson study for learning community (LSLC): conceptualising teachers’ practices within a social justice perspective Discourse
[19] Mustadi A 2014 Fundamental School Reform Through Lesson Study For Learning Community (LSLC): A Study Of Collaborative Learning In Indonesia And Japan Int. Conf. Fundam. Implement. Educ. (ICFIE) 87–95
[20] Chichibu T and Kihara T 2013 How Japanese schools build a professional learning community by lesson study Int. J. Lesson Learn. Stud.