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Development of LSLC-Based Collaborative Learning Model Learning Tools and Their Effects on Critical Thinking Skills

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ABSTRACT

The purpose of this study is to develop collaborative learning-based learning resources and their impact on students' capacity for critical thought. This study used a combination of methods, namely development research (R&D) with Thiagarajan 4D model and experimental research. Data was collected through observations, questionnaires, tests, and interviews. The validity coefficients for the Teaching Module, worksheet, and test were 3.80, 3.80, and 3.70, respectively. Observations showed that 96% of the learning tools met practical criteria. The tools were effective, with 93% of student activities rated very good, 96% of students giving positive responses, and 85% achieving learning completion. A t-test (sig = 0.007) confirmed the collaborative learning tool based on LSLC significantly enhanced students' critical thinking skills.

1. Introduction

The industrial revolution's fast advancements in science and technology 21st-century Version 4.0 encourages human resources to compete globally. The Partnership for 4C Skills are formulated by 21st Century Skills (4C's) especially critical thinking, communication, collaboration and creativity as 21st Century skills (Anwar et al., 2017; Hidayati et al., 2021; Saleh, 2019; Tohani & Aulia, 2022; Widana, 2018). Since 2022, Indonesia has launched the Merdeka Curriculum to catch up with education with other countries as a way to respond to challenges in the 21st century (Hanipah, 2023; Lubis et al., 2023; Sartini & Mulyono, 2022;

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Triadi et al., 2022). The Merdeka curriculum emphasizes critical thinking is one of the Pancasila student profile's aspects (Khasanah & Muthali'in, 2023; Muna & Moh. Fathurrahman, 2023; Purwanto et al., 2023). In the twenty-first century, critical thinking is a crucial talent that kids need to be empowered with (Miterianifa et al., 2021; Saavedra & Opfer, 2018; Živkovic, 2016).

The capacity for critical thought shows that learners have skills in decision making (Tohani & Aulia, 2022) logically with rational and reflective reasoning, able to solve problems, conclude and evaluate decisions (Prameswari et al., 2018) and high order thinking skill (Kurniawan et al., 2021), so that it affects the cognitive of students. Students are said to have the capacity for critical thought if they can find solutions to issues with various knowledge and information possessed by students (Peter, 2012), therefore students who are only able to solve problems without knowing the reason for the concept, cannot be regarded as possessing critical thinking skills.

Ennis provides six indicators circumstance: focus, reason, inference, clarity, and overview (FRISCO) that can demonstrate critical thinking abilities (Andiarini et al., 2018; Mirunnisa & Razi, 2021). FRISCO criteria are explained as follows (1) focus means that students must understand the problem, (2) reason means that students must give the right reason for the answer decision from solving the problem, (3) inference means that students can make reasonable conclusions so that students are able to identify assumptions about problem solutions and consider interpretations of evidence, (4) situation means that students are able to dig up various reinforcement information or supporting parts to help clarify questions in focus and know the answers, (5) clarity means that students can explain all parts of the answers in solving, (6) overview means that students research, check and recheck the correctness of answers thoroughly (Ulfa et al., 2018). FRISCO indicators are widely used by previous researchers, for example research conducted in Pontianak (Raudhah et al., 2019) and in Malang (Zubaidah et al., 2020) to analyze Critical thinking abilities of students.

Subjects that may enhance and cultivate critical thinking abilities in mathematics (Apriza, 2019). This is supported by research conducted by (Arisoy & Aybek, 2021) problem-solving activities learning mathematics has a big impact on critical thinking abilities. However, in fact, the response of students and learning achievement in mathematics subjects is relatively low. Students find it difficult to solve problems in mathematics subjects because they tend to memorize formulas rather than understand the actual concepts. Students' critical thinking abilities, which are directly linked to problem solving, may be developed through initiatives that focus on developing their interpretation, analysis, inference, assessment, explanation and justification, and self-regulation skills (Kravchenko et al., 2022), which begins with habituating the disposition of critical thinking in solving mathematical problems (Kurniati & As'ari, 2021) in the classroom.

The habituation of critical thinking disposition must be accompanied by the strength of components in the learning system, such as learning models, methods, learning tools and evaluation materials to be implemented. Reinforcement of these components will stimulate students to take a more hands-on approach to learning. Selecting an appropriate learning model is crucial in helping students comprehend the content being taught (Prasetiyo & Rosy, 2021)

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and sharpen their analytical abilities. In addition, learning objectives are significantly impacted by the creation of educational resources using certain learning models. If the process of finding information to solve a problem that requires students to think critically is done individually, then students will experience boredom because it feels boring and very burdensome.

The collaborative learning model is anticipated to enhance pupils' capacity for critical thought because collaborative learning is a learning process of discussing in groups to find various opinions or thoughts issued by each individual in the group. (Hobri, 2020). Working together in groups (collaborative learning) rather than being competitive to achieve shared learning goals results in higher achievement and greater productivity (Salma, 2020). Collaborative Learning awakens learners to know known and unknown knowledge, so that they will share and interdepend positively, have relational skills to respect each other's contributions, opinions or ideas (Aderi et al., 2018; Respati, 2018). The application of learning that focuses on discussions between individuals in groups (Collaborative Learning) will create anticipation during KBM, critical thinking skills, exploration, and good problem solving (Sunismi & Fathani, 2017). With the implementation of five stages of Collaborative Learning adapted from Reid, namely engangment, exploration, transformation, presentation, and reflextion can improve critical thinking skills (Anwar et al., 2017; H et al., 2021; Sari et al., 2021).

The mathematics collaborative learning paradigm in this study is combined with Lesson Study Learning Community activities, namely plan (planning), do (implementation), and see (reflection) to be more successful in enhancing pupils' capacity for critical thought. This is supported by previous research, that LSLC can improve learning outcomes (Asih et al., 2018), creative thinking skills (Kusumawati et al., 2019) and students' critical thinking skills (Rinjani, 2023). In addition to the LSLC-based collaborative learning model, providing contextual problem-based essay questions that require students to apply concepts, knowledge or various information that has been learned into a problem to solve problems, can develop critical thinking skills (Nurfathurrahmah, 2018; Yasinta et al., 2020; Zubaidah et al., 2020) and create more meaningful learning.

The creation of devices that are in line with student characteristics and learning objectives is the first step in learning innovations that can accommodate students to achieve learning objectives, according to a review of the literature on the significance of students' critical thinking abilities, particularly in mathematics subjects and mathematics learning problems. In order to test their theories that collaborative learning tools based on lesson study and learning communities might enhance students' critical thinking abilities and learning motivation, researchers built them.

2. Method

This study employed a variety of research methods, including experimental and development research (R&D) using the Thiagarajan 4-D model. Twenty students from SMA Unggulan Hafsa Zainul Hasan Genggong's Class XI 2A served as the study's subjects for the 2023–2024 academic year. In contrast, the population of the experimental study consisted of students from Class XI 2B, which served as the experimental class, and Class XI 2C, which served as the control class.

The initial step in this research is to conduct device development research using Thiagarajan, Semmel & Semmel 4-D model development procedures

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consisting of 1) the define step, which involves front-end analysis, learner analysis, conceptual analysis, task analysis, and defining instructional objectives, in order to ascertain learning needs, 2) the stage of design is the stage carried out to design learning tools according to the define stage, in the form of initial design (prototype) of LSLC-based collaborative learning tools, 3) the develop stage to develop learning tools (prototype) by revising the results of expert assessment, readability tests and learning device tests, 4) the final step in the process of implementing reliable, useful, and efficient learning resources is the dissemination stage.

The learning tool products developed consist of Teaching Modules, student worksheet, and Critical Thinking Test Composition Functions which contain systematic steps of LSLC-based collaborative learning. The six Ennis indicators—focus, reason, inference, circumstance, clarity, and overview—are the standards for critical thinking that are used. (FRISCO). Table 1 displays the indicator that was created, which is the Ennis indicator.

Table 1. The Indicator Critical Thinking

Criteria	Indicators of Critical Thinking
Focus	a. Students are able to gather and record information regarding what is known and requested about the subject, whether it is accurate or not. b. Participants can articulate pertinent details about the topic. c. Students are able to recognize and comprehend the relationship between often asked questions and well-known facts. d. The capacity to communicate knowledge about subjects covered in mathematical puzzles.
Reason	a. Participants can identify methods for resolving issues related to the topic. b. Participants can describe the steps of the method they used to solve the mathematical problem either in writing or verbally. c. In order to reach a conclusion, the student can defend their reasoning using the facts pertinent to each stage of the problem-solving process.
Inference	a. The capacity to solve mathematical problems using appropriately reflected procedures. b. The student is able to make a precise inference.
Situation	Mathematical problems can be solved by students by making connections between relevant facts or past knowledge.
Clarity	The conclusion or response to the question can be understood and clarified by the student.
Overview	From start to finish, students may carefully go over each step and the outcomes of its accomplishment.

Data collection instruments in the study are expert validation sheets, Student activity observation sheets, student response surveys, critical thinking tests, and learning device implementation sheets. The data obtained is primary data to determine the value of validity, practicality, and effectiveness of the product developed. LSLC-based collaborative learning tools are valid if they meet the valid criteria.

The percentage of observations on the learning device implementation sheet indicates the practicality of the device, while student response questionnaires, the Critical Thinking Test recapitulation, and student activity observations show the

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effectiveness of the device. Learning tools are said to be effective if student activity as a proportion is at least that of the active category, Over 80% of students meet the requirements for minimum completeness, and the response of students is positive. If the generated product has been deemed legitimate, workable, and efficient, continue doing experimental research utilizing the experimental class's and the control class's pre- and post-test outcomes. The experimental group used an LSLC-based whereas the control group employed a traditional learning model and the collaborative learning methodology.

Quantitative data analysis in experimental research by conducting hypothesis tests to ascertain if LSLC-based collaborative learning tools have a noteworthy impact on students' critical thinking skills. Hypothesis Test employing parametric test, specifically independent sample t-test, when the data is certified normally distributed and homogenous.

3. Results and Discussion

The learning tools produced inside this research are Teaching Modules, student worksheet and Critical Thinking Test using valid, practical and effective LSLC-based Collaborative Learning tools that have been developed have passed 4 stages (4-D Thiagarajan, Semmel & Semmel) specifically, to define, create (design), develop, and distribute (disseminate).

Define stage, conducted through a requirements analysis through observation of the learning process in the classroom, found that during the learning process and interviews with mathematics teachers, the development of learning tools is needed to help students achieve the learning goals to be achieved. In solving contextual problems the composition function students are not able to convert the information on the problem into a mathematical model, but they can do routine problems that are exactly the same as the example questions the teacher gives, because students do not understand the concept of composition function well. This means that learners have not achieved the ability to analyze, find reasons (rational), conclude, make decisions and evaluate information. The cognitive development stage of high school children whose average age range is 16-18 should have the ability to think abstractly, formulate and respond to problems. In fact, students have not been able to construct knowledge independently.

Results from earlier studies that showed pupils had trouble repeating the teacher's explanations are consistent with this conclusion and do not feel confident to express opinions because didk participants have not been able to construct knowledge or concepts independently (Hariyanti & Wutsqa, 2020). Students who are unable to construct their knowledge mean that students are unable to think critically. Because by thinking critically, learners can build mathematical knowledge and develop rational attitudes to choose the best alternative choice (Farib et al., 2019). Apart from observations and interviews, researchers also analyzed the CP and TP of the Composition Function material at Independent Curriculum to design learning tools.

Design stage, designing the initial design (prototype) of LSLC-based Collaborative Learning tools, namely Teaching Modules, student worksheet and Critical Thinking Test composition function materials. Device development must pay attention to supporting components, specifically: etymology, social structure, response theory, assistance network, influence of training, and effect of

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accompaniment in accordance with LSLC-based Collaborative Learning.

The Teaching Modules prepared based on the Independent Curriculum on the Merdeka Learning Platform are divided into two, namely: 1) general identity consisting of general module information, initial competence, Pancasila student profile, facilities and infrastructure, learning models and methods, and student targets, 2) core components consisting of learning outcomes (CP), Learning Objectives (TP), indicators of achievement of learning objectives (IKTP), meaningful understanding, lighter questions, learning activities, assessment, remedial, enrichment, teacher reflection and student reflection.

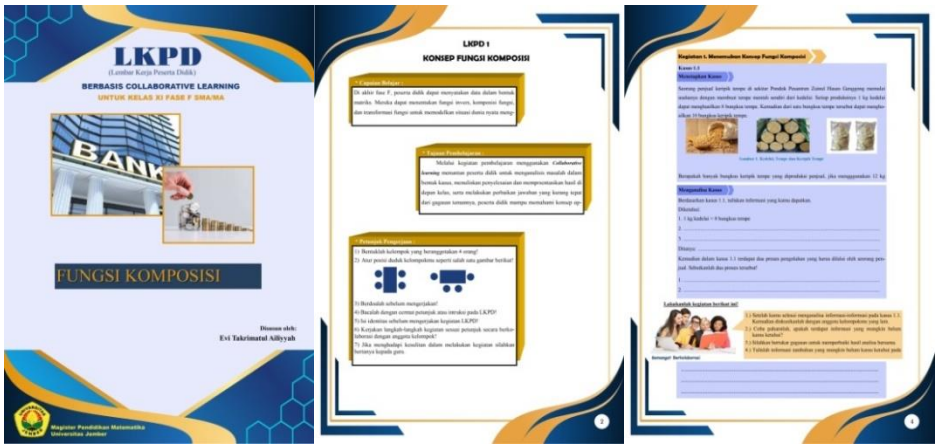
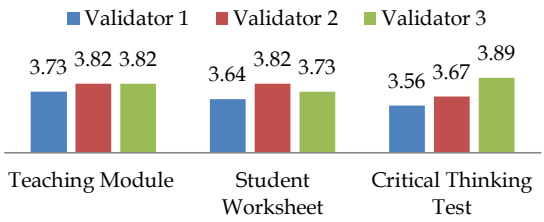


Figure 1. Student Worksheet Design

Furthermore, the LSLC-based Collaborative Learning model's phases were followed in the development of student worksheet, and Ennis' indications were utilized to gauge students' critical thinking abilities on the Critical Thinking Test as a Learning Outcome Test. The following example of student worksheet design can be seen in Figure 1.

Table 2. Learning Tools Expert Validation Analysis Results

Value (V_a)	Validity Level	Expert Validation Results
$V_a = 4$ $3 \leq V_a < 4$ $2 \leq V_a < 3$ $1 \leq V_a < 2$	Highly Valid Valid Quite Valid Invalid	
Total average		3.79

Develop stage, obtained the outcomes of the learning tool prototype's modification through expert validation. The assessment was conducted by two lecturers of Universitas Jember and one mathematics teacher of SMA Unggulan Hafsa Zainul Hasan Genggong. Table 2 presents a summary of the expert validation outcomes.

Based on Table 2, The average total score of the assessment of the three validators is 3.79, which indicates that it has a valid category. The device that was

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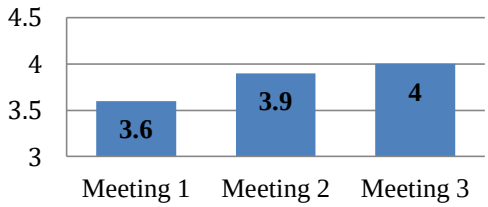
declared valid was tested in class XI 2A of SMA Unggulan Hafsa Zainul Hasan Genggong for 3 meetings for face-to-face learning and one meeting for the Learning Outcomes Test. The results of the trial with learning devices show a useful analysis derived from the observation sheet of the use of learning equipment. The practical data summary is displayed in Table 3.

Table 3. Examination of Observational Data from the Use of Learning Tools

Value (SR)	Validity Level	OKPP Results
$90\% \leq SR$ $70\% \leq SR < 90$ $50\% \leq SR < 70$ $SR < 50\%$	Excellent Good Good enough Bad	
Total average		3.80

According to Table 3, Over the course of the three meetings, the average overall teacher assessment score was 3.80, so the percentage value was 96%, which shows the practicality of good learning tools. Student response surveys, observation sheets of student activities, and the comprehensiveness of student learning are used to analyze the efficacy of learning resources. The recapitulation uses the findings from student response surveys and observations of their activities in Table 4 and Table 5.

Table 4. Analysis of Student Activity Observation Results

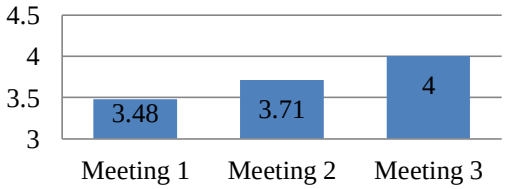
Value (P_s)	Category	Results of Observation of Student Activities
$90\% \leq SR$ $70\% \leq SR < 90$ $50\% \leq SR < 70$ $SR < 50\%$	Excellent Good Good enough Bad	
Total average		3.73

Table 4. displays the findings from the first to the third meeting's observation of student activities in a row is 3.48; 3.71 and 4, an average of 3.73 was obtained, so that the percentage value of student activity was 93% which showed that the value (Ps) was in the range of $90\% \leq Ps$ which showed the activeness of students had a very good category.

Table 5. Analysis of Student Response Results

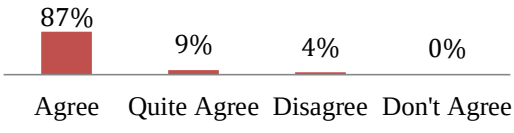
Value (P)	Category	Results of Student Response Questionnaire
$90\% \leq P$ $70\% \leq P < 90$ $50\% \leq P < 70$ $P < 50\%$	Excellent Good Good enough Bad	

Table 5. demonstrates that up to 96% of students do well when utilizing LSLC-based collaborative learning tools to learn about the composition function, so it is discovered that the proportion value of reactions from students is in the

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range of and has a very good category, while 17 out of 20 students achieve completeness, so that 85% of students are deemed finished. Considering the findings of the observations of student activities, student response questionnaires, and the completeness of the test of learning outcomes results, it was determined that LSLC-based collaborative learning tools were declared effective.

In the **dissemination stage**, learning tools that have fulfilled reliable, useful, and efficient standards can be disseminated. This learning tool was then socialized to teachers at SMA Unggulan Hafsa Zainul Hasan Genggong to be used in other classes. This learning device is printed and stored in the library of SMA Unggulan Hafsa Zainul Hasan Genggong. After the dissemination stage, experimental research was carried out to determine how learning devices affect students' ability to think critically. The experimental investigation was carried out by giving a pre-test before learning composition functions, as well as a post-test for both the experimental and control courses concluded after learning. Prior to conducting the hypothesis test, precondition tests, such as homogeneity and normality tests, were performed on the pre- and post-test data for the two groups. The following are the normalcy test results and the homogeneity of the pre- and post-test values, respectively, in Tables 6, 7, and 8.

Table 6. Pre-Test and Post-Test Values Normality Test Results

Test Normality		**Kolmogorov-Smirnov**		
	Class	**Statistic**	**df**	**Sig.**
Critical Thinking Skills	Pre-test experiment	.138	24	.200
.	Pre-test control	.129	24	.200
	Post-test experiment	.165	24	.092
	Post-test control	.109	24	.200

Table 7. Pre-test Homogeneity Test Results

	Test of Homogeneity of Variance				
		Levene Statistic	**df1**	**df2**	**Sig.**
Critical Thinking Skills	Based on Mean	.023	1	46	.880
(Pre-test)	Based on Median	.027	1	46	.871
.	Based on Median and with adjusted df	.027	1	42.418	.871
	Based on trimmed mean	.028	1	46	.868

Based on Table 6, The experimental class pre-test sig value was 0.200 (> sig 0.05), the control class pre-test sig value was 0.200 (>0.05), the experimental class post-test sig value was 0.92 (sig >0.05), and the control class post-test sig value was 0.200 (sig >0.05), according to the results of the Kolmogorov-Smirnov normality test. It was determined that the pre-test and post-test values in the experimental class and control class were normally distributed.

Table 8. Post-test Homogeneity Test Results

	Test of Homogeneity of Variance			
	Levene Statistic	**df1**	**df2**	**Sig.**

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Critical Thinking Skills (Post-test) .	Based on Mean	.002	1	46	.966
	Based on Median	.002	1	46	.966
	Based on Median and with adjusted df	.002	1	45.545	.966
	Based on trimmed mean	.001	1	46	.970

The pre-test value data for the experimental class and control class are homogenous, as shown by Table 7. sig value = 0.880 (sig >0.05) and Table 8. sig value = 0.966 (sig >0.05). This indicates that there is homogeneity between the post-test value data for the experimental and control classes. parametric test analysis of the data from the hypothesis test, specifically utilizing independent sample t-tests.

Table 9. Displays the findings of the t-test

Levene's Test for Equality of Variances		**t-test for Equality of Means**				
				Two-Sided	**Mean**	**Std. Error**
		T	**df**	**p**	**Difference**	**Difference**
Equal variances assumed .002	.966	2.813	46	.007	4.125	1.466

Table 9. shows that the value of sig = 0.007 (sig < 0.05), which indicates that the use of LSLC-based collaborative learning technologies has a major impact on students' ability to think critically. This success is influenced, among other things, by the creation of learning resources that are adapted to the learning model according to the requirements and learning goals of students in the Independent Curriculum. LSLC-based collaborative learning tools encourage students to be active in discussions, foster positive interdependence, and foster a caring attitude towards students. The stages of the collaborative learning model, namely engagement, exploration, transformation, presentation, and reflection, contained in the learning activities in the Teaching Module and the steps to complete the student worksheet, can direct students to collaborate well. These are the specific phases of collaborative learning, as shown in Table 10.

Table 10. Collaborative Learning Stage

Stage	**Activity of Collaborative Learning**
Engagement	1. Teachers analyze the level of ability and intelligence of each student. 2. Teachers form groups of 4-5 pupils in each group in which there are high, medium and low-skilled students.
Exploration	1. Teachers give LKPD that contains mathematical contextual problems 2. The students accepted the conditions of the discussion given in the subject. 3. Students dig information on the subject 4. Students formulate questions 5. Analyze information to gather solutions ideas

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Stage	Activity of Collaborative Learning
Transformation	1. Students in each group exchange ideas, ideas or opinions in solving the problem 2. Participants do each other's grades, accept and appreciate the opinions of each other 3. Interaction of mutual learning encourages students to clarify, describe and synthesize concepts as alternative solutions. 4. Each group finds a solution to each formula of the problem. 5. Each group prepares the answers to the discussions.
Presentation	1. Each group presents the results of its discussion, while the other group observes, contemplates, compares and responds to the presentations of other groups. 2. Ask an individual to respond to a group or group with a group about something not understood.
Reflection	Students analyze their ability to understand the materials taught and analyze the shortcomings and advantages of the learning process, as a material for teachers to plan more effective learning to learning goals.

Providing math problems based on contextual problems of composition function material in student worksheet requires students to think critically. Previous studies showing that problem-based learning may enhance critical thinking abilities corroborate this (Idris et al., 2020; Simanjuntak & Sudibjo, 2019; Suparya, 2020; Tanjung & Nababan, 2018). Through the processes of individually developing concepts, debating them, and picking up knowledge from one another, the LSLC-based collaborative learning approach assists students in developing their critical thinking abilities. Arguing on LSLC-based *collaborative learning* is not to compete with each other to be the most correct, but to achieve a common goal.

The ability of students to solve challenges demonstrates their capacity for critical thought (Satwika et al., 2018; Windari & Yanti, 2021). From the data from the analysis of written tests and interviews with students in experimental classes, it shows that there are students who meet all indicators of critical thinking abilities. Furthermore, with the introduction of collaborative learning technologies, critical thinking in the experimental class has improved more than critical thinking in the control class. Based on some of the points raised, it may be inferred that creating reliable, useful, and efficient teaching resources might help students become more adept at critical thinking.

4. Conclusions

The creation of LSLC-based collaborative learning tools satisfies the requirements of being valid, practical, and effective, according to the researchers' examination of the study's findings and the above-discussed debate. In addition, the hypothesis test using a parametric test, namely the independent simple t-test, shows that LSLC-based collaborative learning tools have a significant effect on students capacity for critical thought. Based on observations during learning, it

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was concluded that LSLC-based collaborative learning tools increase learning motivation, and student participation in debates should be encouraged.

Based on the conclusion, the outcome of creating collaborative learning tools based on LSLC is focused on fostering critical thinking skills in grade XI mathematics lessons of SMA Unggulan Hafsa Zainul Hasan Genggong and can be used as one of the teaching materials. The suggestion given is that there is a need to continue this research to develop collaborative learning tools that can enhance creative abilities, learning outcomes, learning motivation, and critical thinking skills in different materials and other subjects.

Author Contributions

The first and second authors contributed to creating the scientific articles and managing the publication process. The third, fourth, and fifth authors focused on collecting, processing, and analyzing the research data.

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Declaration of Competing Interest

The authors declare that there are no conflicts of interest.

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