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Google Classroom-Based Blended Learning Learning Tool to Improve Scientific Literacy and Critical Thinking Skills of Students in Chemical Bonding Material

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Abstract: The purpose of this study was to obtain high-quality google classroom-based Blended learning learning tools to improve scientific literacy and critical thinking skills of class X students of Public Senior High School 3 Langsa. and find out the differences in the increase in scientific literacy of class X students of Public Senior High School 3 Langsa after the application of Google Classroom-based Blended Learning learning tools. This research consisted of two stages. The first stage is R & D. Based on the type of research, this research is research and development (R & D). The development in this study follows the development procedure developed by Borg & Gall. The population in this study were all students of class X at Public Senior High School 3 Langsa City which consisted of 6 MIA classes, namely 180 students. Meanwhile, which were selected using the purposive sampling method. The results of the study show that Google Classroom-based Blended Learning learning tools have been developed to improve scientific literacy and critical thinking skills of class X students of Public Senior High School 3 Langsa. These tools are in the form of valid and effective lesson plans and worksheets to improve students' scientific literacy and critical thinking.

Keywords: Blandeed Learning; Critical Thinking Skills; Google Classroom; Scientific Literacy

Introduction

The problem of the learning process in Indonesia is experiencing a very significant change. This has happened due to the spread of the Covid-19 virus which has occurred since 2019. Teaching and learning activities have been replaced by the government through online teaching and learning using available online learning applications. Through these regulations, online teaching and learning activities, which have never been optimally achieved before, become the only option for learning (Simbolon et al., 2023); (Gudoniene et al., 2025). With regard to skills in the 21st century, the focus of education being carried out in Indonesia today is to improve student learning outcomes to master the 4C abilities (critical thinking collaboration, communication, and creativity) which are demands in the 21st century, including science education (science). One of the 21st century skills that is of concern in education is scientific literacy and critical thinking or critical thinking (Herlinawati et al., 2024); (Umami et al., 2023). There are various 21st century learning innovations that can be applied in learning in Indonesia. One of them is the application of the Blended Learning Model (MBL) which

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is very suitable for facing challenges in Indonesia in the 21st Century and preparing a learning environment for achieving 21st century competencies.

In addition, the changes that are occurring in the world community towards digitalization are forcing the learning process in schools. The school keeps up with technological developments. Teachers and students are required to be literate in digital technology (Ma'rufah Rohmanurmeta et al., 2024); (Getenet et al., 2024). Blended learning be one of the suitable learning for distance learning. Apart from providing unlimited time and place, Blended learning allows students to explore more about science (Rahman et al., 2020); (Lee et al., 2016). The application of Blended learning in learning activities at school shows a positive increase in students' scientific literacy skills (Lee et al., 2016); (Tong et al., 2022). Blended learning has a positive influence on mastery of knowledge, thinking skills, motivation and learning independence at all levels of education (Lusa et al., 2021); (Hafeez, 2021). The application of Blended learning cannot be separated from the use of technology. Information and Communication Technology provides facilities that are easy and accessible to students of all levels of education.

The use of technology as a learning facilitator is very possible because the current school-age generation is a digital generation that is used to living in a digital device environment (Tambunan & Mahmudi, 2024); (Liu et al., 2024). One technology that has been known to the world is the Google platform. One of the chemistry subject matter at the high school level is the material of chemical bonds. Chemical bond material is material that has abstract characteristics, and proof is needed from tracing activities by conveying to students to investigate, analyze, and conclude the results of their research (Santos-Trigo, 2024); (Rohati et al., 2023); (Yeo & Tzeng, 2019). Chemical bonding material is abstract and far from everyday experience, for example, one cannot see atoms, structures, and how they react with other atoms (Constable & Housecroft, 2020); (Scerri, 2024). Students as future generations are expected to have a high level of scientific literacy and critical thinking skills as human resources ready to compete in the era of globalization (Kwangmuang et al., 2021); (Soelistya, 2025). Therefore, it is necessary to conduct research to reveal scientific literacy and critical thinking skills, especially in chemistry lessons.

By knowing the level of scientific literacy and critical thinking skills of students from an early age, this data can be used as a basis for improving the learning process that focuses on developing scientific literacy and critical thinking skills of students so that a generation that is ready to face the industrial revolution era 0.4 with basic competencies is obtained. 21st century.

Method

This research consists of two stages. The first stage is R & D. Based on the type of research, this research is research and development (R & D). The development in this study follows the development procedure developed by Borg & Gall in (Thornhill-Miller et al., 2023). According to Borg and Gall, the research and development (R & D) approach in education includes ten steps, namely: Preliminary Studies (Research and Information Collecting), Planning Research (Planning), Design Development (Develop Preliminary of Product), Trial Initial Field Testing, Main Product Revision, Main Field Test, Operational Product Revision, Operational Field Testing , Final Product Revision, and Final Product Dissemination and Implementation.

The population in this study were all students of class X at Public Senior High School 3 Langsa City which consisted of 6 MIA classes, namely 180 students. While the samples in the study were one class of students as an experimental class and one class of students as a control class, totaling 60 students. The instruments used in this study are test and non-test instruments.

Results and Discussion

Lesson plan development results

The lesson plan developed uses a blended learning approach with models. Flipped classroom learning on chemical bonds material. The method used in learning names are discussions, assignments, lectures, and questions and answers. In addition to completing learning activities, researchers developed classroom media as the main media in learning blended learning based on Google Classroom. Google classroom media was developed according to the flow of activities in the Lesson plan that has been prepared and validated.

Student Worksheet Development Results

In addition to lesson plans and google classroom media, Student Worksheet was developed as a supporting learning device product in google classroom-based blended learning. The Student Worksheet design that is made follows the standard Student Worksheet format with the following outline: cover, Foreword, Instructions for Using Student Worksheet, learning objectives, learning materials, Learning activities (data collection, observation, and data processing), Exercise, Conclusion, Evaluation and Bibliography. Student worksheets are used during learning through google classroom media.

Lesson plan and student worksheet validation results

Product designs that have been made by researchers in the form of lesson plans and worksheets are then validated by experts. The product validation stage uses an assessment with a Likert scale. The measured indicators are broken down into sub-indicators. These sub-indicators are used as benchmarks in making instrument items in the form of statements. Based on the validation results that have been carried out, validation results are obtained with a percentage of 84% in the valid category. The Student Worksheet in this study was also validated by experts with an assessment sheet consisting of 27 items covering content, presentation, language and graphic criteria. The results of the assessment show a percentage of 88% with a very valid category. Experts who become validators provide input and suggestions which then become a reference for researchers to revise the Lesson Plan and Student Worksheet that have been developed. Following are the validator's suggestions and input on learning devices.

Table 1. Input, Comments from Learning Device Validators

Validators	Feedback, comments
Lesson plan	Add learning videos
	Separate learning activities in class and online
Worksheet	Add introductions to concepts related to everyday life
	Add video links
	Change the appearance of LKPD to be more attractive

Learning tools that have been validated are then revised according to expert input and used for trials. The target users of learning devices are students of SMAN 4 Langsa City class

Field trials

The trial was conducted in class X IPA 2, which consisted of 30 students. Google classroom-based blended learning is given to students. Then, a response questionnaire was given to the learning and Student Worksheet used. Response data is used to determine the feasibility of Student Worksheet and Lesson Plan whether they are appropriate for use in the teaching and learning process. The results of student responses to Google Classroom-based blended learning as a whole show that the percentage of student responses is 60% in the fairly decent category. In addition, the results of students' responses to the Student Worksheet used were 63% in the fairly decent category.

Final Revision of Limited Field Test Results (Main Product Revision)

The revision was carried out as a follow-up to the process of design and development of learning device products. The revisions made were on the aspect of the composition of the material on Google Classroom, the technical delivery of the material, and the technical implementation of the pretest and posttest. Meanwhile, the Student Worksheet was revised in terms of the appearance and composition of the Student Worksheet framework. Learning revisions and Student Worksheets as supporting materials for blended learning are urgently needed.

Main Field Test

The main field trial is used to determine the student's response to the product that has been improved based on the initial trial. The main field trials were carried out in class X-IPA 3 and X-IPA 4. The results of student responses to blended learning based on google classroom and Student Worksheet. The results of calculations on student response data obtained a value of 70% in the appropriate category for Student Worksheet and a value of 69% for the appropriate category for the google classroom-based blended learning learning process.

Operational Field Test (Operational Field Test)

The activities carried out in the operational field trial were to test the effectiveness of Student Worksheet and Lesson Plan to increase scientific literacy and critical thinking skills. Field trials were carried out on students in class X-IPA 6 as the control class and students in class X-IPA 5 as the experimental class.

Differences in increasing scientific literacy

The results of the pretest, posttest, and N-gain scientific literacy of the experimental group and the control group can be seen in Table 2

Table 2. Pre-test, post-test and N-gain Science Literacy scores for the treatment and control groups

Process Skills	GroupExperiment			Control Group		
	Pretest	Posttest	N-gain	Pretest	Posttest	N-gain
Maximum Value	70	100	1.00	80	90	0.86
Min Value	0	60	0.42	0	20	0
Average value	30	92	0.88	38	64	0.40

The analysis of the pretest, posttest, and N-gain scores of students' scientific literacy in the experimental and control classes is presented in Table 2. The data show a clear difference in the level of improvement between the two groups. The experimental class achieved an average pretest score of 30 and a posttest score of 92, with an N-gain value of 0.88, which falls into the high category. In contrast, the control class obtained an average pretest score of 38 and a posttest score of 64, with an N-gain value of 0.40, categorized as moderate. These results indicate that the implementation of the Google Classroom-based blended learning model effectively enhanced students' scientific literacy compared to conventional teaching methods. The high improvement observed in the experimental group can be explained by the characteristics of the blended learning approach, which integrates digital and face-to-face learning environments. Through Google Classroom, students were able to access a variety of resources such as materials, videos, and interactive worksheets, allowing them to explore scientific phenomena independently. This model also encouraged students to connect scientific concepts with real-life contexts, seek information from multiple sources, and critically evaluate the accuracy of data. Such activities align with the main components of scientific literacy—understanding scientific concepts, applying scientific processes, and making evidence-based decisions (Amijaya et al., 2024).

In addition, the blended learning environment provides a flexible learning experience that is not limited by time or place. Students can review the materials repeatedly, engage in online discussions, and receive direct feedback from teachers through the Google Classroom platform. This continuous interaction fosters inquiry skills and scientific reasoning, which are central to developing scientific literacy. When students are actively involved in questioning, analyzing, and drawing conclusions based on evidence, they strengthen their ability to apply scientific thinking in everyday situations (Vo & Simmie, 2025); (Kotsis, 2024). The findings of this study are consistent with those of (Lestari et al., 2021); (Agus Supriyadi et al., 2023); (Febriyani et al., 2024), who reported that the application of a blended learning model integrated with a STEM approach significantly improved students' scientific literacy skills. Similarly, (Papendieck & Clarke, 2024) found that digital-based worksheets in blended learning environments enhanced students' ability to interpret data and explain scientific phenomena logically.

Differences in improving students' critical thinking

The recapitulation of the results of the pre-test, post-test and N-gain of the experimental and control group students can be seen in Table 3.

Table 3. Pretest, Posttest and N-gain scores of students in the experimental group and the control group

Process Skills	GroupExperiment			Control Group		
	Pretest	Posttest	N-gain	Pretest	Posttest	N-gain
Maximum Value	10	10	0	0	60	0.55
Min Value	70	80	0.62	30	100	1
Average value	29	56	0.36	12	83	0.81

Based on the results of the pretest, posttest, and N-gain analysis, there was a noticeable difference in the improvement of critical thinking skills between the experimental and control classes. The experimental class, which received learning through the Google Classroom-based blended learning model, obtained an average posttest score of 83 with an N-gain value of 0.81, categorized as high. Meanwhile, the control class, which received conventional instruction, achieved an average posttest score of 56 and an N-gain value of 0.36, which falls into the moderate category. These results indicate that the implementation of digital-based blended learning had a positive effect on improving students' critical thinking abilities (Haftador et al., 2023); (Hasanah & Malik, 2020).

This improvement occurred because the blended learning approach allowed students to actively engage before, during, and after the learning process. Through access to materials, videos, and assignments provided in Google Classroom, students had the opportunity to study concepts independently in advance (Masruddin et al., 2024); (Solihin et al., 2024). During face-to-face sessions, class time could be focused on discussions, problem analysis, and tasks that required critical reasoning. Such a learning pattern trains students to observe phenomena, evaluate information, and make decisions based on logical reasoning (Vermunt & Donche, 2017); (Tolba & Al-Osaimi, 2023).

In addition, the use of Google Classroom created space for two-way interaction between teachers and students as well as among students themselves. The more open communication and feedback process helped students refine their thinking, particularly in connecting abstract chemical concepts to real-life situations. Reflection and online discussion activities also encouraged students to reassess their arguments and

understand different perspectives (Hamadi et al., 2023); (Wang et al., 2025). These patterns of interaction foster intellectual independence and confidence, which are key indicators of critical thinking ability (Chan & Lee, 2021); (Chen et al., 2022).

Conversely, students in the control class tended to receive information directly from the teacher with limited opportunities to explore concepts or express their opinions (Bremner et al., 2022); (Gillett-Swan & Baroutsis, 2024). This caused their improvement in critical thinking skills to be lower than that of students in the experimental class. Teacher-centered instruction restricted the development of analytical, evaluative, and reasoning skills. In conclusion, the application of the Google Classroom-based blended learning model made a significant contribution to the enhancement of students' critical thinking skills.

Conclusion

Blended learning learning tools based on google classroom have been developed to improve scientific literacy and critical thinking skills of class X students of SMAN 3 Langsa. These tools are in the form of valid and effective lesson plans and worksheets to improve students' scientific literacy and critical thinking. Google Classroom-based blended learning models make a major contribution to the development of students' analytical, evaluative, and reasoning skills.

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Author Contributions
Conceptualization; methodology.; P. M.; validation; formal analysis; A.; investigation; A. U. T.; resources; M. S; data curation: H; writing—original draft preparation; Z.; writing—review and editing.; M. H.; visualization: I. K. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest
The authors declare no conflict of interest.

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