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Fostering Scientific Literacy through Integrated STEM Teaching Materials on Basic Laws of Chemistry

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Abstract

The research aims to develop integrated teaching materials with a STEM approach to enhance students' scientific literacy, explicitly focusing on Basic Chemical Law Materials. The study utilized a Research and Development (R&D) approach employing the 4D (define-design-development-disseminate) research model. The research instruments included a test to measure students' scientific literacy and a non-test instrument to gather validation data from experts and assess student responses. The findings demonstrated high feasibility percentages, with 91.4% for content, 89% for presentation, 93.2% for language, 86.6% for scientific literacy, 93.2% for STEM, and 90% for media. Moreover, based on the scientific literacy test results, the N-gain pre-test and post-test indicated a substantial increase with a score of 0.74, classifying it as a high increase. Consequently, it can be concluded that developing integrated teaching materials with a STEM approach effectively enhances students' scientific literacy in basic laws of chemistry.

Keywords: basic law of chemistry, scientific literacy, STEM, teaching materials

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1. Introduction

Education is very important in determining the quality of a nation's human resources, and is also an aspect that must be prioritized in the growth of a country. Good education must be able to shape one's knowledge and abilities. Education must lead to the formation of students to be able to build knowledge capacity develop level thinking skills high, such as critical thinking, creating decisions, and solving problems. Therefore it is necessary education can be developed increase the potential and abilities of students optimally, so as to be able to adapt with circumstances and changes and able to work collaboratively (Sutiani et al., 2022).

Everyone recognizes the 21st century as the century of knowledge, the cornerstone for many facets of daily life. The 21st century learning paradigm places a strong emphasis on students' capacity for critical thought, the ability to relate academic content to real-world situations, information technology proficiency, communication skills, and teamwork. The integration of literacy skills, knowledge skills, skills and attitudes, and technological expertise is known as 21st Century learning. The most crucial component of education is literacy; pupils who can fully engage in literacy activities will undoubtedly get more knowledge than their counterparts. Information literacy, media literacy, and Information, Communication, and Technology (ICT) or ICT literacy are all examples of literacy in education. Media literacy and ICT literacy imply that teachers must be technologically literate in order to create ICT based learning media (Suluh, 2018).

Trends in education policy science in the 21st century quality improvement education to produce Resources Qualified and capable

human resources (HR). Compete in the era of globalization. Change and current developments in the world impact of the development of Science and Technology in the era of globalization which can be viewed as adaptation problems to be anticipated and resolved wisely and creatively the 21st century demands a new set of abilities known as 21st century talents. For instance, success in today's complicated environment requires good teamwork and problem-solving skills. As complexity increases, it becomes more important for experts to collaborate and communicate clearly in order to solve issues and develop new solutions. In order to generate students who are capable of producing scientific and technological innovation, chemistry education in the 21st century should focus on both improving students' knowledge acquisition and nurturing their 21st century abilities. In the meanwhile, pupils must be highly motivated for learning to be more effective. One of the abilities that students must have in 21st century learning is scientific literacy (Nasution et al., 2019).

Scientific literacy also refers to the variety of literacy related with the application of digital technology in the field of science in the form of electronic technology, which includes gear and software that aid in the scientific learning process. As a result, scientific literacy is important because understanding of science can provide individual satisfaction and pleasure after studying nature, making a decision requires information and scientific thinking, every public discourse and debate requires the involvement of science and technology, and scientific literacy is important. Reasoning, creative thinking, making judgments, and problem solving are all required in the workplace since they require higher-order thinking skills. Every person is expected to have scientific literacy, which includes scientific knowledge, scientific process skills, and a scientific attitude. Scientific literacy development is critical in this context. Every person is required to have scientific literacy, which includes scientific knowledge, scientific process skills, and a scientific attitude. A scientifically literate society may use scientific knowledge to identify issues and make conclusions based on facts in order to comprehend and produce decisions about nature and the changes that humans have made to it (Dewi et al., 2021).

Regarding this, PISA does not particularly limit the scope of science content to knowledge that is added to the school science curriculum, but also includes knowledge that is acquired through other sources of information that are readily accessible. The following criteria were used to choose science-related content is applicable to actual circumstances, is anacrucial knowledge for long-term use, and is suitable for youngsters under the age of 15's developmental stage. The Program for International Student Assessment (PISA) research, a four-year international examination of reading literacy achievement, mathematics, and science in school students, provides evidence of the urgency of literacy (Sativa & Eliza, 2023). According to Indonesia's 2018 PISA results, the country dropped to 72nd place overall out of 78 nations. When compared to the PISA results from 2015, the results showed a considerable decline. Reading literacy, mathematics literacy, and science literacy were the areas of literacy that showed the greatest reduction (Amini & Sinaga, 2021; Sativa & Eliza, 2023).

In learning there are several instruments needed so that learning goes well and gets a satisfactory output. Teaching materials or books are one of the learning instruments that are required to be acquired. A good book should be able to include both informational content that will broaden students' perspectives and content that will help students develop their attitudes and skills (Sutiani et al., 2020).

Additionally, books must be able to raise students' literacy levels. Learning materials are a type of learning resource that includes materials or lecture materials that students and lecturers utilize during the lecture process. Learning materials include a systematic framework and sequence, explain the

objectives to be reached, and assist students in learning autonomously, allowing them to master the competence as a whole and integrated (Sutiani et al., 2017). Based on observations made at SMAN 12 Medan, it was discovered that at the time, SMAN 12 was implementing an independent curriculum; yet, books employing an independent curriculum are still incredibly hard to come by.

One strategy for raising students' scientific literacy levels is to use a teaching method that encourages participation from the class. To develop scientific literacy abilities, the STEM (Science, Technology, Engineering, and Mathematics) approach is applied. When employing the STEM approach, the learning experience will be more varied and creative, allowing kids to understand many academic subjects using examples from the actual world. Students that take part in STEM education can learn more, become more adept at conquering challenges in the real world, and improve their critical thinking skills. STEM students are the ideal target audience for implementing Integrative Thematic Learning because they incorporate four important academic subject areas: science, technology, engineering, and mathematics (Rohmah et al., 2019).

Basic laws of chemistry are not a difficult subject to learn, however students frequently give incorrect answers when answering questions. Through the use of appropriate models and instructional materials, teachers can improve the results of student learning and understanding. centered on students (Andani & Yulian, 2018).

The basic laws of chemistry study matter that is not physically visible directly to students, concepts in the basic laws of chemistry are abstract. Law basic chemistry is considered difficult by students because the concepts are abstract, concrete, and math (Asfuriyah et al., 2017).

Based on the research by Putri et al. (2022), Students 10th grade SMAN 15 Padang have difficulty studying basic chemistry law materials. Internal and external factors are recognized as causes that create students' learning difficulties in fundamental chemical law. one of them is The most influential internal characteristics are aspects of student motivation and enthusiasm in studying.

Furthermore, development research conducted by Pratiwi et al. (2019), The development of guided inquiry-based electronic modules on the subject of basic chemical laws shows that piloting guided inquiry-based modules can increase student learning outcomes by 80%.

In line with this, the class action research conducted by Sofyan (2021) shows that there is an influence of the learning model on learning outcomes and has a positive impact on students and learning.

The researchers conducted research related to the problems above by developing teaching materials that were integrated with STEM with a focus on students' scientific literacy skills and teaching materials that were in accordance with the current curriculum.

2. Research Method

The goal of this development research was to provide instructional materials that could raise students' levels of scientific literacy. This instructional material is available both online and offline in the form of an e-book. The STEM parts of this book's development are examined. The participants in this study included chemistry instructors, media specialists, and 10th grade at SMA Negeri 12 Medan.

The 4D (Define, Design, Development, and Disseminate) development model theory based on Thiagarajan (1974) was employed in the construction of this work. The steps of development for this research, we can see in Figure 1.

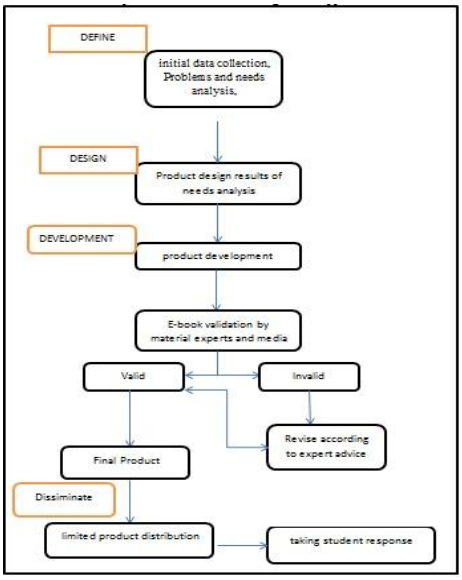

Figure 1. Research Design

In the define stage, the researcher will analyze some of the books used, conduct interviews with teachers regarding the constraints faced by teachers during learning, and observe students during learning.

In the design stage, the researcher will design the book according to needs, in the design stage, the researcher will design with the help of three applications, including Ms Word, Canva, and Flip Pdf Pro. After being designed, it will continue with the development stage where at this stage the teaching materials that have been designed will be validated by material experts and media experts, after being validated, they will be revised according to the directions and suggestions from experts. The next stage is the dissemination stage, where the teaching materials that have been developed will be distributed to students to see the response and development of their scientific literacy abilities. The instruments in this study were non-test and non-test instruments. Non-test instruments in the form of observations, interviews, and questionnaires. A questionnaire was used to see the feasibility value of teaching materials from experts and student responses. while Table 1 is a table of eligibility criteria categories.

Table 1. Criteria Instruction

Average Score (%)	Validation Criteria
81-100	Very worth it
61-80	Worthy
41-60	Decent enough
21-40	less worthy
<20	Not feasible

(Susanti, 2021)

The test instrument is in the form of scientific literacy questions which are given to students as a pre-test and post-test. the data obtained is descriptive qualitative and quantitative data, where the data obtained from the questionnaire will be grouped and classified according to the criteria and the data from the student scientific literacy test will be analyzed by the N-gain test. For improvement criteria based on the N-gain test can be seen in Table 2.

Table 2. N-gain Category

N-Gain Value	Classification
N-Gain ≥ 0,7	High
0,30 – 0,70	Moderate
0,00 – 0,29	Low

3. Result and Discussion

Based on the results of the define stage it was found that the books that have been used so far have not fully applied the concept of scientific literacy in their writing. The average book is in the sufficient category. The obstacle faced by the teacher during learning is that practicum is not carried out as one of the learning activities that can help students understand the material. Based on the results of observations made on students, it was found that students felt that the books used were less interesting and monotonous so students were lazy to read books.

In the next stage, the design stage of teaching materials is designed using Ms Word as preparation of teaching materials, then Canva will transfer it to add some emoticons and illustrations to add to the attractiveness of teaching materials, then the teaching materials are loaded in flipbook format using Flip PDF Pro**.** The display of teaching materials can be seen in Figure 2.

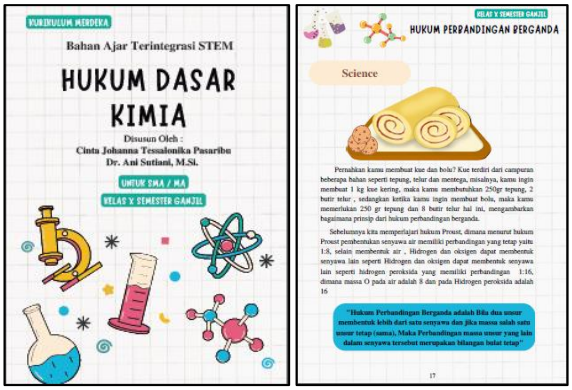

Figure 2. Display of Teaching Materials

This teaching material is integrated with STEM where the science in this teaching material is the application of concepts from the basic laws of chemistry in everyday life. This teaching material is also equipped with several basic chemical law experiments. The display of the science section can be seen in Figure 3.

Figure 3. Display of Science Section

In the science section, some calculations are entered as part of mathematics in solving everyday life problems. The display of the mathematics section can be seen in Figure 4.

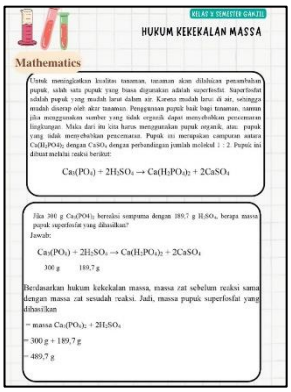

Figure 4. Display of Mathematics Section

In the technology section, the use of technology in this teaching material is in the form of using learning videos originating from YouTube and using virtual labs. Display of the technology section can be seen in Figure 5.

Figure 5. Display of Technology Section

The advancement of science and technology encourages every human to have scientific literacy as a survival skill. The capacity of scientific literacy is vital for students to learn since it pertains to how students understand the environment, health, and other societal concerns in the modern period that are heavily reliant on technology and scientific advancement (Kahar et al., 2022).

The condition of school facilities and infrastructure, school management, and school human resources are the causes driving students' lack of scientific literacy (Ardianto & Rubinni, 2016).

The presence of supporting tools (literacy), learning enjoyed by children with creative and diverse learning methods in order to minimize boredom, and learning saturation experienced by children when their learning activities are successful were all factors that influenced learning. The scaffolding is finished when the youngster is able to acquire the talent or ability while developing his freedom in finishing his assignment (Gormally et al., 2012 ; Anshar et al., 2023).

The creation of this teaching resource is explained in order to aid and direct students in understanding the subject matter better, offer context, and also to increase students' reading abilities with an appealing design.

The use of visualizations in the form of pictures, videos, graphics, and so on, as well as factual examples, encourages students to understand and practice their scientific literacy skills, as well as draw conclusions based on evidence, in order to understand and generate decisions related to nature and its changes caused by human activity (Prasetyo et al., 2021).

Learning nowadays must keep up with the times in the age of globalization, one way being to integrate STEM. In the study of science, the relationship between science and technology cannot be separated. STEM is a scientific subject that is inextricably linked to each other. Science necessitates the use of mathematics as a tool for data processing, whereas technology and engineering are applications of science (Nurtanto, 2018; Kahar et al., 2022).

When paired with learning paradigms that can promote scientific literacy, STEM is more appropriate. The designs of the instructional materials created thus far include. to find out the feasibility of the teaching materials developed, these teaching materials are then assessed by experts, and the results of the feasibility assessment of these teaching materials can be seen in Table 3.

Table 3. Table of The Percentage of The Average Value of All Assessments Expert

No	Criteria	Validator			(%)	Feasibility Criteria
		V1	V2	V3		
1.	Content Feasibility	4.5	4.58	4.66	91.4	Very worth it
2.	Presentation Feasibility	3.87	4.75	4.75	89	Very worth it
3.	Language Eligibility	4.83	4.66	4.5	93.2	Very worth it
4.	Scientific Literacy Feasibility	4	4	5	86.6	Very worth it
5.	STEM Feasibility	5	4	5	93.2	Very worth it
6.	Media Feasibility	4.33	4.66	4.5	90	Very worth it

The next stage is the dissemination stage, at this stage the material will be known how students respond to teaching materials. The graph of student responses can be seen in Figure 3.

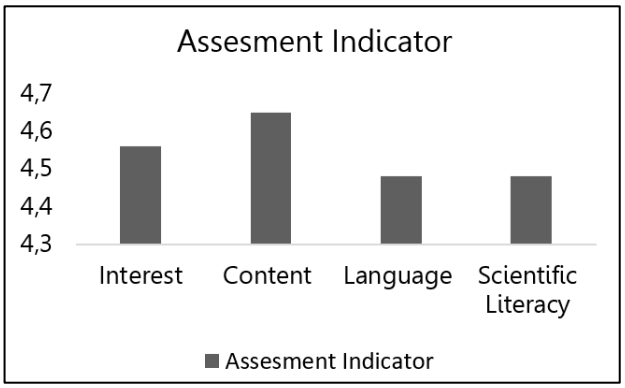

Figure 3. Graph Student Respon

Based on the graph, it can be seen that the average of the overall student responses is Based on the tables and graphs, it can be seen that the average of student responses is 4.54 (90.8%) with very worth its criteria.

The next data is the data from the students' scientific literacy test results in Table 4, which are the results of the students' pre-test and post-test.

Table 4. Table of Pre-test and Post-test Results

Test	Total Value Result	Average Value Result
Pre-test	517	17.23
Post-test	2373	79.1

Based on the results of the table, it can be seen that the student test results are low. Graph of pre-test and post-test comparison of students' scientific literacy test can be seen in Figure 4.

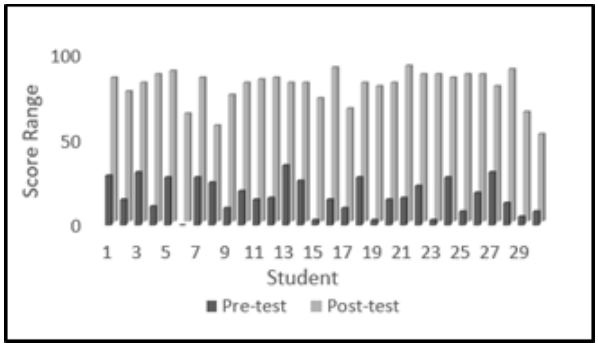

Figure 4. Comparison of Student Pre-test and Post-test Result

Based on Figure 4, it is clear from the comparison graphs between the student post-test and pre-test scores that educational materials that incorporate STEM can help students' scientific literacy abilities. It is evident that the results of student tests are developing quickly. The N-gain test can also support this. The results of the concentration and distribution of data on pre-test and post-test values can be seen in Table 5.

Table 5. Measures of Centralization and Data Distribution of Pre-test and Post-test Results

No	Centralization and Data Distribution	Pre-test	Post-test
1.	Lowest Value	0	51
2.	Highest score	35	91
3.	Average	17,23	79,1
4.	Median	15,5	81
5.	Mode	15	81
6.	Standard Deviation	9,81	9,79

To prove an increase in test results can be done with the N-gain test. As for the results of the N-gain test, we can see in Table 6.

Table 6. N-gain Result

N-Gain	Value
Average	79,1
Category	High

From the results of the N-gain test, it was found that the average result is at 0.74, which is safe according to the criteria, so the increase that occurs is in the high category.

The utilization of teaching materials as learning resources has reached 85%, with the teaching materials used not presenting contextual STEM subjects. Almost all teachers have yet to understand how to use the STEM approach to learning. The goal is to employ educational resources to help students make connections between school, the workplace, and the global world. So that students can compete in a knowledge-based global era, guided inquiry is used to increase students' abilities in scientific literacy in accordance with the objectives of guided inquiry, which is science in discovering concepts and technologies by discussing many applications related to the issue (Indrasari et al., 2020).

4. Conclusion

Based on research data and analysis Basic Law of Chemistry Teaching Materials that have been developed get an average percentage value of 90.6% from the validator for material Feasibility and 90% For media feasibility. The Student response for the teaching gets an overall percentage value of 90.8% and receives a good response from the Student. The results of the N-gain pre-test and post-test of students, it was found that the increase in student test results was 0.74, which is an increase in the high category.

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