14 (2) (2025) 328-340

**Unnes Science Education Journal**
Accredited Sinta 2

https://journal.unnes.ac.id/journals/usej

# Development of a Sway-Based Electronic Module Using a STEM Approach to Enhance Students' Scientific Literacy

**Eka Nurrohmah Khumairoh✉, Ellianawati Ellianawati, Lisdiana Lisdiana**

**DOI: http://dx.doi.org/10.15294/usej.v13i1.29569**

Universitas Negeri Semarang, Indonesia

## Article Info

Submitted 2025-06-02
Revised 2025-07-11
Accepted 2025-08-30

## Keywords

E-Module; Science Literacy; STEM; Sway



## Abstract

Scientific literacy is one of the abilities that encourages students to solve problems. Students still struggle to apply concepts to solve problems in everyday life, presenting a challenge for schools to develop teaching materials that train students' scientific literacy skills in analyzing and solving problems related to Science, Technology, Engineering, and Mathematics. This study aims to analyze the characteristics, validity, practicality, and effectiveness of the Sway e-module STEM Approach in improving students' scientific literacy skills. E-modules on the human respiratory system material were developed using the ADDIE development model, with 113 students as research subjects. The results of the study showed that (1) The validity of the Sway e-module STEM approach has a very valid category based on the assessment of five raters. (2) Sway e-module STEM Approach have the ideal characteristics that an e-module with a very good category should have. (3) STEM-based Sway e-modules are very practical to use in the learning process. (4) Sway e-module STEM Approach are effective in improving students' scientific literacy skills, with an average n-gain of the experimental class of 0.50 and the control class of 0.29. Based on the research results, it can be concluded that e-modules that integrate the STEM approach and are presented using Microsoft Office Sway are more effective in improving students' scientific literacy skills, especially in the aspect of evaluating and designing scientific questions with indicators of proposing ways to explore scientifically the questions given, with an n-gain of 0.79.

## How to Cite

Khumairoh, E. N., Ellianawati, E., & Lisdiana, L. (2025). Development of a Sway-Based Electronic Module Using a STEM Approach to Enhance Students' Scientific Literacy. *Unnes Science Education Journal*, 14(2), 328-340.

✉ Correspondence Author:
E-mail: eka_nurrohmahkh@students.unnes.ac.id

p-ISSN 2252-6617
e-ISSN 2502-6232

## INTRODUCTION

The 5.0 community era requires students to be able to adapt in exploring creative-imaginative ideas, designing creative products, and producing technological products that are beneficial for the community and the environment (Suyidno et al., 2020). Scientific literacy has received more attention as a primary goal of science education because scientific literacy encourages critical thinking, the creation of scientific evidence, and problem-solving skills (Alwaqfi & Saleh, 2023). Scientific literacy is a skill every human being must have because scientific literacy helps individuals solve modern community problems that follow development of science and technology, and social problems (Pujiati, 2019). Indonesian students scored 359 points in reading on the 2022 Programme for International Student Assessment (PISA), well below average score for OECD member countries, which ranges from 472 to 480 points (OECD, 2023). Indonesia's 2022 PISA results showed a science score of 383, 102 points lower than the OECD average (OECD, 2023).

The STEM approach is an effective approach to improving scientific literacy skills. According to Ramulumo (2025), students in STEM-focused schools demonstrate significantly higher levels of scientific literacy and are more cognitively prepared to engage with scientific ideas. Ramulumo (2025) emphasized that the STEM approach is crucial for developing scientific reasoning and equipping students with cognitive tools for lifelong learning. This is in line with the statement of Nistilawati and Satriawan (2025) who stated that STEM-based learning is effective in improving scientific literacy because STEM integrates conceptual understanding with scientific skills through contextually oriented learning activities and problem-solving.

Teaching materials are one of the learning resources that support teachers in presenting materials to students to digest the material, so it is important for teachers to prepare teaching materials that are in accordance with the needs of students (Wulansari et al., 2018). Students need teaching materials that can be used online, simple, adaptive, and independent so that students are able to practice scientific literacy skills to solve problems in real life and prepare themselves to face world challenges (Kimianti & Prasetyo, 2019).

E-modules can be selected as one of the best teaching materials to improve students' understanding because they are easy to use and have an eye-catching appearance Catching, and the language used is very friendly, so that it makes it easier for students to learn which has an impact on increasing motivation and providing meaningful improvements in student learning outcomes (Pramana et al., 2020). The use of E-modules also saves more costs on procuring teaching materials with an electronic approach, so that they are easier to use and have a very long storage period (Qatimah & Mulyadi, 2022). One of the applications that can help package E-Modules to be a teaching material that attracts students' interest in reading is Microsoft Office Sway.

Microsoft Office Sway can help teachers produce creative two-way learning media without having to download special applications, this is because Microsoft Office Sway is easy to reach via web without taking up storage media on computer, laptop, or device (Ardian et al., 2020). Developing e-modules Sway can facilitate use of teaching materials, students can study material repeatedly without being limited by time and place, this will increase students' opportunities to hone scientific literacy skills (Atdhini et al., 2023).

The implementation of E-LKPD with a STEM approach by improving the scheduling of learning implementation time is the most appropriate action to foster literacy, numeracy and science skills (Syaifudin, 2022). Pratiwi & Rachmadiarti (2022) revealed that e-book STEM approach has been proven to be valid and feasible for training science literacy skills. Hutomo (2022) revealed that the e-module STEM approach is very suitable to be used as an alternative learning resource to improve the literacy skills profile of students. This is in line with the findings Prasetyo et al. (2021), who revealed that students' learning outcomes and science literacy skills increased after implementing e-modul STEM approach.

Previous studies have analyzed the validity, practicality, and feasibility of e -LKPD and e - books STEM approach, but no one has developed an e-module STEM approach. The novelty of this study is that it has the additional objective of analyzing the effectiveness e-modul Sway STEM approach in improving students' scientific literacy skills in the Human Respiratory System material. The choice of teaching materials in the form of e-modules is because e-modules are teaching materials that are equipped with activity guides that guide students independently to train students' scientific literacy skills, so that they can not only instill concepts but also train students' psychomotor skills and scientific literacy skills. In addition, this e-module is also equipped with self-evaluation to measure students' understanding of each material, so that students can know extent of their understanding of material being studied.

Respiratory System material is abstract material, but it is very closely related to lives of students. Abstract material is material that cannot be seen, touched, or experienced directly by the five senses, but can only be understood through thought and concepts. This material often relates to ideas, concepts, or principles that require higher-level thinking processes to understand. In addition, the topics raised in the e-module in this study related to the still hot social issue, namely Covid-19 pandemic which attacks respiratory organs of the lungs. E-module which was developed in this study also discusses social topics related to cigarettes, as we know cigarettes are familiar items for high school students. By studying e-module it is expected that students have knowledge about dangers of smoking and can then make conscious and independent decisions to maintain health of respiratory organs. Raising social issues in e-modules this can increase students' interest in reading, so it is hoped it can improve students' scientific literacy skills.

Students still have difficulty applying abstract concepts to solve problems in everyday life, so this is a challenge for schools to provide teaching materials that can train students' scientific literacy skills in analyzing and solving problems related to Science, Technology, Engineering, and Mathematics. This study aims to analyze the characteristics, validity, practicality and effectiveness of the STEM-approach Sway e-module in improving students' scientific literacy skills.

## METHOD

This research is development research using the ADDIE development model. This research aims to analyze the characteristics, validity, practicality, and effectiveness of the Sway e-module STEM approach to improve the scientific literacy skills of high school students. The scientific literacy competencies studied consist of explaining scientific phenomena, evaluating, and designing scientific questions, and interpreting data and evidence scientifically. The ADDIE model was schematized by Branch as a learning system design in Figure 1.


Figure 1. ADDIE Model Scheme
(Source: Rayanto & Sugianti, 2020)

Characteristic analysis Sway e-module STEM approach conducted by distributing questionnaires to 10 Biology teachers. Data collection techniques to measure the characteristics of e-modules based on the Likert scale. The formula used is as follows.

$$\text{Kindergarten} = \frac{TS\_e}{TS\_max} \; x \; 100\%$$

Information:
Kindergarten : Characteristic Level
$TS_{-e}$ : Total empirical score
$TS_{-max}$ : Total maximum expected score

The average percentage of characteristics obtained was then interpreted using Table 1 (Wulandari et al., 2022).

**Table 1.** Characteristic Criteria Based on Percentage

| Percentage (%) | Interpretation |
|---|---|
| 85 % ≤ TK ≤ 100 % | Very good |
| 70 % ≤ TK < 85 % | Good |
| 60 % ≤ TK < 70 % | Enough |
| 50 % ≤ TK < 60 % | Not enough |
| 0 % ≤ TK < 50 % | Less than once |

The validity test was processed by referring to the Aiken's V statistical formula sourced from Suci & Zainul (2023) as follows.

$$V = \frac{\sum S}{n\,(c-1)}$$

$$S = r - l_o$$

Information:
V : Validity index of Aiken
S : r – lo
r : Value given by the validator
lo : Lowest value in validity assessment
c : Highest value in validity assessment
n : Total number of validators

Writer set p value < 0.01, which means allowing a 1% error opportunity with 5 raters and 5 scale options, the V table value is set at 0.90.

Data collection techniques to measure the percentage of validity of e-modules based on the Likert scale obtained from the validation sheet. The formula used is as follows.

$$NP_{\text{r1-n}} = \frac{TS\_e}{TS\_max} \; x \; 100\%$$

V : Validity
$TS_{-e}$ : Total empirical score
$TS_{-max}$ : Total maximum expected score

The average percentage of validity obtained was then interpreted using Table 2. (Riduwan, 2015).

**Table 2.** Validity Criteria Based on Percentage

| Percentage | Interpretation |
|---|---|
| 81 % – 100 % | Very Valid |
| 61 % – 80 % | Valid |
| 4 1% – 60 % | Quite Valid |
| 21 % – 40 % | Less Valid |
| 0 % – 20 % | Invalid |

Practicality analysis Sway e-module STEM approach is done by 5 teacher. The results of practicality observations based on questionnaire instruments using the Guttman model criteria with the answers "Yes" and "No" are then interpreted based on the Guttman scale. The calculation of the percentage of data obtained using the formula.

$$\text{Practicality (\%)} = \frac{Score\ Obtained}{Maximum\ score}\ x\ 100\%$$

Average percentage of practicality obtained was then interpreted using Table 3 (Riduwan, 2011).

**Table 3** Practicality Criteria Based on Percentage

| Percentage | Interpretation |
|---|---|
| 81 % – 100 % | Very Practical |
| 61 % – 80 % | Practical |
| 4 1% – 60 % | Practical Enough |
| 21 % – 40 % | Less practical |
| 0 % – 20 % | Not Practical |

Product implementation was carried out to analyze effectiveness of the Sway e-module STEM approach to improve students' scientific literacy skills. Implementation was carried out in experimental class and control class, with a total of 113 students. The experimental class is a class that uses e-modules Sway STEM approach on the Human Respiratory System Material, while the control class is a class that uses a conventional module STEM approach. The product implementation design used in this study is Pretest-Posttest Control Group Design. The sampling technique used is purposive sampling. Where sampling is done with certain considerations , including students having the same average cognitive ability, classes are taught by the same teacher and classes have the same schedule, namely in the morning.

Science literacy is measured using a test instrument based on the Minimum Competency Assessment (AKM) consisting of 30 questions, with simple multiple choice questions, complex multiple choice questions and essays. The questions used have contained 10 indicators of scientific literacy studied, with the provision that there are 3 questions for each indicator of scientific literacy. The scientific literacy indicators that are measured include:

1. Recalling and applying appropriate scientific knowledge
2. Identifying, using, and generating clear models and representations
3. Making and justifying appropriate predictions
4. Explaining the potential impact of scientific knowledge on society
5. Identifying questions from a given scientific inquiry
6. Proposing ways to explore a given question scientifically
7. Evaluating ways to explore a given question scientifically
8. Transforming data from one representation to another
9. Analyzing data from one representation to another
10. Evaluating scientific arguments and evidence from a variety of sources

Pre-test and post-test result data from the experimental and control classes were analyzed using SPSS 24.0 software by conducting normality tests, homogeneity tests, Mann Whitney U tests and n-gain tests to determine the effectiveness of the product.

## RESULT AND DISCUSSION

### Characteristics of Sway E-modules with a STEM Approach

Based e-module on the human respiratory system material is packaged digitally using a website-based application, Microsoft Office Sway, which can be accessed using gadgets, computers, or tablets with a stable internet connection by simply opening a link via a browser or scanning a QR without having to download files so as not to increase the storage capacity on the device. The cover and QR e-module display can be seen in Figure 2.


**Figure 2.** The display Cover and QR E - Module

The ideal characteristics that an e-module should have include self instructional, self contained, stand alone, adaptive and user friendly, and one additional characteristic of the writer, namely self evaluation. Table 4 shows the percentage data of the characteristics of the Sway e -module approach STEM.

**Table 4.** Results of E-Module Characteristic Test

| Characteristics Assessed | Percentage | Category |
|---|---|---|
| Self-Instruction | 98% | Very good |
| Self-Contained | 98% | Very good |
| Stand Alone | 96% | Very good |
| Adaptive | 97% | Very good |
| User Friendly | 97% | Very good |
| Self Evaluation | 96% | Very good |
| Average | 97% | Very good |

E-module characteristic test results Sway Approaching STEM obtained a very good category. This e-module is a teaching material that can guide the learning process independently because it is equipped with learning achievements and objectives, instructions for use, STEM features and mapping and aspects of scientific literacy, and concept maps. Students can learn independently and know what they need to master to achieve learning objectives. This is in line with Lastri's statement (2023) that e-modules can measure students' level of understanding independently , so that teachers and students can know which parts have been completed and which have not been completed.

This e-module contains complete and intact learning materials, namely about Human Respiratory System. The integrity of material in the e-module can be seen in the Respiro-Fact feature Respiro - Concept and Respiro - Think in Figure 3.


**Figure 3.** Respiro-Fact, Respiro-Concept and an Respiro-Think

Respiro-Fact, contains interesting facts related to the concept of the human respiratory system in everyday life presented in an infographic and simple practical video about the dangers of smoking. Respiro-Concept, contains explanations of scientific concepts about the system. Respiration in humans which is presented in the form of images, animations, videos, and short explanations using simple language. Respiro-Think , contains videos related to the relationship between the respiratory process and Boyle's Law which directs students to analyze mathematical and physical concepts in the mechanism of human respiration which directs students to practice their ability to explain phenomena scientifically.

E-modul this has fulfilled the characteristics of self contained, with the Respiro-Fact, Respiro-Concept, and Respiro-Think. Yatin et al. (2023) self contained in the e-module contains content-rich material in the form of visual images, so that it is clear to understand and enjoyable for students. Wulansari et al. ( 2018) reinforce by stating that the e-module is an organized teaching material which can describe the material in a structured way so that students can easily learn material. Kimianti & Prasetyo (2019) stated that e-modules is a teaching material supports scientific literacy skills so that students are able to find solutions when encountering problems in real life and facing world issues. This is in accordance with Respiro-Fact feature which contains phenomena in everyday life by presenting information related to the "Dangers of Smoking" in the form of infographics and simple practical videos about the dangers of smoking. E-modul a good one must also be able to stand alone, so that it does not require other supporting teaching materials. Characteristics stand alone reflected in Respiro - Activity feature which can be seen in Figure 4.

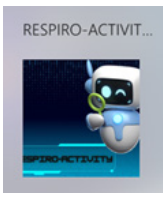



**Figure 4.** Respiro - Activity

Respiro - Activity contains activities that train students to design an infographic based on the results of exploration and evaluation of a scientific article, this activity can train scientific literacy skills in designing and evaluating scientific investigations. This shows that the e-module Sway approach STEM not only contains learning materials, but is equipped with student activities that train students' scientific literacy skills. In line with Wulansari et al. (2018) stated in the e-module There are learning activities that direct students to be active as learning centers. E-module Sway The STEM approach can be used independently because apart from containing complete material, the e-module also equipped with learning activities that train students' scientific literacy skills .

Sway e-module approach STEM packaged digitally using a website -based application , Microsoft Office Sway, which can be accessed using gadgets, laptops, tablets or computers. This e-module can be accessed online without having to download the materials and media contained therein, so it does not fill up the memory of the electronic device used. This shows that e-modul Sway approach STEM in the human respiratory system material has adaptive and user-friendly characteristics, because its use is in accordance with technological developments and is easily accessible. Azaly & Fitrihidajati (2022) stated that teaching materials using the Microsoft Office Sway approach can be accessed simply by opening the link via a browser without having to download the file so that it does not increase the storage capacity on the device . The research results of Atdhini et al. (2023) confirm that e-modules approach Microsoft Sway as Learning resources are easy to access, so that students can learn anytime and anywhere .

E-modul Sway approach This STEM has fulfilled the ideal characteristics that an e-module should have. with a very good category. Furthermore, the e-module is implemented in the learning process to determine the practicality and effectiveness of the Sway e-module with a learning approach. STEM to improve students' scientific literacy skills.

**Validity of Sway E-module with STEM Approach**

Results of validity analysis of e-module items Sway approach STEM using Aiken's V formula shows the average value of 35 statement items in the questionnaire that has been filled by 5 raters included in the valid category. The assessment of the validity of the E-Module includes several aspects, including aspects of content, language, presentation, STEM, science literacy, appearance and use of the E-Module . Table 5 shows the percentage data of the validity of the e-Module. module Sway approach STEM in every aspect assessed.

**Table 5.** E-module Validation Results

| Rated Aspect | Percentage | Category |
|---|---|---|
| Content Eligibility | 96% | Very Valid |
| Language Eligibility | 93% | Very Valid |
| Presentation Eligibility | 96% | Very Valid |
| STEM | 94% | Very Valid |
| Science Literacy | 96% | Very Valid |
| Appearance | 95% | Very Valid |
| Use | 96% | Very Valid |
| Average | 95% | Very Valid |

Based on the validation results by five raters , consisting of two expert lecturers and three Biology teachers, the validity results of all aspects obtained a very valid category. This happened because the process of making the e-module had gone through stages of developing teaching materials in accordance with the development model that had been determined by the author. which is valid. This e-module has undergone a process of improvement based on direction and input from the raters. The aspects that have been improved include , aspects of language feasibility, aspects of presentation feasibility, STEM aspects and aspects of the appearance of the e-module . After the author made improvements to the e-module , the author communicated the results of the improvements to the raters so that the resulting e-module changed for the better.

The use of simple and easy-to-understand language in e-modules can help students in using e-modules . Therefore, e-modules must be composed using simple language . Azaly & Fitrihidajati (2022) stated that e-modules that use Microsoft Office media Sway using sentences that are easy to understand , so that it becomes one of the attractions for students to use e-modules with Microsoft Office media. Sway . This finding is reinforced by the research results of Yatin et al. (2023) who paid attention to the provisions for using language in loading e-modules, including using language that is equivalent to the level of cognitive maturity. learners .

The presentation of e-modules equipped with learning flows, explanations of e-module features and clear instructions for completing

evaluation questions can help students understand clear instructions so that e-modules can be used independently while at school, at home or anywhere . Lastri (2023) stated that use E-modules have a positive impact because they support students in understanding the material better, this is because e-modules are equipped with expected learning objectives , students can learn anytime and anywhere. where even.


**Figure 5.** STEM Approach Practical Video

Sway e-modules with a STEM approach must highlight the STEM aspects in them. The STEM aspects in the e-module can be seen in the presentation of STEM-approach practicum videos (Figure 5) and infographics (Figure 6).

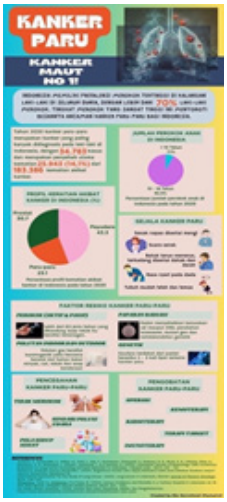



**Figure 6.** Infographics STEM approach

The video shown contains a tutorial on making a lung demonstration tool when smoking a cigarette, explaining the harmful substances contained in cigarettes and how the concept of pressure differences can cause cigarettes to be sucked into the artificial lungs. The presentation of this learning video is a work that follows the development of science and technology, so it is expected to be able to increase students' awareness in facing life's challenges so that they are able to make wiser decisions to maintain the health of the respiratory system. Kimianti & Prasetyo (2019) states that e-modules support scientific literacy skills so that students are able to find solutions when encountering problems in real life and facing world issues. Furthermore Widya et al. (2019) explains that students will become individuals who have self-regulation skills, are able to produce creative answers to every problem with logical reasoning and have expertise in the field of technology.

The infographics presented are the visualization results of several scientific articles presented in the form of images and diagrams and equipped with harmonious colors, so that it will increase students' interest and motivation to read. This finding is in accordance with the characteristics of e-modules conveyed by Raqzitya & Agung (2022) that the presentation of material in the form of interesting learning photos and videos can encourage students' enthusiasm for learning. Raqzitya & Agung (2022) emphasized that material presented in written form and cannot be seen directly will be difficult to understand, so it needs to be transformed into images so that the material can be conveyed properly.


**Figure 7.** Overall View of E-Module Before Revision (Left) and After Revision (Right)

The appearance of the e-module is an attraction for students; therefore, the e-module must be designed with a harmonious color composition, appropriate image layout and display various media such as images, animations, and videos. This is in line with the statements of Raqzitya & Agung, 2022; Wulansari et al. (2018) that the presentation of material in the E - Module

is able to raise the determination of students because it is equipped with interesting interactive media such as images, videos, audio, animations and interactive features. The appearance of the e-module before and after revision can be seen in Figure 7.

The results of the improvements to the E-Module have produced the Sway e-module. approach STEM is very valid based on the assessment of five raters. So that the Sway e-module approach STEM is suitable for use in the learning process.

**Practicality of Sway E-module with STEM Approach**

Practicality assessment of the Sway e-module using a learning approach STEM based on several aspects, namely ease of understanding sentences, practicality in operation, ease of understanding material, and ease of self-evaluation. Table 6 shows the percentage data of the practicality of the Sway e-module approach STEM.

**Table 6.** Results of the E-Module Practicality Test

| Rated aspect | % | Category |
|---|---|---|
| Ease of Understanding Sentences | 100% | Very Practical |
| Practicality of Operation | 100% | Very Practical |
| Ease of Understanding Material | 100% | Very Practical |
| Ease of Self-Evaluation | 100% | Very Practical |
| Average | 100% | Very Practical |

The results of the practicality test of the Sway e-module approach STEM get very practical category. Sway e-module STEM approach has a sentence structure that is easy to understand and user-friendly because it is easy to access using gadgets, laptops, computers or tablets with a stable internet connection, making it easy for students to understand the material. This is in line with Azaly & Fitrihidajati (2022) stated that students can understand the material and develop their skills in the learning process because the teaching materials use the Microsoft Office Sway approach. have precise concepts, facts, illustrations and clear definitions of the material and do not give rise to misunderstandings. Wulansari et al. (2018) states that e-modules are electronic versions of modules that can be accessed via electronic devices such as computers, laptops, tablets or even smartphones. Furthermore, Azaly & Fitrihidajati (2022) states that teaching materials are based on an approach Microsoft Office Sway can be accessed simply by opening the link via a browser without having to download the file so it does not increase the storage capacity on the device .

Kimianti & Prasetyo (2019) stated that e-modules are teaching materials that can be accessed online, are easy to use independently, thus encouraging students' scientific literacy skills so that they can produce solutions to every real problem and to equip them in facing world challenges. Atdhini et al. ( 2023) stated that the e-module teaching materials developed were based on Microsoft Sway. valid, practical, and quite effective.

**The Effectiveness of Sway E-module with STEM Approach to Improve Science Literacy Skills**

Science literacy skills are tested through the implementation of a pretest and posttest. The aspects of this study focus on the scientific literacy aspects of the competency domain. science consisting of three aspects, namely explaining scientific phenomena, evaluating and designing scientific questions, and interpreting data and evidence scientifically. The three aspects consist of ten indicators of scientific literacy skills. The ten indicators of scientific literacy are implemented in 30 questions tested, each indicator of scientific literacy consists of 3 questions. Figure 8 shows the average pre-test and post-test scores of students' scientific literacy skills obtained in the experimental and control classes.

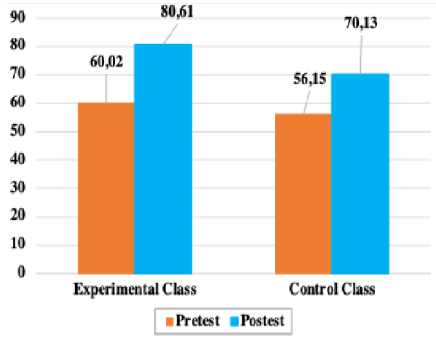
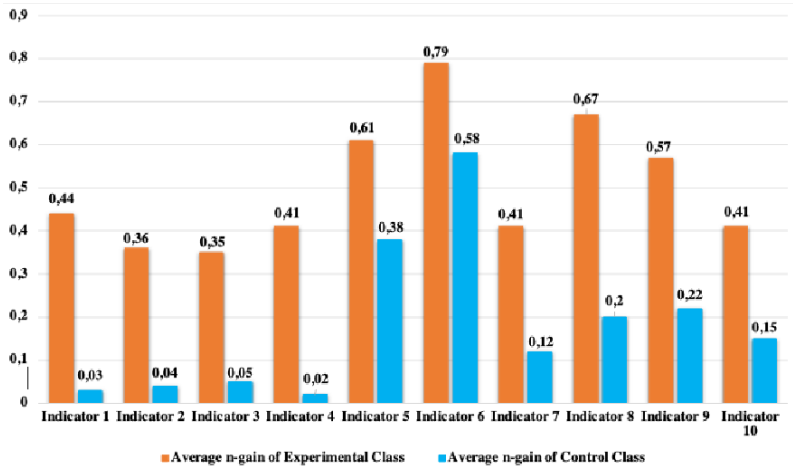



**Figure 8.** Average Pre-test and Post-test Scores of the Experimental Class and the Control Class

The average post-test scores in the experimental and control classes showed an increase, indicating that STEM-based learning implemented in teaching materials can improve students' scientific literacy skills. Purnomo et al. (2023) revealed that integrating STEM into learning activities can improve scientific literacy skills because STEM provides opportunities for students to identify

real-life problems. Nilyani et al. (2023) confirmed that STEM-based learning has a significant impact on students' scientific literacy and critical thinking skills. Furthermore, Putri et al. (2022) revealed that students' scientific literacy and conceptual understanding can be improved by using a STEM approach during the learning process. Learning will be more interesting and student-centered if the STEM approach is implemented in learning activities.

The average data of n-gain value of scientific literacy skills for each indicator in the knowledge and competency domains of experimental and control classes can be seen in Figure 9.




Indicator Description:

1. Recalling and applying appropriate scientific knowledge
2. Identifying, using, and generating clear models and representations
3. Making and justifying appropriate predictions
4. Explaining the potential impact of scientific knowledge on society
5. Identifying questions from a given scientific inquiry
6. Proposing ways to explore a given question scientifically
7. Evaluating ways to explore a given question scientifically
8. Transforming data from one representation to another
9. Analyzing data from one representation to another
10. Evaluating scientific arguments and evidence from a variety of sources

**Figure 9.** N-Gain Values for Each Science Literacy Indicator

The average n-gain of the experimental class's scientific literacy skills is in the medium category and the control class's is in the low category. Although the average n-gain of the experimental class is in the medium category, the average n-gain of the experimental class's scientific literacy skills is greater than that of the control class. This is due to the use of the Sway e-module with a STEM approach. in the experimental class can improve students' literacy skills

better. This proves that the choice of method of presenting teaching materials affects students' literacy skills. Fuadi et al. (2020) stated that students have difficulty understanding the material because scientific literacy is only taught through textbooks without linking it to the real-life context of students, so it has not fully touched the souls of students. In addition, the results of the study by Dayu et al. (2024) confirm that integrating Microsoft Sway into educational practices can significantly improve independent learning, leading to better academic outcomes and equipping students with the skills needed to solve complex problems in real-world situations.

The lowest average post-test scores for the experimental and control classes were in the aspect of explaining scientific phenomena, particularly with the indicators of identifying, using, and producing clear models and representations. To support students in this area, the Sway e-module with a STEM approach includes activities targeting these skills, specifically in the Respiro-Concept and Respiro-Think features. In Respiro-Concept, students study the material through short descriptions, images, and videos. Next, in Respiro-Think, students watch videos of the hu-

man respiration mechanism to analyze the related mathematical and physical concepts.

Activities in the Respiro-Concept and Respiro-Think features are dominated by reading materials in the form of images and by watching several learning videos from YouTube. These videos are presented in English with Indonesian subtitles. Some students had difficulty reading the translated text. Others did not see the instructions in the e-module to activate translation mode on YouTube. Some students could read the translated text but had difficulty understanding the sentences provided by YouTube's automatic translation feature. According to Zahara et al. (2024), findings from YouTube's translation feature showed inaccurate results, lower acceptability, and only moderate readability. This affects the audience's understanding. Therefore, the author considers using Indonesian-language learning videos in the future or, if using English videos, conducting a text translation analysis first.

The experimental and control classes experienced the highest average increase in n-gain values on the same indicator, namely the indicator proposing ways to explore scientifically the given questions. This occurred because the experimental and control classes experienced the same learning activities. Learning activities in the Respiro-Activity feature increased the indicator proposing ways to explore scientifically the given questions, namely when students discussed to analyze scientific articles and create infographics based on scientific articles that had been analyzed by students. Activities in the Respiro-Activity feature include Science, Technology, Engineering and Mathematics competencies that can improve students' scientific literacy skills.

Science competencies in the Respiro-Activity feature are trained by familiarizing students with discussing and analyzing scientific articles related to the human respiratory system related to everyday life. Putri et al. (2024) stated that group discussions can help students convey arguments logically and support them with relevant evidence. The scientific article analyzed by students was related to the analysis of the spread of the Covid-19 virus in the city of Cirebon. Covid-19 (Corona Virus Disease 2019) is a large family of viruses that can cause disease in animals and humans, in humans it is known to cause respiratory infections ranging from the common cold to more severe diseases (Ginting et al. 2023).

Technological competency in the Respiro-Activity feature is trained by using a gadget to create an infographic. Technical competency in the Respiro-Activity feature is trained by using the Canva application to create an infographic in groups. Mathematical competency in the Respiro-Activity feature is trained by producing data in the form of graphs or diagrams based on the results of the analysis of the spread of the Covid-19 virus in each sub-district of Cirebon City. This proves that there is a relationship between activities in the Respiro-Activity feature and STEM which can improve scientific literacy skills. This is in line with Nistilawati and Satriawan (2025) who stated that STEM-based learning is effective in improving scientific literacy, because STEM integrates conceptual understanding with scientific skills through contextually oriented learning activities and problem-solving. Purnomo et al. (2023) stated that integrating STEM into learning activities can improve science literacy skills because STEM provides opportunities for students to identify real-life problems. Ramulumo (2024) confirmed the statement of Purnomo et al. (2023) that students exposed to STEM education showed higher levels of visual and scientific literacy . Astuti et al. (2023) stated that the STEM approach can improve students' scientific literacy and creativity. Astra et al. (2023) and Ilma et al. (2023) supports previous findings, that the application of STEM- based teaching materials is very helpful in improving students' scientific literacy.

The average n - gain value of the experimental class in the aspect of evaluating and designing scientific questions with the indicator of proposing ways to explore scientifically the questions given is included in the high category, while the control class is included in the medium category. This is due to the difference in the teaching material media provided to the experimental and control classes, the experimental class uses the Sway e-module with a STEM approach , while the control class uses a conventional module with a STEM approach . The use of the Sway e-module with a STEM approach succeeded in providing a higher average increase in n-gain values because it is more interesting and motivating for students. This is in line with the statement of Raqzitya & Agung ( 2022 ) which states that e-modules can encourage students' enthusiasm and increase students' curiosity to continue trying and honing their abilities through practice questions to develop students' interests. Dayu et al. (2024) stated that integrating Microsoft Sway into educational practices can significantly improve self-directed learning, leading to better academic outcomes and equipping learners with the skills necessary for complex problem solving in real-world situations. Platini et al. (2022) stated that interactive e-modules using the Microsoft Office Sway ap-

proach are suitable for use in improving literacy . Yatin et al. (2023) confirms that the average posttest score for students' scientific literacy and numeracy abilities has increased after studying using e-modules with a STEM approach.

The results of the work of students in the experimental and control classes in the form of infographics containing information about the spread of the Covid-19 virus in the city of Cirebon can be seen in Figure 10.


**Figure 10.** Infographic of the Experimental Class's Work Results (Left) and the Control Class's Work (Right)

The Respiro-Activity in the e-module directs students in groups to analyze a scientific article about the spread of the Covid-19 virus in Cirebon. The results of the students' analysis are then interpreted in an infographic created using the Canva application. Figure 4.30 shows the infographic created by the experimental class (left) and the control class (right). There are differences between the experimental and control class's work. The experimental class' infographic includes a bar chart showing Covid-19 transmission in each sub-district in Cirebon, while the control class' infographic does not.

The infographics created by the experimental and control classes in Figure 8 demonstrate the students' ability to interpret written data into images with concise explanations, graphs, and a more engaging display. The group activity of creating the infographics fostered scientific literacy and creativity in designing infographics using the Canva application. This activity also fostered cognitive, psychomotor, and affective skills. This is in line with Pratama et al. (2025) who stated that the project-based STEM approach trains students to work together in groups to develop ideas, solve problems using media projects, and draw conclusions based on data analysis from investigations. Astuti et al. (2023) confirmed that the STEM approach can improve students' scientific literacy and creativity.

## CONCLUSION

E-modules that integrate the STEM approach and are presented using Microsoft Office Sway are more effective in improving students' scientific literacy skills. The effectiveness test in the experimental class obtained significant results compared to the control class in improving scientific literacy skills, especially in the aspect of evaluating and designing scientific questions with indicators proposing ways to explore scientifically the questions given. Activities in the Respiro-Activity feature contain Science, Technology, Engineering and Mathematics competencies that can improve scientific literacy skills, especially in the indicator suggests a way to scientifically explore the given question. This proves that there is a relationship between activities in the Respiro-Activity feature and STEM which can improve scientific literacy skills. This study focuses on the scientific literacy skills of the competency domain. science consists of three aspects, namely explaining scientific phenomena, evaluate and design scientific questions, and interpret data and evidence scientifically. It is recommended to conduct research that focuses on other domains, such as context, knowledge and attitude domains. The goal is to obtain comprehensive analysis results for each domain of scientific literacy skills.

## REFERENCES

Ardian, S., Hasanah, W. K., & Rana, F. I. (2020). Pemanfaatan Microsoft Sway dan Microsoft Form. *Pendidikan Sejarah dan Ilmu Sejarah*, 3(2), 66–74.

Astra, I. M., Henukh, A., & Uskenat, K. (2023). The effectiveness of STEM-Based Science Teaching Materials in Improving elementary School Students' Science Literacy. *Journal of Physics: Conference Series,* 2582(1), 1–8. https://doi.org/10.1088/17426596/2582/1/012047

Astuti, W., Sulastri, S., Syukri, M., & Halim, A. (2023). Implementasi Pendekatan Science, Technology, Engineering, and Mathematics untuk Meningkatkan Kemampuan Literasi Sains dan Kreativitas Siswa. *Jurnal Pendidikan Sains Indonesia*, 11(1), 25–39. https://doi.org/10.24815/jpsi.v11i1.26646

Atdhini, A. R., Putri, R. F., & Yulinda, R. (2023). Pengembangan E-Modul Berpendekatan Microsoft Sway untuk Melatih Literasi Sains Siswa. *Journal on Teacher Education*, 5(1), 136–

145.

Azaly, Q. R., & Fitrihidajati, H. (2022). Pengembangan Media Pembelajaran Berpendekatan Microsoft Office Sway pada Materi Perubahan Lingkungan untuk Melatihkan Kemampuan Literasi Sains Siswa Kelas X SMA. *Berkala Ilmiah Pendidikan Biologi (BioEdu)*, 11(1), 218–227. https://doi.org/10.26740/bioedu.v11n1.p218-227

Dayu, D. P. K., Nafisah, D., & Cindy, A. H. (2024). Microsoft Sway Media for Students' Independent Learning in The Independent Curriculum Era. *Journal of Learning and Technology*, 3(1), 10–18. https://doi.org/10.33830/jlt.v3i1.9730

Fuadi, H., Robbia, A. Z., Jamaluddin, J., & Jufri, A. W. (2020). Analisis Faktor Penyebab Rendahnya Kemampuan Literasi Sains Peserta Didik. *Jurnal Ilmiah Profesi Pendidikan*, 5(2), 108–116. https://doi.org/10.29303/jipp.v5i2.122

Ginting, K., Manik, H. G. M., Simbolon, A. J., Wani, H. S., & Rahmadi, M. T. (2023). Analisis Penyebaran Virus Covid-19 di Kota Cirebon Menggunakan ArcGIS. *El-Jughrafiyah*, 3(1), 38-45.

Hutomo, B. A., Saptono, S., & Subali, B. (2022). Development of E-module Based on Science, Technology, Engineering, and Mathematics (STEM) To Improve Science Literacy of Junior High School Students. *Journal of Innovative Science Education,* 11(2), 241–249. https://doi.org/10.15294/jise.v10i1.54066

Ilma, A. Z., Wilujeng, I., Widowati, A., Nurtanto, M., & Kholifah, N. (2023). A Systematic Literature Review of STEM Education in Indonesia (2016-2021): Contribution to Improving Skills in 21st Century Learning. *Pegem Egitim ve Ogretim Dergisi*, 13(2), 134–146. https://doi.org/10.47750/pegegog.13.02.17

Alwaqfi, E. J. F., & Saleh, S. (2023). The Effect of STEM-based 5E Module (in the topic of Waves) in Enhancing Scientific Literacy Among Ninth-grade Students in Doha, Qatar. *International Journal of Academic Research in Progressive Education and Development*, 12(4). https://doi.org/10.6007/ijarped/v12-i4/20023

Kimianti, F., & Prasetyo, Z. K. (2019). Pengembangan E- Modul IPABerpendekatan Problem Based Learning Untuk Meningkatkan Literasi Sains Siswa. *Jurnal Teknologi Pendidikan*, 07(02), 91–103. https://doi.org/http://doi.org/10.31800/jtp.kw.v7n2.p91--103

Lastri, Y. (2023). Pengembangan Dan Pemanfaatan Bahan Ajar E-Modul Dalam Proses Pembelajaran. *Jurnal Citra Pendidikan*, 3(3), 1139–1146. https://doi.org/10.38048/jcp.v3i3.1914

Mulyadi, Q. &. (2022). Kriteria Pengembangan E-Modul Interaktif, 4(2), 125–131.

Nistilawati., & Satriawan, M. A. (2025). The Effectiveness oOf STEM-Based Learning In Improving Students' Science Literacy In Temperature aAnd Heat, *Jurnal Inovasi Fisika dan Inovasi*, 1(1), 7–11.

Platini, L. T., Abdurrahman, A., & Lengkana, D. (2022). Development and Implementation of Interactive e-Module using Microsoft Sway to Improve Disaster Literacy Skills. *Jurnal Pendidikan MIPA*, 23(3), 854–871. https://doi.org/10.23960/jpmipa/v23i2.pp854-871

Pramana, M. W. A., Jampel, I. N., & Pudjawan, K. (2020). Meningkatkan Hasil Belajar Biologi Melalui E-Modul Berpendekatan Problem Based Learning. *Jurnal Edutech Undiksha*, 8(2), 17. https://doi.org/10.23887/jeu.v8i2.28921

Prasetyo, D., Marianti, A., & Alimah, S. (2021). Improvement of Students' Science Literacy Skills Using STEM-Based E-Modules. *Journal of Innovative Science Education*, 10(2), 216–221. Retrieved from http://journal.unnes.ac.id/sju/index.php/jise

Pratama, H., Matsun, Puspitasari, Y. D., & Maduretno, T. W. (2025). Science Literacy through STEM-Based Project Based Learning Model. *Jurnal Penelitian Pendidikan IPA*, 11(7), 320–330. https://doi.org/10.29303/jppipa.v11i7.11

Pratiwi, R. S., & Rachmadiarti, F. (2021). Pengembangan E-Book Berpendekatan Science, Technology, Engineering, and Mathematics (Stem) Materi Pertumbuhan dan Perkembangan Tumbuhan untuk Melatihkan Keterampilan Literasi Sains. *Berkala Ilmiah Pendidikan Biologi (BioEdu)*, 11(1), 165–178. https://doi.org/10.26740/bioedu.v11n1.p165-178

Pujiati, A. (2019). *Peningkatan Literasi Sains dengan Pembelajaran STEM Di Era Revolusi Industri 4.0*. Universitas Indraprasta PGRI Jakarta INFO, 0812(80), 547–554.

Purnomo, S., Rahayu, Y. S., & Agustini, R. (2023). Effectiveness of ADI-STEM to Improve Student's Science Literacy Skill. *IJORER : International Journal of Recent Educational Research*, 4(5), 632–647. https://doi.org/10.46245/ijorer.v4i5.382

Putri, M. A., Salsabilla, S., Yusuf, S., & Susilo, B. E. (2024). Studi Literatur: Penerapan Metode Pembelajaran Diskusi Kelompok untuk Meningkatkan Keterampilan Komunikasi Siswa di Sekolah Menengah Pertama. *PRISMA, Prosiding Seminar Nasional Matematika*, 7, 437-441. 349. Retrieved from https://proceeding.unnes.ac.id/prisma

Putri, R. M., Asrizal, A., & Usmeldi, U. (2022). Meta-analisis Efek Pendekatan STEM pada Literasi Sains dan Pemahaman Konsep Peserta Didik di Setiap Satuan Pendidikan. *Jurnal IPA & Pembelajaran IPA*, 6(1), 86–98. https://doi.org/10.24815/jipi.v6i1.23897

Ramulumo, M. (2024). Exploring the Impact of Early STEM Education on Science and Visual Literacy. *Journal of Education in Science, Environment and Health*, (July), 216–229. https://doi.org/10.55549/jeseh.725

Ramuluno, M. M. (2025). The Impact of Early Childhood STEM Education on Children's Science Literacy. *Preschool Education: Global Trends*, 7, 68 - 95. https://doi.org/10.31470/2786-703X-2025-7-68-95

Raqzitya, F. A., & Agung, A. A. G. (2022). E-Modul Berpendekatan Pendidikan Karakter Sebagai Sumber Belajar IPA Siswa Kelas VII. *Jurnal Edutech Undiksha,* 10(1), 108–116. Retrieved from https://ejournal.undiksha.ac.id/index.php/JEU/article/view/41590

Riduwan. (2015). *Dasar-Dasar Statistika*. Bandung: Alfabeta.

Suci, D. H., Zainul, R., Kimia, J., Matematika, F., & Alam, I. P. (2023). Pengembangan Modul Berpendekatan Think, Pair and Share (TPS) Pada Materi Kimia Hijau (Green Chemistry) dalam Kehidupan Sehari-Hari. *Jurnal Pendidikan Tambusai*, 7(2), 14224–14234.

Suyidno, S., M, A. S., Arifuddin, M., Misbah, M., & Siswanto, J. (2020). Menyiapkan Peserta Didik untuk Masyarakat 5.0 Mmelalui Creative Responsibility Based Learning. *Jurnal Pendidikan Fisika Dan Keilmuan (JPFK)*, 6(1), 25. https://doi.org/10.25273/jpfk.v6i1.6041

Syaifudin, M. (2022). Efektivitas E-LKPD Berpendekatan STEM untuk Menumbuhkan Keterampilan Literasi Numerasi dan Sains dalam Pembelajaran Listrik Dinamis di SMA Negeri 1 Purbalingga. *Jurnal Riset Pendidikan Indonesia (JRPI),* 2(2), 211–220.

Widya, Rifandi, R., & Laila Rahmi, Y. (2019). STEM education to fulfil the 21st century demand: A literature review. *Journal of Physics: Conference Series,* 1317(1). https://doi.org/10.1088/1742-6596/1317/1/012208

Wulansari, E. W., Kantun, S., & Suharso, P. (2018). Pengembangan E-Modul Pembelajaran Ekonomi Materi Pasar Modal Untuk Siswa Kelas Xi Ips Man 1 Jember Tahun Ajaran 2016/2017. *Jurnal Pendidikan Ekonomi: Jurnal Ilmiah Ilmu Pendidikan, Ilmu Ekonomi Dan Ilmu Sosial,* 12(1), 1. https://doi.org/10.19184/jpe.v12i1.6463

Yatin., Abidin, Z., & Arip, A. G. (2023). Pengembangan E-Modul Berpendekatan STEM Dengan Media Canva Untuk Meningkatkan Literasi Sains dan Numerasi Siswa SMP. *Jurnal Ilmiah Wahana Pendidikan*, 9(22), 888-903.

Zahara, R., & Nurhuda, Z. (2024). Analisis Kualitas Terjemahan Otomatis Subtitle pada Channel Youtube (Indo4arab Khalid Nahdi). Akhlak, 1(4), 321-337. https://doi.org/10.61132/akhlak.v1i4.448 Yusuf, A. M., Hidayatullah, S., & Tauhidah, D. (2022). The relationship between digital and scientific literacy with biology cognitive learning outcomes of high school students. *Assimilation: Indonesian Journal of Biology Education*, 5(1), 9–18. https://doi.org/10.17509/aijbe.v5i1.43322

Zahara, R., Nurhuda, Z., Tarjamah, P., Adab, F., D., & Hidayatullah, U. I. N. S. (2024). Analisis Kualitas Terjemahan Otomatis Subtitle Pada Channel Youtube ( Indo4arab Khalid Nahdi). *Humaniora*, 1(4).