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Development and Validity Analysis of a Phenomenon-Based Advance Organizer Chemistry Learning Tool for Training Science Literacy in High School Students

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Abstract: Educational developments in the 21st century require students to be prepared to face global competition. This preparedness can be supported by several basic skills that are equipped to each student as the future generation of the nation, for example, science literacy. Specifically, the study aims to produce and test the validity of a phenomenon-based advance organizer learning tool consisting of a teaching module, student worksheet, textbook, and science literacy assessment instrument. The method used is RnD, with the research design chosen being Thiagarajan's 4D model, which consists of define, design, develop, and disseminate. Data were obtained from three expert validators through validation sheets and analyzed using Aiken's V formula to determine the validity level of each component of the developed learning tools. The expected outcomes include teaching modules, student worksheets, textbooks, and science literacy questions to be applied in chemistry education. Research data was obtained from three validators using a validation sheet. The validators consisted of two lecturers from the Faculty of Mathematics and Natural Sciences at Unesa and one chemistry teacher from Puri 1 Senior High School in Mojokerto Regency. The data was analyzed based on the validity criteria of each element of the learning tools using Aiken's validation. Previously, the learning tools were reviewed by two chemistry lecturers from the Faculty of Mathematics and Natural Sciences at Unesa with the assistance of a review sheet to obtain suggestions and input. The validity data showed that the learning tools were valid, with validity data meeting the validity criteria, where the teaching module scored 0.86 on the Aiken scale, the student worksheet scored 0.86 on the Aiken scale, the textbook scored 0.89, and the science literacy questions scored 0.99. These findings indicate that the developed learning tools meet high validity criteria and are suitable for use in chemistry learning. The integration of the phenomenon-based approach with the advance organizer model provides a structured framework that helps students connect abstract chemistry concepts with real-world phenomena, thereby improving science literacy and engagement. In conclusion, the phenomenon-based advance organizer chemistry learning tool developed in this study is valid and feasible to be implemented in high school classrooms to train students' science literacy skills, and further research is recommended to test its effectiveness in improving learning outcomes.

Keywords: Advance Organizer; Phenomena; Science literacy; Validity

Introduction

Students' difficulty in understanding abstract concepts is often a major challenge in chemistry learning. One of the contributing factors is teaching methods that are uninteresting and irrelevant to everyday life (Novianto et al., 2024). Chemistry learning at the high school level also often faces challenges due to

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the complexity of the material, especially topics such as petroleum. A preliminary study conducted at Puri 1 Senior High School in Mojokerto Regency in August 2024 revealed that 68% of 36 students experienced difficulties in understanding chemistry material. Specifically, 73% of students stated that the topic of petroleum was very difficult to understand; 45% of them considered the material to be overly reliant on memorization, while 55% found it challenging to grasp the technical terms associated with the subject. These difficulties highlight the need for more effective and contextual learning models to enhance students' understanding. An interview with an educator at Puri 1 Senior High School in Mojokerto Regency also showed that learning tools related to everyday life can help students understand the material more easily. This issue highlights the need for contextual, phenomenon-based, and relevant learning models to enhance students' understanding of chemistry, as these challenges not only affect conceptual understanding but also contribute to low student interest in science, particularly chemistry, which impacts their overall science literacy skills (Putra, 2022).

Various studies have discussed phenomenon-based learning models that effectively improve students' understanding of scientific concepts in chemistry lessons. Research conducted by Fatmi et al. (2024) shows that phenomenon-based models can motivate students by linking scientific concepts to everyday experiences. Another study by Nurholisa et al. (2022) proves that phenomenon-based learning not only improves students' understanding but also motivates them to actively participate in the learning process. Additionally, there is a need for a learning model that helps students connect abstract concepts with their prior knowledge, thereby enhancing understanding. One such model is the Advance Organizer model, designed to help students connect new knowledge with existing cognitive structures (Sartika et al., 2022). Research by Widyastuti (2021) shows that the use of the Advance Organizer model in online learning on chemical bonding material effectively improves student learning outcomes. In addition, a study by Amri et al. (2020) found that the application of this model can improve students' understanding of atomic structure material. However, this study has not discussed the implementation of the Advance Organizer model based on phenomena in chemistry material, especially the topic of petroleum. This study attempts to fill the existing gap by combining the two models into one learning tool.

Previous studies have shown the success of the Advance Organizer learning model in helping students understand abstract concepts, but its implementation in the context of phenomenon-based learning is still limited. However, this study attempts to address this issue by combining the phenomenon-based learning model with the Advance Organizer model on the topic of petroleum. Additionally, to cultivate skills relevant to the current era to support global living, students are expected to begin practicing scientific literacy in understanding complex material through scientific literacy indicators. This study offers novelty by integrating science literacy indicators as part of the evaluation of the success of the learning tools. Therefore, this study not only develops learning tools that are theoretically relevant but also practically applicable in the classroom. This presents an opportunity to contribute new insights into enhancing science literacy among high school students. Science literacy is one of the key competencies of the 21st century that students must master in order to face global challenges (Warmadewi, 2022). Science literacy among students in Indonesia remains a concern. According to research conducted by Saija (2019) the science literacy profile of students in chemistry lessons showed that 77.95% of students were at the moderate level of science literacy (Sari et al., 2022). In 2022, the science literacy profile declined and fell into the adequate category with an average score of 64.03%. Meanwhile, in 2023, the science literacy profile of students again declined to 45.8% in the adequate category (Rohmaya et al., 2023). This data shows that the science literacy of Indonesian students still needs to be improved, especially in chemistry learning, which is considered difficult by many students. Students' science literacy skills are expected to enable them to explain phenomena scientifically, construct and evaluate scientific investigation designs, and research and use scientific information for decision-making relevant to everyday life (OECD 2023). The science literacy indicators focused on in this study refer to the PISA 2025 Science Framework developed by the Organisation for Economic Cooperation and Development (OECD). By focusing on these indicators, the developed learning tools are expected to enhance students' science literacy competencies in line with international standards. This study aims to address this need through innovative, phenomenon-based learning tools on the topic of petroleum.

Advance organizers are often used to help students organize new knowledge with what they already know, which is very important in improving scientific concept understanding (Shifa et al., 2025). However, although advance organizers are effective in organizing information, some weaknesses arise, especially in the context of science literacy. First, if not designed properly, the advance organizer model can cause confusion among students, especially those with limited prior knowledge who require further scaffolding (Slavin, 2015). Second, this model emphasizes individual learning and overlooks the importance of social interaction, which is crucial in collaborative learning (Sartika et al., 2022). Additionally, implementing the advance organizer model in the classroom requires extra preparation time, making it less flexible in classrooms with time constraints (Ramadhani et al., 2023).

On the other hand, phenomenon-based learning offers a more engaging approach by involving students in observing and analyzing relevant real-world phenomena, such as chemical phenomena in everyday life, which motivates students to think critically and apply their knowledge (Dendodi et al., 2024). However, this model also has limitations, as it may become less effective if not supported by sufficient knowledge structuring required to connect new knowledge with real-world experiences (Syaharani et al., 2024). The combination of these two models—the phenomenon-based advance organizer—can address this limitation by providing the initial cognitive framework needed to understand complex scientific phenomena. This enables students not only to understand theories but also to apply them practically, thereby significantly enhancing their science literacy skills.

The integration of the phenomenon-based learning approach with the advance organizer model is theoretically supported by Ausubel's meaningful learning theory, which posits that learning becomes effective when new information is anchored to relevant prior knowledge in a learner's cognitive structure. The use of advance organizers serves as a conceptual bridge that enables students to connect previously acquired knowledge with new, abstract chemistry concepts (Vivian & Aziaka, 2025). Similarly, phenomenon-based learning is grounded in constructivist theory, emphasizing that students actively construct understanding through authentic engagement with real-world contexts (Adipat, 2024). The combination of these two approaches provides both cognitive structure and contextual relevance, allowing students to meaningfully internalize scientific concepts and enhance their scientific literacy in abstract topics such as petroleum.

The rationale for conducting this study is also supported by empirical evidence showing that Indonesian students' science literacy remains relatively low, as indicated by various national and international assessments. Recent bibliometric analyses reveal that science and chemical literacy are emerging yet underdeveloped research areas in Indonesia, with students often struggling to engage in evidence-based reasoning and contextual understanding (Yuendita & Rohaeti, 2025). Furthermore, previous studies highlight the urgent need to improve inquiry-based and contextual learning practices to foster students' scientific reasoning and literacy skills (Kotsis, 2024). Therefore, this research aims to offer a pedagogically grounded and contextually relevant solution to enhance the quality of chemistry learning in high schools through the development of a phenomenon-based advance organizer learning tool that connects classroom concepts with real-life phenomena.

The title "Development and validity analysis of phenomenon-based advance organizer chemistry learning tools to improve science literacy among high school students" was chosen based on the need to bridge the gap between theory and practice in chemistry learning. In addition, this research is expected to make a significant contribution to improving the quality of chemistry learning in high schools, particularly in the subject of petroleum. Through the development of innovative and phenomenon-based learning tools, students are expected to gain a deeper and more practical understanding of chemistry concepts, thereby enhancing their scientific literacy. This aligns with the objectives of the Merdeka Curriculum, which emphasizes the development of competencies and literacy (Martatiyana et al., 2023).

Method

This study developed a learning design, student worksheets, textbooks, and science literacy tests on the subject of petroleum. The development procedure consisted of several steps in the 4D model development procedure, namely through four stages: define, design, develop, and disseminate. The stages of implementation are presented in Figure 1.

The three stages of development include techniques for validating or assessing the feasibility of product designs for use. In this activity, experts in each field will also evaluate the devices that have been developed. Expert validation is conducted to determine the validity of the learning design, student worksheets, student textbooks, and pretest and posttest questions on the topic of petroleum. These will be validated by chemistry education lecturers and chemistry educators to obtain validation results, as well as comments and suggestions for improving the learning tools to make them more valid. Learning tools and data collection instruments that have undergone the validation stage are revised based on suggestions and validators, resulting in revisions. This stage aims to determine one aspect of product development quality, namely validity. Data analysis is conducted using scores obtained from the validation sheet using the Likert scale model. The Likert scale used in this validation sheet is a modified Likert scale without the middle option. The purpose of modifying the scale is to eliminate weaknesses (Nair et al., 2025). Scores for each answer option are obtained based on calculations using the Likert scale, as shown in Table 1.

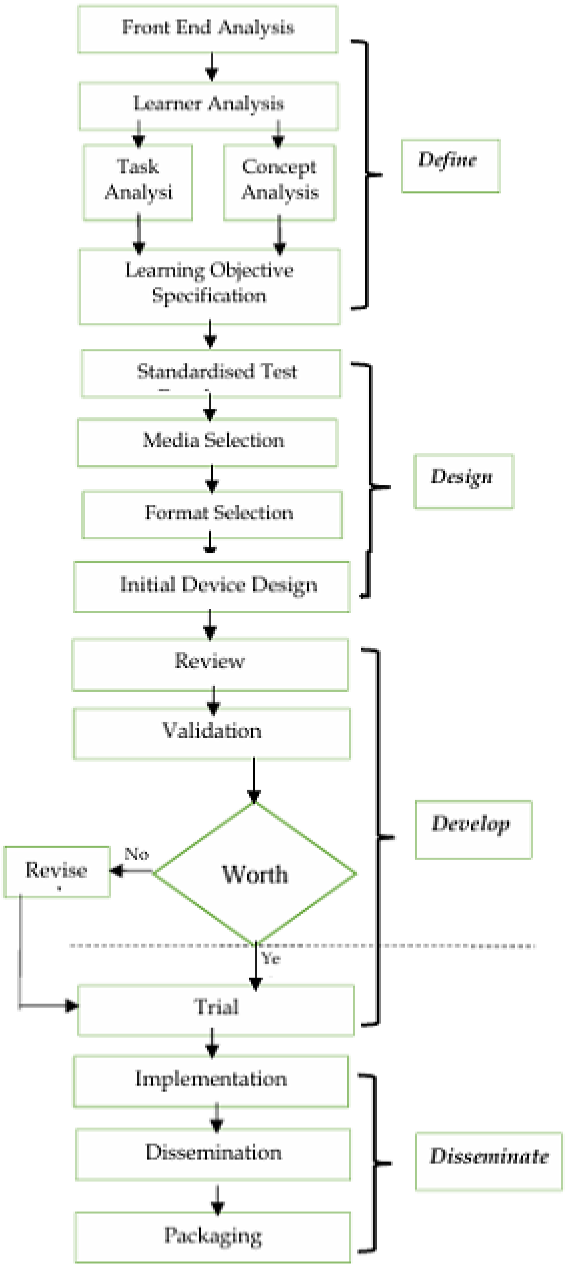


Figure 1. 4D Model research procedure chart

Table 1. Scoring of the Likert Scale Validation (Riduwan, 2015)

Assessment	Scale Values
Not conducted	1
Very poor	2
Poor	3
Good	4
Very good	5

The validity analysis of each element of the learning tool uses Aiken's validation, determined by the following formula:

$$V = \frac{\sum s}{[n-(c-1)]} \quad (1)$$

Explanation:
V = Item validity
$\sum s$ = Total number of points given by the assessor (r) minus the lowest validity score (lo) from the three validators
lo = Lowest validity score
c = Highest validity score
r = Points given by the assessor
n = Number of raters

The analysis results obtained are used to determine the validity of the learning tool based on the interpretation of the Aiken index coefficient presented in Table 2.

Table 2. Interpretation of Aiken Index Coefficients

Interval V	Criteria
$V > 0.8$	High Validity
$0.4 < V \leq 0.8$	Moderate Validity
$V \leq 0.4$	Low Validity

Based on these criteria, the learning tool is considered to meet the criteria if the Aiken V validity coefficient is > 0.8 with a high validity rating, so that the learning tool is declared suitable for use. Furthermore, revisions are made after the chemistry learning tool is validated by the validator. The validator's suggestions are used as improvements and refinements for researchers to produce a valid product that can be tested.

Result and Discussion

Development of Learning Tools

The initial stage began with the development of test standards aimed at measuring student learning outcomes in learning based on the Advance Organizer model and phenomena. This test consisted of a pretest and posttest to measure students' science literacy and knowledge (Nurjanah et al., 2017). The tests are designed based on learning objectives and student analysis to ensure that the science literacy skills being taught can be achieved. The media used must be appropriate for the learning objectives and characteristics of the students. In this study, phenomenon-based learning tools use media that are easily accessible and relevant to the students' life contexts, including the use of videos and images that support understanding of the material. The selection of appropriate media helps increase student interest and ensures effective learning. During the design phase, the selection of learning tool formats, such as textbook layouts and student worksheets, was also a key focus. The format of the learning tools is adapted to the Merdeka curriculum and the phenomenon-based Advance Organizer model. The presentation of the material must be in line with the structured learning objectives, using easy-to-read fonts, relevant images, and an appealing layout for the learners. This aims to create a pleasant learning environment and facilitate the learners' understanding.

After the analysis stage, the initial design of the learning tools began to be developed, including textbooks, student worksheets, and science literacy test questions. This development process involved determining titles and teaching materials that were in line with the Merdeka curriculum. The design aimed to ensure that each element of the learning tools supported the desired learning objectives and was appropriate to the needs and characteristics of the students. This initial design is then tested through validation and revision by the supervising lecturer and validators.

The textbooks and student worksheets are developed by integrating the Advance Organizer model and phenomena, and are tailored to the learning objectives. The textbook aims to provide a comprehensive understanding of petroleum materials, while the student worksheets are designed to train students' science literacy skills through structured activities. Each element in the textbook and student worksheets is designed to activate students' cognitive schemas so that they can relate new material to their existing knowledge.

Science literacy tests are part of the evaluation conducted to measure improvements in students' ability to explain phenomena, construct scientific investigations, and critically interpret scientific data. These tests are measured using pre-tests and post-tests, the results of which can be compared to see if there has been an improvement in students' science literacy skills (Warmadewi, 2022). Test results were analyzed to determine the effectiveness of learning tools in improving science literacy. Learning activities were designed to include Advance Organizers tailored to real-life phenomena relevant to students' lives. In this case, learning activities focused on the topic of petroleum and various related phenomena. Evaluation was conducted using questionnaires and observation sheets to obtain data on student engagement in learning activities. The creation of student worksheets and textbooks in this study uses a format that is appealing to students in terms of form, color, font size, and interesting videos and images. The student worksheets and modules are designed to be a guide for students in the classroom and to achieve learning objectives. The following are the elements of the learning tools.

The teaching module provides an overview of the contents of the three activities on the topic of petroleum. The main cover consists of the title and an illustration depicting the process of petroleum extraction. The first learning step contains the learning objectives, which are that through the phenomena presented, students will be able to explain the process of petroleum formation in a simple and correct manner. The second learning step aims for students to be able to interpret data and evidence scientifically to correctly identify the positive and negative impacts of petroleum use on the environment. The third learning step aims for students to be able to evaluate and design investigations into alternative energy sources to replace petroleum correctly.

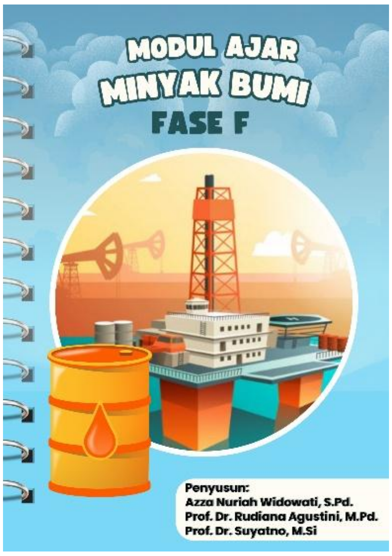


Figure 2. Teaching module display

Student worksheet 1 provides an overview of how the use of petroleum affects the environment, with a dominant blue color. The content of student worksheet 1 contains phenomena around us related to the topic of petroleum for analysis and to practice scientific literacy.

Figure 3. Student worksheet 1 display

Student worksheet 2 illustrates how the use of petroleum affects the environment with the color yellow. It contains phenomena around us related to the topic of petroleum for analysis and to develop scientific literacy.

Figure 4. Student worksheet 2 display

Student worksheet 3 provides an overview of how the use of petroleum affects the environment, with the addition of green color. It contains phenomena around us related to the topic of petroleum.

Figure 5. Student worksheet 3 display

The textbook content includes a section on how to use the textbook, highlighting its features. The textbook content also includes an introduction to stimulate students to begin learning. The textbook content also includes a summary of the material to help students understand the topic of petroleum.

Figure 6. Student textbook display

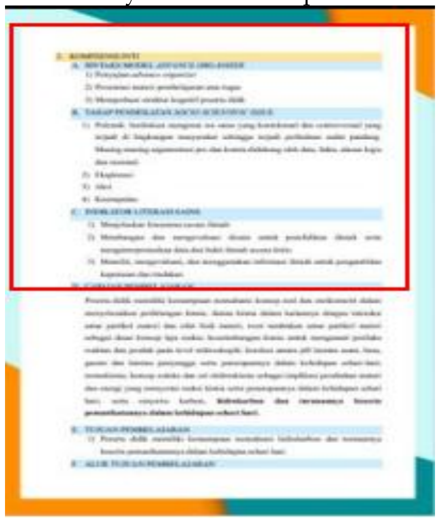
The learning device design that has been developed produces a product that then enters the review stage by the supervising lecturer to obtain input, suggestions, and comments for improvement of the learning device. The input provided is presented in Table 3.

Table 3. Results of Learning Tool Analysis

Component	Suggestion
Teaching module	In the general information, the stages of Advance Organizer, science literacy indicators and phenomena are added.
Worksheet 1	Added links that connect to direct sources
Worksheet 2	Added links that connect to direct sources
Worksheet 3	Added links that connect to direct sources
Textbook	Video cannot be opened

Suggestions and criticisms obtained from the results of the review by the supervisor were then used as a guide to improve the learning device so that the revisions were made which are presented in Table 4.

Table 4. Revision Results After Review

Suggestion	Improvement Result
In the teaching module in the general information section, *Advance Organizer* stages, science literacy indicators and phenomena were added.	The teaching module already has a general information section, namely the stages of Advance Organizer, science literacy indicators and phenomena.
	
Learner worksheet 1 added links that connect to direct sources	Added a link that connects to the direct source on learner worksheet 1.
Learner worksheet 2 added links that connect to direct sources	Added to worksheet 2 a link that connects to a direct source
Learner worksheet 3 added link connecting to direct source	Add on Learner worksheets 3 links that connect to direct sources
Video cannot be opened	Video can be opened

Validation of Learning Tools

All of these tools were validated to ensure that each element met the criteria of feasibility and relevance to the learning objective of improving the science literacy of high school students. The following are the validation results described in Table 5.

The validation results of the teaching module developed using the phenomenon-based *Advance Organizer* model show that this chemistry learning tool has very good quality, based on the assessment conducted by validator 1, validator 2, and validator 3 using the Aiken validity index. The assessment was conducted on several main aspects, namely media, material, and time, all of which gave a strong indication that this learning tool could be effectively applied in chemistry learning at the high school level.

In the media aspect, validator 1 and validator 2 gave a very good assessment with an average Aiken validity index value of 0.90, which indicates that the media used in this teaching module is very suitable and can support the learning process. The media in question includes various visual and interactive elements, such as images, graphics, and videos, which are designed to make it easier for students to understand complex chemical materials. This is in accordance with previous research which shows that technology-based learning media, such as augmented reality and video tutorials, are very effective in helping students understand chemical materials and increase their interest in learning (Sari et al., 2022). The use of appropriate media can improve the understanding of the chemical concepts taught, as well as encourage students to be more active in the learning process. Both validators considered that the organization of the media in this learning tool is very good, clear, and accessible, providing a strong basis for learners to understand the information in a more interactive way.

Table 5. Learning Tool Validation Results

Assessed Aspect	Average Item Validity	Criteria
Teaching Module		
Formulation of Learning Objectives	0.83	High validity
Content Presented	0.85	High validity
Language	0.89	High validity
Time	0.87	High validity
Average	0.86	High validity
Learner worksheet		
Content	0.87	High validity
Presentation	0.88	High validity
Language	0.83	High validity
Graphics	0.87	High validity
Average	0.86	High validity
Teaching Materials		
Content	0.90	High validity
Presentation	0.88	High validity
Language	0.92	High validity

Assessed Aspect	Average Item Validity	Criteria
Graphics	0.87	High validity
Average	0.89	High validity
Science Literacy Pretest-Posttest Questions		
Content	0.98	High validity
Construct	0.99	High validity
Linguistic	1	High validity
Average	0.99	High validity

In the material aspect, validator 3 gave a very positive assessment of the suitability of the material presented with the chemistry learning objectives set out in the curriculum. With an average Aiken validity index value of 0.87, this indicates that the material presented in the teaching module is very relevant, in accordance with curriculum standards, and can achieve the desired learning objectives. Validator 3 also provided constructive feedback regarding the use of some chemical terms that may be too complex for high school students and suggested that some explanations be simplified to facilitate students' understanding. However, overall the material presented was considered very appropriate and able to provide a deep understanding of chemical concepts. This result is in line with the findings of Muhammadiah et al. (2022) which shows that learning materials that are relevant to the curriculum and delivered in a way that is easy to understand greatly affect the effectiveness of learning and increase students' understanding.

The time aspect included in the learning tool also received positive ratings from all three validators. Each learning stage has been well organized in terms of time allocation, providing sufficient time for students to understand the material, conduct discussions, and do in-depth exercises or experiments. Aiken's validity index on the time aspect reached an average value of 0.85, indicating that the time setting in this teaching module is appropriate and in accordance with the learning needs in the classroom. Good time management in the learning process is very important so that students do not feel rushed in understanding the material presented and can make the best use of time to explore each concept. This is in line with the principles of learning planning that emphasize the importance of effective time management so that the teaching and learning process can run smoothly and in accordance with the predetermined objectives.

Overall, the results of this validation indicate that the teaching module developed has high validity in each aspect assessed. With a consistently high Aiken's validity index in the media, material, and time aspects, this phenomenon-based Advance Organizer model chemistry learning tool is very feasible to be applied in learning in high school classes. The assessments conducted by validator 1, validator 2, and validator 3 provide strong evidence that this learning tool is not only relevant to the learning objectives, but also designed in a way that pays attention to the needs of students in understanding chemistry material more deeply and applicatively.

The high validity results obtained in this study are consistent with previous findings demonstrating the effectiveness of the advance organizer model in improving students' conceptual understanding and cognitive structuring. Widowati (2025) reported that students who learned with the advance organizer model showed significantly higher academic performance compared to those using conventional instruction. Similarly, Widyastuti (2021) found that advance organizer-based materials on chemical bonding improved comprehension and retention among high school learners. These findings suggest that the advance organizer model effectively assists students in organizing new information into coherent cognitive structures, which in turn promotes meaningful learning. The integration of real-world phenomena, as implemented in this research, further strengthens these benefits by making learning more contextual and engaging (Khalil, 2025).

Moreover, the alignment between this study's findings and recent literature supports the argument that phenomenon-based learning plays a crucial role in enhancing science literacy. According to Megawati (2023), the inclusion of authentic phenomena helps students connect scientific theory with observable reality, thereby improving their critical thinking and problem-solving abilities. Sharma (2025) also emphasized that phenomenon-based contexts stimulate students' inquiry and strengthen their literacy skills through evidence-based reasoning. When both approaches are combined, as in this study, the resulting learning tools provide a structured yet inquiry-oriented pathway that not only improves conceptual mastery but also develops students' ability to apply scientific principles in real-world contexts. This finding aligns with the objectives of the merdeka curriculum, which prioritizes competency-based and contextual learning.

The worksheet prepared in this study aims to train students' science literacy skills through structured activities. The validation of worksheet was carried out based on the same criteria as the teaching module. Based on the results of the validation of the Learner Worksheet conducted by validator 1, validator 2, and validator 3, the learning tools developed showed high validity in all aspects assessed, both in terms of media, material, and presentation. The assessment was carried out using Aiken's validity index (V) to ensure that each aspect in the worksheet meets the expected criteria in chemistry learning. In the media aspect, which was assessed by validator 1 and validator 2, the learning tool obtained a very high Aiken validity index value of 0.90. This indicates that the media used, including images, videos, and graphics, are well designed and strongly support the learning objectives. The media is expected to help learners understand complex chemical materials and increase their engagement in the learning process. These results support previous findings showing that the use of technology-based learning media, such as augmented reality and interactive videos, can improve learners' understanding of chemistry and science concepts in general (Yanto & Sari, 2025) .

In the material aspect, which was assessed by validator 3, the Aiken validity index also showed very good results of 0.87, indicating that the material presented in the worksheet was very much in accordance with the learning objectives and the applicable curriculum. Nevertheless, some constructive suggestions were given to simplify some of the chemical terms used, to make it easier for high school students to understand. This is in line with research by Amelia et al. (2024) which shows that the suitability of the material with the curriculum is very important in improving the quality of learning. Overall, validator 3 assessed that the material presented is very relevant to the competencies to be achieved in chemistry learning, and the material has been arranged systematically and well structured, making it easier for students to understand complex chemical concepts.

The presentation aspect of the worksheet which includes the order of the material, the language used, and the graphic design, received a positive assessment from the three validators, with an average Aiken validity index of 0.83 to 0.92. The presentation of the material has been arranged in a logical order, providing sufficient time for students to understand each part of the material. Validator 1 and validator 2 assessed that the graphic design and layout of text and images were very supportive of the learning objectives, with the Aiken validity index reaching 0.92. The language aspect also received a good assessment with a value of 0.83 indicating that the language used in the worksheet is clear, precise, and in accordance with the Improved Spelling (EYD), so that it can be easily understood by students. This is in line with the findings of Hartono et al. (2023) who suggested that the use of appropriate language in the presentation of learning materials is key to ensuring effective understanding among learners.

Overall, the results of this validation indicate that the worksheet developed has high validity and is ready to be applied in chemistry learning in senior high schools. With a consistently high Aiken's validity index in all aspects, this learning tool is seen to improve the quality of chemistry learning and help students understand chemistry concepts better. The assessments from validator 1, validator 2, and validator 3 provide strong evidence that these worksheets are not only relevant to the applicable curriculum but also designed in a way that takes into account the needs of learners in understanding chemistry material more deeply.

The coursebook designed in this study aims to provide a comprehensive understanding of petroleum material. Based on the validation results of the developed coursebook, it can be concluded that this coursebook shows very high validity which includes various important aspects in the preparation of *Advance Organizer-based* chemistry coursebooks to improve the science literacy of high school students. Based on the results of coursebook validation conducted by validator 1, validator 2, and validator 3, the developed coursebook has high validity in almost all aspects assessed, with the average Aiken validity index reaching a value of 0.83 to 1. This assessment covers various aspects that are important in ensuring that this textbook meets the educational criteria needed to support chemistry learning in high schools.

The first aspect assessed was the suitability of the material with the Merdeka curriculum. The validation results show that the material presented in this textbook is very much in accordance with the applicable curriculum and the basic competencies set out in the national education standards. Validator 1, validator 2, and validator 3 agreed that the material on chemical concepts, especially regarding petroleum, is very relevant to the learning objectives and can provide a deep understanding to students. The Aiken validity index of 0.92 indicates that the materials are highly valid and can be used in a wider learning context.

In the aspect of learning objectives and learning outcomes, this coursebook received an excellent assessment from validator 2 and validator 3, with an Aiken validity index of 0.92, which indicates that the objectives formulated in this coursebook are very clear and can be achieved well. The learning objectives in this coursebook are also considered to support the development of students' science literacy, by connecting theory with practical applications in everyday life. This is relevant to the findings of Apeadid & Amedeker (2024) , which showed that clearly structured learning objectives increase learning effectiveness and help learners to achieve the desired competencies. The media aspect used in the textbook also received a positive assessment, with the Aiken validity index reaching 0.92, indicating that the images, graphs, and tables used have been well organized and support students' understanding of the chemical material taught.

The linguistic aspects in the coursebook also received very good ratings from the three validators. Validator 1, validator 2, and validator 3 assessed that the use of language in this coursebook is very much in accordance with the Improved Spelling (EYD) and is easily understood by students. With an Aiken validity index of 0.83, this shows that the language used is clear and on target, and in accordance with the level of understanding of students at the high school level. These results support previous research that emphasizes the importance of using appropriate language in learning, so that the material can be well received and understood by students (Ualikhanova et al., 2024). These results are also consistent with the findings of Widowati et al. (2023), who developed chemistry worksheets enriched with Wordwall-based quizzes and reported high levels of validity and effectiveness in fostering students' critical thinking skills. This similarity reinforces that developing interactive and contextual learning tools can enhance students' engagement and higher-order thinking abilities, aligning with the objectives of the phenomenon-based Advance Organizer model implemented in this study. In addition, in the aspect of graphics, the design and layout of the coursebook also received a very good assessment, with the Aiken validity index reaching 0.92, indicating that the layout of this coursebook has been well designed, making it easier for students to process the information presented.

Overall, the validation results show that the textbooks developed are very valid and ready to be used in learning chemistry in high school. With a high Aiken validity index in almost all aspects, this textbook can be applied in teaching chemistry to support the improvement of students' science literacy. These results show that this textbook is not only in accordance with curriculum standards, but also designed with attention to various aspects that support the understanding of the material by students.

Pretest and posttest were used to measure the improvement of students' science literacy before and after learning. The validity of the test is based on the criteria of conformity with the science literacy indicators to be trained. The test given must be in accordance with the learning objectives and measure the ability of students to explain phenomena, construct scientific investigation designs, and interpret scientific data critically. Based on the results of validation of pretest and posttest questions of science literacy conducted by three validators. Based on the results of the validation of pretest and posttest questions conducted by validator 1, validator 2, and validator 3, this evaluation tool shows high validity in all aspects assessed, with a high average Aiken validity index in each category. This validation involved key aspects such as the suitability of the material to the subject matter taught, question indicators, material sequence, science literacy, and the language used in the questions. Validator 1 and validator 2 gave very positive assessments on most questions, with an average Aiken validity index reaching 0.92 for the suitability of the material with the curriculum and basic competencies set in chemistry learning. This indicates that the questions prepared are very relevant and in accordance with the learning objectives to be achieved, and can measure students' understanding of the chemical concepts taught, such as petroleum. This assessment is also in line with research showing that questions that are in accordance with learning materials can facilitate students' understanding more effectively (Daryanes et al., 2023).

In the question indicator aspect, which assesses how well the question can measure the desired learning outcomes, validator 3 gave a rating of 5 on most questions. The Aiken validity index on the question indicator reached 0.92, which indicates that the questions prepared have the ability to measure the competence of students very well. This also reflects the suitability between the question indicators and the learning objectives set out in the teaching tool. Validator 1 assessed that the sequence of material in the pretest and posttest questions was logically arranged and well structured. The questions are arranged to follow a flow that makes it easier for students to understand the material gradually, with an average Aiken validity index of 0.85, which indicates that the order of the questions strongly supports an organized learning flow. This assessment shows that the questions pay attention to the level of difficulty that is appropriate for the learners' abilities, and can facilitate their understanding of more complex material, such as chemical reactions related to petroleum phenomena.

In the aspect of the language used in the questions, which was also assessed by the three validators, the validation results showed that the use of language used in the questions was in accordance with the Improved Spelling (EYD) and easily understood by high school students. The Aiken validity index on the linguistic aspect reached 0.92, indicating that the questions had been formulated clearly and precisely. Validator 2 assessed that the questions not only test the cognitive aspects of students, but also support the development of science literacy through questions that link chemical concepts with real phenomena, which are expected to improve students' critical thinking skills. On the science literacy aspect, assessed by validator 1, validator 2, and validator 3, the questions received a very high rating, with an average Aiken validity index reaching 0.95, indicating that these questions can improve learners' skills in analyzing and understanding scientific phenomena that occur around them.

Overall, the validation results of the pretest and posttest questions show that the questions prepared to measure students' understanding of chemistry material are very valid and can be applied in chemistry learning to improve students' science literacy. With a high Aiken validity index in each aspect, these pretest and posttest questions are ready to be used in the learning evaluation process, to ensure that the learning objectives are well achieved. The assessments from validator 1, validator 2, and validator 3 provide a clear picture that these questions are not only relevant to the applicable curriculum but can also measure learners' understanding in a precise, systematic, and structured way.

Conclusion

The results of this research show that the phenomenon-based Advance Organizer chemistry learning tools developed—including the teaching module, student worksheets, textbook, and science literacy test—have met high validity criteria based on expert evaluations, with Aiken's V values ranging from 0.86 to 0.99. These findings confirm that each component is well-designed in terms of content, presentation, language, and time allocation, and is aligned with the objectives of the merdeka curriculum. The integration of the Advance Organizer model with phenomenon-based learning provides a coherent framework that enables students to connect abstract chemical concepts to real-world contexts, thereby fostering deeper understanding and strengthening scientific literacy. In conclusion, the developed learning tools are declared valid, feasible, and pedagogically sound for implementation in high school chemistry learning, particularly on the topic of petroleum, and they have strong potential to improve students' science literacy and readiness for 21st-century learning.

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Conflicts of Interest
The authors declare that there are no conflicts of interest in this research.

References

Adipat, S. (2024). Transcending traditional paradigms: the multifaceted realm of phenomenon-based learning. *Frontiers in Education*, *9*(January), 1–5. https://doi.org/10.3389/feduc.2024.1346403
Amelia, O., Sundari, P. D., Mufit, F., & Dewi, W. S. (2024). Analisis Kebutuhan Pengembangan E-Modul dengan Pendekatan Contextual Teaching and Learning Untuk Meningkatkan Pemahaman Konsep Pada Materi Energi Terbarukan. *Jurnal Ilmiah Profesi Pendidikan*, *9*(1), 34–39. https://doi.org/10.29303/jipp.v9i1.1849
Amri, K., & Mardianto. (2020). Penggunaan Model Pembelajaran Advance Organizer dalam Meningkatkan Hasil Belajar Siswa pada Materi Unsur, Senyawa dan Campuran. *Jurnal Mahasiswa Al Maksum*, *1*(2), 28–35. https://doi.org/10.24114/jtp.v17i2.65185
Apeadid, S., & Koku Amedeker, M. (2024). Enhancing Students' Academic Performance through Advance Organizers in a Cooperative Learning Classroom at a Senior High School in the Ashanti Region, Ghana. *East African Journal of Education and Social Sciences*, *4*(6), 48–57. https://doi.org/10.46606/eajess2023v04i06.0333
Daryanes, F., Darmadi, D., Fikri, K., Sayuti, I., Rusandi, M. A., & Situmorang, D. D. B. (2023). The development of articulate storyline interactive learning media based on case methods to train student's problem-solving ability. *Heliyon*, *9*(4), e15082. https://doi.org/10.1016/j.heliyon.2023.e15082
Dendodi, Simarona, N., Elpin, A., Bahari, Y., & Warneri. (2024). Analisis Penerapan Augmented Reality dalam Meningkatkan Efektifitas Pembelajaran Sains di Era Digital. *Alacrity : Journal Of Education*, *4*(3), 293–304. https://doi.org/10.52121/alacrity.v4i3.456
Fatmi, N., Fitriani, H., & Fauzan, F. (2024). Sosialisasi konsep ilmu fisika dan kimia dalam kearifan lokal aceh. *Jurnal Pengabdian Sosial, 2*(2), 2562-2568. https://doi.org/10.59837/zjs16b54
Hartono, A., Djulia, E., Hasruddin, & Jayanti, U. N. A. D. (2023). Biology Students' Science Literacy Level on Genetic Concepts. *Jurnal Pendidikan IPA Indonesia*, *12*(1), 146–152. https://doi.org/10.15294/jpii.v12i1.39941
Khalil, S. (2025). Community-based learning: Connecting education to real-world issues and local contexts. *International Conference" Actual Economy: Local Solutions for Global Challenges", 2022*, 346–348. Retrieved from https://conferaces.com/index.php/journal/article/view/450

Kotsis, K. T. (2024). Integrating Inquiry-based Learning in the New Greek Primary Science Curriculum. *European Journal of Education and Pedagogy*, *5*(6), 63–71. https://doi.org/10.24018/ejedu.2024.5.6.899

Martatiyana, D. R., Derlis, A., Aviarizki, H. W., Jurdil, R. R., Andayani, T., & Hidayat, O. S. (2023). Analisis Komparasi Implementasi Kurikulum Merdeka Dan Kurikulum 2013. *Muallimuna : Jurnal Madrasah Ibtidaiyah*, *9*(1), 96. https://doi.org/10.31602/muallimuna.v9i1.11600

Megawati, Riady, Y., Firman, Fitrah, Y., & Kusmana, A. (2023). Implications of falsification theory and the constructivism paradigm in the development of science education and learning. *ETUDE: Journal of Educational Research*, *4*(1), 9–13. https://doi.org/10.56724/etude.v4i1.257

Nair, S., Hurly, J., & Saylor, D. (2025). Evaluating the strengths and limitations of structured modified rankin scale validation studies – A systematic review. *Journal of Stroke and Cerebrovascular Diseases*, *34*(5), 108242. https://doi.org/10.1016/j.jstrokecerebrovasdis.2025.108242

Novianto, A., Fitriani, N., Deniswa, A. S., Izzati, M. H., Firdaus, F., Ningrum, N., & Dewi, R. C. (2024). Analisis Kesulitan Belajar Matematika dalam Penerapan Kurikulum Merdeka di Sekolah Dasar. *Jurnal Ilmiah Kependidikan*, *12*(2), 946–960. https://doi.org/10.20961/jkc.v12i2.88914

Nurholisa, N., Legiani, W. H., & Nida, Q. (2022). Pengembangan Media Pembelajaran Augmented Reality Berbasis Fenomena Sosial Pada Mata Pelajaran PPKn Di SMAN 1 Mancak. *Jurnal Kewarganegaraan*, *6*(1), 298–306. https://doi.org/10.31316/jk.v6i1.2430

Nurjanah, A., Sudin, A., & Sujana, A. (2017). Literasi Sains Dalam Pembelajaran Berbasis Masalah. *Jurnal Pena Ilmiah*, *2*(1), 581–590. Retrieved from https://ejournal.upi.edu/index.php/penailmiah/article/view/10036

OECD 2023. (2022). PISA PISA 2022 Results Malaysia. *Journal Pendidikan*, 10. Retrieved from https://www.oecd.org/publication/pisa-2022-results/country-notes/malaysia-1dbe2061/

Putra, I. M. T. P. (2022). Kajian Literatur Sistematis: Integrasi Model Inkuiri Berbasis Socioscientific Issues pada Pembelajaran IPA. *Jurnal Pendidikan Mipa*, *12*(3), 919–928. https://doi.org/10.37630/jpm.v12i3.704

Ramadhani, R., Syahputra, E., & Simamora, E. (2023). *Model Ethno–Flipped Classroom: Solusi Pembelajaran Fleksibel dan Bermakna*. Indonesia Emas Group.

Rohmaya, N., Suardana, I. N., & Tika, I. N. (2023). Efektifitas E-LKPD Kimia SMA/MA dengan Model Pembelajaran Berbasis Masalah Berkonteks Isu-isu Sosial Sains dalam Meningkatkan Literasi Sains Peserta Didik. *Jurnal Pendidikan Mipa*, *13*(1), 25–33. https://doi.org/10.37630/jpm.v13i1.825

Saija, M. (2019). Profil Kemampuan Literasi Kimia Siswa SMA Negeri 3 Ambon. *Jurnal Kiprah*, *7*(2), 99–106. https://doi.org/10.31629/kiprah.v7i2.1463

Sari, N., Husain, H., & Anwar, M. (2022). Kemampuan Literasi Sains Peserta Didik Kelas Xi Mipa Sma Negeri 8 Bone Pada Model Dl Materi Koloid. *SCIENCE : Jurnal Inovasi Pendidikan Matematika Dan IPA*, *2*(3), 326–337. https://doi.org/10.51878/science.v2i3.1513

Sartika, R., Mukarromah, & Nurdin, S. (2022). Jurnal pendidikan Islam. *Jurnal Pendidikan Islam*, *1*(3), 327–346. Retrieved from https://doaj.org/article/1e8aebf063e94d09a7eb93f04cf4b8fd

Sharma, M. (2025). Elementary Science Teacher Candidates' Noticing and Interpretation of Student Sensemaking in the Context of Classroom-Level Phenomenon- Based Assessments. *Electronic Journal For Research In Science & Mathematics Education*, *29*(3), 1–28. Retrieved from https://ejrsme.icrsme.com/article/view/23823

Shifa, L., Nadhifah, I., Al-hasan, F. T., & Anbiya, B. F. (2025). Peran Teori Kognitivisme Dalam Meningkatkan Proses. *Jurnal Teknologi Pendidikan*, *5*(1). https://doi.org/10.37304/jtekpend.v5i1.17405

Slavin, R. E. (2015). Cooperative Learning. *Review of Educational Research*, *50*(2), 315–342. https://doi.org/10.3102/00346543050002315

Syaharani, E. R., Cahyaningrum, S. N., & Putri, N. N. E. (2024). Literature Review: Efektivitas Metode Pembelajaran Tanya Jawab dalam Meningkatkan Aktivitas Belajar Siswa pada Kurikulum Merdeka. *Jurnal Pendidikan Guru Sekolah Dasar*, *1*(3), 12. https://doi.org/10.47134/pgsd.v1i3.296

Ualikhanova, B., Ormanova, G., Berdaliyev, D., Mussakhan, N., Bakdaulet, A., & Güdekli, E. (2024). Impact of Phenomenon-Based Learning on High School Physics Education in Shymkent, Kazakhstan. *Qubahan Academic Journal*, *4*(4), 225–236. https://doi.org/10.48161/qaj.v4n4a1203

Vivian, L., & Aziaka, S. L. (2025). Effect of Simulation Based Learning on Biology Students ' Academic Performance and Retention in Secondary School in Port Harcourt Metropolis. *International Journal of Innovative Education Research*, *13*(2), 158–168. https://doi.org/10.5281/zenodo.15363732

Warmadewi, I. A. P. N. (2022). Penerapan Model Pembelajaran Inkuiri Terbimbing Berbasis Literasi Sains dalam Pembelajaran IPA. *Jurnal Pendidikan Mipa*, *12*(2), 325–331. https://doi.org/10.37630/jpm.v12i2.600

Widowati, A. N., Agustini, R., & Suyatno. (2025). Improving Students ' Science Literacy through the Use of Phenomenon-Based Advance Organizer Chemistry Learning Tools in Petroleum Material. *Jurnal Pendidikan IPA*, *11*(8), 958–969. https://doi.org/10.29303/jppipa.v11i8.10219

Widowati, A. N., & Yonata, B. (2023). Validitas Worksheet Diperkaya Dengan Wordwall Quiz Untuk Melatihkan Keterampilan Berpikir Kritis Pada Materi Konfigurasi Elektron. *UNESA Journal of Chemical Education*, *12*(3), 179–188. https://doi.org/10.26740/ujced.v12n3.p179-188

Widyastuti, N., Riswandi, R., & Fitriawan, H. (2021). The Development of Advance Organizer Based Distance Learning in Chemistry Bonding Material. *Journal of Education Technology*, *5*(2), 228–235. https://doi.org/10.23887/jet.v5i2.33613

Yanto, N., & Indah Sari, N. (2025). Exploring Scientific Literacy in Science Classrooms: A Literature Study. *VENN: Journal of Sustainable Innovation on Education, Mathematics and Natural Sciences*, *4*(3), 164–173. https://doi.org/10.53696/venn.v4i3.292

Yuendita, D., & Eli Rohaeti. (2025). Research Trends on the Integration of Ethnoscience in the Learning of Chemistry as the Development of Chemical Literacy: A Systematic Review. *Indonesian Journal of Educational Research and Review*, *8*(1), 210–222. https://doi.org/10.23887/ijerr.v8i1.85334