SPEKTRA: Jurnal Kajian Pendidikan Sains
Vol. 12, No. 1, 2026, pp. 38-60
ISSN: 2548-642X, DOI: 10.32699/5ms6xm18

DEVELOPMENT OF A DEEP LEARNING BASED E-MODULE INTEGRATED WITH UNIVERSAL DESIGN FOR LEARNING (UDL) ON THE RESPIRATORY SYSTEM

Andi Tenri Ampa Nurfitria Papada[1], Adnan[1], Faisal[1], Firdaus Daud[1], Muhiddin Palennari[1]
[1]Master Program of Biology Education, Postgraduate Program, Universitas Negeri Makassar, Makassar, Indonesia

Article Info

Article history:
Received 19/03/2026
Accepted 22/04/2026
Published 30/04/2026

Keywords:
Conceptual understanding;
Deep learning;
Electronic module;
Respiratory system;
Universal Design for Learning

ABSTRACT

The rapid advancement of education has led to a shift toward more flexible and student-centered learning. However, instructional materials used in schools are still largely conventional and lack interactivity, which may reduce student engagement and limit conceptual understanding. Therefore, integrating deep learning approaches with Universal Design for Learning (UDL) principles into digital teaching materials is considered important to promote meaningful and inclusive learning. This study focuses on developing an e-module on the respiratory system based on a deep learning approach integrated with UDL principles, as well as evaluating its validity, practicality, and effectiveness. This research adopts a research and development (R&D) approach using the ADDIE model. The study was conducted at SMAN 6 Sinjai, involving 30 students as participants. Data were collected through expert validation sheets, practicality questionnaires completed by teachers and students, and learning outcome tests. Data analysis was carried out using Aiken's V to assess validity, percentage analysis to evaluate practicality, and N-Gain to measure effectiveness. The developed e-module incorporates meaningful, conscious, and enjoyable learning activities, contextual problem-solving tasks, and multiple forms of representation, engagement, and expression to accommodate diverse learners. The results show that the e-module has high validity, is practical for classroom implementation, and is effective in improving students' conceptual understanding, as indicated by the N-Gain results. These findings imply that the developed e-module can facilitate more meaningful, inclusive, and effective biology learning, particularly in enhancing students' understanding of the respiratory system

Corresponding Author:
Adnan
Master Program of Biology Education, Postgraduate Program, Universitas Negeri Makassar, Makassar, Indonesia
Email: adnan@unm.ac.id

1. INTRODUCTION

Rapid developments in the education sector over the past few decades have driven a significant paradigm shift, with the learning process now moving toward a more flexible and learner-centered approach (González-salamanca *et al*., 2020). However, the implementation of this approach has not yet been fully realized in educational practice in Indonesia. Based on PISA findings, Indonesia was ranked 74th out of 79 participating countries in 2018 and later improved

to 68th out of 81 countries in 2022 (OECD, 2019; OECD, 2023). Although there has been an improvement in rankings, the overall scores indicate a decline in student performance. This suggests that various efforts to improve the quality of education in Indonesia have not yet yielded optimal or significant results (Adnan *et al*., 2025; Ismawati *et al*., 2023; Wijayanto *et al*., 2023).

One factor contributing to the low quality of learning is the availability and quality of instructional materials. Research by Megavitry *et al*., (2023) indicates that the quality of instructional materials influences learning effectiveness, academic outcomes, and student satisfaction. However, current practices in the field are still dominated by the use of conventional instructional materials with limited media variety. Modules serve as an alternative teaching material that can be used in both print and digital (e-module) formats. E-modules offer advantages by integrating interactive media such as audio, video, and animation, thereby supporting self-directed and more meaningful learning (Delita *et al*., 2022; Setiyani *et al*., 2020). However, research conducted by Syahfitri & Muntahanah, (2023) indicates that the utilization of e-modules in biology education remains suboptimal. This is evidenced by limitations in their use and availability, as well as students' low understanding of interactive modules.

Although e-modules offer various advantages, their use must be tailored to students' needs and circumstances. An analysis of student needs at SMAN 6 Sinjai indicates that they require teaching materials that are flexible, interactive, easily accessible at any time, and present content in a logical sequence from basic to advanced concepts. Students also expect illustrations, diagrams, animations, clear summaries, reflections, and automatic feedback. However, the e-modules currently available are still poorly structured, unengaging, and do not fully support student engagement in active thinking. This results in students' learning needs not being optimally met and leads to low conceptual understanding. (Adnan & Bahri, 2018). Students' poor conceptual understanding is also evident in various studies. Adnan *et al*., (2021) reported that only 36.23% of students were able to interpret scientific data, indicating a weak understanding of the scientific process. Research by Myanda *et al*., (2020) also found that regarding the respiratory system, only 37.7% of students understood the concepts, while 41.6% held misconceptions and 20.7% did not understand the concepts. This situation indicates that students are still experiencing significant difficulties in understanding biological concepts. Therefore, these findings underscore the need for more meaningful learning strategies to improve students' understanding of biological concepts.

This lack of conceptual understanding can be addressed through the use of visual media that helps students visualize the learning process, making complex concepts easier to grasp (Menendez *et al*., 2024). Therefore, electronic modules (e-modules) are considered more practical, easier to understand, and capable of incorporating interactive features that printed modules cannot provide (Ahmmed *et al*., 2020). Several studies indicate that interactive digital e-modules tailored to students' needs can update knowledge, improve access to learning, facilitate information sharing, and foster creativity and student engagement in learning (Kumar *et al*., 2023; Setiyani *et al*., 2020). Differences in students' learning styles, abilities, and backgrounds necessitate the use of flexible and adaptive e-modules. The Universal Design for Learning (UDL) approach is relevant because it provides an inclusive learning framework capable of accommodating student diversity (Bastoni *et al*., 2024; Roski *et al*., 2021). UDL consists of three main principles: engagement, representation, and action and expression. The engagement principle emphasizes the use of various strategies to enhance student motivation and participation. The representation principle involves presenting content in diverse formats to make it easier to understand. Meanwhile, the action and

expression principle provides students with opportunities to demonstrate their understanding through various means. The application of these principles in digital e-modules is essential to meet the diverse learning needs of students (Casebolt & Humphrey, 2023).

Although UDL based e-modules can improve accessibility and accommodate various learning styles, this approach does not fully guarantee the achievement of deep learning. Therefore, a Deep Learning approach is needed that fosters students' active engagement, critical and reflective thinking skills, and meaningful understanding. The Deep Learning approach emphasizes a deep learning process through active participation and the ability to apply knowledge to develop higher-order thinking skills (Aqeel *et al*., 2022; Wang *et al*., 2021). In this study, the application of Deep Learning is focused on the educational context in Indonesia by integrating the principles of conscious, meaningful, and enjoyable learning, thereby providing a more comprehensive and in-depth learning experience (Mu'ti, 2025)

To date, the development of e-modules that integrate *Deep Learning* and UDL remains limited, particularly in biology education, even though both play a crucial role in creating deep, inclusive, and flexible learning experiences. Theoretically, UDL provides diverse learning pathways tailored to students' needs, while Deep Learning emphasizes critical engagement and conceptual understanding. Without UDL, deep learning is not optimally accessible to all students, whereas without Deep Learning, UDL tends to become merely a meaningless variation in presentation. The integration of both allows students not only to engage but also to achieve a deeper understanding (Zhu & Niyozov, 2024) This is particularly important for the complex and abstract subject matter of the 11th-grade respiratory system curriculum (Myanda *et al*., 2020), necessitating the development of visual, interactive, and contextual e-modules to support understanding while accommodating students' diverse learning styles. Based on these issues, this study aims to develop an e-module based on the Deep Learning approach integrated with the principles of UDL for the high school 11th-grade respiratory system curriculum. This development is expected to produce digital instructional materials that are adaptive, inclusive, and capable of enhancing students' conceptual understanding more deeply. Additionally, this study also aims to evaluate the quality of the developed e-module, covering aspects of validity, practicality, and effectiveness in supporting students' conceptual understanding.

2. METHOD

2.1. Research Design

This study is a research and development (R&D) project that uses the ADDIE model as its development framework. The ADDIE model in this study comprises five main stages: analysis, design, development, implementation, and evaluation (Branch, 2009 in Cheung, 2016). The selection of the ADDIE model is based on its systematic and structured characteristics, ranging from the needs analysis stage to evaluation at each stage. This makes the model suitable for supporting a focused and comprehensive e-module development process in this study. The research procedures carried out are described as follows:

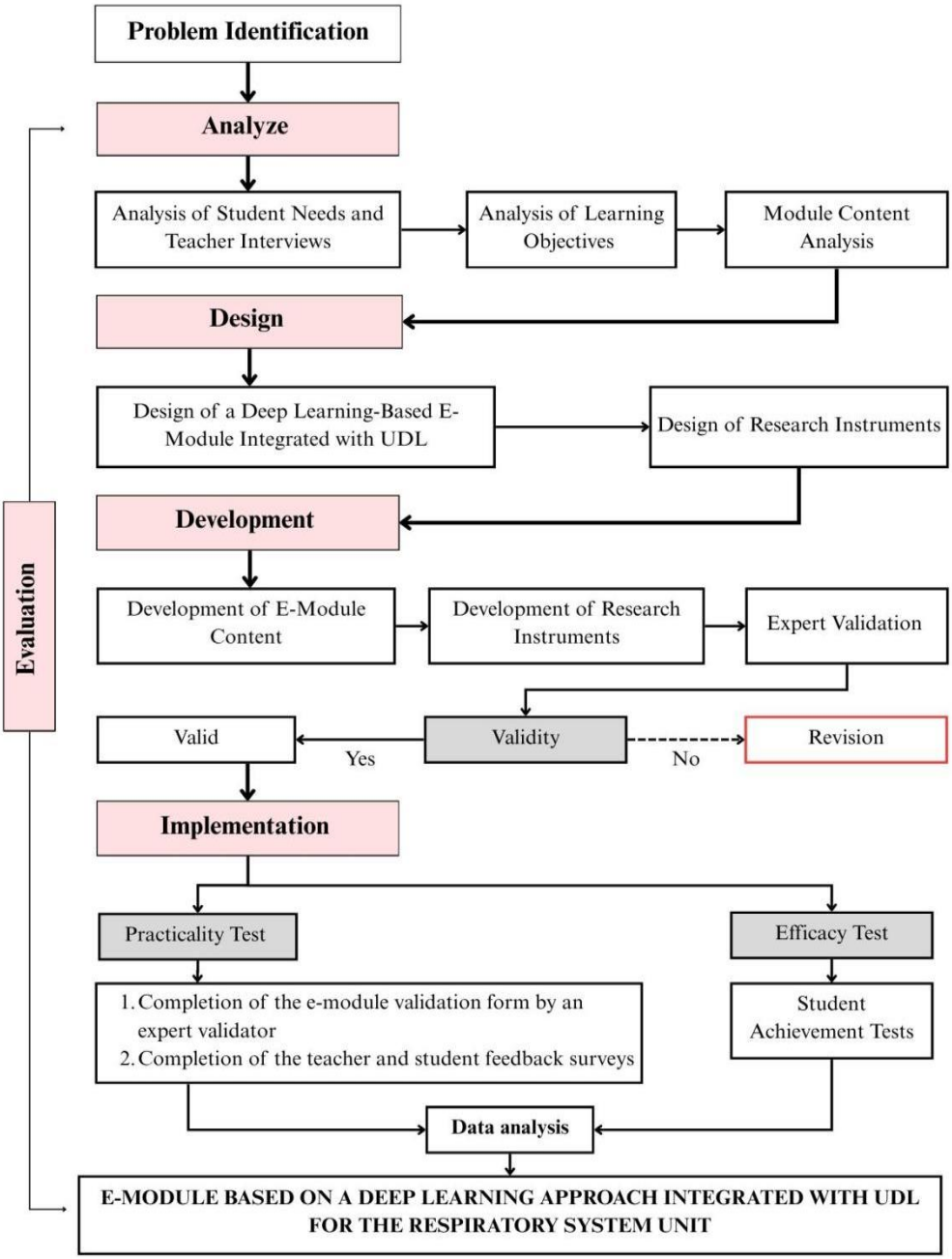

Figure 1. Research Development Procedures Based on the ADDIE Model

Based Figure 1, the subjects in this study included validators, teachers, and students. The validators consisted of three experts in the fields of subject matter, media, and language. In addition, this study also involved one biology teacher and 30 eleventh-grade students from SMAN 6 Sinjai. The sampling technique used was purposive sampling, with participants selected based on their suitability for the study's objectives.

2.2. Data Collection Instruments

The instruments used in this study included questionnaires and tests. The questionnaire was used to measure validity through expert evaluation and to assess the practicality of the e-module based on responses from teachers and students. The scale used in the questionnaire was a

four-point scale, ranging from 1 (not relevant) to 4 (very relevant). Meanwhile, the test instrument consisted of 25 items, including 20 multiple choice questions and 5 essay questions. The questions were designed based on cognitive levels ranging from C1 to C6, aiming to measure students' conceptual mastery of the respiratory system material.

2.3. Data Analysis Techniques

2.3.1. Validity Test of the E-module

The data analysis technique used in the e-module validity test was Aiken's V formula, which aims to measure the level of agreement among expert validators on each item in the validation instrument. The validation instrument consisted of 84 items that were evaluated by three validators. Aiken's V formula is presented in Equation (1):

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

The V score is calculated based on the score assigned by the validator (r), taking into account the lowest score (lo) and the highest score (c) on the rating scale. The S score is an adjusted score, defined as the difference between the assigned score and the lowest score (S = r − lo), where lo = 1 and c = 4. The results of the Aiken's V calculation were then interpreted based on the criteria established by (Siagian *et al*., 2023), as shown in Table 1:

Table 1. Validity Level Criteria

Indeks Validasi *Aiken's V*	**Category**
$0.75 \leq V \leq 1$	Highly Valid
$0.50 \leq V < 0.75$	Valid
$0.25 \leq V < 0.50$	Less Valid
$0.00 \leq V < 0.25$	Invalid

Based Table 1, following the validity test, the next step was to conduct a reliability test, specifically the Percentage of Agreement test proposed by Grinnell (1988) as cited in (Nasrah *et al*., 2015), using the formula presented in Equation 2:

$$R = 1 - \frac{A-B}{A+B} \quad (2)$$

The instrument reliability coefficient (R) is determined based on the level of agreement among validators, where (A) indicates the percentage of evaluations that assigned high scores (agreement), while (B) indicates the frequency of evaluations that assigned low scores The instrument reliability criteria are based on the guidelines proposed by Altman, as cited in Sudiyatno (2010), The range of values is interpreted as follows: a value less than 0.20 indicates a very low level of agreement; 0.20 – 0.40 falls into the low agreement category; 0.41 – 0.60 indicates moderate agreement; 0.61– 0.80 is categorized as high agreement; and 0.81 – 1.00 reflects a very high level of agreement.

2.2.1. Practicality Test of the E-Module

To assess the practicality of the e-modules, a questionnaire was administered to teachers and students, and the formula presented in Equation 3 was used:

$$P = \frac{F}{N} x\ 100 \quad (3)$$

The final score (P) is calculated from the obtained score (F) by comparing it to the maximum score (N). The results of the practicality test will then be interpreted based on the practicality categories according to (Cahyadi, 2019) , as presented in Table 2:

Table 2. Practicality Criteria

Scale	Category
80 < x ≤ 100	Very Practical
60 < x ≤ 80	Practical
40 < x ≤ 60	Fairly Practical
20 < x ≤ 40	Not Very Practical
0 < x ≤ 20	Very Impractical

2.2.1. Testing the Effectiveness of the E-module

The effectiveness of the e-module was evaluated using a single-group design with a pretest-posttest pattern. In practice, a class of 30 students took a pretest before instruction began, followed by a posttest after the instructional process was completed. The level of effectiveness was determined by comparing the pretest and posttest results using the N-Gain formula (Hake, 1998) as follows:

$$(g) = normalized\ gain = \frac{Posttest - Pretest}{Skor\ maksimum - Pretest} \quad (4)$$

The results of the data processing will then be converted into categories based on (Kartikasari et al., 2023) as presented in Table 3:

Table 3. N-gain Criteria

Scale	Category
(g) ≥ 0,70	High
0,30 ≤ (g) < 0,70	Medium
(g) < 0,30	Low

3. RESULTS AND DISCUSSION

3.1. Characteristics of a Deep Learning-Based E-Module Integrated with UDL

3.1.1 Analysis

The analysis phase aimed to identify the learning needs of 11th grade students at SMAN 6 Sinjai. Findings from observations and needs analysis indicate that the learning process remains constrained by the complexity of biology content, less innovative teaching materials, and the limited use of digital learning resources due to inadequate facilities. These factors contribute to students' low conceptual understanding. Meanwhile, although most students have access to digital devices and the internet, they require more flexible and interactive learning materials that are systematically organized, in depth, contextual, varied, incorporate reflection, and support independent learning. This study is directed toward developing interactive and flexible e-modules as instructional materials to better accommodate students' learning needs identified through needs analysis. The e-modules were developed to support more meaningful, in-depth, and inclusive learning through the application of the Deep Learning approach integrated with the principles of Universal Design for Learning (UDL). This approach was chosen because it fosters active student engagement and provides various learning access alternatives tailored to individual needs, in line with curriculum requirements that emphasize deep and inclusive learning.

Findings reported by Ambarita by Ambarita., *et al* (2025) indicate that the Deep Learning approach transforms the learning process beyond mere memorization by fostering conceptual understanding and practical application. This approach also promotes greater student engagement and fosters the development of higher order thinking skills, including critical analysis, problem-solving, and reflective thinking. Additionally, UDL was adopted due to its suitability for integration into online modules, as UDL prioritizes flexibility, accessibility, and responsiveness to the diverse needs of learners (Seymour, 2024)

3.1.2 Design

Referring to the outcomes of the needs analysis, the design phase focused on systematically constructing the e-modules by organizing both their structural components and presentation. The design included elements such as the cover, introduction, navigation menu, content, learning activities, summary, reflection, and assessment. This structured arrangement is intended to facilitate students' understanding progressively, from basic to more complex concepts. Previous studies by Delita *et al*., (2022) and Delungahawatta *et al*., (2022) highlight that well-structured e-modules can promote more independent, adaptive, and flexible learning in accordance with students' learning pace. The e-module cover is designed to be visually appealing through a combination of blue, white, and bright colors, featuring illustrations and respiratory system icons that align with the content. The design is organized systematically with interactive buttons to facilitate navigation. The selection of font type, size, and color is tailored to ensure readability and visual harmony, thereby enhancing student interest and engagement. This aligns with the findings (Khoirunna'imah & Anbiya, 2024) that the use of colorful and illustrated visual elements can support understanding while fostering students' interest in learning.

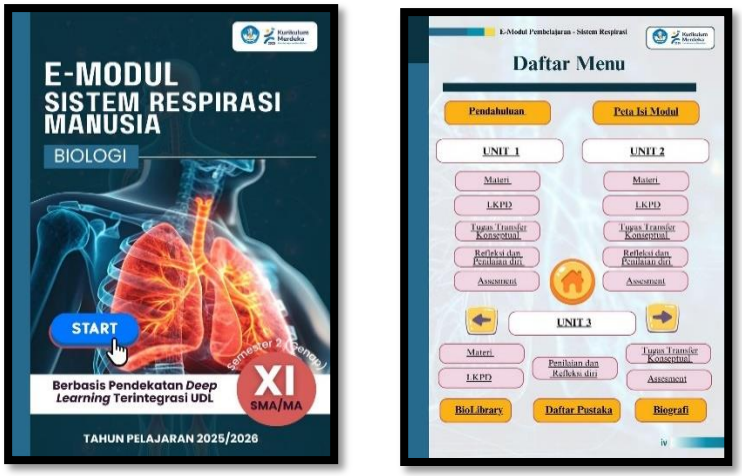

Figure 2. Initial design of the e-module

Based Figure 2, the main menu of the e-module is designed to help students navigate each section systematically, including the introduction, table of contents, learning units, BioLibrary, bibliography, and author biography. Each unit contains course material, worksheets, conceptual transfer tasks, reflections, self-assessments, and progressively structured assessments to help students organize information and understand concepts more effectively (Hasyim, 2017).

3.1.3 Development

The e-module was developed using the Canva platform and supported by Padlet and Wordwall as supplementary tools. These three applications were used to organize content, present interactive activities, and facilitate learning assessments, thereby supporting the implementation of the designed instructional plan. In line with this development, in the initial stage, this e-module has integrated the Deep Learning approach into the lesson materials through contextual introductions, learning objectives, content exploration, and assessment. However, preliminary analysis indicates that these learning components do not yet fully reflect the principles of Deep Learning in an optimal manner. Based on the validation results, the validators then provided a number of improvement suggestions to strengthen the implementation, including adding guiding questions, CER-based worksheets (Claim, Evidence, Reasoning), reflection activities, contextual transfer tasks, and reinforcing interactive assessments such as crossword puzzles and digital quizzes.

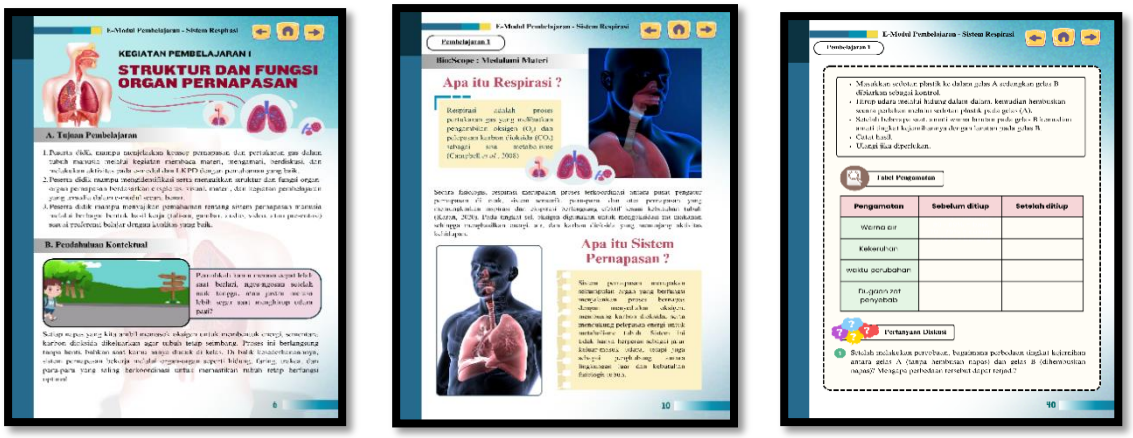

Figure 3. Pre-revision version of the e-module

Figure 4. The appearance of the e-module after revision

Based Figure 4, the introductory activity begins with a contextual problem accompanied by a driving question, followed by the presentation of learning objectives at cognitive levels C4–C6. During the exploration phase, students engage in guided inquiry through guiding questions and in-depth study of the material. Next, CER based worksheets (Claim, Evidence, Reasoning) are used to solve problems related to the respiratory system by formulating claims, finding evidence, and presenting scientific reasoning. Learning is also reinforced through reflection activities and contextual transfer tasks, such as relating the material to conditions in the surrounding environment. Additionally, the e-module is equipped with interactive features such as videos, animations, digital quizzes, and crossword puzzles (TTS) to enhance student engagement. This development aligns with the Deep Learning approach as outlined by Zainal *et al*., (2021) who state that this approach enables students to build a more comprehensive understanding through active engagement in learning. Additional support is provided by Ambarita., *et al* (2025), who highlight that the Deep Learning approach extends beyond content mastery by promoting the development of students' higher level thinking abilities, including critical thinking, problem-solving, creativity, and reflective thinking.

The three principles of Universal Design for Learning (UDL) are integrated into the online module through various methods of content presentation, engaging students, and providing them with opportunities to express their understanding. Learning materials are presented in various formats, such as text, images, videos, and animations, to support diverse representations. Student

engagement is encouraged through guiding questions, discussions, and individual and group activities. Additionally, opportunities for action and self expression are provided through task choices, self-assessment, and reflective activities. Revisions are then made based on validation feedback to strengthen the application of UDL principles, including the addition of features that allow students to choose how they access learning materials, thereby increasing the flexibility of learning according to their preferences.

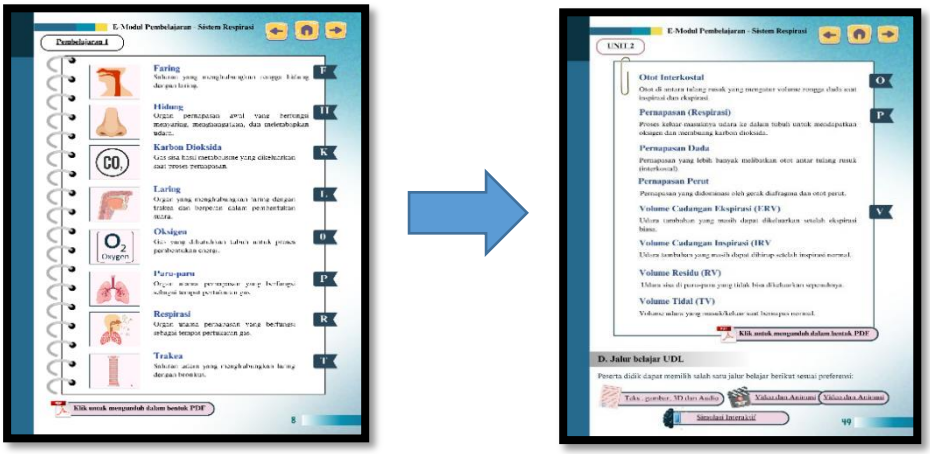

Figure 5. Pre- and post-revision views of the e-module

Based Figure 5, the Universal Design for Learning (UDL) approach aims to reduce barriers to learning by offering students a variety of ways to access and build knowledge. Therefore, learning is designed to be flexible and inclusive through diverse forms of content presentation, student engagement, and opportunities to demonstrate understanding. This concept is reflected in the design of electronic modules that combine diverse content formats and tailored learning activities to support students' learning needs (Bastoni *et al*., 2024; Roski *et al*., 2021). Integrating the principles of Deep Learning and Universal Design for Learning (UDL) into the development of online modules supports the design of more inclusive and meaningful learning experiences. UDL offers flexible learning pathways, while Deep Learning fosters critical thinking, reflection, and deeper conceptual understanding. As a result, the learning process becomes more accessible and strengthens students' overall understanding (Zhu & Niyozov, 2024).

3.2. Validity Test Results for the E-module

The expert validation phase is part of the development process in the ADDIE model. The expert validation of the e-module consists of content validation, media (construct) validation, and language validation, conducted by three expert validators.

3.2.1. Content Validation Results

The results of the validation of the e-module content by subject matter experts are presented in Table 4 as follows:

Table 4. Results of the Content Validity and Reliability Tests for the E-module

Aspect	Statement Item	V (aspect)	Description	R (aspect)	Description
Content Appropriateness	Items 1-3	0,851852	Very valid	0,904761905	Very good agreement
Alignment with the Curriculum	Items 4-7	0,861111	Very valid	0,857142857	Very good agreement
Presentation	Items 8-9	0,888889	Very valid	0,857142857	Very good agreement
Final Grades for V and R		0,864198	Very valid	0,873015873	Very good agreement

Based Table 4, the validity test results in Table 4, the content aspect of the e-module received a validity coefficient (V) of 0.864198, classified as "highly valid," and a reliability coefficient (R) of 0.873015873, indicating "very good agreement" among validators. The summary of the expert validators' comments on the content aspect of the e-module is as follows:

Table 5. Analysis of Expert Validators' Comments on E-module Content

Main theme	Description
Content quality	The module is well-structured, and the material on the respiratory system is accurate, contextual, and supported by relevant learning activities.
Enhancing Deep Learning	The concepts of deep learning, metacognitive reflection, and the integration of Claim–Evidence–Reasoning (CER) in worksheets need to be reinforced.
Suggestions for improvement	Adding references and supporting data, clarifying the stages of deep learning, and improving the module's assessment and navigation.

Based Table 5, these results indicate that the e-module content met the feasibility criteria in terms of content accuracy (V = 0.851852), alignment with the curriculum (V = 0.861111), and presentation quality (V = 0.888889). This aligns with the findings of Wulandari & Purwanto, (2019) that the integration of competencies, learning objectives, and content tailored to students significantly influences the validity of the developed content. In line with these quantitative results, the validators' comments also indicated that the respiratory system material was deemed to have been presented scientifically and systematically, supported by contextual examples and an engaging visual design, thereby aiding student understanding. Pedagogically, this can be explained through the Cognitive Theory of Multimedia Learning by (Mayer, 2024) which states that learning involves two channels of information processing verbal and visual so that integrating both into the e-module enhances understanding while reducing students' cognitive load. Furthermore, the use of contextual examples aligns with constructivist theory, which emphasizes that knowledge is actively constructed through experience and interaction, rather than passively transferred (Arega & Hunde, 2025). Thus, this integration of visual and contextual elements supports meaningful learning, as emphasized by (Jannah & Faelasup, 2025) who state that effective instructional materials must be relevant to students' real lives so that they can be applied in daily life.

Nevertheless, the validators also provided several suggestions for improvement, such as adding references to each section, including supporting data as scientific evidence, and strengthening the implementation of deep learning through activities that encourage analysis, scientific reasoning, and metacognitive reflection. This feedback was then used as the basis for revisions aimed at improving the quality and depth of the content in the e-module.

3.2.2. Media Validation Results

The results of the e-module validation by media experts are presented in Table 6 as follows:

Table 6. Results of the Validity and Reliability Test for the Media Expert E-module

Aspect	Statement Item	V (aspect)	Description	R (aspect)	Description
Completeness of the E-module	Items 1-6	0,907407	Very valid	0,92857142	Very good agreement
Presentation quality	Items 7-16	0,888889	Very valid	0,9	Very good agreement
Software	Items 17-20	0,833333	Very valid	0,84523809	Very good agreement
Consistency	Items 21-26	0,87037	Very valid	0,84920634	Very good agreement
Graphics and visualization	Items 27-40	0,920635	Very valid	0,91836734	Very good agreement
Interactivity	Items 41-44	0,888889	Very valid	0,88095238	Very good agreement
Emotional and social engagement	Items 45-47	0,777778	Very valid	0,88888888	Very good agreement
Inclusivity	Items 48-50	0,62963	Valid	0,82222222	Very good agreement
Contextual relevance and real-world connections	Items 51-54	0,888889	Very valid	0,89285714	Very good agreement
Digital literacy enhancement	Items 55-58	0,861111	Very valid	0,89285714	Very good agreement
Final Grades for V and R		0,87164751	Very valid	0,89146141	Very good agreement

Based Table 6, the results of the e-module validity test in Table 6 show an average V value of 0.8716, classified as “highly valid,” and a reliability coefficient R of 0.8914, indicating “very good agreement” among validators. The summary of expert validators’ comments on the e-module content is as follows:

Table 7. Analysis of Expert Validators' Comments on the E-module Materials

Main theme	Description
Media quality and presentation	The visual design, layout, image and video quality, and navigation are rated as good and appealing, thereby enhancing the user experience.
Enhancing interactivity	There is a need to enhance cognitive interactivity, strengthen metacognition, and develop assessments based on the Claim–Evidence–Reasoning (CER) model.
Recommendations for media development	Maintaining font consistency, enhancing reasoning-based quizzes, and improving accessibility features such as captions, alt text, and low-bandwidth access in accordance with UDL principles.

Based on Table 7, the analysis results, several aspects received high scores, particularly graphics and visualization (V = 0.9206) and the comprehensiveness of the e-module (V = 0.9074). This indicates that the quality of the visual design, images, and videos in the module was rated very highly and supports the presentation of the material in an engaging manner. This finding aligns with the validators' comments stating that visual design, layout, and media quality are the e-module's primary strengths. Nadori & Hoyi,(2021) also noted that presenting an engaging e-module fosters students' interest in learning.

In contrast, the aspects of inclusivity (V = 0.6296) and emotional and social engagement (V = 0.7778) received lower scores compared to the other aspects. Theoretically, this can be explained through the UDL principle, which emphasizes that the quality of accessibility and engagement is determined by the fulfillment of multiple means of representation and engagement (CAST, 2024) The lower inclusivity score indicates that the representation aspect is not yet optimal, particularly regarding limitations in accessibility features such as subtitles and alternative text. Meanwhile, the emotional and social engagement aspects, which remain in the valid category, indicate that the engagement principle has been implemented; however, its level of optimality is still lower compared to other aspects in fostering students' emotional and metacognitive engagement. Thus, these varying scores reflect differences in the degree to which UDL principles have been achieved in the design of the e-modules. This aligns with Sina, (2025) who emphasizes that accessibility aims to ensure all learners benefit equally from learning without discrimination.

3.2.3. Language Validation Results

The results of the validation of the e-module by language experts are presented in Table 8 as follows:

Table 8. Results of the validity and reliability tests of the e-module by language experts

Aspect	Statement Item	V (aspect)	Description	R (aspect)	Description
Clear	Items 1-3	0,777778	Very Valid	0,904762	Very good agreement
Communicative	Items 4	0,888889	Very Valid	0,857143	Very good agreement

Appropriateness for students' development	Items 5-6	0,722222	Valid	0,928571	Very good agreement
Adherence to language conventions	Items 7-8	0,888889	Very Valid	0,857143	Very good agreement
Use of symbols and icons	Items 9-10	0,833333	Very Valid	0,857143	Very good agreement
Creative presentation	Items 11-13	0,777778	Very Valid	0,793651	Good agreement
Final Grades for V and R		0,803419	Very Valid	0,8644688	Very good agreement

Based Table 8, the results of the validity test for the language aspect show an average V value of 0.8034, classified as "highly valid," and a reliability coefficient (R) of 0.8644, indicating "very good agreement" among validators. The summary of comments from expert validators on the language aspect of the e-module is as follows:

Table 9. Analysis of Expert Validators' Comments on the Language of the E-module

Main theme	Description
Clarity of language	The language of the e-module is clear, communicative, and appropriate for the students' level.
Consistency of terminology	Scientific terminology is used correctly, but there are still some inconsistencies in terminology.
Suggestions for improvement	Simplification of conceptual terms, strengthening of metacognitive reflection, and consistent use of terminology.

Based Table 9, on the analysis results, high scores were found in the communicative aspect and adherence to language norms (V = 0.8889), indicating that the language in the e-module was rated as clear, coherent, and consistent with Indonesian language norms. This aligns with the validators' comments, who assessed the module's language as communicative and easily understood by students. Communicative language can create a pleasant learning atmosphere because it emphasizes communicative interaction among students and active student participation (Mubarok *et al*., 2024). However, the aspects of alignment with student development (V = 0.7222) and creativity in language presentation (V = 0.7778) received relatively lower scores. These findings are consistent with the validators' feedback, which suggested simplifying conceptual terms such as "Deep Learning" and "UDL," as well as strengthening the wording of the reflection section to better encourage students' metacognition and scientific reasoning.

3.2.4. Validation Results for All Aspects

Based on the results of the content validity analysis conducted by subject matter experts, media experts, and language experts, the scores for these three aspects were averaged to determine the final validity score of the e-module, as follows:

Table 10. Results of the Validity and Reliability Tests for All Aspects

Aspect	V-value	Reliability
Content	0,864198	0,873015873
Media	0,87164751	0,891461412
Language	0,803419	0,864468864
Average	0,846422	0,876315383
Category	Very valid	Very good agreement

Based on Table 10, the e-module achieved an average validity score (V = 0.8464), classified as "highly valid," and a reliability coefficient of 0.8763, indicating very good agreement among the validators. The high scores in the media (V = 0.8716) and content (V = 0.8642) aspects can be explained by the assessment characteristics, which tend to be more objective, particularly regarding visual elements, material structure, and content alignment with the curriculum—aspects that validators can directly observe. This aligns with the principles of multimedia learning, which emphasize that good visual representation enhances the quality of perception and the suitability of learning media (Mayer, 2024). Meanwhile, the language aspect received a lower score (V = 0.8034) although it remained in the "highly valid" category, which theoretically indicates that the level of readability and clarity of instructions remain aspects that are more subjective in expert evaluation. In the context of instructional material evaluation, the language aspect is often influenced by students' prior knowledge and reading ability. These factors determine how easily students comprehend the language in the text, including sentence coherence and the clarity of instructions within the material (Smith et al., 2021). Thus, these variations in validity scores not only reflect the level of suitability but also differences in assessment characteristics across aspects within the e-module. This reinforces the view of Rofiyadi & Handayani, (2021) hat expert validation is necessary to ensure the acceptability and usability of the module in the learning process

3.3. Results of the E-Module Usability Test

Once the product has been deemed valid and suitable for use in the learning process, the next step in the ADDIE model is the implementation phase, which involves testing the product's practicality with teachers and students

3.3.1. Students

The results of the e-module usability test conducted on 30 students at SMAN 6 Sinjai are presented in Table 11 as follows:

Table 11 Results of the Practicality Test for Students

Aspect	Number of Items	Total Score for each aspect
Effectiveness	3	305
Efficiency	3	314

Creativity	3	321
Readability	3	311
Interactivity	3	320
Accessibility	2	216
Total score for this aspect		1787
Maximum score		2040
Percentage		87,60%
Category		Very practical

Based Table 11, the total practicality scores for each aspect in Table 11 were then converted into percentages and presented in the following bar chart:

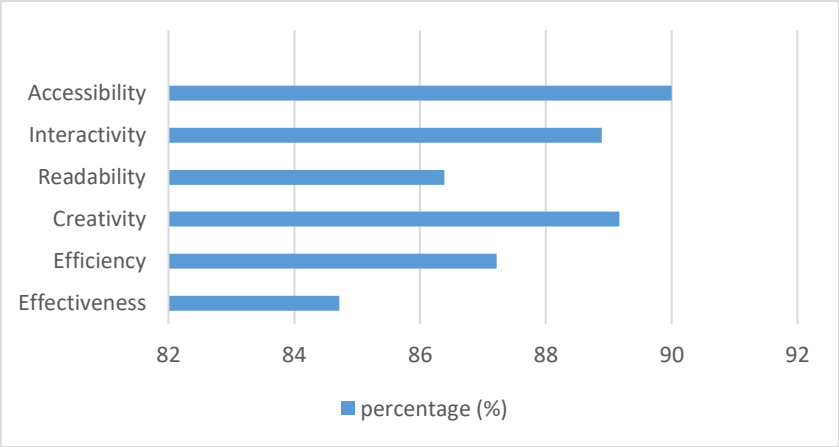

Figure 6. Percentage diagram of students' practicality tests for each aspect

Based Figure 6, the results of the e-module usability test showed a score of 87.60% in the "very practical" category, indicating that the e-module is easy to use and supports the learning process. A summary of student comments on the e-module usability test is as follows:

Table 12. Summary of Student Comments on the E-module Usability Test

Main theme	Description
Clarity of content	The material is well-organized, clear, and supports the students' learning process.
Ease of use	Navigation and features such as voice and audiobooks make the e-module easy to use.
Module layout	The design is quite appealing, but we recommend adding visual elements such as images or illustrations.
Technical improvements	Some sections of the material are too long, and there are minor issues with the navigation buttons or unit selection.

Based Table 12, the results of the e-module usability analysis, most aspects received high scores. The highest score was in the creativity category at 89.16%, followed by the interactivity category at 88.88%, indicating that the features, layout, and activities within the e-module are effective in increasing students' interest and engagement in learning. The efficiency aspect scored

87.20% and readability 86.38%, indicating that the e-module is fairly easy to learn independently. Meanwhile, the effectiveness aspect scored 84.70% and the accessibility aspect 90%, indicating that the e-module functions well and is easily accessible to students during the learning process.

The practicality of an e-module is not solely determined by the number of features available, but by the extent to which those features can effectively facilitate the learning process. Ease of access and structured navigation allow students to manage their learning independently, in line with the principles of self-directed learning (Nazarianpirdosti et al., 2021)Additionally, the use of audio and visual media helps make the presentation of material clearer and easier to understand, as explained in the Cognitive Theory of Multimedia Learning (Cavanagh & Kiersch, 2023) This explains the high practicality ratings, as the e-module is not only engaging but also supports ease of use and comprehension. However, student feedback regarding simplifying the language and improving the layout indicates that readability and visual aspects still need improvement to optimize the learning experience.

3.3.1. Teacher

The results of the practicality test of the e-module for biology teachers at SMAN 6 Sinjai are presented in Table 13 as follows:

Table 13. Teacher Practicality Test Results

Aspect	Number of Items	Total Score for each aspect
Cover Page	4	15
Clarity of Figures/Tables	4	13
Language	4	14
Clarity of Writing	4	14
Color Scheme	4	15
Use of Terms/Symbols/Icons	1	4
Learning Activities	3	12
Motivation to Engage with the Learning Material	4	14
Integrasi Deep Learning	1	4
UDL Integration	1	4
Reflection	1	4
Total score for this aspect		113
Maximum score		124
Percentage	91,12%	
Category	Very practical	

Based Table 13, the total scores for the teachers' practicality test in each aspect in Table 13 were then converted into percentages and presented in the following chart:

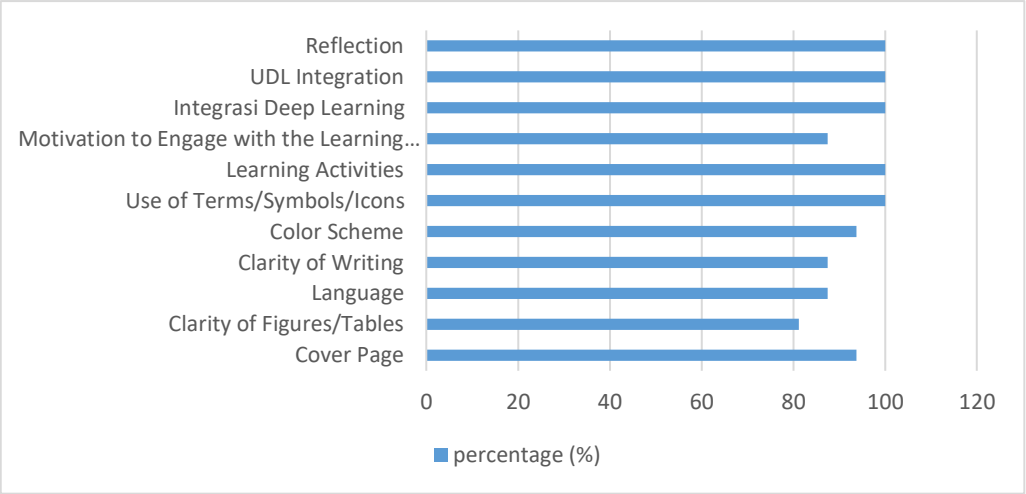

Figure 7. Percentage diagram of the teacher practicality test for each aspect

Based Figure 7, the overall results of the usability test conducted by teachers showed a 91.12% rating in the "very practical" category, indicating that the e-module is easy to use in the learning process. A summary of student comments on the e-module usability test is as follows:

Table 14. Summary of Teachers' Comments on the E-module Usability Test

Main theme	Description
Ease of use	Metacognitive reflection features, flexible assignment formats, automated summative assessments, and structured worksheets support the learning and evaluation process.
Learning organization	The large number of activities within a single unit requires effective time management.
Technical issues	Reliance on an internet connection and the need for an initial learning curve when using digital features.
Suggestions for improvement	Addition of estimated activity durations, provision of an offline version, and improvements to the interface and content.

Based on Table 14, the results of the usability test conducted by teachers, several aspects received very high scores: the use of terms/symbols/icons, learning activities, Deep Learning integration, UDL integration, and reflection, each of which reached 100%, indicating that the e-module is easy to use and supports active learning. The cover page and color composition aspects received 93.75%, while language, clarity of writing, and motivation to engage with the learning material received 87.5%, indicating that the content is presented clearly and engagingly. Meanwhile, the clarity of images/tables aspect received 81.25%, though it still falls within the "very practical" category. These findings indicate that high ratings of e-modules are influenced not only by the presence of features but also by their role in supporting students' cognitive processes and learning regulation. Metacognitive reflection features and structured worksheets enable students to plan, monitor, and evaluate their learning processes, which are at the core of self-regulated learning (Ratnayake et al., 2024). Additionally, structured reflection helps students identify weaknesses and design learning improvements. On the other hand, flexible assignment formats and automated summative tests provide rapid and continuous feedback, thereby

strengthening the learning evaluation process (S. K. S. Cheung et al., 2021). These factors explain why e-modules are considered effective by teachers, as the available features not only facilitate learning but also enhance students' autonomy and learning awareness. Meanwhile, suggestions regarding the addition of time estimates and offline access indicate that optimization is still needed in terms of time management and access flexibility to improve the overall user experience

3.3. Results of the E-Module Effectiveness Test

The descriptive statistics for the effectiveness test of the e-module, conducted using the n-gain formula, are presented in Table 15:

Table 15 Descriptive statistics for the n-gain test

	N	Minimum	Maximum	Mean	Std. Diviation
Ngain score	31	0,68	0,94	0,8428	0,07102
Ngain persen	31	68,29	94,44	84,2818	7,10172
Valid N (listwise)	31				

Based Table 15, the N-gain test results in Table 15 show an average value of 0.8428, which falls into the high category, with a range of 0.68 to 0.94. This relatively high improvement in students' conceptual understanding not only demonstrates the effectiveness of the e-module but can also be explained by the application of Deep Learning principles, which motivate students to go beyond mere memorization and strive to understand concepts in a deep and meaningful way. Activities such as material exploration, reflection, and contextual tasks within the e-module help students connect new knowledge with prior experiences and build a deeper understanding (Wang et al., 2021). Cognitively, the integration of multimedia in e-modules supports information processing through verbal and visual channels, as described in the Cognitive Theory of Multimedia Learning, thereby helping to improve conceptual understanding and retention. Additionally, the principles of Universal Design for Learning (UDL), which provide diverse means of representation, motivation, and engagement, also enable students with diverse learning characteristics to understand the material more effectively (Bastoni et al., 2024). Thus, the high N-gain score reflects that the e-module design is not only technically effective but also successfully facilitates deep learning processes, which contribute to improved student conceptual understanding.

CONCLUSION

The Deep Learning-based electronic module integrated with Universal Design for Learning (UDL) in this study aims to facilitate meaningful, inclusive, and flexible learning. The research results indicate that the electronic module meets standards of validity, practicality, and effectiveness. Its suitability has been confirmed through expert evaluation, while user feedback indicates that the module is easy to use, engaging, and contributes to enhancing students' conceptual understanding. Furthermore, the integration of Deep Learning and UDL principles in this electronic module encourages active student participation and creates a learning experience that is more responsive to learners' needs. These results also indicate that the electronic module

can serve as an alternative form of interactive and inclusive digital instructional material, while supporting the development of more adaptive and high quality technology based learning..

REFERENCES

Adnan, A., Saenab, S., Rahmatullah, R., Almunawarah, R., Sahira, S., Aulia, M. A., & Jannah, H. N. (2025). Citizen science project (CSP) learning model as innovation learning in improving 21st century skills. *BIO-INOVED : Jurnal Biologi-Inovasi Pendidikan*, *7*(1), 27. https://doi.org/10.20527/bino.v7i1.20799

Adnan, & Bahri, A. (2018). Beyond effective teaching: Enhancing students' metacognitive skill through guided inquiry. *Journal of Physics: Conference Series*, *954*, 10–15. https://doi.org/10.1088/1742-6596/954/1/012022

Adnan, Mulbar, U., Sugiarti, & Bahri, A. (2021). Scientific literacy skills of students: Problem of biology teaching in junior high school in South Sulawesi, Indonesia. *International Journal of Instruction*, *14*(3), 847–860. https://doi.org/10.29333/iji.2021.14349a

Ahmmed, B., Mudunuru, M. K., Karra, S., James, S. C., Viswanathan, H., & Dunbar, J. A. (2020). Pflotran-sip: A pflotran module for simulating spectral-induced polarization of electrical impedance data. *Energies*, *13*(24), 1–19. https://doi.org/10.3390/en13246552

Ambarita, J., Purnamasari, U., & Siahaya, A. (2025). *Deep learning as a pathway to pedagogical transformation in Indonesia*. *18*, 17–30.

Aqeel, M., Abbas, J., Shuja, K. H., Rehna, T., Ziapour, A., Yousaf, I., & Karamat, T. (2022). The influence of illness perception, anxiety and depression disorders on students mental health during COVID-19 outbreak in Pakistan: a Web-based cross-sectional survey. *International Journal of Human Rights in Healthcare*, *15*(1), 17–30. https://doi.org/10.1108/IJHRH-10-2020-0095

Arega, N. T., & Hunde, T. S. (2025). Constructivist instructional approaches: A systematic review of evaluation-based evidence for effectiveness. *Review of Education*, *13*(1), 1–34. https://doi.org/10.1002/rev3.70040

Bastoni, A., Perez, L., & Sell, C. (2024). Using Universal Design for Learning to Design Self-Paced Professional Development Modules for Adult Education Instructors. *Adult Literacy Education: The International Journal of Literacy, Language, and Numeracy*, *6*(1), 17–22. https://doi.org/10.35847/abastoni.lperez.csell.6.1.17

Cahyadi, R. A. H. (2019). Pengembangan Bahan Ajar Berbasis Addie Model. *Halaqa: Islamic Education Journal*, *3*(1), 35–42. https://doi.org/10.21070/halaqa.v3i1.2124

Casebolt, T., & Humphrey, K. (2023). Use of Universal Design for Learning Principles in a Public Health Course. *Annals of Global Health*, *89*(1), 1–12. https://doi.org/10.5334/aogh.4045

CAST. (2024). *The Universal Design for Learning Guidelines The goal of UDL is learner agency that is purposeful & reflectve , resourceful & authentc , strategic & acton-oriented . Design Multiple Means of Design Multiple Means of Design Multiple Means of Engagement Act*. 2024.

Cavanagh, T. M., & Kiersch, C. (2023). Using commonly-available technologies to create online multimedia lessons through the application of the Cognitive Theory of Multimedia Learning. *Educational Technology Research and Development*, *71*(3), 1033–1053. https://doi.org/10.1007/s11423-022-10181-1

Cheung, L. (2016). Using the ADDIE Model of Instructional Design to Teach Chest Radiograph Interpretation. *Journal of Biomedical Education*, *2016*, 1–6. https://doi.org/10.1155/2016/9502572

Cheung, S. K. S., Kwok, L. F., Phusavat, K., & Yang, H. H. (2021). Shaping the future learning environments with smart elements: challenges and opportunities. *International Journal of Educational Technology in Higher Education*, *18*(1), 1–9. https://doi.org/10.1186/s41239-021-00254-1

Delita, F., Berutu, N., & Nofrion. (2022). Online Learning: the Effects of Using E-Modules on Self-Efficacy, Motivation and Learning Outcomes. *Turkish Online Journal of Distance Education*, *23*(4), 0–3. https://doi.org/10.17718/tojde.1182760

Delungahawatta, T., Dunne, S. S., Hyde, S., Halpenny, L., McGrath, D., O'Regan, A., & Dunne, C. P. (2022). Advances in e-learning in undergraduate clinical medicine: a systematic review. *BMC Medical Education*, *22*(1), 1–13. https://doi.org/10.1186/s12909-022-03773-1

González-salamanca, J. C., Agudelo, O. L., & Salinas, J. (2020). Key competences, education for sustainable development and strategies for the development of 21st century skills. A systematic literature review. *Sustainability (Switzerland)*, *12*(24), 1–17. https://doi.org/10.3390/su122410366

Hasyim, A. (2017). Membangun Konsep Bertahap Danmodel Pembelajaran Pendidikan Kewarganegaraan Di Sekolah Menegah Atas. *PARAMETER: Jurnal Pendidikan Universitas Negeri Jakarta*, *29*(2), 121–133. https://doi.org/10.21009/parameter.292.01

Ismawati, E., Hersulastuti, Amertawengrum, I. P., & Anindita, K. A. (2023). Portrait of Education in Indonesia: Learning from PISA Results 2015 to Present. *International Journal of Learning, Teaching and Educational Research*, *22*(1), 321–340. https://doi.org/10.26803/ijlter.22.1.18

Jannah, M., & Faelasup, F. (2025). Analisis Konseptual Desain Materi Pembelajaran : Prinsip , Karakteristik, dan Langkah-Langkahnya. *JUPERAN: Jurnal Pendidikan Dan Pembelajaran*, *04*(02), 657–666.

Kartikasari, M., Ismet, I., & Sriyanti, I. (2023). Development of an E-Module Based on the 5E Learning Cycle to Improve the Creative Thinking Abilities of Junior High School Students. *Jurnal Penelitian Pendidikan IPA*, *9*(SpecialIssue), 121–129. https://doi.org/10.29303/jppipa.v9ispecialissue.6528

Khoirunna'imah, A., & Anbiya, B. F. (2024). Menumbuhkan minat belajar siswa melalui media buku bergambar dalam pembelajaran di tingkat MI/SD. *Jurnal Harmoni Nusa Bangsa*, *2*(1), 56–61.

Kumar, A. P., Omprakash, A., Mani, P. K. C., Kuppusamy, M., Wael, D., Sathiyasekaran, B. W. C., Vijayaraghavan, P. V., & Ramasamy, P. (2023). E-learning and E-modules in medical education—A SOAR analysis using perception of undergraduate students. *PLoS ONE*, *18*(5 May), 1–14. https://doi.org/10.1371/journal.pone.0284882

Mayer, R. E. (2024). The Past, Present, and Future of the Cognitive Theory of Multimedia Learning. *Educational Psychology Review*, *36*(1), 1–25. https://doi.org/10.1007/s10648-023-09842-1

Megavitry, R., Salfin, S., Akbar, K. F., & Taryana, T. (2023). Analysis of Learning Material Quality and Teacher-Student Interaction on Learning Achievement and Student Satisfaction Level in Distance Education in Indonesia. *The Eastasouth Journal of Learning and Educations*, *1*(03), 147–160. https://doi.org/10.58812/esle.v1i03.160

Menendez, D., Donovan, A. M., Mathiaparanam, O. N., Klapper, R. E., Yoo, S. H., Rosengren, K. S., & Alibali, M. W. (2024). The Role of Visual Representations in Undergraduate Students' Learning about Genetic Inheritance. *Education Sciences*, *14*(3). https://doi.org/10.3390/educsci14030307

Mu'ti, A. (2025). Pembelajaran Mendalam. *Naskah Akademik Pembelajaran Mendalam Menuju Pendidikan Bermutu Untuk Semua*, 1–75.

Mubarok, A. M., Haryadi, H., & Agus Nuryatin. (2024). Analisis Pendekatan komunikatif Pembelajaran Bahasa Indonesia. *Jurnal Onoma: Pendidikan, Bahasa, Dan Sastra*, *10*(1), 225–231. https://doi.org/10.30605/onoma.v10i1.3168

Myanda, A. A., Riezky, M. P., & Maridi, M. (2020). Development of Two-Tier Multiple-Choice Test to Assess Students' Conceptual Understanding on Respiratory System Material of 11th Grade of Senior High School. *International Journal of Science and Applied Science: Conference Series*, *4*(1), 44. https://doi.org/10.20961/ijsascs.v4i1.49457

Nadori, S., & Hoyi, R. (2021). Pengembangan Media Pembelajaran Fisika Menggunakan Software Aurora 3D Materi Pengukuran. *Journal Evaluation in Education (JEE)*, *1*(3), 78–82. https://doi.org/10.37251/jee.v1i3.138

Nasrah, Jasruddin, & M. Tawil. (2015). Pengembangan Perangkat Pembelajaran Fisika Berbasis Pendekatan Contexstual Teaching and Learning (CTL) untuk Memotivasi dan Meningkatkan Hasil Belajar Fisika Peserta Didik Kelas VIIISMP Negeri 1 Balocci Pangkep. *Jurnal Pendidikan Fisika*, *5*(2), 235–247.

Nazarianpirdosti, M., Janatolmakan, M., Andayeshgar, B., & Khatony, A. (2021). Evaluation of Self-Directed Learning in Nursing Students: A Systematic Review and Meta-Analysis. *Education Research International*, *2021*. https://doi.org/10.1155/2021/2112108

OECD. (2019). How does PISA define and measure reading literacy? *PISA in Focus*, *No.101*.

OECD. (2023). PISA 2022 Results. In *Factsheets: Vol. I*. https://www.oecd-ilibrary.org/educstion/pisa-2022-results-volume-i_53f23881-en

R. Hake, R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, *66*(1), 64–74. https://doi.org/10.1119/1.18809

Ratnayake, A., Bansal, A., Wong, N., Saseetharan, T., Prompiengchai, S., Jenne, A., Jeneni, & Thiagavel, 1 Aarthi Ashok1. (2024). Awareness To Promote Students ' Self-Regulated Learning. *Journal of Microbiology and Biology Education*, *25*(1), 1–16.

Rofiyadi, Y. A., & Handayani, S. L. (2021). Pengembangan Aplikasi E-Modul Interaktif Berbasis Android Materi Sistem Peredaran Darah Manusia Kelas V Sekolah Dasar. *JPDI (Jurnal Pendidikan Dasar Indonesia)*, *6*(2), 54. https://doi.org/10.26737/jpdi.v6i2.2575

Roski, M., Walkowiak, M., & Nehring, A. (2021). Universal design for learning: The more, the better? *Education Sciences*, *11*(4). https://doi.org/10.3390/educsci11040164

Setiyani, Putri, D. P., Ferdianto, F., & Fauji, S. H. (2020). Designing a digital teaching module based on mathematical communication in relation and function. *Journal on Mathematics Education*, *11*(2), 223–236. https://doi.org/10.22342/jme.11.2.7320.223-236

Seymour, M. (2024). Mejorando la Experiencia del Estudiante en Línea mediante la Aplicación del Diseño Universal para el Aprendizaje (DUA) al Aprendizaje y la Enseñanza de los Métodos de Investigación. *Revista Educación y Tecnologías de La Información*, *29*(3), 2767–2785. https://link.springer.com/content/pdf/10.1007/s10639-023-11948-6.pdf

Siagian, A. F., Ibrahim, M., & Supardi, Z. A. I. (2023). Creative-scientific decision-making skills learning model for training creative thinking skills and student decision making skills. *Nurture*, *17*(1), 10–17. https://doi.org/10.55951/nurture.v17i1.141

Sina, I. (2025). *Utilization of Infrastructure for Accessibility of Students with Disabilities in Inclusive Junior High Schools*. *12*(1), 37–42.

Smith, R., Snow, P., Serry, T., & Hammond, L. (2021). The Role of Background Knowledge in Reading Comprehension: A Critical Review. *Reading Psychology*, *42*(3), 214–240. https://doi.org/10.1080/02702711.2021.1888348

Syahfitri, J., & Muntahanah, M. (2023). Needs Analysis of the Biology Interactive Module Based on Bengkulu Local Wisdom. *International Journal of STEM Education for Sustainability*, *3*(1), 139–155. https://doi.org/10.53889/ijses.v3i1.142

Wang, Z., Cai, L., Chen, Y., Li, H., & Jia, H. (2021). The Teaching Design Methods Under Educational Psychology Based on Deep Learning and Artificial Intelligence. *Frontiers in Psychology*, *12*(October), 1–10. https://doi.org/10.3389/fpsyg.2021.711489

Wijayanto, R., Rinanto, Y., & Muzzazinah, M. (2023). Pengembangan e-modul struktur dan fungsi jaringan tumbuhan bagi peserta didik kelas XI SMA. *Bio-Pedagogi*, *12*(1), 36. https://doi.org/10.20961/bio-pedagogi.v12i1.58070

Wulandari, Y., & Purwanto, dan W. E. (2019). *Kelayakan Aspek Materi , Bahasa dan Media*. *Volume 6*(1), 61–67.

Zainal, A., Sagala, G. H., & Silalahi, S. A. (2021). Do Learning Approaches Matter on Setting the Time Spent for Pre-Service Teachers? *Cakrawala Pendidikan*, *40*(3), 613–624. https://doi.org/10.21831/cp.v40i3.42771

Zhu, Q., & Niyozov, S. (2024). Towards Deep Learning in Online Courses: A Case Study in Cross-Pollinating Universal Design for Learning and Dialogic Teaching. *Journal of the Scholarship of Teaching and Learning*, *24*(3), 87–104. https://doi.org/10.14434/josotl.v24i3.35331