JPPIPA 10(3) (2024)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Development of A Smart Module on Hydrological Cycle Based on SDGs as A Source of Science Studies for Primary School Students

Santa[1], Suci Siti Lathifah[2*], Delima Nur Aulia[1], Azzura Gryniprillady Meyradhia[2]

[1] Primary School Teacher Education, Pakuan University, Bogor, Indonesia.
[2] Science Education, Pakuan University, Bogor, Indonesia.

Received: December 11, 2023
Revised: February 8, 2024
Accepted: March 25, 2024
Published: March 31, 2024

Corresponding Author:
Suci Siti Lathifah
suci.sitilathifah@unpak.ac.id

DOI: 10.29303/jppipa.v10i3.6515

Abstract: The purpose of creating smart modules is to enhance the quality of technology-based learning and increase student-teacher engagement, based on the Sustainable Development Goals (SDGs). This e-module development employs research and development (R&D) methods to produce and evaluate educational products. The aim of product development is to enhance practicality, efficiency, and effectiveness, which are evaluated through testing. The interactive module was validated by electronic media experts, linguists, and material experts, achieving a validation rate of 93.80%, 98.40%, and 94%, respectively. These results indicate that the module is highly effective and valid. According to the Electronic Readability Test, the module scored 97.50%, placing it in the highly suitable category. The effectiveness of the smart module product on water cycle material was evaluated based on the average pretest, posttest, and n-gain scores, as well as teacher and student response questionnaires from 15 respondents. The average pretest, posttest, and n-gain scores were 64.66, 86.33, and 0.60 (60%), respectively, indicating a medium level of effectiveness with a fairly effective outcome. Furthermore, according to teacher and student surveys, 92% and 93.80% respectively found the software to be highly suitable. So, it can be concluded that the a smart module considered valid, practical, and effective.

Keywords: Electronic Interactive module; SDGs; Learning Resources

Introduction

The world is currently in a technological era dominated by the pervasive use of digital machines and the internet. The world is currently in a technological era dominated by the pervasive use of digital machines and the internet. This paradigm shift has brought about rapid and significant changes to all aspects of human life, including education. Technology should be integrated into the learning process because it has the potential to enhance assessment methodologies, foster greater student engagement and motivation, aid in lesson delivery and assessment, offer diverse modes for students to demonstrate their learning, promote access to knowledge and competency development, and facilitate lifelong learning (Davies & West, 2014; Karimov et al., 2020). The incorporation of technology in primary school education enhances the learning process by offering ease, enjoyment, and innovation to learners' experiences. As children are growing up in a world of technological advancements, the integration of technology into thematic learning in primary schools has become increasingly crucial (Sa'odah et al., 2022). It enables children to familiarize themselves with technology, which ultimately benefits them in their future education and career paths.

Digital e-learning, also referred to as e-learning, is a potential solution to the challenge of providing universal access to education and improving learning outcomes, particularly in developing countries. The advantages of digital e-based learning encompass 24/7 access to learning, reduced costs, increased outreach to larger audiences, personalized instruction leading to more impactful learning, flexibility, and potential to

How to Cite:
Santa, Lathifah, S. S., Aulia, D. N., & Meyradhia, A. G. (2024). Development of A Smart Module on Hydrological Cycle Based on SDGs as A Source of Science Studies for Primary School Students. *Jurnal Penelitian Pendidikan IPA*, *10*(3), 1492-1499. https://doi.org/10.29303/jppipa.v10i3.6515

enhance innovative thinking and aptitudes of students (Abed, 2019; Li et al., 2011; Yusuf & Al-Banawi, 2013). Smart modules incorporating interactive electronic modules with the aid of Flip PDF Professional serve as a learning medium. The employment of e-modules through Flip PDF Professional has resulted in effective academic support for students, as attested by experts and students alike. These modules have proven to support the learning process (Seruni et al., 2019; Thahir et al., 2022).

SDGS-based education incorporates the Sustainable Development Goals (SDGs) into curricula and learning outcomes to address real-world problems and promote sustainable development. The SDGs, a set of 17 goals by the United Nations, aim to achieve a more sustainable and equitable future by 2030. Integrating the SDGs into education requires redefining Education for Sustainable Development (ESD) as a tool for societal transformation toward sustainability. This involves creating a common sustainability vision, recognizing necessary competencies, and deploying suitable teaching strategies and learning approaches (Cheong, 2017; Nugroho et al., 2022). Integrating the Sustainable Development Goals (SDGs) into the curriculum and pedagogical experience is crucial (Dreifuss-Serrano & Herrera, 2022). When combined with SDGs issues, the smart module developed in this research becomes more engaging and can enhance students' understanding of sustainability. In science, we will study the hydrological cycle, beginning with its definition, stages, and effects, as well as the factors that affect it, including groundwater and surface water. We will also explore how water quality impacts human life. The hydrological cycle, commonly referred to as the water cycle, is the continuous rotation of water from the earth to the atmosphere and back.

Knowledge of the hydrological cycle is vital for supporting the SDGs on climate action. The Earth's climate has undergone various changes in the past 150 years due to global warming, causing the melting of glaciers, loss of snow cover, shrinking sea ice, increased atmospheric water vapor, and rising sea levels. As temperatures rise, precipitation patterns change, and the frequency or intensity of extreme weather events like storms, floods, droughts, and heat waves increase. A warming climate leads to sea level rise, alterations in snow and ice coverage, extended growing periods, and effects on infrastructure, public health, and ecosystems (Brinkmann, 2021). Supporting this, there is proof of rainfall pattern modifications, storm frequency changes, and altered drought occurrences (Schofield, 2011). The addition of greenhouse gases to the atmosphere is the cause of climate change, and this phenomenon is anticipated to persist in the subsequent years (Gettelman & Rood, 2016). Climate change impacts vary across different regions, exhibiting diverse patterns of change. The repercussions of climate change have far-reaching ecological, economic, and social implications. Consequently, the development of smart modules is expected to assist educators in presenting science-based problems on hydrological cycles in digital modules, allowing students to explore environmental issues and support the achievement of SDGs.

Method

The ADDIE model, which stands for Analysis, Design, Development, Implementation, and Evaluation, is utilized as a development model. Its use includes the creation of learning innovations, instructional material development, and improving learning outcomes. Research has demonstrated that this approach has been efficacious in providing learning materials, achieving exceptional learning results, and preparing educational materials for traditional and electronically-assisted instruction methods (Drljača et al., 2017; Ranuharja et al., 2021).

The analysis stage of developing smart module teaching materials involves conducting field studies to gather information needed for content creation. During the design stage, initial design and structure formation for the smart module occurs, which includes KD. 3.8 taken from the hydrological cycle material. Specifically, the analysis examines the hydrological cycle and its effects on Earth's events and the sustainability of living organisms. Smart modules contain not only knowledge development, indicators, and learning objectives, but also materials, videos, summaries, and formative tests in the form of interactive quizzes. These modules are created to enhance materials and learning objectives obtained from various sources such as books, articles, and the internet.

The Development stage brings the product to life while a team of media, language, and material experts validate the smart module. The purpose of this validation is to obtain feedback from diverse validators regarding the efficacy of the teaching materials for student testing. During the implementation stage, the validated product will be incorporated into the learning process. The Smart module will be utilized in tandem with a pretest-posttest instrument to calculate the N-Gain value, thereby determining the product's effectiveness in enhancing student learning outcomes. Product trials were conducted using a one-group pretest-posttest design. Prior to treatment, learners will be administered a pretest, followed by a posttest after treatment. This allows for a more accurate comparison of performance before and after treatment. In addition to administering a pretest-posttest, students are required to complete a questionnaire to assess the level of comprehension and readability of the smart module, followed by a response questionnaire evaluating the

efficacy of the interactive e-module. Please refer to Figure 1 for the trial design.

Figure 2. One group pretest-posttest design

Description:
O1 : Pretest score (before treatment)
O2 : Posttest value (after given treatment)
X : Treatment (group counseling)

This stage aims to establish the impact of smart modules on students. A limited trial in a real-life classroom setting, involving 15 learners in a single class, was conducted to test this. The last stage of ADDIE involves evaluation. At this stage, we evaluate the results of the readability test questionnaire, along with feedback from learners, teachers, and various validators, to determine the success of the developed smart module product. If found suitable, the module can be distributed and utilized in schools.

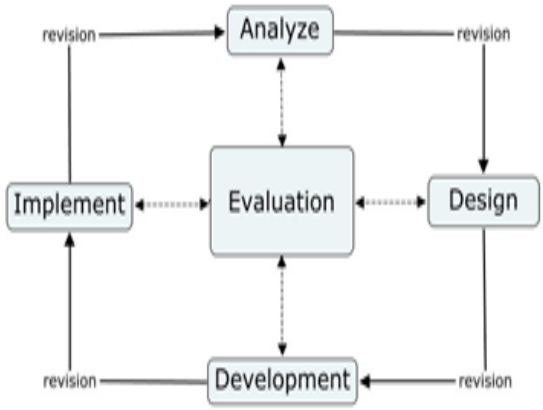

Figure 1. ADDIE development model

Result and Discussion

The creation of smart modules discussed in this study pertains to the research and development procedures derived from the ADDIE development model utilized for designing learning systems. This model involves five stages: analysis, design, development, implementation, and evaluation. The outcome of the product development is the smart modules on hydrological cycle material, designed for use in fifth grade classrooms at SDN Julang Bogor City.

The initial stage commences with the analysis phase. The purpose of this analysis stage is to identify learning needs and problems encountered while conducting modern learning activities in an objective manner. During this stage, we analyzed the curriculum, concepts, learner characteristics, teaching materials, and formulated learning objectives. Needs analysis was conducted through teacher interviews with the fifth-grade teachers at SDN Julang and classroom observations. Based on the interview results, the school's inadequate facilities and infrastructure still lead to the use of modules derived from printed books for learning, including thematic books that are transformed into in-house modules. Consequently, learning is dull and fails to inspire motivation to learn (Chalupa, 2021). In today's day and age, students require teaching materials that are engaging and encourage learning (Zulfira et al., 2024). One form of using technology in learning activities is in interactive learning media (Majid et al., 2023). Teaching materials for students and teachers can take the form of interactive electronic modules. The preference for smart modules was due to their flexibility, enabling independent learning and motivating students, with usability anywhere and anytime (Abed, 2019; Li et al., 2011; Yusuf & Al-Banawi, 2013).

The second stage involves designing the smart module structure, where a design process is carried out. The smart module was developed based on KD 3.8, which analyzes the hydrological cycle's impact on events on Earth and the survival of living things. It should be noted that smart modules lack KD, learning objectives, material, learning videos, summaries, and interactive quizzes in the form of formative tests. Smart modules are designed to supplement learning objectives and materials obtained from various sources, including books, articles, and the internet.

Developing a technology-based learning media plan is crucial in education as it enhances the efficiency, effectiveness, and safety of the learning process (Hikmawan et al., 2019; Kustyarini et al., 2020; Andy et al., 2021).

The third phase involves constructing smart modules that were previously designed. These modules comprise hydrological cycle material and will be presented to media experts, linguists, and material specialists for validation. This process ensures that the resulting interactive e-modules are appropriate for educational use by both teachers and students. Validating electronic-based teaching media is crucial to identify and address deficiencies and their effectiveness in the learning process (Sumiati et al., 2020). Media experts conduct evaluations on smart module products, considering the display aspects with images, videos, and audio media. The ease of use of smart modules is also assessed by media experts to facilitate student learning. Table 1 presents the results of the media expert evaluation.

Table 1. Media expert validation results

Number	Aspect	Value of each aspect	Max Score	Percentage	Criteria
1	Attractive presentation display	27	30	90%	Valid
2	Completeness of the contents of the smart module components	25	25	100%	Valid
3	Clarity of media instructions	9	10	90%	Valid
	Overall Score		(61:65) x 100% = 93.80%		P>80% (Valid)

Linguists assess speech factors in compliance with Indonesian Spelling Guidelines, as well as the appropriateness of sentence structure, to ensure ease of comprehension for students utilizing the smart module. Refer to table 2 for the results of linguistic validation.

Table 2. Linguist validation results

Number	Aspect	Value of each aspect	Max Score	Percentage	Criteria
1	Appropriateness of straightforward language	20	20	100%	Valid
2	Orderliness and cohesiveness of thought flow	9	10	90%	Valid
3	Suitability of language that is easy to understand with the level of development of students	15	15	100%	Valid
4	Use of language in accordance with the Indonesian Spelling Guidelines	20	20	100%	Valid
	Overall Score		(64:65) x 100% = 98.40%		P>80% (Valid)

Material experts evaluate the contents of the Smart module, considering its suitability with KI, KD, learning objectives, and the comprehensiveness of the material. Table 3 displays the results of material expert validation.

Table 3. Material expert validation results

Number	Aspect	Value of each aspect	Max Score	Percentage	Criteria
1	Attractive presentation display	27	30	90%	Valid
2	Completeness of the contents of the smart module components	25	25	100%	Valid
3	Clarity of media instructions	9	10	90%	Valid
	Overall Score		(61:65) x 100% = 93.80%		P>80% (Valid)

This smart module features an attractive layout and clear language. Created by researchers, the module comprises 49 pages initially saved in Word and later converted to electronic format using the Flip Pdf Professional application. Its accessibility on both mobile devices and computers allows for ultimate flexibility in usage. The smart module comprises an introductory section, table of contents, image list, user instructions, learning objectives, concept maps, learning materials (including descriptions, videos, summaries, and formative assessments), glossary, bibliography, and author profile. The validation from each expert reported high validity, allowing implementation of this smart module into the learning process. The developed e-learning platform adheres to the specified parameters, resulting in heightened functionality and effectiveness throughout the learning process (Nikmah et al., 2019; Risniawati et al., 2020).

Additionally, its implementation marks the fourth stage. The smart module presented in this study covers the stages and understanding of the hydrological cycle, including its effects on living organisms, the influencing factors, groundwater and surface water, as well as the impact of water quality on human life. This module was designed for fifth-grade students at SDN Julang in Bogor City. The trial consisted of two classroom sessions. The process of meeting 1 involves several stages for students, including completing pretest questions, reading Smart Module Material 1, viewing images and videos, taking formative tests 1, and filling out a questionnaire to evaluate the readability of the language, material, and Smart Module layout, and to determine whether it can be easily comprehended by students. Meeting 2 comprises of reading Smart Module Material 2, taking formative test 2, and finally answering posttest questions post-learning.

The study tested the efficacy of smart modules in a single class, with a limited sample size, using the N-gain test to measure the impact of smart module teaching materials on learning effectiveness. Figure 3 shows a diagram of the average increase in science learning outcomes.

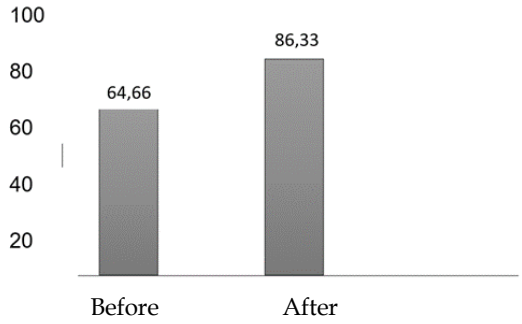

Figure 3. Improvement in science learning outcomes before and after using smart modules

The pretest and posttest results of 15 students in the limited test showed varying scores, with a significant overall improvement. The average pretest score was 65.66, while the average posttest score was 86.66, indicating an increase in science learning outcomes following the use of smart module teaching materials.

The study tests the effectiveness of smart module teaching materials on the hydrological cycle through a Pre-Experimental Design, specifically a one-group pretest-posttest design. The objective of this test is to assess biology learning outcomes by achieving N-gain. Smart module instructional materials are effective if students achieve an N-gain with a minimum of 0.30 - 0.70 (30%-70%), which meets the medium criteria. Table 4 displays the test results.

Table 4. N-gain value

No	Implementation Criteria	Pretest	Posttest
1	Number of learners	15	15
2	Total Score	970	1.295
3	Maximum score	85	100
4	Minimum score	45	70
5	Average	64.66	86.33
	N-Gain value		0.60 (Medium)

In the pilot study, the N-gain value was 0.6 (60%), placing it in the moderate category with a reasonably effective level. This aligns with the statement that the 0.30 - 0.70 (30%-70%) range falls under the moderate category. The smart module provides easily accessible and contextualized instructional materials and learning media that students can use autonomously to enhance their understanding of various subjects (Maison & Wahyuni, 2021). The formatting of the educational tool is aesthetically pleasing and user-friendly. This enhances students' desire to learn and promotes their reading proficiency (Abed, 2019).

Finally, the evaluation stage determines the success of the smart module product. This is achieved by analyzing the results of the readability test questionnaire, gathering feedback from students, teachers, and validators, and assessing whether the product meets expectations. The students' readability test serves as an evaluation for calculating the efficacy of implementing Smart modules on Hydrological Cycle Material. A limited trial, with a focus on Class V and only 15 students in a real-life situation, implemented the Smart modules. The results from the students' readability test can be found in Table 5.

Table 5. Learner readability test results

Component	Statement															Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Total score	75	75	75	69	70	75	75	68	75	75	71	69	75	75	75	1097
Maximum score	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	1125
Percentage (%)																97.50%

The student readability test questionnaire yielded a score of 97.50% indicating very good criteria, which demonstrates that the smart module teaching materials have excellent readability levels for students. The effectiveness of smart modules was evaluated using questionnaires for teachers and learners. Please refer to Tables 6 and 7 for the results of the teacher and learner responses to the use of smart modules. Please refer to Tables 6 and 7 for the results of the teacher and learner responses to the use of smart modules.

The response questionnaire from the teachers resulted in a rating of 92%, with the criteria being rated as very good. Based on this data, it can be concluded that the smart module teaching material is greatly effective in facilitating teacher learning.

Table 6. Results of teacher response to use of smart modules

Component	Statement										Total
	1	2	3	4	5	6	7	8	9	10	
Total score	5	4	5	5	5	4	4	5	5	4	46
Maximum score	5	5	5	5	5	5	5	5	5	5	50
Percentage (%)											92%

Table 7. Results of learners' response to the use of smart modules

Component	Statement										Total
	1	2	3	4	5	6	7	8	9	10	
Total score	75	75	65	70	62	73	65	75	75	71	704
Maximum score	75	75	75	75	75	75	75	75	75	75	750
Percentage (%)											93.80%

The student response questionnaire results indicate a 93.8% rating with very good criteria for the smart module teaching material, suggesting it receives a highly positive response from learners. Electronic-based learning modules present numerous benefits, including accessible, self-paced learning materials that cater to students' convenience (Maison & Wahyuni, 2021). Second, the incorporation of machine learning models in industrial systems provides intelligence enhancement, allowing for real-time parameter prediction and monitoring (D. Li et al., 2023). Thirdly, e-learning courses facilitate independent work and self-education among students, leading to the acquisition of both general and professional. Additionally, e-learning modules aid in familiarizing students with the operation and use of electronic devices, which is vital for engineering activities (Dinu & Petre, 2018). Digital learning media is highly suitable for use in the learning process to enhance student engagement and improve learning outcomes (Amalia et al., 2024). Furthermore, these modules amalgamate technological, pedagogical, and content knowledge, offering diverse learning resources and promoting contextual and creative thinking in learners (Rufaida & Nurfadilah, 2021). The use of e-modules has the potential to enhance students' cognitive abilities and self-awareness attitudes (Qomariyah & Pertiwi, 2023). Therefore, it is possible that in the future the use of printed books will be replaced by more practical e-books. It is assumed that the ease with which the teacher conveys material to students creates good learning (Paramitha et al., 2023).

Conclusion

Based on the research conducted in the development of smart modules on Hydrological Cycle Material, the following conclusions can be drawn: 1). The smart module developed using the ADDIE Model approach received validation through expert evaluation and readability test questionnaires, with a score of 93.80%. The validation conducted by linguists and material experts yielded results with high validity percentages of 98.40% and 94%, respectively. Based on the readability test of the smart module trial, the results fell within the "very suitable" category at 97.50%; 2). The effectiveness of smart module products on the hydrological cycle material was determined by averaging the pretest, posttest, and n-gain scores, along with questionnaires from both teachers and students. A total of 15 student participants were involved. The average pretest, posttest, and n-gain scores were 64.66, 86.33, and 0.60 (60%), respectively, which fall in the medium category and indicate a fairly effective level of effectiveness. Meanwhile, the survey results from both teachers and students indicate a 92% and 93.80% satisfaction rate, respectively, falling under the "very suitable" category.

Acknowledgments

We would like to express our gratitude to Pakuan University for funding this research, as well as to the teachers and students of SDN Julang Kota Bogor who generously contributed to this study.

Author Contributions

S.S.L and S contributed to the conceptualization of the research idea, product development, data analysis, and article writing. D.N.A and A.G.M assisted with the technical process during the study. All authors have read and agreed to the published version of the manuscript.

Funding

The research was supported by Pakuan University Bogor, Indonesia.

Conflicts of Interest

The authors have disclosed that there are no conflicts of interest in relation to the publication of this paper.

References

Abed, E. K. (2019). Electronic Learning and its benefits in education. *EURASIA Journal of Mathematics,*

Science and Technology Education, *15*(3). https://doi.org/10.29333/ejmste/102668

Amalia, S., Safrida S, & Ulva, S. M. (2024). Differentiated learning integrated with social emotional awareness and digital learning media in improving the students motivation and learning outcomes. *Jurnal Penelitian Pendidikan IPA*, *10*(1), 239–245. https://doi.org/10.29303/jppipa.v10i1.5354

Andy, W. H., Fakhruddin, Martono, Khafid, M., Sunusi, S., & Setyawan, H. (2021). Developing learning media based project board in electronic materials to improve the analysis capability and skills for the cadets of PIP Semarang. *Turkish Journal of Computer and Mathematics Education (TURCOMAT)*, *12*(6), 2686–2694. https://doi.org/10.17762/turcomat.v12i6.5769

Brinkmann, R. (2021). Our climate change challenge. In *Practical Sustainability*, 13–36. https://doi.org/10.1007/978-3-030-73782-5_2

Chalupa, C. (2021). Increasing motivation among language learners through individualized assessment. *Central European Journal of Educational Research*, *3*(2), 1–13. https://doi.org/10.37441/cejer/2021/3/2/9564

Cheong, L. Y. (2017). Evidence Based education and the UN Sustainable Development Goals (SDGs) 2016–2030. In *Children and Sustainable Development*, 85–92. https://doi.org/10.1007/978-3-319-47130-3_7

Davies, R. S., & West, R. E. (2014). Technology integration in schools. In *Handbook of Research on Educational Communications and Technology*, 841–853. https://doi.org/10.1007/978-1-4614-3185-5_68

Dinu, C., & Petre, V. C. (2018). Educational platform for developing and prototyping electronic assemblies. *2018 International Conference and Exposition on Electrical And Power Engineering (EPE)*, 1–4. https://doi.org/10.1109/EPE43946.2018.9044167

Dreifuss-Serrano, C., & Herrera, P. C. (2022). SDGs for the assessment of voluntourism learning experiences. *2022 IEEE International Humanitarian Technology Conference (IHTC)*, 27–31. https://doi.org/10.1109/IHTC56573.2022.9998409

Drljača, D., Latinović, B., Stanković, Ž., & Cvetković, D. (2017). ADDIE model for development of e-courses. *Proceedings of the International Scientific Conference - Sinteza 2017*, 242–247. https://doi.org/10.15308/Sinteza-2017-242-247

Gettelman, A., & Rood, R. B. (2016). Climate change and global warming. In *Demystifying Climate Models*, *2*, 23–35. https://doi.org/10.1007/978-3-662-48959-8_3

Hikmawan, T., Sutarni, N., & Hufad, A. (2019). The role of electronic learning media in creativity learning. *Journal of Physics: Conference Series*, *1375*(1), 012030. https://doi.org/10.1088/1742-6596/1375/1/012030

Karimov, M. A., Dadaboyeva, D. I., & Khaydarova, S. K. (2020). Information technologies in the learning process. *International Journal on Integrated Education*, *3*(1), 23–25. https://doi.org/10.31149/ijie.v3i1.261

Kustyarini, K., Utami, S., & Koesmijati, E. (2020). The importance of interactive learning media in a new civilization era. *European Journal of Open Education and E-Learning Studies*, *5*(2). https://doi.org/10.46827/ejoe.v5i2.3298

Li, D., Kakosimos, P., & Peretti, L. (2023). Machine-learning-based condition monitoring of power electronics modules in modern electric drives. *IEEE Power Electronics Magazine*, *10*(1), 58–66. https://doi.org/10.1109/MPEL.2023.3236462

Li, X., Liang, B., Zhang, M., & Fu, G. (2011). Research on digital electronics teaching. In *Information Computing and Applications*, *244*, 515–521. https://doi.org/10.1007/978-3-642-27452-7_70

Maison, & Wahyuni, I. (2021). Guide inquiry science e-module development for improving junior high school students' scientific literacy. *Journal of Physics: Conference Series*, *1876*(1), 012089. https://doi.org/10.1088/1742-6596/1876/1/012089

Majid, N. W. A., Rafli, M., Nurjannah, N., Apriyanti, P., Iskandar, S., Nuraeni, F., Putri, H. E., Herlandy, P. B., & Azman, M. N. A. (2023). Effectiveness of using assemblr edu learning media to help student learning at school. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 9243–9249. https://doi.org/10.29303/jppipa.v9i11.5388

Nikmah, C., -, T., & Nasrudin, H. (2019). Validation of learning media using Argument Driven Inquiry (ADI) learning model. *International Journal of Scientific and Research Publications (IJSRP)*, *9*(11), p9509. https://doi.org/10.29322/IJSRP.9.11.2019.p9509

Nugroho, O. F., Juwita, S. R., & Febrianti, N. (2022). STEM education planning based on contextual issues Sustainable Development Goals (SDGs). *Pedagonal : Jurnal Ilmiah Pendidikan*, *6*(2), 159–168. https://doi.org/10.55215/pedagonal.v6i2.5554

Paramitha, D., Prasetyo, Z. K., Jumadi, J., & Siregar, A. N. (2023). Influence of use of problem-based learning e-book materials of optical equipment on improving students' critical thinking ability. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 9149–9155. https://doi.org/10.29303/jppipa.v9i11.5165

Qomariyah, N., & Pertiwi, K. R. (2023). Development of e-modules assisted by smart apps creator on reproductive system material to improve cognitive abilities and self-awareness attitudes towards reproductive health of class XI SMA/MA learners.

Jurnal Penelitian Pendidikan IPA, *9*(11), 9063–9074. https://doi.org/10.29303/jppipa.v9i11.4924

Ranuharja, F., Ganefri, G., Fajri, B. R., Prasetya, F., & Samala, A. D. (2021). Development of interactive learning media edugame using addie model. *Jurnal Teknologi Informasi Dan Pendidikan*, *14*(1), 53–59. https://doi.org/10.24036/tip.v14i1.412

Risniawati, M., Serevina, V., & Delina, M. (2020). The development of E-learning media to improve students' science literacy skill in Senior High School. *Journal of Physics: Conference Series*, *1481*, 012075. https://doi.org/10.1088/1742-6596/1481/1/012075

Rufaida, S. & Nurfadilah. (2021). The development of device learning based on TPACK (technological pedagogical content knowledge) in the form of hypercontent modules in electronics courses. *Journal of Physics: Conference Series*, *1806*(1), 012006. https://doi.org/10.1088/1742-6596/1806/1/012006

Sa'odah, S., Yuniasih, N., & Haryanti, Y. D. (2022). Learning technology in elementary school. *AL-ISHLAH: Jurnal Pendidikan*, *14*(4), 6739–6744. https://doi.org/10.35445/alishlah.v14i4.1488

Schofield, N. (2011). *Climate Change and its Impacts – Current understanding, future directions.* In Basin Futures: Water reform in the Murray-Darling Basin. ANU Press. https://doi.org/10.22459/BF.05.2011.04

Seruni, R., Munawaoh, S., Kurniadewi, F., & Nurjayadi, M. (2019). Pengembangan modul elektronik (e-module) biokimia pada materi metabolisme lipid menggunakan flip pdf professional. *JTK (Jurnal Tadris Kimiya)*, *4*(1), 48–56. https://doi.org/10.15575/jtk.v4i1.4672

Sumiati, M., Rizal, F., & Anwar, M. (2020). Development of mobile-learning media on basic electricity and electronics subject. *Jurnal Pendidikan Teknologi Kejuruan*, *3*(1), 14–19. https://doi.org/10.24036/jptk.v3i1.3423

Thahir, I., Kasman, Ddin, R., & Rhamadan, N. (2022). Pembuatan bahan ajar e-modul menggunakan aplikasi flip pdf professional. *I-Com: Indonesian Community Journal*, *2*(3), 533–541. https://doi.org/10.33379/icom.v2i3.1785

Yusuf, N., & Al-Banawi, N. (2013). The impact of changing technology: the case of e-learning. *Contemporary Issues in Education Research (CIER)*, *6*(2), 173. https://doi.org/10.19030/cier.v6i2.7726

Zulfira, R., Halim, A., Khaldun, I., Mahzum, E., Nazar, M., & Kasli, E. (2024). Effect of interactive learning media using visual basic for application excel spreadsheet to reduce misconception in physics learning. *Jurnal Penelitian Pendidikan IPA*, *10*(1), 28–36. https://doi.org/10.29303/jppipa.v10i1.6387