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Validity of Wetland-Based Chemistry Teaching E-Module with SCCrT Model Assisted with Liveworksheet to Improve Students' 6c Skills

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Abstract: Anticipating a less-than-optimal learning process to facilitate students in developing 6C Skills, it is necessary to develop wetland-based teaching E-modules using the Scientific Critical Creative Thinking (SCCrT) model with the help of Liveworksheets. This study aims to analyze the validity of a wetland-based chemistry teaching e-module using the SCCrT model assisted by Liveworksheets to enhance students' 6C skills. This research and development (R&D) study uses the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation), focusing on the Analysis, Design, and Development stages. The research method employed is qualitative with a descriptive approach. Data was collected through a validation process in which five expert validators filled out a validation sheet. This process aimed to gather valuable feedback on the design and development of the e-module being created. The validation results were then analyzed using a Likert scale, and they indicated that the module is highly valid based on content, presentation, language, and media. Based on these findings, it can be concluded that the wetland-based chemistry e-learning module with the SCCrT model, supported by Liveworksheets, has proven to be valid and is highly feasible for use in improving students' 6C skills in an effective way.

Keywords: 6C skills; E-module; Liveworksheet; SCCrT; Wetland

Introduction

In the era of fast-paced globalization and rapid technological advances, education is not just about transferring knowledge but must also prepare students to face future challenges (Alenezi et al., 2023; Zhang et al., 2024). One of the key elements in 21st-century education is the development of 21st-century skills (6C Skills), which include Critical Thinking, Creativity, Collaboration, Communication, Citizenship, and Character Education (Chun & Abdullah, 2022; Mariano & Chiappe, 2021). These skills are very important because they provide a foundation for students to adapt to a world that continues to change, is connected globally, and presents new, more complex challenges (Fernandes et al., 2024; Barus, 2024).

However, even though these skills have been recognized as essential in education, their implementation in Indonesia still faces various obstacles. One of them is the dominance of conventional learning methods that emphasize theoretical mastery of material and knowledge transfer through lecture and

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memorization approaches. Methods like this still dominate classrooms in many schools in Indonesia, while educational evaluations mostly measure students' cognitive aspects through written exams, not critical thinking skills, creativity, or collaboration (Vuorio et al., 2024; Jason, 2023). This approach prevents students from developing the skills necessary to solve real-world problems that involve multidisciplinary skills and the ability to work in teams.

This challenge becomes increasingly complex in the context of chemistry learning. Chemistry material, which is abstract and requires a deep understanding of concepts, is often complex for students to apply in everyday life. Approaches that still focus on memorizing formulas and concepts also tend to hinder the development of critical thinking skills and creativity, which are necessary to face the global challenges of the 21st century (Chiu, 2022; Mennani et al., 2023; Rano et al., 2023). Therefore, there is an urgent need for innovation in learning methods and media that effectively convey chemistry material and integrate and develop 6C skills in students.

One innovation that can be proposed is the development of a wetland-based e-learning module in chemistry learning using the SCCrT (Scientific Critical Creative Thinking) model. The SCCrT model emphasizes three main aspects that complement each other, namely scientific thinking, which focuses on a science-based approach to solving problems; critical thinking, which teaches students to analyze, evaluate, and question assumptions in existing information; and creative thinking, which involves the ability to generate new ideas and innovative solutions (Rusmansyah, et al., 2023a).

Integrating these three aspects in the wetland-based chemistry learning module is expected to improve students' critical and creative thinking abilities and allow them to apply chemical knowledge in more relevant real-world contexts, especially in pressing environmental issues. Wetlands, a very important and ecologically and socially relevant ecosystem in Indonesia, were chosen as the context for chemistry learning. With its diversity of wetland ecosystems, such as swamps, lakes, and mangrove forests, Indonesia has a big responsibility to maintain its sustainability. Wetlands have a vital role in maintaining global environmental balance, such as controlling floods, storing carbon, and providing habitat for various species (Campbell, 2020; Ramachandra et al., 2024; Hoover, 2021).

Learning chemistry linked to wetland issues not only teaches scientific concepts but also builds students' environmental awareness and citizenship skills (Rusmansyah et al., 2023b). In supporting more interactive and responsive learning, the use of Liveworksheets as a digital platform allows students to engage in a variety of more flexible and enjoyable learning activities, such as interactive exercises, quizzes, and collaborative assignments online (Argarini & Najibah, 2023; Yuliana et al., 2023). This platform allows learning tailored to student needs, despite facing different technological obstacles in each region.

This research aims to develop and test the validity of a wetland-based e-learning module using the SCCrT model and Liveworksheets assistance in improving students' 6C skills. The validation process is carried out by experts (validators) who evaluate the module based on content, presentation, language, and media. The results of this validation will be the basis for knowing the extent to which this module can be widely applied in formal education in Indonesia. Thus, it is hoped that this research can make a significant contribution to innovation in learning media that is relevant to the educational needs of the 21st century, as well as supporting the development of skills needed to face global challenges in the future.

Method

This research is included in the research and development (R&D) category, which aims to develop a wetland-based chemistry learning e-module using the SCCrT model assisted by Liveworksheets. It is valid and suitable for use. This research uses the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) development model) (Branch, 2009; Sugiyono, 2022). However, this research only focuses on the first three stages, namely Analysis, Design, and Development, to test the validity of the e-module being developed up to the development stage.

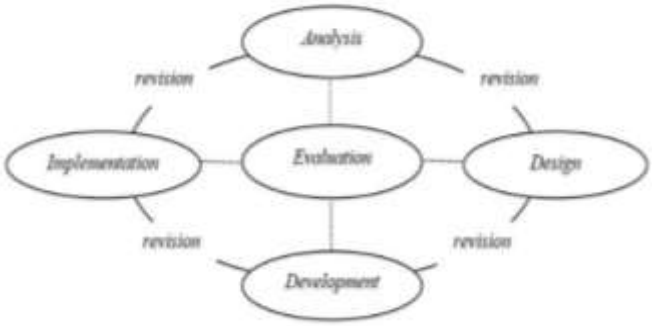

Figure 1. ADDIE development model

This research aims to develop a wetland-based chemistry learning e-module that is valid and suitable for use with the SCCrT model assisted by Liveworksheets. It is hoped that this e-module can improve the quality of chemistry learning with a more

interactive and effective approach, in accordance with student needs and the applicable curriculum.

The research phase begins with the Analysis Phase, which involves analyzing learning needs to determine chemistry topics relevant to the wetland concept. In addition, an analysis of the applicable curriculum was carried out to adjust the material to be included in the e-module, as well as an analysis of student characteristics to ensure that the e-module being developed could be accessed and understood easily by students. At the end of this stage, the problems that will be addressed through e-module development are formulated. The e-module structure is designed at the Design Stage, including material division into systematic chapters. The design of content and learning media, such as the use of Liveworksheets, is also considered to convey the material in a way that is interesting and easy for students to understand. The Development Phase focuses on implementing the e-module that has been designed, followed by a validation process by experts to measure the quality of the content, presentation, language, and media used in the e-module. This validation is critical to ensure that the e-module developed meets predetermined learning standards.

The main instrument used in this research is a validation sheet designed to assess the quality of e-modules from four main aspects: content, presentation, language and media. Each aspect is assessed by five expert validators, and the scores given will be analyzed quantitatively using descriptive statistics to calculate the average score and classify the quality of the e-module. Qualitatively, analysis was carried out by identifying themes from validator feedback regarding needed improvements. The assessment scale used is a 0-100 scale, with categories: 0-49 = Not Appropriate, 50-64 = Fair, 65-79 = Good, and 80-100 = Very Good (Widoyoko, 2012).

The results of this data analysis are hoped to provide a clear picture of the extent to which the e-module developed meets the established standards and is ready for use in wetland-based chemistry learning.

Result and Discussion

This research aims to develop and evaluate the validity of a wetland-based chemistry teaching e-module using the SCCrT (Scientific Critical Creative Thinking) model supported by the Liveworksheet platform. The development of this e-module is focused on the three initial stages of the ADDIE model, namely Analysis, Design, and Development, to ensure that the resulting product meets high-quality standards before being implemented further.

After development, this e-module was validated by five experts competent in chemistry, education, and learning technology. Validation is carried out using a validation sheet that covers four main aspects: Content, Presentation, Language, and Learning Media. Each aspect is evaluated through several assessment items designed to assess the module's quality comprehensively.

The validation results show that this e-module is in the "Very Good" category overall, with several outstanding aspects, such as the quality of the learning media and the suitability of the content to the curriculum. The high average score in all aspects assessed indicates that this e-module has met the validity criteria required for use in the learning process.

Table 1 and Figure 2 provide the results of each aspect that has been validated, including analysis of data from five validators and interpretation of the findings obtained.

Table 1. Validation results from validators

Validation Aspect	Validator					Value	Category
	I	II	III	IV	V		
Contents	85	88	90	87	89	87.80	Very Good
Presentation	85	87	88	86	88	86.80	Very Good
Language	82	85	84	83	86	84.00	Very Good
Instructional Media	90	92	88	91	89	90.00	Very Good

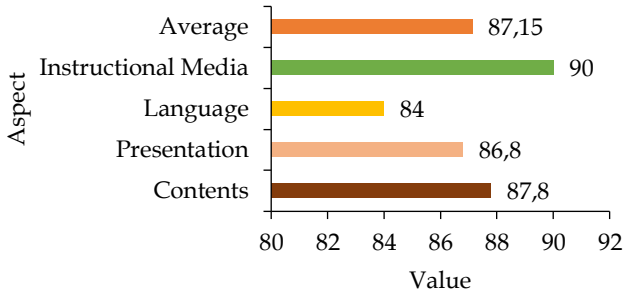

Figure 2. Validity results for each aspect

Figure 3. Example of a wetland-based SCCrT model e-module

The validation results of the wetland-based chemistry teaching e-module using the SCCrT model supported by the Liveworksheet platform show that this product is very good overall. Five experts who are competent in chemistry, education, and learning technology carried out the validation. Based on the data obtained, several important points can be discussed from each aspect assessed.

Content Aspect

The content aspect received a very good rating, indicating that the materials were aligned with the curriculum and were relevant to the students' needs. Validators appreciated that the material was designed in accordance with curriculum standards and learning objectives. Moreover, the content's relevance to real-world contexts, particularly wetland ecosystems, enhances students' motivation to engage with the subject matter (Aulia & Rudyatmi, 2023; Hasbie et al., 2023; Sulastri et al., 2022). The contemporary nature of the content and its adaptation to students' comprehension levels were also commended (Fitri et al., 2024; Hendrawensi et al., 2024).

The alignment of content with curriculum standards ensures that the e-module supports the achievement of learning objectives. However, to further enhance student engagement, the addition of more practical activities or experiments related to wetland chemistry could be beneficial. These hands-on experiences would help solidify the students' understanding by providing real-life context to the theoretical content (Aprilia et al., 2023; Chotimah et al., 2024).

Presentation Aspect

The presentation aspect also received a high rating, indicating that the module's content was presented logically and clearly. Validators praised the structure and clarity of the material, including the use of illustrations and visuals that support students' understanding (Ismail et al., 2024; Syahri et al., 2024; Yantoro et al., 2024). However, there were some suggestions for improvement, particularly regarding the clarity of activity instructions and the integration of images with the text.

A well-structured presentation is crucial for ensuring that students can easily follow and comprehend the material. While the overall presentation was well-received, clearer instructions for certain activities and better integration of images and text could enhance the learning experience. This would help ensure that students are not only engaged but also able to follow the learning process without confusion.

Language Aspect

The language aspect received a very good rating, with validators noting that the terminology used in the e-module was appropriate and understandable for students. The language was simple yet precise, which facilitated effective learning (Addas et al., 2022; Saputra et al., 2023). The use of correct grammar and consistency in scientific terms also contributed positively to the overall quality of the e-module. However, some sections of the text could still be simplified further for better clarity.

The use of clear, simple language is vital for ensuring that students can fully understand complex scientific concepts. While the language used in the e-module was generally well-suited to the target audience, some sentences could be simplified to further enhance comprehension, especially for students with varying levels of understanding (Ismail et al., 2024; Melinia et al., 2024).

Instructional Media Aspect

The instructional media aspect received the highest score, reflecting the excellent quality of the visual display, media interactivity, and the appropriateness of the media for the content being taught. Validators noted the effective use of interactive features, such as quizzes and multimedia elements, which significantly enhance student engagement (Saputra & Octavia, 2024; Ula et al., 2025; Yulando et al., 2019). The clarity of navigation within the media and the alignment of media features with the learning objectives were also highly appreciated.

Interactive media play a crucial role in keeping students engaged and supporting their understanding of the material. The inclusion of interactive quizzes and multimedia elements was well-received, as these features make learning more dynamic and enjoyable. However, there is potential to further enrich the media with more advanced interactive elements, such as virtual laboratories or simulations that allow students to experiment with chemical concepts in a controlled, virtual environment (Paristiowati et al., 2024; Purnamasari et al., 2024; Utaminingsih & Ellianawati, 2025).

Conclusion

The validation results of the wetland-based chemistry teaching e-module developed using the SCCrT (Scientific Critical Creative Thinking) model and supported by the Liveworksheet platform indicate that this e-module meets high-quality standards in content, presentation, language, and learning media. The structured integration of curriculum-aligned material enhances student understanding of complex chemistry

concepts, while the interactive features of Liveworksheet significantly improve engagement. This research contributes to the advancement of chemistry learning by offering an innovative approach to integrating wetland ecosystem topics, fostering critical thinking, and encouraging collaborative learning. The findings highlight the potential of this e-module to address challenges in chemistry education by providing an accessible, interactive, and student-centered learning tool. Future implementation on a broader scale could further enhance students' motivation and learning outcomes, supporting more effective and engaging chemistry education.

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Author Contributions

Conceptualization, R. and A.H.; methodology, P.S. & L.A.L.R.; software, preparation of original writing draft, M.N.A.; formal analysis, investigation, M.; resource, project administration, P.S.; data curation, supervision, R.; writing-review and editing, visualization, L.A.L.R.; acquisition of funds, R., A.H., P.S., and M.

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Conflicts of Interest

This research involves no conflicts of interest, and all funding sources are acknowledged in the manuscript. The authors declare that this research complied with ethical guidelines, safeguarding the dignity, rights, and well-being of participants.

References

Addas, R. K., Muliati, M., & Patak, A. A. (2022). Exploring the Use of Content and Language Integrated Learning for Online Learning in Chemistry Major. *International Journal of Humanities and Innovation (IJHI)*, *5*(1), 8-14. https://doi.org/10.33750/ijhi.v5i1.140

Alenezi, M., Wardat, S., & Akour, M. (2023). The Need of Integrating Digital Education in Higher Education: Challenges and Opportunities. *Sustainability (Switzerland)*, *15*(6). https://doi.org/10.3390/su15064782

Aprilia, A., Sari, M. M., & Putri, R. F. (2023). Development of Student Worksheets in the Context of Wetlands in the Sub-Material of Water Pollution in Grade VII Middle School. *Journal of World Science*, *2*(7), 977–988. https://doi.org/10.58344/jws.v2i7.337

Argarini, D. F., & Najibah, D. (2023). Pengembangan Liveworksheets Interaktif untuk Meningkatkan Kemampuan Berpikir Kritis Siswa. *Prismatika: Jurnal Pendidikan dan Riset Matematika*, *6*(1), Article 1. https://doi.org/10.33503/prismatika.v6i1.3412

Aulia, P. I., & Rudyatmi, E. (2023). Development of E-Module Materials on Plants Structure and Tissue Function Based on Discovery Learning for High School Students. *Journal of Biology Education*, *12*(1), 53–60. https://doi.org/10.15294/jbe.v12i1.61519

Barus, R. A. (2024). 4C Skills of The 21st Century: Their Nature and Importance in Primary School Learning. *Multidisciplinary Indonesian Center Journal (MICJO)*, *1*(2). https://doi.org/10.62567/micjo.v1i2.88

Branch, B. (2009). *Instructional Design: The ADDIE Approach*. Library of Congress.

Campbell, D. (2020). Wetlands. In *Encyclopedia of the World's Biomes* (Vols 4–5, pp. 99–113). https://doi.org/10.1016/B978-0-12-409548-9.11810-X

Chiu, M.-H. (2022). My Journey in Chemistry Education. *Pure and Applied Chemistry*, *94*(8), 919–941. https://doi.org/10.1515/pac-2021-1103

Chotimah, P. C., Helmi, H., & Arafah, K. (2024). Development of Physics Teaching Modules Oriented to Scientific Approach to Improve Students' Science Process Skills. *Jurnal Penelitian Pendidikan IPA*, *10*(12), 10116–10123. https://doi.org/10.29303/jppipa.v10i12.8960

Chun, T. C., & Abdullah, M. N. L. Y. (2022). Contemporary Practices in Teaching 21st Century Skills at Malaysian Primary Schools: Do Environmental Factors and Teacher's Attitudes Matter? *Asia Pacific Journal of Educators and Education*, *37*(1), 61–85. https://doi.org/10.21315/apjee2022.37.1.4

Fernandes, N., Welsman, A., Yeager, T., Rajaraman, G., & Sinnayah, P. (2024). Wiki Technology in Block Teaching and Blended Learning: Fostering Development of 4C 21st Century Skills - Critical Thinking, Communication, Collaboration and Creativity. *Journal of Block and Intensive Learning and Teaching*, *11*(2). https://doi.org/10.15209/jbilt.1322

Fitri, M. N., Asrizal, A., Amnah, R., Hidayati, H., Emiliannur, E., & Helma, H. (2024). Development of Global Warming E-Module Integrated with PBL Model and Ethnoscience to Promote Students'

Environmental Literacy. *Jurnal Penelitian Pendidikan IPA*, *10*(11). https://doi.org/10.29303/jppipa.v10i11.9059

Hasbie, M., Abdullah, A., Rusmansyah, R., Aufa, M. N., Fitri, M. A., Saputra, M. A., & Hairunnisa, H. (2023). Development of Science Module on the Topic of Interaction of Living Things and the Environment Using the Scientific Critical Thinking (SCT) Model to Improve Critical Thinking Ability and Self-Efficacy. *Jurnal Penelitian Pendidikan IPA*, *9*(3), 1348–1351. https://doi.org/10.29303/jppipa.v9i3.2458

Hendrawensi, H., Hidayati, A., Fetri, Y., & Zurwina, Z. (2024). Development of Electronic Module (E-Module) Based on Case Method in Science Subjects at Junior High School. *Jurnal Penelitian Pendidikan IPA*, *10*(6), 3486–3492. https://doi.org/10.29303/jppipa.v10i6.6796

Hoover, K. S. (2021). Evaluating Impacts of a Wetland Field Trip: A Case Study with Urban Middle School Students. *Applied Environmental Education & Communication*, *20*(3), 203–220. https://doi.org/10.1080/1533015X.2020.1754967

Ismail, M., Supeno, S., & Rusdianto, R. (2024). Development of Web-Based Modules to Improve Digital Literacy and Learning Outcomes in Science Learning. *Jurnal Paedagogy: Jurnal Penelitian dan Pengembangan*, *11*(3), 451–451. https://doi.org/10.33394/jp.v11i3.11133

Jason, J. (2023). Exploring Experiential Learning: Enhancing Secondary School Chemistry Education Through Practical Engagement and Innovation. *Journal of Education, Humanities and Social Sciences*, *22*, 475–484. https://doi.org/10.54097/ehss.v22i.12508

Mariano, W. K., & Chiappe, A. (2021). 21st-Century skills and Their Relationship to STEAM Learning Environments: A Review. *Revista de Educación a Distancia*, *21*(68). https://doi.org/10.6018/red.470461

Melinia, S., Ismet, I., & Yusup, M. (2024). Development of Physics Module Based on Ethnoscience with the Local Wisdom of House Limas Palembang to Improve Thinking Ability. *Jurnal Penelitian Pendidikan IPA*, *10*(11), 8319–8327. https://doi.org/10.29303/jppipa.v10i11.8654

Mennani, M., Raouf, K., & Khyati, A. (2023). Investigation the Association between the Moroccan High School Chemistry Program and Students' Reasoning. *Journal of Educational and Social Research*, *13*(5), 279–297. https://doi.org/10.36941/jesr-2023-0137

Paristiowati, M., Dianhar, H., Hasibuan, N. A. P., & Fitriani, F. (2024). Integration of Various Digital Media with Flipped Classroom Models in Chemistry Learning: An Analysis of Student Activities. *Orbital: Jurnal Pendidikan Kimia*, *8*(1), 104–118. https://doi.org/10.19109/ojpk.v8i1.21928

Purnamasari, E. F., Maasawet, E. T., Hudiyono, Y., Subagiyo, L., Herliani, H., & Akhmad, A. (2024). Effectiveness of Biology E-Module Teaching Materials Based on Flip Pdf Professional Application to Improve Learning Outcomes and Critical Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, *10*(11), 8892–8898. https://doi.org/10.29303/jppipa.v10i11.9147

Ramachandra, T. V., Asulabha, K. S., Jaishanker, R., & Sincy, V. (2024). Editorial Wetlands for Human Well-Being. *Journal of Environmental Biology*, *45*(2), i–iv. https://doi.org/10.22438/jeb/45/2/Editorial

Rano, R., Kochkarova, K., & Erkhan, T. (2023). Improving the Methodology of Teaching Chemistry Lessons at School with the Help of Different Games. *American Journal of Applied Science and Technology*, *3*(10), 15–19. https://doi.org/10.37547/ajast/volume03issue10-04

Rusmansyah, R., Abdul, H., Aufa, M. N., & Isnawati, I. (2023a). Validity and Reliability of Scientific Critical Creative Thinking Model to Improve Critical Thinking Skills and Creative of Chemistry Teachers Candidates. *AIP Conference Proceedings*, *2673*. Retrieved from https://pubs.aip.org/aip/acp/article-abstract/2673/1/120006/2885340/Validity-and-reliability-of-scientific-critical

Rusmansyah, R., Rahmah, S. A., Syahmani, S., Hamid, A., Isnawati, I., & Kusuma, A. E. (2023b). The Implementasi Model PjBL-STEAM Konteks Lahan Basah untuk Meningkatkan Kemampuan Berpikir Kritis dan Self-Efficacy Peserta Didik. *JINoP (Jurnal Inovasi Pembelajaran)*, *9*(1). https://doi.org/10.22219/jinop.v9i1.23493

Saputra, M. A., Hadi, S., Sholahuddin, A., Sulastri, A., Hasbie, M., Aufa, M. N., & Fitri, M. A. (2023). The Validity of Science Module with the Collaborative Based Science Learning Model to Improve Critical Thinking Skills and Decision Making Skills. *Jurnal Penelitian Pendidikan IPA*, *9*(2), 639–644. https://doi.org/10.29303/jppipa.v9i2.2496

Saputra, R. S., & Octavia, B. (2024). E-Module Assisted by Augmented Reality with a Discovery Learning Model on Virus Material to Increase Scientific Literacy and Learning Independence for Class X High School Students. *Jurnal Penelitian Pendidikan IPA*, *10*(11), 8507–8518. https://doi.org/10.29303/jppipa.v10i11.8795

Sugiyono, S. (2022). *Metode Penelitian Kuantitatif, Kualitatif, R & D*. Bandung: CV Alfabeta.

Sulastri, A., Badruzsaufari, B., Dharmono, D., Aufa, M. N., & Saputra, M. A. (2022). Development of Science

Handouts Based on Critical Thinking Skills on the Topic of the Human Digestive System. *Jurnal Penelitian Pendidikan IPA*, *8*(2), 475–480. https://doi.org/10.29303/jppipa.v8i2.1156

Syahri, W., Fuldiaratman, F., & Ekaputra, F. (2024). Development of Project Based Learning E-Modules in Chemistry Learning Design Course Using Flipbook Builder Application. *Jurnal Penelitian Pendidikan IPA*, *10*(11), 8311–8318. https://doi.org/10.29303/jppipa.v10i11.8686

Ula, A., Setyono, P., Yamtinah, S., & Havyarimana, C. (2025). Validity of the Content of Science E-Module Based on Problem Based Learning Containing Ethnoscience to Improve Students' Critical Thinking Ability. *Jurnal Pendidikan Sains Indonesia*, *13*(1), 158-177. https://doi.org/10.24815/jpsi.v13i1.41509

Utaminingsih, E. S., & Ellianawati, E. (2025). Development of Steam-Based E-Modules on Human Circulatory Topics Containing Critical Reasoning and Independent Characters. *Turkish Online Journal of Distance Education*, *26*(1). https://doi.org/10.17718/tojde.1368962

Vuorio, E., Pernaa, J., & Aksela, M. (2024). Lessons for Sustainable Science Education: A Study on Chemists' Use of Systems Thinking across Ecological, Economic, and Social Domains. *Education Sciences*, *14*(7). https://doi.org/10.3390/educsci14070741

Widoyoko, E. P. (2012). *Teknik Penyusunan Instrumen Penelitian*. Yogyakarta: Pustaka Pelajar. Retrieved from http://library.stik-ptik.ac.id/detail?id=49195&lokasi=lokal

Yantoro, Y., Sholeh, M., Budiono, H., & Sastrawati, E. (2024). Development of an Integrated Teaching Module for TaRL Approach Based on Differentiated Learning. *Jurnal Penelitian Pendidikan IPA*, *10*(12), 10178–10187. https://doi.org/10.29303/jppipa.v10i12.9166

Yulando, S., Sutopo, S., & Chi, T. F. (2019). Electronic Module Design and Development: An Interactive Learning. *American Journal of Educational Research*, *7*(10), 694–698. https://doi.org/10.12691/education-7-10-4

Yuliana, V., Copriady, J., & Erna, M. (2023). Pengembangan E-Modul Kimia Interaktif Berbasis Pendekatan Saintifik Menggunakan Liveworksheets pada Materi Laju Reaksi. *Jurnal Inovasi Pendidikan Kimia*, *17*(1), 1–12. https://doi.org/10.15294/jipk.v17i1.32932

Zhang, X., Feng, L., Cheng, G., Wang, R., Li, W., & He, Y. (2024). Transformation of Education in the Digital Age: Theory and Practice of Constructing a Digital University and Lifelong Learning System. *ACM International Conference Proceeding Series*, 160–167. https://doi.org/10.1145/3696230.3696260