JPPIPA 10(11) (2024)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

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

Interactive E-Book Colligative Properties of Solutions: Connecting Science and Society in Chemistry Learning

Muhammad Anwar[1], Alimin[1], Munawwarah[1*]

[1] Chemistry Education Study Program, FMIPA, Universitas Negeri Makassar, Makassar, Indonesia

Received: July 19, 2024
Revised: September 08, 2024
Accepted: November 25, 2024
Published: November 30, 2024

Corresponding Author:
Munawwarah
munawwarah@unm.ac.id

DOI: 10.29303/jppipa.v10i11.8579

Abstract: This study presents the development of an interactive e-book on the colligative properties of solutions in chemistry. The primary objective of this e-book is to enhance student engagement and understanding by integrating socio-scientific issues (SSI) to connect the material with everyday topics. The development methodology followed Borg and Gall's research and development approach, limited to the fifth stage, which is the main product revision. Validation instruments included both content validation and media validation. Interactive aspects of the e-book feature links in the table of contents, video displays, and a comprehensive presentation of questions complete with scores and solutions in the practice and competency test sections. Content validation results indicated that the e-book is valid, while media validation results placed it in the highly valid category. The incorporation of SSI aims to provide a relevant and engaging learning experience for students.

Keywords: Colligative properties; Interactive e-book; Learning media.

Introduction

In the contemporary educational landscape, the integration of digital technologies with pedagogical methodologies has transformed traditional learning paradigms, offering innovative avenues for student engagement and understanding. Integrating Information and Communication Technology (ICT) into the educational process significantly benefits both teachers and students (Ghavifekr & Rosdy, 2015). Chemistry, a cornerstone of scientific education, often presents significant cognitive challenges due to its abstract nature and complex concepts. but of course this requires appropriate methods so that learning runs in accordance with the learning objectives (Henrie et al., 2015). Among these, the study of colligative properties of solutions is pivotal, encompassing phenomena such as boiling point elevation, freezing point depression, vapor pressure lowering, and osmotic pressure (Akhter & Alam, 2023). These properties are not only fundamental to the discipline but also have extensive applications in both everyday life and industrial processes.

Colligative properties, defined as properties of solutions that depend on the ratio of solute particles to solvent molecules, rather than the identity of the solute itself, play a critical role in both theoretical and applied chemistry. Understanding these properties is essential for grasping how solutes affect the physical properties of solvents (Lauth, 2023). For instance, the use of antifreeze in car radiators, the effectiveness of saline solutions in medical treatments, and the preservation of food through freezing are all practical applications of colligative properties (Atkins et al., 2023).

In academic settings, the mastery of these concepts is crucial for students as they navigate through complex chemical equations and predict the outcomes of various chemical reactions. However, traditional methods of teaching these properties often fall short in making these abstract concepts tangible and relatable to students' daily lives one of which is proven through observing manual laboratory activities and virtual laboratories

How to Cite:
Munawwarah, Anwar, M., & Alimin. (2024). Interactive E-Book Colligative Properties of Solutions: Connecting Science and Society in Chemistry Learning. *Jurnal Penelitian Pendidikan IPA*, *10*(11), 9208–9215. https://doi.org/10.29303/jppipa.v10i11.8579

(Penn & Ramnarain, 2019). The interactive e-book addresses this gap by offering a multidimensional learning experience that combines theoretical knowledge with practical applications, thereby fostering a deeper understanding and appreciation of chemistry (Anwar, 2021; Munawwarah & Anwar, 2016; Wahyuni et al., 2019).

Socio-Scientific Issues (SSI) pedagogy integrates scientific content with societal concerns, promoting an educational framework that is both relevant and reflective of real-world complexities (Fang et al., 2019; Sadler et al., 2016). By incorporating SSI into the study of colligative properties, the e-book not only enhances students' grasp of chemical principles but also encourages them to consider the broader societal context in which these principles operate (Rahayu, 2019). This method engages students in discussions about environmental sustainability, public health, and ethical implications, thereby enriching their scientific inquiry with a multidimensional perspective (Genisa et al., 2020; Zuin et al., 2021).

For example, the environmental impacts of road salting for ice control, the ethical considerations in pharmaceutical formulations, and the societal benefits and risks associated with water purification methods are all topics that can be explored through the lens of colligative properties. By engaging with socio-scientific issues, students can better appreciate the relevance of chemistry in addressing societal challenges, thus preparing them to contribute meaningfully to discussions that intertwine science and social responsibility (Fisher, 2019). This approach not only supports the development of scientific knowledge but also fosters a sense of responsibility and critical thinking (Pratiwi et al., 2016), preparing students to be informed and engaged citizens (Rahayu et al., 2018).

Interactive e-books represent a significant advancement in educational technology, offering a dynamic and engaging alternative to traditional textbooks. These digital tools integrate multimedia elements such as animations, interactive simulations, and quizzes, which cater to various learning styles and enhance the retention of complex concepts. The utilization of the "Chemistry Challenge" e-book also contributes positively to enhancing students' chemical literacy levels (Pratama & Rohaeti, 2024). In the context of colligative properties, interactive simulations can vividly illustrate how different solutes affect the physical properties of solvents, providing a visual and hands-on learning experience that traditional methods cannot offer .

The "Interactive E-Book Colligative Properties of Solutions" is designed to harness these technological advantages, making chemistry more accessible and engaging for students. By incorporating interactive elements, the e-book facilitates a deeper understanding of how theoretical concepts manifest in practical applications, thus bridging the gap between classroom learning and real-world experience.

The "Interactive E-Book Colligative Properties of Solutions: Securing Science and Society in Chemistry Learning" represents a forward-thinking approach to chemistry education, integrating advanced technological tools with a robust pedagogical framework. By aligning the study of colligative properties with socio-scientific issues, this e-book not only enhances students' understanding of key chemical concepts but also prepares them to navigate and contribute to the complex interconnections between science and society. This approach promotes scientific literacy by encouraging students to navigate the multifaceted nature of these issues, thereby enhancing their ability to engage with and contribute to societal discussions (Ke et al., 2023). Similarly, illustrate how case studies, such as the Flint water crisis, can be utilized to introduce concepts of equity and power within the chemistry curriculum. This method contextualizes chemical education and empowers students to recognize and address the socio-political dimensions of scientific problems (Buckley & Fahrenkrug, 2020).

By focusing on the intersection of science and societal relevance, this e-book promotes a deeper understanding of how colligative properties impact various industries and everyday life. The interactive features allow students to engage with the material in a dynamic and immersive way, fostering active learning and critical thinking skills. This research connects the concept of colligative properties of solutions with various socio-scientific issues, marking a novel development in the field. Previous studies have developed educational materials on similar topics but have employed different approaches. Therefore, this research is significant as it addresses the numerous applications of colligative properties in various everyday life issues. Furthermore, the incorporation of societal connections encourages students to appreciate the practical implications of chemistry, thereby increasing motivation and interest in the subject.

Method

This research was conducted by adapting the development research model by Borg & Gall, limited to the fifth stage. The stages involved in the development of this interactive e-book can be seen in Figure 1.

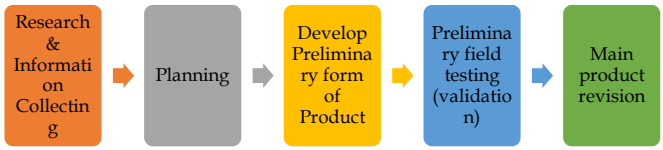


Figure 1. Development Stages Using the Borg & Gall Method Up to Stage 5

After the development of the e-book, content validation and media validation were conducted by two experts for each type of validation. The instruments are questioners included a content validity instrument to assess the validity of the content or material presented in the instructional material. The next instrument was the media validity instrument, which evaluated aspects such as appearance, features, writing, readability, etc. The criteria for the validity of this instructional material are presented in Table 1.

Table 1. Categories of Validity Levels

Score	Information
$3.5 \leq \overline{V} \leq 4$	HV (Highly Valid)
$2.5 \leq \overline{V} < 3.5$	V (Valid)
$1.5 \leq \overline{V} < 2.5$	SV (Sufficiently valid)
$\overline{V} < 1.5$	TV (Not Valid)

Result and Discussion

The Development of Interactive E-Book

This instructional material begins with analyzing the students' needs regarding digital teaching materials in chemistry learning. Subsequently, the researcher develops a storyboard tailored to the current curriculum. This storyboard serves as the foundation for developing interactive e-book instructional materials. It starts with creating learning indicators, constructing concept maps or material structures, followed by developing content descriptions and exercises aligned with the learning indicators. It integrates the Socio-Scientific Issues (SSI) approach and creates competency test questions.

The development of concept maps or material structures aims to create a sequence and demonstrate the connections between sub-topics explained within the e-book. Through concept mapping, students' understanding of a subject matter can be enhanced (Malekzadeh et al., 2020). Competency indicators are outlined to serve as references in developing the learning material described in the instructional materials. These indicators are based on the current curriculum to ensure that the developed teaching materials can enhance students' competencies according to applicable standards.

The next step involves integrating the presented material with the SSI approach, aiming to demonstrate to users of the instructional materials the connections and applications of concepts presented within current environmental and societal issues. The instructional approach shows positive outcomes in planning, developing, and resolving issues related to SSI learning (Genisa et al., 2020). Competency test questions are designed to assess users' understanding of the instructional material after studying the content presented in the e-book.

The developed storyboard is incorporated into an interactive e-book application. All aspects outlined in the storyboard are included in the application used to compose the e-book, enriched with interactive elements such as videos, images, audio, links to relevant websites, and a feature for answering questions that provides immediate results and feedback. The front page layout of this instructional e-book can be viewed in Figure 2.

Figure 2. The Cover

The cover of this e-book is designed to showcase scientific aspects and their relevance to social issues in everyday life. The cover is crafted to be communicative and represent the content of the book comprehensively. Next, the interface of using this interactive e-book can be seen in Figure 3.

The purpose of this user guide is to provide information to help users more easily access this digital book. This page outlines various sections, including how to open the book, use different features, interact with the content, and navigate the table of contents. Figure 4 shows the table of contents and a description of the competency indicators that are expected to be achieved after students use this instructional material.

Figure 3. Page of User Guide

The table of contents feature in this e-book simplifies the process for students to explore the desired material without having to browse through pages one by one. Users can click on the entries in the table of contents and be taken directly to the specific pages. This is one of the interactive aspects of this e-book. Additional interactive aspects of the e-book can be seen in Figure 5.

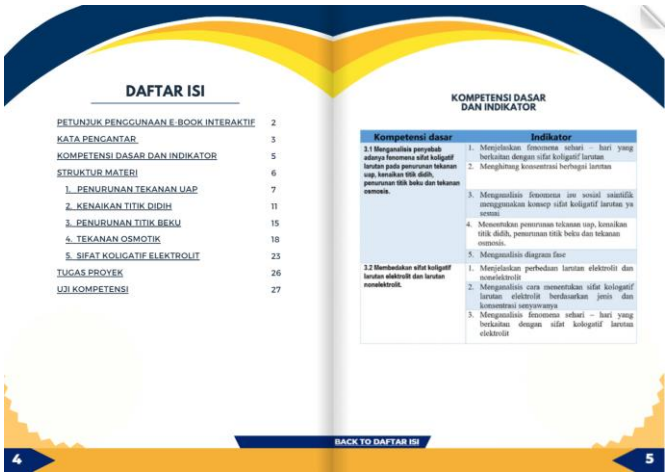
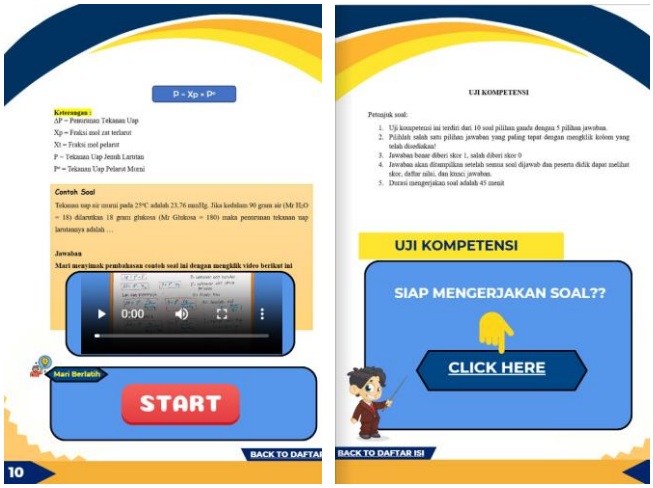


Figure 4. Table of Contents, Basic Competencies, and Indicators

Figure 5 illustrates several interactive features presented in this e-book. The figure shows that the developed e-book includes video presentations as an audiovisual feature. Additionally, there are buttons in the "Let's Practice" section for completing exercises and in the "Competency Test" section at the end of the entire learning module. These features allow users to answer questions related to the material they have studied, and upon completing the practice exercises, students will immediately see their scores and the answer keys. This feature helps students learn independently using this e-book. This aligns with the research conducted by Munawwarah et al. (2017) which found that interactive e-books can help students gain knowledge independently.



(a) (b)

Figure 5. Interactive Aspects in E-book

Apart from the interactive side, the integration of Socio-Scientific Issues (SSI) aspects in this e-book is one of the most important parts of its presentation. This is a distinctive feature of this instructional material. Figure 6 illustrates an example of the SSI approach used in the developed material. By incorporating SSI aspects into the instructional content, students are expected to develop critical thinking skills through the exploration of issues occurring in daily life (López-Fernández et al., 2022). Moreover, SSI-based learning has been linked to improved scientific literacy (Chowdhury et al., 2020).

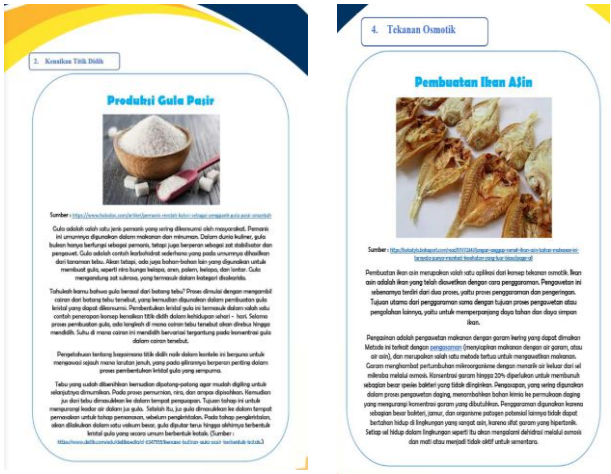


Figure 6. SSI Apect in E-Book

The relevance of SSI in education also extends to fostering student motivation and engagement (George et al., 2021). highlight that the inclusion of socio-scientific topics can significantly increase students' motivation to learn chemistry by demonstrating the subject's applicability to everyday life. This is

particularly important in a time when many students perceive science as disconnected from their personal experiences. By addressing contemporary issues through the lens of science, educators can create a more engaging and meaningful learning environment. This is further supported by Zidny & Eilks (2022) who emphasize that SSI-based education cultivates students' informal reasoning skills, allowing them to integrate their knowledge and confront controversial scientific dilemmas effectively.

Validation of Interactive E-Book

The validation of educational materials developed for teaching is a crucial step in ensuring their effectiveness, relevance, and quality. Validating educational materials through expert review and empirical testing not only enhances their credibility but also ensures that they meet the educational needs of students. One significant reason for validating educational materials is to ensure content validity. Lau et al. (2023) highlight that expert validation is essential for assessing the relevance and accuracy of educational content. This process involves input from subject matter experts who evaluate the material's alignment with educational standards and learning objectives. Similarly, Martínez-Riera et al. (2022) emphasize that content validation through expert review is critical for developing educational modules that are scientifically rigorous and effective in achieving learning outcomes.

Table 2. The validation data for each content aspect of the interactive e-book instructional material is presented.

E-Book Aspects	Average
Material Accuracy	3.70
Up-to-Dateness	3.33
Communicativeness	3.33
Overall Average	3.45

The validation data of the content and media of the SSI-based interactive e-book are presented in Figure 2 and Table 3, respectively.

Table 3. The validation data for each media aspect in the interactive e-book instructional material is presented.

E-book Aspects	Average Score
Media Design	3.78
Navigation / Media Operation	3.88
Overall average	3.83

There are two types of validation conducted on this instructional material: content validation and media validation. Content validation aims to ensure the accuracy of the material presented in the instructional material. This validation includes verifying the correctness of the developed curriculum indicators, concepts, theories, and laws presented in accordance with the developed indicators, as well as the accuracy in writing reactions and molecules of compounds. This process involves two validators from the chemistry department faculty.

In addition to content validation, media validation was also conducted by two media experts. This was done to assess the suitability of instructional material presented in electronic form. Several aspects reviewed in this validation include the appearance of the interactive e-book (font types, background usage, and accuracy in positioning images according to margins) and the functionality of features within the instructional material. The validity level category of this interactive e-book content is classified as "Valid" with a validity level of 3.45. The validity level category of this interactive e-book media is classified as "Highly Valid" with a validity level of 3.83. Based on both content and media validation results, the developed interactive e-book instructional material has achieved validity standards.

The results of this content validation identified several aspects that needed improvement: the first is about "*accessibility of the link to our interactive e-book ... this interactive e-book?"*. The second is foreign words should be italicized. The next is about Improve several terms in the e-book to use standard terminology and be more appropriate. Several parts of "Basic Competencies" need to be revised. In this section, the questions and answer choices presented in the test are included.

Another aspect is the writing, which involves constructing sentences with clear meaning and maintaining consistency in writing chemical compound formulas. One of the primary reasons for ensuring clarity in chemical formulas is to facilitate understanding among students and professionals. According to (Suastika & Utami, 2023) clear communication in educational materials is crucial for effective learning. When chemical formulas are presented in a consistent manner, it reduces ambiguity and enhances comprehension, allowing students to grasp complex concepts more easily. Moreover, consistency in writing chemical formulas is vital for maintaining scientific accuracy. Furthermore, the use of standardized notation in chemical formulas promotes effective collaboration among scientists. Kelana et al. (2023) emphasize that clear and consistent communication is essential for interdisciplinary collaboration, particularly in research settings where chemists must work alongside professionals from other fields. Improvements in sentence structure and indicators are considered necessary because they are essential in delivering the material in the instructional material.

Conclusion

Teaching materials in the form of an interactive e-book on the topic of colligative properties of solutions have been developed in accordance with the current curriculum. The development of the e-book began with the creation of a storyboard as a reference for developing the interactive e-book. Several interactive aspects of the e-book include links in the table of contents, features for completing practice questions and competency tests, and video presentations. The teaching materials present Socio-Scientific Issues (SSI) as an approach to studying the content in the e-book. Content validation falls into the valid category, while media validation is categorized as very valid.

Acknowledgments
We would like to extend our deepest gratitude to Universitas Negeri Makassar for their invaluable financial support through the PNBP funding, which was instrumental in the successful execution of our research on the "Interactive E-Book on Colligative Properties of Solutions: Connecting Science and Society in Chemistry Learning." Our sincere appreciation goes to the Faculty of Mathematics and Natural Sciences for providing the necessary resources and an encouraging research environment. Special thanks to our research team members whose dedication, hard work, and insightful contributions were crucial to the development of this interactive e-book; their commitment to excellence and innovative approach played a significant role in bringing this project to fruition. We would also like to acknowledge the valuable feedback from our colleagues and students, whose constructive input helped us refine and improve the e-book, aligning our content with the learning needs and scientific literacy goals we aimed to achieve. Finally, we appreciate the support and encouragement from our families and friends, whose patience and understanding allowed us to devote the necessary time and effort to this research. Thank you to everyone who believed in this project and contributed to its success.

Author Contributions
M.A., A., M.: Conceptualization and methodology. M.A..; validation and revision. A.,: formal analysis, and resources. M.: writing—original draft preparation, visualization and revision All authors have read and agreed to the published version of the manuscript.

Funding
The development and research of the project titled "Interactive E-Book on Colligative Properties of Solutions: Connecting Science and Society in Chemistry Learning" were generously funded by the PNBP (Non-Tax State Revenue) of the Faculty of Mathematics and Natural Sciences, Universitas Negeri Makassar. This support was instrumental in advancing the integration of socio-scientific issues into the chemistry curriculum, enhancing the educational experience for students and educators alike.

Conflicts of Interest
The authors of this research hereby declare that there are no conflicts of interest related to this study. The research was conducted independently, without any influence from external financial, professional, or personal interests that could have affected the outcomes or the integrity of the research. All findings and conclusions presented are solely the result of the authors' analysis and efforts.

References

Akhter, M., & Alam, M. M. (2023). Colligative Properties. In *Physical Pharmacy and Instrumental Methods of Analysis* (pp. 21–44). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-36777-9_3

Anwar, M. (2021). An interactive e-book development based on green chemistry study on Hydrocarbon. *Journal of Physics: Conference Series*, *1899*(1), 12161. https://doi.org/10.1088/1742-6596/1899/1/012161

Atkins, P. W., Paula, J., & Keeler, J. (2023). *Atkins' physical chemistry*. Oxford university press.

Buckley, P. D., & Fahrenkrug, E. (2020). The Flint, Michigan Water Crisis as a Case Study to Introduce Concepts of Equity and Power Into an Analytical Chemistry Curriculum. *Journal of Chemical Education*. https://doi.org/10.1021/acs.jchemed.9b00669

Chowdhury, T., Holbrook, J., & Rannikmäe, M. (2020). Socioscientific Issues Within Science Education and Their Role in Promoting the Desired Citizenry. *Science Education International*. https://doi.org/10.33828/sei.v31.i2.10

Fang, S.-C., Hsu, Y.-S., & Lin, S.-S. (2019). Conceptualizing socioscientific decision making from a review of research in science education. *International Journal of Science and Mathematics Education*, *17*, 427–448. https://doi.org/10.1007/s10763-018-9890-2

Fisher, M. (2019). Systems Thinking and Educating the Heads, Hands, and Hearts of Chemistry Majors. *Journal of Chemical Education*. https://doi.org/10.1021/acs.jchemed.9b00346

Genisa, M. U., Subali, B., Agussalim, A., & Habibi, H. (2020). Socio-Scientific Issues Implementation as Science Learning Material. *International Journal of Evaluation and Research in Education*, *9*(2), 311–317. Retrieved from https://eric.ed.gov/?id=EJ1256085

George, A., Zowada, C., Eilks, I., & Gulacar, O. (2021). Exploring Chemistry Professors' Methods of Highlighting the Relevancy of Chemistry: Opportunities, Obstacles, and Suggestions to Improve Students' Motivation in Science Classrooms. *Education Sciences*.

https://doi.org/10.3390/educsci11010013

Ghavifekr, S., & Rosdy, W. A. W. (2015). Teaching and learning with technology: Effectiveness of ICT integration in schools. *International Journal of Research in Education and Science*, *1*(2), 175–191. Retrieved from https://eric.ed.gov/?id=EJ1105224

Henrie, C. R., Halverson, L. R., & Graham, C. R. (2015). Measuring student engagement in technology-mediated learning: A review. *Computers & Education*, *90*, 36–53. https://doi.org/10.1016/j.compedu.2015.09.005

Ke, L., Kirk, E., Lesnefsky, R., & Sadler, T. D. (2023). Exploring System Dynamics of Complex Societal Issues Through Socio-Scientific Models. *Frontiers in Education*. https://doi.org/10.3389/feduc.2023.1219224

Kelana, A. J., Irfan, D., Maksum, H., Wulansari, R. E., & Efrizon. (2023). Flipbook Based E-Module With Case Method in Vehicle Testing Course. *Journal for Lesson and Learning Studies*. https://doi.org/10.23887/jlls.v5i3.57186

Lau, P. N., Teow, Y., Tammy Low, X. T., & Bernice Tan, S. T. (2023). Integrating Chemistry Laboratory–tutorial Timetabling With Instructional Design and the Impact on Learner Perceptions and Outcomes. *Chemistry Education Research and Practice*. https://doi.org/10.1039/d2rp00055e

Lauth, J. S. (2023). Solutions. In *Physical Chemistry in a Nutshell* (pp. 99–109). Springer. https://doi.org/10.1007/978-3-662-67637-0_7

López-Fernández, M. D. M., González-García, F., & Franco-Mariscal, A. J. (2022). How can socio-scientific issues help develop critical thinking in chemistry education? a reflection on the problem of plastics. *Journal of Chemical Education*, *99*(10), 3435–3442. https://doi.org/10.1021/acs.jchemed.2c00223

Malekzadeh, N., Ghasemizad, A., Taheri, A., & Mashayekh, P. (2020). The Effect of Concept Map on Academic Achievement of Thinking and Media Literacy Course. *Propósitos y Representaciones*, *8*. https://doi.org/10.20511/pyr2020.v8nSPE3.762

Martínez-Riera, J. R., González, C. I. A., Bermeo, R. N. Z., Curcio, F., Correa, J. A. G., González, C. E., Melo, P., & Galletta, M. (2022). Educational Strategies to Promote Adherence to Treatment in Patients With Cardiovascular Disease. *International Journal of Environmental Research and Public Health*. https://doi.org/10.3390/ijerph19169841

Munawwarah, M., Anwar, S., & Sunarya, Y. (2017). How to Develop Electrochemistry SETS-Based Interactive E-Book? *Journal of Physics: Conference Series*, *895*, 12112. https://doi.org/10.1088/1742-6596/895/1/012112

Munawwarah, P., & Anwar, S. (2016). The Development of Interactive E-Book Learning Materials Through 4S TMD. In *ISQAE 2016 INTERNATIONAL SEMINAR ON QUALITY & AFFORDABLE* (p. 402). Retrieved from https://shorturl.asia/jqZPn

Penn, M., & Ramnarain, U. (2019). A comparative analysis of virtual and traditional laboratory chemistry learning. *Perspectives in Education*, *37*(2), 80–97. https://doi.org/10.18820/2519593X/pie.v37i2.6

Pratama, F. I., & Rohaeti, E. (2024). How does "chemistry challenge" e-book affect the chemical literacy profile? A study to test learning media effectiveness. *Jurnal Penelitian Pendidikan IPA*, *10*(5), 2253–2260. https://doi.org/10.29303/jppipa.v10i5.7018

Pratiwi, Y. N., Rahayu, S., & Fajaroh, F. (2016). Socioscientific issues (SSI) in reaction rates topic and its effect on the critical thinking skills of high school students. *Jurnal Pendidikan IPA Indonesia*, *5*(2), 164–170. https://doi.org/10.15294/jpii.v5i2.7676

Rahayu, S. (2019). Socio-scientific issues (SSI) in chemistry education: Enhancing both students' chemical literacy & transferable skills. *Journal of Physics: Conference Series*, *1227*(1), 12008. https://doi.org/10.1088/1742-6596/1227/1/012008

Rahayu, S., Setyaningsih, A., Astarina, A. D., & Fathi, M. N. (2018). High school students' attitudes about socioscientific issues contextualized in inquiry-based chemistry instruction. *Proceedings of the 2nd International Conference on Education and Multimedia Technology*, 80–84. https://doi.org/10.1145/3206129.3239436

Sadler, T. D., Romine, W. L., & Topçu, M. S. (2016). Learning science content through socio-scientific issues-based instruction: A multi-level assessment study. *International Journal of Science Education*, *38*(10), 1622–1635. https://doi.org/10.1080/09500693.2016.1204481

Suastika, I. N., & Utami, A. A. I. D. A. (2023). Test the Validity of the Multicultural Education Course at the E-Learning (Moodel Learning Management System) Universitas Pendidikan Ganesha. *ICLSSE 2022: Proceedings of the 4th International Conference on Law, Social Sciences, and Education, ICLSSE 2022, 28 October 2022, Singaraja, Bali, Indonesia*. https://doi.org/10.4108/eai.28-10-2022.2326354

Wahyuni, W. S., Anwar, S., Priscylio, G., Lestari, O., Agustina, N. R., & Oktasari, C. (2019). How to develop colligative properties of solution chemistry e-book based science process skills approach with 4S TMD models. *Proceeding*

STEMEIF, 225–238. Retrieved from https://digitallibrary.ump.ac.id/333/2/29. Full Paper_Weny.pdf

Zidny, R., & Eilks, I. (2022). education sciences Learning about Pesticide Use Adapted from Ethnoscience as a Contribution to Green and Sustainable Chemistry Education. *Education Sciences*. https://doi.org/10.3390/educsci12040227

Zuin, V. G., Eilks, I., Elschami, M., & Kümmerer, K. (2021). *Education in Green Chemistry and in Sustainable Chemistry: Perspectives Towards Sustainability*. In Green Chemistry. https://doi.org/10.1039/d0gc03313h