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Development of a Multi-Representation Electrochemistry E-Book Utilizing 3D PageFlip Technology

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ABSTRACT

Physical Chemistry II course in the Chemistry Education Study Program is one of the subjects with an abstract nature, such as Electrochemistry materials. The abstract nature of Electrochemistry makes it difficult for students to observe the processes occurring in Electrochemical systems directly. When explained theoretically, these concepts are often challenging for students to understand. Therefore, teaching Electrochemistry requires an e-book that incorporates chemical representations, particularly multiple representations. To address this, it is deemed necessary to develop an Electrochemistry e-book based on multiple representations using 3D PageFlip. This e-book integrates multiple representations, enabling students to independently study and comprehend Electrochemistry materials while providing flexibility and convenience. An Electrochemistry e-book with multiple representations, particularly in a computer-assisted learning format, is a viable alternative to support student learning. This study aims to develop an Electrochemistry e-book using 3D PageFlip based on multiple representations. This software allows the creation of interactive and engaging educational resources. The resulting e-book aims to enhance students' individual abilities and increase their interest and motivation, which in turn is expected to improve their academic performance and learning outcomes. Moreover, this multimedia learning tool is intended to address challenges related to students' limited comprehension during classroom learning processes, accommodate individual characteristics, and offer alternative solutions to the low self-actualization of students. Through this e-book, students can revisit and explore difficult concepts, facilitating deeper understanding. The ultimate goal of this research is to produce an Electrochemistry e-book based on multiple representations across macroscopic, microscopic, and symbolic levels using 3D PageFlip. This e-book will align with the applicable curriculum and adhere to educational principles while incorporating essential educational elements. By improving concept mastery in Electrochemistry, this resource is expected to enhance students' cognitive abilities and overall learning outcomes.

Keyword: eBook, electrochemistry, multi-representation, 3D Pageflip.

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INTRODUCTION

Based on the curriculum of the Chemistry Education Study Program at the Faculty of Teacher Training and Education (FKIP), Jambi University, Physical Chemistry I is a highly important course in the undergraduate program (S1). It is part of the Science and Expertise Courses (MKK) group. As an MKK course, Physical Chemistry I supports other Science and Expertise Courses. Chemistry holds a crucial position among other sciences as it can explain macro phenomena at the micro (molecular) level. Furthermore, Physical Chemistry I makes significant and meaningful contributions to the development of applied sciences, such as agriculture, health, fisheries, and technology.

Therefore, this course is essential. However, many students lack enthusiasm and interest in learning it, as evidenced by the low learning outcomes they achieve. This issue can be attributed to the course material, which is dense with theories and abstract concepts, requiring high reasoning skills at macroscopic, microscopic, and symbolic levels. To date, the teaching of Physical Chemistry I, particularly on the topic of Electrochemistry in the Chemistry Education Study Program at FKIP Jambi University, has been conducted using cooperative learning models. However, these efforts have not significantly improved student learning outcomes.

Multiple representations are forms of representation that integrate text, real images, or graphics. Learning through multiple representations is expected to bridge students' understanding of chemical concepts. Chemical representations are developed sequentially, starting from observable phenomena, chemical equations, atomic and molecular models, and symbols.

Johnstone (2000) categorizes chemical representations into three levels. The macroscopic level is tangible and involves visible and real chemical substances. The submicroscopic level, while also real, is not visible; it consists of particulate levels that can be used to explain the movement of electrons, molecules, particles, or atoms. Lastly, the symbolic level encompasses various types of representations, including images and algebraic symbols (Acree, 1995; Alessi, 2001; Bayraka, 2010; Elisa, E., Zurweni, Z., Wiratmaja, I. G., Nugraha, I. N. P., & Widayana, G., 2022).

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The teaching of chemistry so far has predominantly represented two phenomena: macroscopic and symbolic or mathematical, while the sub-microscopic level is hardly addressed. The role of these three levels of chemical phenomena in learning receives insufficient attention, leading to difficulties for students in transferring knowledge through interconnections between levels. As a result, students struggle to acquire the conceptual knowledge needed to solve problems. Conceptual knowledge is an essential component that students must possess when studying chemistry, as it should be stored in long-term memory and easily retrievable. For the knowledge acquired by students to enter long-term memory, they must be encouraged to use their mental models to connect these three levels of chemical phenomena (Chandrasegaran, 2007; Chittleborough, 2007; Chittleborough, 2008).

Several previous studies have shown that students consistently face difficulties in explaining sub-microscopic representations based on macroscopic and symbolic representations. Students tend to focus more on the transformation from the macroscopic level to the symbolic level but fail to transform from macroscopic and symbolic levels to the sub-microscopic level (Chandrasegaran, 2007; Chittleborough, 2007; Chittleborough, 2008; Sunyono, 2011). This is because the knowledge acquired and stored in memory is difficult to retrieve or is challenging to encode into long-term memory.

Students' difficulties in transforming between the macroscopic, symbolic, and sub-microscopic levels of chemical phenomena often stem from a lack of training in sub-microscopic representation. Traditional Basic Chemistry courses tend to separate these three levels, which hinders students' ability to interpret sub-microscopic structures of molecules, as highlighted by Devetak et al. (2009). Integrating all three levels in teaching can enhance conceptual understanding and problem-solving abilities (Acree, 1995; Alessi, 2001; Chandrasegaran, 2007; Chittleborough, 2008; Sunyono, 2011). Leveraging ICT-based learning tools, such as e-books with computer-assisted learning, provides an alternative approach to bridge these gaps. These tools not only foster independent learning but also address individual learning challenges, enhancing students' motivation and academic performance (Susanto, G.R.E., Elisa, E., & Dantes, K.R., 2024).

ICT-based e-books with features like 3D animations and virtual molecular models (Computerized Molecular Modeling) enable simultaneous visualization of molecular representations and processes at the molecular level. Such tools align with Mayer's cognitive theory and situative theory, supporting external symbolic representation transformation into mental models and inquiry-based learning (Chandrasegaran, 2007; Chittleborough, 2008; Sunyono, 2011). This approach improves students' understanding of macroscopic and microscopic concepts, particularly in subjects like Physical Chemistry I, with a focus on Electrochemistry. The development of a multiple-representation e-book tailored to the current curriculum and educational standards offers a practical solution to enhance the professional competence of future chemistry educators.

METHODS

The research was conducted in the Physical Chemistry Laboratory of UP-MIPA, Jambi University; the Basic Chemistry Laboratory of PMIPA FKIP, Jambi University; and the Computer and Programming Laboratory of the Chemistry Education Study Program, FKIP, Jambi University. The teaching of Physical Chemistry I was carried out with third-semester students of the Chemistry Education Study Program during the even semester of the 2020/2021 academic year. The entire research process, from preparation to report writing, involving the research team, took approximately six months. The study population consisted of 30 third-semester students enrolled in the Chemistry Education Study Program, all of whom were included as the sample.

The tools used in the study included standard laboratory equipment, whiteboards, markers, overhead projectors, transparency sheets, digital cameras, handy cams, and computers equipped with software such as ISIS Draw, 3D Pageflip, ACD Laboratory, Chem Office, and Flash. The materials included common chemicals for laboratory practices, course outlines for Physical Chemistry I, textbooks, and teaching media specifically developed for Electrochemistry using computer-assisted learning applications. The study adopted the ADDIE development model due to its clear and systematic approach suitable for designing computer-based learning media. The development process involved five stages: analysis, design, development, implementation, and evaluation. During the analysis phase, the researchers identified needs, student characteristics, course materials, and appropriate educational technology. The design phase included drafting learning media, creating flowcharts, and storyboarding to structure the media. The development phase utilized 3D Pageflip software to produce an interactive e-book featuring visuals, animations, texts, and background music, which was validated iteratively by media and content experts.

The implementation phase tested the validated e-book with a small group of 10 students. Finally, the evaluation phase involved formative assessments to refine the product based on feedback from experts and students.

The study collected both qualitative and quantitative data. Qualitative data included feedback from content and media experts, as well as student responses, to guide improvements in the learning media. Quantitative data, gathered through Likert-scale questionnaires, provided scores for evaluating the media's effectiveness and student engagement. Data analysis combined descriptive approaches for qualitative data and interval-scale processing for quantitative data, ensuring comprehensive evaluation of the 3D Pageflip-based Ideal Gas e-book as a teaching tool.

RESULTS AND DISCUSSION

In this study, the development model used for the e-Book on Electrochemistry Based on Multiple Representations Using 3D Pageflip is the ADDIE model, which consists of the following stages: i) Analysis, ii) Design, iii) Development, iv) Implementation, and v) Evaluation. Each stage of the ADDIE model is further elaborated in detail, specifically for the phases of analysis, design, development, implementation, and evaluation, and presented in the form of a development flowchart.

Examples of several e-Books on Electrochemistry developed using 3D Pageflip for Physical Chemistry II learning can be seen in Figures 1 and 2.

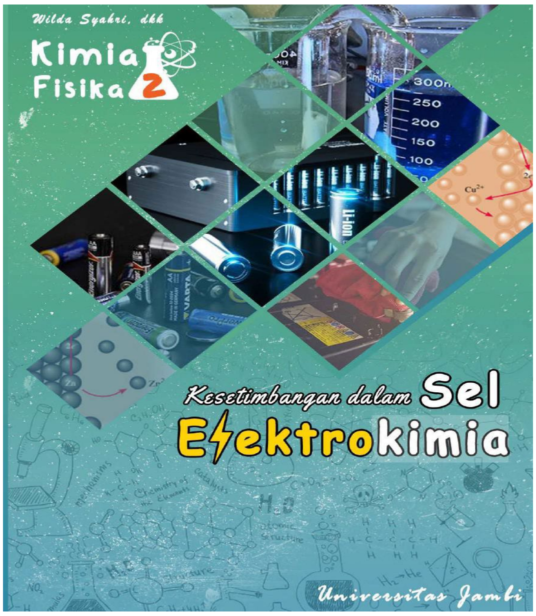

Figure 1. Book cover

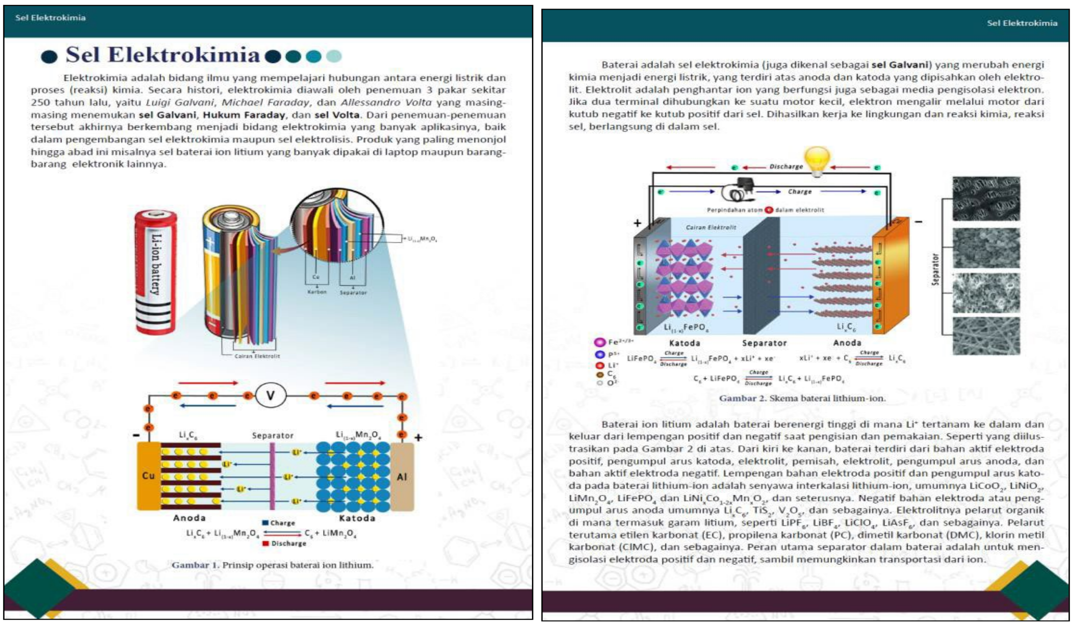

Figure 2. Examples of the contents of the Electrochemistry e-Book.

Data from the validation of content experts and the e-book using 3D Pageflip consists of two aspects: the content/learning material aspect and the e-book design aspect. The criteria for the content/learning material aspect were rated as "very good," and the criteria for the e-book design aspect were also rated as "very good" by the expert team.

Table 1. Quality of the Prototype Model of the Electrochemistry e-Book Using 3D Pageflip (Second Validation Results).

Aspects	Skor		Average	Interpretation
	Expert 1	Expert 2		
Image and Color Aspects	4,48	4,48	4,48	Very good
Video and Animation Aspects	4,48	4,46	4,47	Very good
Average	**4,48**	**4,47**	**4,475**	**Very good**

Table 2. Quality of Materials in the Electrochemistry e-Book Using 3D Pageflip (Second Validation Results)

Aspects	Skor		Average	Intepretation
	Expert 1	Expert 2		
Learning Aspects	4,46	4,46	4,46	Very good
Content Aspects	4,44	4,44	4,44	Very good
Average	**4,45**	**4,45**	**4,45**	**Very good**

Overall, the subject matter experts and e-book evaluators stated that as a new teaching material, this e-book can assist students in understanding Electrochemistry topics, especially abstract concepts at the microscopic level, while also making learning time more efficient. After being validated by experts, it is recommended that the Electrochemistry e-book using 3D Pageflip be made clearer and more detailed to facilitate its use by lecturers and students in classroom learning. Additionally, the cover design should be made more attractive and focused.

CONCLUSION

Learning with the Electrochemistry e-book using 3D Pageflip can explore students' individual abilities and create an appeal, thereby motivating students to improve their performance and learning outcomes. Additionally, this Electrochemistry e-book can bridge the limitations in students' comprehension abilities during classroom teaching and learning processes. It helps to understand and address the individual characteristics of students. Moreover, with the aid of this Electrochemistry e-book, it can overcome issues related to low self-actualization among students, allowing them to revisit and explore topics that are less understood through the e-book developed based on multiple representations.

The result of this research is an Electrochemistry e-book at the macroscopic, microscopic, and symbolic levels using the 3D Pageflip application, which aligns with the current curriculum, adheres to educational principles, and incorporates educational elements.

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REFERENCES

Arbi, Y., CIVED, M. I.-, & 2018, undefined. (n.d.). Pemanfaatan Limbah Cangkang Kelapa Sawit Menjadi Briket Arang Sebagai Bahan Bakar Alternatif. *Ejournal.Unp.Ac.Id*, *5*(4). Retrieved December 5, 2023, from https://ejournal.unp.ac.id/index.php/cived/article/view/102724

Elisa, E., Zurweni, Z., Wiratmaja, I. G., Nugraha, I. N. P., & Widayana, G. (2022). Peningkatan Keterampilan Dasar Laboratorium Kimia Teknik melalui Praktikum Mandiri Berbantukan Media Laboratorium Virtual di Masa Pandemi Convid 19. *Journal of The Indonesian Society of Integrated Chemistry, 14(1), 68 - 76*. https://doi.org/10.22437/jisic.v14i1.16837

Kahariayadi, A., Kahariayadi, A., Setyawati, D., haida, N., Diba, F., & Roslinda, E. (2016). Kualitas Arang Briket Berdasarkan Persentase Arang Batang Kelapa Sawit (Elaeis Guineensis Jacq) Dan Arang Kayu Laban (Vitex Pubescens Vahl). *Jurnal hhhhhhhHutan Lestari*, *3*(4), 561–568. https://doi.org/10.26418/jhl.v3i4.13182

Kaltim miliki 99 pabrik pengolahan kelapa sawit - ANTARA News Kalimantan Timur. (n.d.). Retrieved September 11, 2023, from https://kaltim.antaranews.com/berita/174753/kaltim-miliki-99-pabrik-pengolahan-kelapa-sawit

Kementerian ESDM RI - Media Center - Arsip Berita - Perusahaan Wajib Menjual Batubara Paling Rendah Sebesar HPB. (n.d.). Retrieved December 27, 2023, from https://www.esdm.go.id/id/media-center/arsip-berita/perusahaan-wajib-menjual-batubara-paling-rendah-sebesar-hpb

Martynis, M., Sundari, E., & Sari, E. (2012). Pembuatan Biobriket dari Limbah Cangkang Kakao. *Jurnal Litbang Industri*, *2*(1), 35–41. https://doi.org/10.24960/JLI.V2I1.598.35-41

Moeksin, R., Ade, K., Pratama, A., & Tyani, D. R. (2017). Pembuatan Briket Biorang Dari Campuran Limbah Tempurung Kelapa Sawit Dan Cangkang Biji Karet. In *Jurnal Teknik Kimia* (Vol. 23, Issue 3).

Nugraha, A., Nizar, M., Karakteristik, R., Limbah, B., Kayu, A., Berperekat Tapioka, A., Ramadhan, M. N., Yani, J. A., 36 Banjarbaru, K., & Selatan, K. (n.d.). *Multitek Indonesia: Jurnal Ilmiah Karakteristik Briket Limbah Arang Kayu Alaban Berperekat Tapioka*. http://journal.umpo.ac.id/index.php/multitek

Parinduri, L., & Parinduri, T. (2020). Konversi Biomassa Sebagai Sumber Energi Terbarukan. *JET (Journal of Electrical Technology)*, *5*(2), 88–92.

Purba, K. P. S. B. R., & Sirajuddin, S. (2021). Pengaruh Waktu Dan Kecepatan Udara Pada Proses Oksidasi Parsial Dalam Pembuatan Biobriket Dari Cangkang Kelapa Sawit. *Jurnal Chemurgy*, *5*(2), 61–71. https://doi.org/10.30872/CMG.V5I2.6033

Sidabutar, V. T. P. (2018). Kajian Peningkatan Potensi Ekspor Pelet Kayu Indonesia sebagai Sumber Energi Biomassa yang Terbarukan. *Jurnal Ilmu Kehutanan*, *12*(1), 99. https://doi.org/10.22146/jik.34125

Susanto, G.R.E., Elisa, E., & Dantes, K.R. (2024). Pengaruh Penerapan Media Pembelajaran Pemeliharaan Listrik Sepeda Motor Berbasis Flash Terhadap Hasil Belajar Siswa Teknik Bisnis Sepeda Motor (TBSM). *Jurnal Pendidikan Teknik Mesin, 12(1)*. *https://doi.org/10.23887/jptm.v12i1.38731*

Tambaria, T. N., & Serli, B. F. Y. (2019). Kajian Analisis Proksimat pada Briket Batubara dan Briket Biomassa. *Jurnal Geosains Dan Teknologi*, *2*(2), 77. https://doi.org/10.14710/jgt.2.2.2019.77-86