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Environmental Chemistry in Context: A Digital Supplement on Coconut Shell Briquettes

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Abstract
This study aimed to assess the validity of a local-issue-based coconut shell briquette e-supplement developed for an environmental chemistry course, as well as to evaluate student responses to the material. Utilizing the Research and Development (R&D) method with the ADDIE model and a descriptive quantitative approach, the study measured both expert evaluations and learner perceptions. The e-supplement was reviewed by two content experts, two linguistic experts, and two media experts, and was tested by ten students enrolled in the Chemistry Education program at FKIP UNTAN. Data were collected through a combination of direct and indirect communication techniques, along with measurement instruments including validity assessment sheets and response questionnaires. The findings revealed that the e-supplement achieved a validity score of 81.25% in material quality, 87.50% in linguistic clarity, and 94.44% in media presentation. Additionally, student responses indicated a high level of approval, with a 91.5% positive rating. Based on these results, the e-supplement is considered suitable for implementation in environmental chemistry education, and it shows promising potential to support contextual learning and contribute to Education for Sustainable Development (ESD).

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INTRODUCTION

Coconut is a plant that is widely found throughout Indonesia, thriving both in mountainous regions and lowland areas. Often referred to as the "Tree of a Thousand Uses," every part of the coconut tree holds valuable benefits for human life. In West Kalimantan, coconut plantations are also abundant, with Kubu Raya Regency being one of its producing areas. According to data from the Provincial Office of Plantation and Livestock of West Kalimantan, the coconut plantation area in Kubu Raya Regency expanded by 0.7% an increase of 220 hectares from 29,531 hectares in 2021 to 29,751 hectares in 2022. This expansion was accompanied by a proportional increase in coconut production, rising by 273 tons from 34,993 tons to 35,266 tons during the same period. The 0.7% rise in production has led to a growing volume of coconut waste. Notably, coconut shell briquettes possess high calorific value and offer an efficient alternative energy source for rural communities (Madhusanka et al., 2025).

Based on observations conducted in Punggur Kecil Village, Kubu Raya Regency, it was found that coconut shells are not yet being utilized by the local community. These shells are merely piled up without any further processing, resulting in unpleasant odors that linger around the area. Utilizing coconut waste for briquette production aligns with the principles of a circular economy and contributes to the global reduction of agro-industrial waste (Bot et al., 2023).

According to interviews with residents, the community tends to sell whole coconuts or extract the flesh for copra production, while the shells are left unused and accumulate as waste. Yet, processing coconut shells into value-added products such as briquettes could support the circular economy and reduce environmental pollution (Vieira et al., 2024). Moreover, coconut shell briquettes offer a sustainable energy solution for rural communities by lowering carbon emissions and reducing reliance on fossil fuels (Yirijor & Bere, 2024).

The Faculty of Teacher Training and Education (FKIP) at Tanjungpura University, specifically the Chemistry Education, serves as an educational institution committed to addressing local issues by promoting the use of contextual teaching materials. Such resources can help convey subject matter in relation to real-world problems faced by communities, thereby fostering more authentic learning experiences. Interviews with students revealed that existing teaching materials do not sufficiently explore local environmental challenges—particularly soil pollution resulting from the accumulation of coconut shell waste. Motivated by these findings, the researcher aims to develop an e-supplement based on coconut shell briquettes to support student learning in environmental chemistry courses, while simultaneously contributing to community efforts in resolving local environmental issues. Integrating biomass waste such as coconut shells into sustainable education curricula can strengthen the achievement of SDGs 4 and 15 (Kumar, 2025). This aligns with the principles of Education for Sustainable Development (ESD) outlined in SDGs 4 and 15, as defined by UNESCO (2020), which emphasize that quality education must be relevant to students' life contexts and promote the sustainable use of natural resources to preserve terrestrial ecosystems. Furthermore, Nursyifa et al. (2024) suggest that developing ESD-based teaching modules can support the achievement of SDG 15 through contextual learning that fosters cognitive, social, and behavioral engagement in environmental stewardship.

Through the development of a locally rooted e-supplement addressing coconut waste, students are provided the opportunity to apply chemical knowledge in resolving contextual environmental issues. This aligns with the Intended Learning Outcomes (ILO) of the Environmental Chemistry course, specifically Special Skill 4 (KK4), which states: “Able to apply chemistry knowledge to solve contextual problems.” Additionally, Sub-CPMK 6 of the course emphasizes students’ ability to analyze factors contributing to soil pollution. The local issue observed in Punggur Kecil Village namely the accumulation of coconut shell waste—serves as a highly relevant example to support these learning goals. Contextual, problem-based learning approaches have proven effective in enhancing student engagement with environmental issues and fostering the development of community-based solutions (Reimers, 2024). This e-supplement development is also consistent with constructivist theory, which underscores the idea that learners build knowledge through direct experience and reflection on real-life situations. According to Ulya (2024), constructivism encourages students to actively construct meaning by engaging with a learning environment that is both relevant and meaningful. In this context, students do not merely grasp chemical concepts theoretically but internalize them through active involvement in pressing local issues.

Furthermore, this approach implements the principles of Contextual Teaching and Learning (CTL), which emphasizes the connection between academic content and students’ real-life experiences. According to Johnson (2020), CTL allows students to discover meaning in learning through their personal, social, and cultural contexts. By presenting the issue of coconut shell waste as a learning topic, the e-supplement encourages students to think critically, conduct inquiry, and collaborate in developing locally based solutions. CTL is grounded in constructivist philosophy, and the two approaches complement each other in fostering active, reflective, and contextual learning. To support student understanding of this issue, an e-supplement has been developed as a learning medium based on local problems. This e-

supplement is designed to facilitate contextual, flexible, and independent learning through digital platforms.

An e-supplement is an additional learning medium that is user-friendly and accessible via various electronic devices without the use of paper-based materials (Jariati & Yenti, 2020). The e-supplement was developed in the form of a flipbook using AnyFlip software, which can convert PDFs into book-style displays. According to Handayati (2020), AnyFlip is a tool specifically designed to help educators create engaging learning media such as e-books. The e-supplement enables flexible learning that can be accessed anytime and anywhere via digital devices, thereby supporting independent learning (Sabianto, A., et al., 2022).

Based on theoretical considerations, it is essential to develop an e-supplement that integrates environmental chemistry content with the local issue of coconut shell waste. Such integration not only strengthens contextual learning but also contributes to the achievement of the Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education) and SDG 15 (Life on Land), through sustainable education and the utilization of biomass waste as an alternative energy solution. This study resulted in the creation of a coconut shell briquette e-supplement based on a local issue for the environmental chemistry course, which is deemed suitable for student use.

METHOD

This research employed the Research and Development (R&D) methodology. The procedure for developing the e-supplement followed the ADDIE development model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation (Cahyadi, 2019). However, the implementation phase was not conducted in this study, as the primary objective was to assess the validity of the e-supplement and gather student responses. Evaluation was carried out at each stage of the process.

The flow of the ADDIE model stages as proposed by Branch (2009) is illustrated in Figure 1.

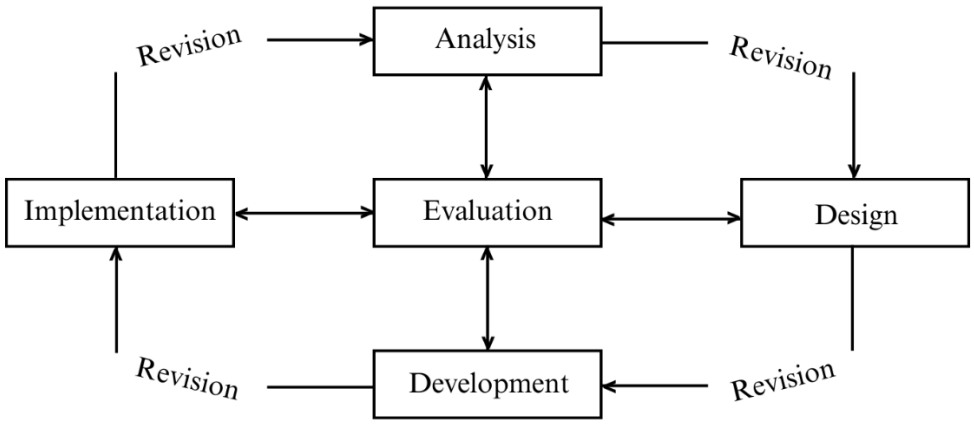


Figure 1. Steps of the ADDIE Model (Branch, 2009)

Based on Figure 1, several stages were carried out, beginning with the analysis phase. This stage involved identifying local needs and potentials through interviews and community documentation, serving as contextual references for developing instructional media (Spatioti et al., 2022). The analysis phase focused on assessing environmental needs and curriculum alignment. These assessments were conducted using interviews, surveys, and documentation

from the residents of Punggur Kecil Village, Kubu Raya Regency, as well as students from the Chemistry Education Program at FKIP Untan. Interviews with students revealed that existing teaching materials do not yet cover local issues in sufficient detail, particularly soil pollution caused by the accumulation of coconut shell waste. The data obtained from this identification process served as the foundation for designing the e-supplement as a learning medium based on local problems.

The second stage is the design phase, which involves several key steps. First, the selection of software tools to support the development of the e-supplement was carried out. The software used in designing the e-supplement included Canva and AnyFlip. Second, a basic framework was created, consisting of a template design and the layout arrangement of components within the e-supplement. Third, the complete design of the local-issue-based coconut shell briquette e-supplement for the environmental chemistry material was constructed based on a previously developed storyboard. Fourth, the e-supplement was converted into a PDF file format. Fifth, the resulting PDF was uploaded to AnyFlip, followed by an online publication process to obtain a shareable link for the developed e-supplement.

The third phase, development, involved the validation process of the e-supplement by six validators, comprising two content experts, two linguistic experts, and two media experts. The validity instruments were structured based on instructional indicators issued by the National Education Standards Agency (BSNP), covering aspects of content feasibility, linguistic use, and media presentation (Akbar, 2013). Feedback and suggestions from the validators were used to revise the e-supplement until it was deemed valid and suitable for response testing.

The response test was conducted with ten students from the Chemistry Education Program at FKIP Untan, who evaluated the e-supplement's readability, appeal, and clarity through a closed-ended Likert scale questionnaire. Evaluation was performed continuously throughout the analysis, design, and development stages to refine the e-supplement, allowing for ongoing improvements to its quality and relevance as a learning product (Jurianto, 2017).

Data collection techniques included: quantitative measurement through expert validation sheets to assess the quality of the e-supplement; direct communication via interviews with residents of Punggur Kecil Village to reinforce the local context embedded in the e-supplement (Sugiyono, 2017); and indirect communication through student response questionnaires (Arikunto, 2010). Data analysis was carried out on the e-supplement validity assessment using the following steps: (1) calculating the total score given by the validators; (2) calculating the maximum possible score from all items; and (3) determining the percentage of validity. The validity criteria were calculated based on a modified formula adapted from Akbar (2013).

$$V = \frac{TSe}{TSh} \times 100\%$$

Description:
V = Validity
TSe = Total score from the validators
TSh = Maximum expexted score

Table 1. Validity Test Criteria

Percentage Range (%)	Validity Category
86-100	Very Valid
71-85	Valid
56-70	Fairly Valid
41-55	Less Valid
25-40	Not Valid

Adapted from Akbar (2013).

Response questionnaire analysis was conducted through the following steps: (1) calculating the score from the collected data; (2) calculating the total score for each statement; and (3) calculating the percentage of readability. The formula used to analyze the student response data is as follows:

$$\text{PK} = \frac{Total\ score\ from\ collected\ data}{Maximum\ readability\ score} \times 100\%$$

Description:
PK = Readability Percentage (%)
Criteria Score = Maximum Readability Score

Table 2. Student Response test Criteria

Percentage Range (%)	Readability Category
80,1-100	Very Good
60,1-80	Good
40,1-60	Fair
20,1-40	Poor
0,0-20	Very Poor

Adapted from Millah *et al.,* (2012)

RESULT AND DISCUSSION

This research was conducted to assess both the validity of and student responses to a local-issue-based coconut shell briquette e-supplement developed for the Environmental Chemistry course. The following discussion outlines the research findings and elaborates on the data analysis and interpretation, addressing the research questions through the following development stages: Analysis (A), Design (D), and Development (D).

Analysis

In this phase, a needs analysis was conducted to identify issues and determine the appropriate product for development. The analysis involved interviews with a Chemistry Education student from FKIP Universitas Tanjungpura. The interview revealed that students in the Environmental Chemistry course lacked supplementary teaching materials such as an e-supplement that addresses local issues. Additionally, an interview was conducted with a resident of Punggur Kecil Village, Kubu Raya Regency. Based on the interview conducted on March 2, 2024, it was acknowledged that one type of organic waste—coconut shells—had not yet undergone further processing. This is due to the fact that local residents typically harvest coconuts for sale in whole form or extract the flesh to produce copra, leaving the coconut shells unused and resulting in the accumulation of organic waste. The buildup of these coconut shells generates an unpleasant odor throughout the surrounding area.

Design

In the design phase, the product was developed based on issues identified during the analysis stage. The design process included creating the e-supplement framework using a storyboard, developing evaluation instruments, and preparing the necessary software to support the creation of the e-supplement. A storyboard serves as the structural outline of the media to be developed and consists of components such as layout, visual design, and media utilization (Al Rasyid & Partana, 2021). The researcher selected the coconut shell briquette topic based on

issues uncovered during interviews. The e-supplement was created using Canva and then converted into a PDF file, which was subsequently transformed into a Flipbook format using the AnyFlip application. AnyFlip is a digital book creation platform that incorporates links, videos, audio, images, and text. It is specifically designed to produce animated e-books that are accessible on both desktop and mobile devices, making it an effective tool for delivering engaging educational content (Handayati, 2020).

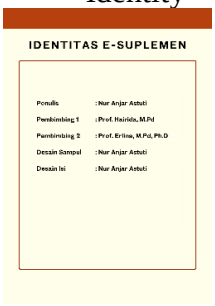
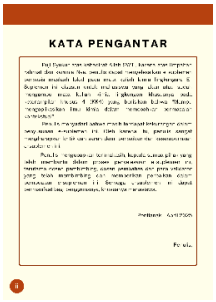
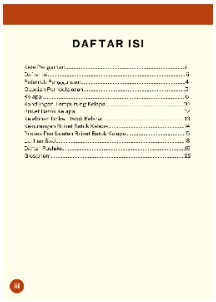
Table 3. Storyboard Components of the E-Supplement

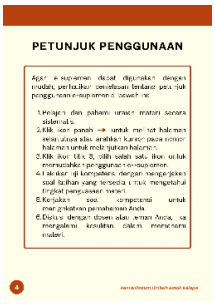
Section	Component
Cover	The front cover features the author's institutional affiliation and institutional logo, followed by the title of the e-supplement and the year of publication. It also includes the author's name and the supervisor's name. To visually reinforce the theme of the content, a relevant image related to the subject matter is displayed.
E-Supplement Identity	Author and supervisor's name.
Preface	Preface to the preparation of the e-supplement.
Table of Contents	Guidance for navigating the contents page of the e-supplement.
User Guide	User guide for using the e-supplement
Learning Outcomes	The graduate learning outcomes are presented.
Content	The e-supplement content is presented.
Practice Questions	Practice questions related to the e-supplement are provided.
References	Explanation of sources obtained for the content of the e-supplement.
Glossary	Explanation of the terms contained in the e-supplement.
Back Cover	Relevant image related to the e-supplement content.

Development

At this stage, the designed product was then developed. The developed product is an e-supplement on coconut shell briquettes based on local issues for the Environmental Chemistry course. The components of the e-supplement are described in Table 4.

Table 4. Components of the E-Supplement

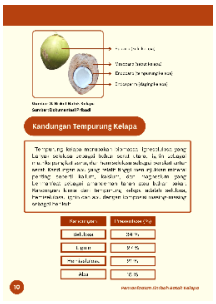
Cover	E-Supplement Identity	Preface	Table of Contents
			
User Guide	Learning Outcomes	Content	Content



Content

Content

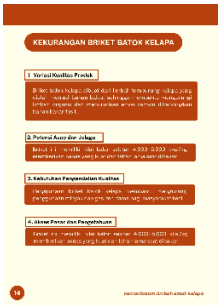
Content



Content

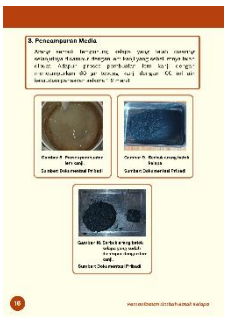
Content

Content



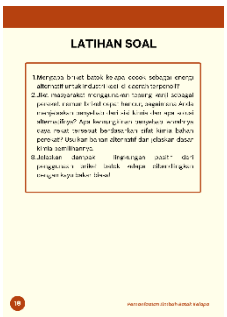
Practice Questions

Reference



Glossary

Back Cover



The software used in developing the e-supplement included Canva and AnyFlip, each serving distinct purposes. Canva was utilized to design the visual appearance and layout of the e-

supplement to make it more attractive and easier to understand, while AnyFlip converted the designed PDF file into a digital flipbook format. The use of both applications supported the presentation of an e-supplement that is not only informative but also visually appealing and easily accessible via digital devices. Canva is recognized for its effectiveness in designing visually engaging instructional media, which enhances learner involvement and comprehension (Darwis et al., 2024). Meanwhile, Utami and Fuad (2023) found that AnyFlip is highly suitable as an educational medium due to its ability to present content in an accessible and visually compelling flipbook format. The development of teaching materials using AnyFlip has been validated and proven practical based on expert evaluations and respondent feedback, making it feasible for instructional use (Gusmilarni et al., 2022). The e-supplement was created using A4 paper size and employed fonts such as Poppins, Touvlo, and Antonio. It contains a total of 23 pages, including the front and back covers.

After development, the e-supplement underwent expert validation to assess its level of validity. The validation process covered several aspects, including content accuracy, linguistic quality, and media presentation. Content validation was conducted by two subject-matter experts using assessment instruments detailed in Table 5.

Table 5. Items for Content Validation Assessment

No	Assesment Items	Percentage (%)
1.	The content presented aligns with the Graduate Learning Outcomes (CPL), specifically Special Skill 4 (KK4).	87,5
2.	The questions in the evaluation correspond to the competencies being assessed.	75
3.	The images displayed effectively support the visualization of the content.	87,5
4.	The chemical formulas and structures used are accurate.	75
5.	The presentation of the content is systematic, coherent, and consistent.	87,5
6.	The developed e-supplement is complete and organized systematically from the cover to the glossary.	75
	Average Percentage of Content Validity	**81,25**
	Category	**Valid**

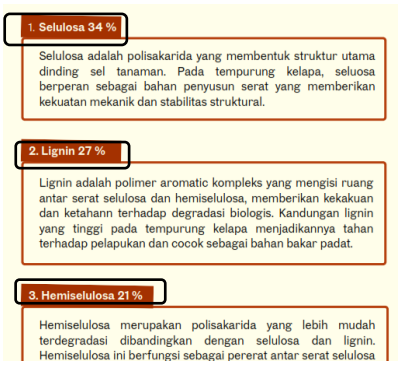
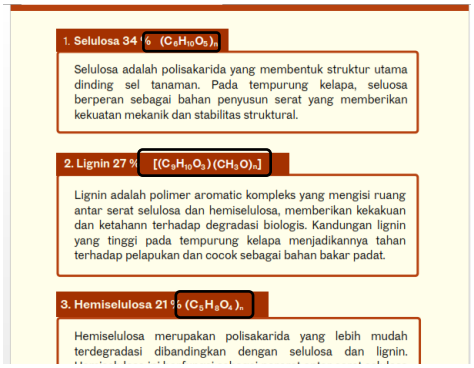
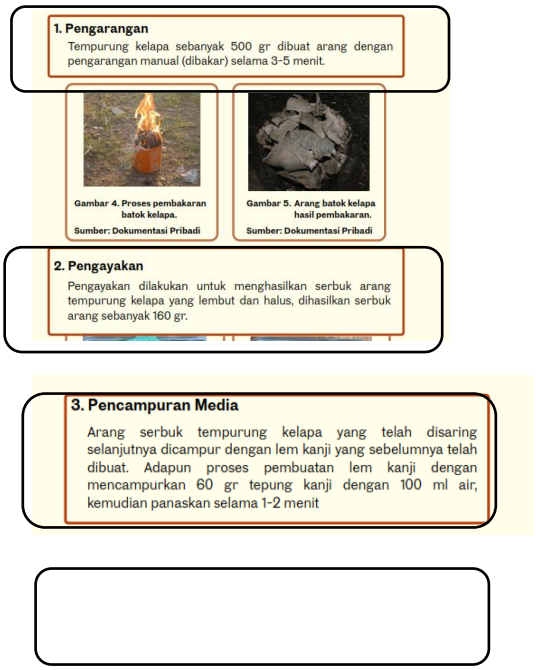
Based on Table 5, the content validation questionnaire consisted of six assessment items used to evaluate the validity of the content in the e-supplement. The content assessment instrument is shown in Table 5. Based on the validation results from content experts, the developed e-supplement demonstrated a high level of feasibility with an average percentage of 81.25%, which falls into the valid category. This validity category is based on criteria calculated using a modified formula from Akbar (2013). Validation was carried out on six assessment items covering the alignment of content with learning outcomes, quality of evaluation questions, visual support, accuracy of formulas and chemical structures, systematic presentation, and completeness of the e-supplement structure.

The highest score was obtained in the aspect of content alignment with Graduate Learning Outcomes (CPL), specifically Special Skill 4 (KK4), with a percentage of 87.5%. This indicates that the e-supplement has successfully integrated students ability to apply chemical knowledge in solving contextual problems, in accordance with the learning objectives of the Environmental Chemistry course. The aspect of content visualization through images also received a high score (87.5%), indicating that the use of illustrations in the e-supplement can strengthen conceptual understanding visually. In addition, the systematic presentation of the content was considered well-organized and consistent, with the same percentage (87.5%), facilitating students in following the learning flow. However, there are several aspects that still need improvement, such as the alignment of evaluation questions with the competencies being assessed (75%), accuracy of formulas and chemical structures (75%), and completeness of the

e-supplement structure from cover to glossary (75%). Although it already meets the validity criteria, enhancement of these aspects will improve the overall quality of the e-supplement and strengthen its effectiveness as a learning medium based on local issues. Thus, the developed e-supplement is declared feasible for use in the learning process, particularly on the topic of soil pollution associated with local issues in Punggur Kecil Village. This e-supplement is expected to support students' competency achievement in a contextual and applicable manner.

The content experts also provided suggestions for improving the e-supplement, including the addition of practice questions, the inclusion of chemical formulas alongside the terms cellulose, lignin, and hemicellulose, and revisions to the quantity and timing details in the procedure for making coconut shell briquettes. Therefore, revisions were carried out, and a comparison between the pre- and post-revision versions can be seen in Table 6.

Table 6. Comparison Before and After Revisions to the Content Aspect of the E-Supplement

Before Revision	After Revision
Inclusion of chemical formulas in the writing of cellulose, lignin, and hemicellulose.	
	
Addition of dosage amounts and timing details in the procedure for making coconut shell briquettes.	
	

Before Revision	After Revision
	

Addition of questions in the practice exercises.

The suggestions provided by the experts were subsequently used in the revision process of the e-supplement. This is in line with the study by Marbun (2023), which stated that expert input is utilized to improve the systematic presentation and strengthen the connection between the content and everyday life. In that study, the validity of the e-supplement content was revised based on expert feedback before the product was declared suitable for use. Moreover, expert input during the development process of the e-supplement is crucial to ensure that the final product is not only content-valid but also practical and aligned with users' needs (Mukhtar et al., 2024). Subsequently, linguistic validation was conducted using the assessment instrument presented in Table 7.

Table 7. Items for Linguistic Validation Assessment

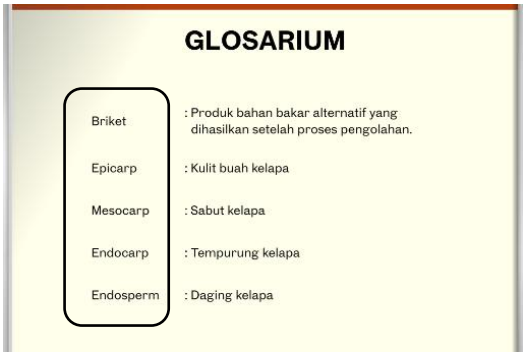
No	Assesment Items	Percentage (%)
1.	The content presented aligns with the Graduate Learning Outcomes (CPL), specifically Special Skill 4 (KK4).	87,5
2.	The words used in the e-supplement are clearly written.	87,5
3.	Effective sentences are used.	87,5
4.	The sentences in the e-supplement effectively convey the intended information.	87,5
5.	The sentence structure adheres to the fifth edition of the Enhanced Spelling Guidelines (EYD), 2022.	87,5
6.	Word choice is appropriate and in accordance with the Enhanced Spelling Guidelines (EYD).	87,5
	Average Percentage of Linguistic Validity	**87,5**
	Category	**Very Valid**

Based on Table 7, the linguistic validation questionnaire consisted of five assessment items to evaluate the linguistic validity of the e-supplement. Referring to the items in Table 7 and the results of the evaluation by linguistic experts, an average percentage of 87.5% was obtained, which falls into the highly valid category. This categorization was based on validity criteria calculated using a modified formula from Akbar (2013). The assessment encompassed five main items that represent the linguistic quality of the e-supplement. The first aspect evaluated was the clarity of the words used, with a percentage of 87.5%, indicating that word choices in the e-supplement were appropriate and free from ambiguity. This is crucial to ensure that students can understand the content without misinterpretation.

Next, the use of effective sentences also received a score of 87.5%, showing that the sentences in the e-supplement were concise, precise, and focused on delivering key information. These sentences successfully conveyed the intended information, as reflected in the third item, which likewise obtained a score of 87.5%. The sentence structures employed complied with the Revised Indonesian Spelling System (EYD), 5th edition, 2022, with a percentage of 87.5%, showing that the e-supplement adheres to official linguistic guidelines. Word choice was also evaluated as accurate and consistent with the EYD principles, receiving the same score (87.5%), thus supporting consistency and appropriateness in academic writing. Overall, the validation results indicate that the linguistic aspects of the e-supplement have met a very high standard. The linguistic used is not only communicative and easily understood but also conforms to academic writing conventions. This is one of the key factors in supporting the effectiveness of the e-supplement as a problem-based learning medium rooted in local issues.

The linguistic experts also provided suggestions for improving the e-supplement, namely to revise the glossary so that the entries are arranged alphabetically. Therefore, a revision was carried out, and a comparison of the e-supplement before and after the revision can be seen in Table 8.

Table 8. Comparison Before and After Revisions to the Linguistic Aspect of the E-Supplement

Before Revision	After Revision
The glossary was written in accordance with alphabetical order	
	

The suggestions provided by the experts were subsequently used in the revision process of the e-supplement. These revisions aim to make it easier for readers to locate and understand the terms used. This suggestion aligns with the findings of Azis (2024), which indicate that arranging glossary entries alphabetically can enhance the accessibility and organization of information in the e-supplement. Subsequently, media validation was conducted using the assessment instrument presented in Table 9.

Based on Table 9, the media validation questionnaire consisted of nine assessment items used to evaluate the media validity of the e-supplement. The media assessment instrument is presented in Table 9. According to the percentage scores of the assessment items, media

validation was conducted to evaluate the quality of visual appearance, layout, and ease of navigation in the developed e-supplement. Based on the evaluation by media experts, an average percentage of 94.44% was obtained, which falls into the highly valid category. This categorization was determined using a validity criterion calculated with a modified formula from Akbar (2013).

Table 9. Items for Media Validation Assessment

No	Assesment Items	Percentage (%)
1.	The layout elements (title, author, image, logo) on the cover are proportionally arranged.	87,5
2.	The text used on the cover is easy to read and understand.	87,5
3.	The e-supplement cover illustration is appropriate to the content content.	87,5
4.	The layout of images and illustrations is proportionally arranged.	100
5.	The spacing between text and images is well-balanced.	100
6.	The spacing between paragraphs is clearly visible.	100
7.	The text in the e-supplement is clearly legible.	87,5
8.	The design of the content pages in the module is engaging.	100
9.	The navigation buttons in the e-supplement are easy to operate.	100
	Average Percentage of Media Validity	**94,44**
	Category	**Very Valid**

The assessment covered nine items representing the design and functionality aspects of digital learning media. The layout of the cover including the placement of the title, author name, images, and logo received a score of 87.5%, indicating that the composition of elements on the cover is proportional and informative. The text on the cover was also rated as easy to read and understand (87.5%), although improvements in font size and contrast could further optimize readability across different devices. The cover illustration was deemed appropriate to the content (87.5%), helping to establish initial context for the reader.

Meanwhile, the internal display of the e-supplement showed excellent quality, with layout of images and illustrations (100%), spacing between text and images (100%), and paragraph spacing (100%) all supporting reading comfort and information clarity. The text within the e-supplement was also rated as clear (87.5%), though further refinement could enhance accessibility, especially for users with visual impairments. The page design of the content received a perfect score (100%), indicating that the e-supplement is aesthetically appealing and capable of enhancing student motivation. Additionally, the navigation features in the e-supplement were rated as excellent (100%), being easy to operate and responsive, thereby supporting self-directed digital learning.

Overall, the media validation results indicate that the e-supplement meets the feasibility standards in terms of design and functionality. Its attractive appearance, proportional layout, and intuitive navigation make it highly suitable for use as a problem-based learning medium rooted in local issues. This finding aligns with the study by Nurjanah (2023), which indicates that digital media such as e-supplements are highly effective in supporting visually oriented learning.

The media experts also provided suggestions for improving the e-supplement, including the addition of the institutional logo, adjustment of the year placement, inclusion of waste-related imagery on the cover, and reduction of background intensity in the subheading sections. Therefore, revisions were carried out, and a comparison between the pre- and post-revision versions can be seen in Table 10.

The suggestions provided by the experts were subsequently used in the revision process of the e-supplement. These recommendations aimed to enhance the aesthetics and readability of the visual display. This aligns with the study by Rahmawati (2023), which stated that design

revisions are carried out based on input from media experts, including adjustments to illustrations, layout, and graphic elements to make the content more engaging and communicative.

Table 10. Comparison Before and After Revisions in the Media Aspect of the E-Supplement

Before Revision	After Revision
Addition of institutional logo, adjustment of year placement, and inclusion of waste imagery on the cover.	
	
Reduction of background intensity in subheading text from 100% to 85%	
	

Based on the validation results and expert suggestions regarding the content, linguistic, and media aspects, it can be concluded that the e-supplement meets the feasibility criteria as a learning medium. To clarify the level of validity for each aspect, a summary of the evaluation results is presented in Table 11.

Table 11. Summary of Validation Assessment Results for the E-Supplement

No	Aspect	Percentage (%)
1.	Content	81,25
2.	Linguistic	87,5
3.	Media	94,44
	Average Percentage of Summary Validity	**87,73**
	Category	**Very Valid**

The recapitulation of validation results indicates that the developed e-supplement falls into the very valid category, with an average percentage score of 87.73%. The media aspect received the highest score, 94.44%, and was categorized as very valid, reflecting the quality of visual design, layout, and effective navigation. The linguistic aspect was also rated as very valid, with a score of 87.5%, supported by the use of effective sentences, good readability, and glossary entries that should be arranged alphabetically. Meanwhile, the content aspect obtained a score of 81.25%, categorized as valid, with suggested improvements in evaluation questions, formula accuracy, and presentation structure.

The evaluation of all three aspects confirms that the e-supplement is suitable for use as a learning resource addressing local environmental issues, although further revisions are needed based on expert feedback to refine the product prior to broader implementation. The average percentage score places the e-supplement in the very valid category, based on validity criteria calculated using a modified formula from Akbar (2013). Expert validation of this very valid learning media supports its feasibility for use in chemistry instruction (Khaeruman et al., 2020). Furthermore, expert assessments demonstrate that the e-supplement is not only content-relevant but also effective in supporting the achievement of learning objectives (Andani et al., 2021). Subsequently, a student response test was conducted on the e-supplement based on the assessment instrument presented in Table 12.

Table 12. Assessment Items for Student Response Test (n=10)

No	Assesment Items	Percentage (%)
1	The front cover of the e-supplement is visually appealing.	92,5
2	The interior design of the e-supplement is attractive.	92,5
3	The text in the e-supplement is not easy to read.	90
4	The images in the e-supplement are clearly visible.	100
5	The instructions in the e-supplement are difficult to understand.	80
6	The images in the e-supplement support the clarity of the content.	92,5
7	The learning content in the e-supplement is easy to understand.	92,5
8	The questions in the e-supplement are easy to understand.	95
9	The e-supplement helps in understanding the subject matter of the Environmental Chemistry course.	85
10	The e-supplement cannot be used for independent learning.	95
	Average Percentage of Student Response Test	**91,5**
	Category	**Very Good**

Based on Table 12, the results of the student response test to the developed e-supplement, an average percentage score of 91.5% was obtained, which falls into the very good category. This calculation was carried out using the descriptive criteria table presented in Table 2. The assessment was based on ten evaluation items, including the attractiveness of the cover and content design, text readability, image clarity, and ease of understanding instructions and questions. The highest score was recorded in the image clarity aspect, at 100%, indicating that the visuals in the e-supplement strongly support content comprehension. Meanwhile, the instruction clarity aspect received the lowest score, 80%, highlighting the need for improvement in that area.

Overall, the e-supplement was considered effective in helping students understand environmental chemistry material and is suitable for use as an independent learning resource. Previous research has shown that e-supplements developed for chemistry education received a very good rating from student response tests, indicating positive reception and high feasibility as a learning tool (Siburian & Sahputra, 2021). The response test was conducted with ten Chemistry Education students from FKIP Universitas Tanjungpura who had completed the Environmental Chemistry course. These ten students voluntarily participated in the study.

These findings align with Sustainable Development Goal (SDG) 4, which emphasizes the importance of inclusive and equitable quality education and lifelong learning opportunities for all, including through the development of contextual learning materials that are relevant to real-world issues (United Nations, 2023a). In addition, the use of coconut shell waste as the central

topic of the e-supplement supports SDG 15, which focuses on the protection and sustainable use of terrestrial ecosystems, including efforts to reduce deforestation and promote biomass utilization as an alternative energy source (United Nations, 2023b).

CONCLUSION

Based on the research and development conducted, this study successfully produced a coconut shell briquette e-supplement based on local environmental issues for the Environmental Chemistry course. The e-supplement was rated very valid, with an average validation score of 87.73%, and received a very good response from Chemistry Education students at FKIP Universitas Tanjungpura, with a student response score of 91.5%. The e-supplement demonstrates positive impacts across academic, social, and environmental dimensions.

Academically, the e-supplement enhances students' contextual understanding of environmental chemistry concepts. Socially, it fosters awareness and concern for local environmental issues. From an environmental perspective, the e-supplement promotes the utilization of coconut shell waste as an eco-friendly alternative energy source, aligning with principles of conservation and deforestation reduction.

The novelty of this research lies in the development of a digital learning resource that integrates environmental chemistry content with local coconut shell waste issues in a contextual and interactive format. It also supports the achievement of SDG 4 by improving the quality of learning through real-world problem-based education, and SDG 15 by promoting environmental conservation through biomass waste utilization.

RECOMMMENDATIONS

Based on the results of the student response test, recommendations for future research include conducting trials on a larger scale and across institutions to obtain more representative findings. In addition, the development of the e-supplement should be directed toward the integration of interactive features, such as the inclusion of videos and engaging quizzes, to enhance student engagement and improve the effectiveness of the learning process.

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