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Development of an Ethnoscience Electronic Student Worksheet on Buffer Solutions Material to Inculcate Islamic Values

Sofi Nihayatul Kamilah[1], Jamil Suprihatiningrum[2]*
[1,2)]Department of Chemistry Education, Universitas Islam Negeri Sunan Kalijaga Yogyakarta, Indonesia
*E-mail Corresponding Author: jamil.suprihatiningrum@uin-suka.ac.id

Abstract

Human actions that exploit natural resources and the environment without limits have caused global conditions to become increasingly concerning. A lack of environmental awareness is also evident in students who neglect to care for and protect the environment, such as by littering. This issue requires serious attention and can be addressed by fostering an environmentally caring character through an integrated ethnoscience approach incorporating Islamic values. Ethnoscience-based learning, integrated with Islamic values, can be facilitated through an electronic student worksheet. This worksheet was designed to help students connect cultural elements with scientific concepts and the teachings of the Quran. Correspondingly, this study developed an electronic student worksheet using a 4D model, encompassing three stages: Define, Design, and Develop. Data from the product development and assessment process were analyzed quantitatively and descriptively. The final product featured character education based on Islamic values. It received an "excellent" rating from material and media experts, while teachers and students responded positively to the media. Overall, this electronic worksheet could potentially improve environmental awareness and instill Islamic values in students.

Keywords: buffer solutions; e-worksheet; ethnoscience; islamic values

Abstrak

Perbuatan manusia yang mengeksploitasi sumber daya alam dan lingkungan tanpa batas menyebabkan kondisi global semakin memprihatinkan. Kurangnya kepedulian terhadap lingkungan juga tampak terjadi pada siswa yang kurang merawat dan menjaga lingkungan, salah satunya yaitu membuang sampah sembarangan. Isu ini perlu mendapat perhatian serius dan dapat didekati dengan penanaman karakter peduli lingkungan melalui pendekatan etnosains terintegrasi dengan nilai-nilai keislaman. Pembelajaran berbasis etnosains terintegrasi nilai-nilai Islam dapat diterapkan dengan bantuan lembar kerja peserta didik elektronik. Melalui lembar kerja ini, peserta didik diharapkan dapat menghubungkan budaya dengan sains ilmiah serta beberapa kandungan Al-Quran. Produk lembar kerja peserta didik elektronik ini dikembangkan dengan model 4D melalui tiga tahap yaitu *define*, *design*, dan *develop*. Data proses pengembangan dan penilaian produk dianalisis secara deskriptif kuantitatif. Produk akhir yang dihasilkan memiliki karakteristik pendidikan karakter berlandaskan nilai keislaman. Produk dinilai Sangat Baik (SB) oleh ahli materi, ahli media, dan guru, dan direspon positif oleh peserta didik. Secara keseluruhan, produk lembar kerja elektronik ini memiliki potensi sebagai media untuk meningkatkan karakter peduli lingkungan sekaligus menanamkan wawasan nilai-nilai keislaman.

Keywords: e-lkpd; etnosains; larutan penyangga; nilai keislaman

Introduction

Education is a means of acquiring the skills necessary for an individual to compete in the global era. It serves as a tool to develop abilities and shape the behavior and personality of students, making them believers with noble morals, skilled, and reasonable. Likewise, the educational process in schools aims to shape attitudes, develop intellectual intelligence, and enhance students' skills according to their needs.

Islam places significant emphasis on environmental stewardship. The concept of the caliphate in Islam designates humans as custodians of the earth, responsible for its care and the sustainability of nature (Novanda, 2023). One clear indication of Islam's concern for the natural environment is the Prophet Muhammad's directive to remove obstacles from the road, which he regards as an act of faith (Muspiroh, 2014). Thus, Islamic education should be at the forefront of fostering environmental awareness, as the principles of environmental education have been integral to Islam from its inception. The Quran provides guidance on how Muslims should interact with the natural environment (Nurulloh, 2019).

Human efforts to support life must align with the environmental values taught in Islam (Muhaimin, 2020). Through the Quran, Allah calls on humans to uphold environmental ethics and contribute to its prosperity (Nasrullah, 2020). However, the increasing pressure on environmental conditions and human life demands are becoming more pronounced (Zuriyani, 2017). Human's unlimited exploitation of natural resources leads to alarming global conditions (Siregar et al., 2023). This unchecked exploitation has significant adverse impacts, such as deforestation, ozone depletion, and global warming (Hartati et al., 2023). These environmental issues stem from human greed, as reflected in Q.S. al-Rum [30]: 41:

ظَهَرَ الْفَسَادُ فِى الْبَرِّ وَالْبَحْرِ بِمَا كَسَبَتْ اَيْدِى النَّاسِ لِيُذِيْقَهُمْ بَعْضَ الَّذِيْ عَمِلُوْا لَعَلَّهُمْ يَرْجِعُوْنَ

There is corruption on land and in the sea because of the deeds of men; Allah wills that they should taste some of the consequences of their deeds so that they may return to the right path.

Efforts to underscore the importance of environmental protection and management include cultivating a character of environmental care through education (Jayawardana, 2016), which lays the foundation for students to develop concern and sensitivity towards their surroundings (Purwanti, 2017). Islamic values, derived from the Quran and Hadith, offer a rich source of character education (Asmara, 2016). These values play a crucial role in shaping and nurturing students' character. Islamic teachings advocate for a holistic approach to life (Mualimin, 2020), which can be imparted to students by integrating Islamic values into teaching materials (Sari et al., 2019). This integration helps students understand and embody good character in accordance with Islamic teachings (Nurhamdiah et al., 2020).

Character education is vital because current educational practices have not effectively focused on building and developing character (Priyantini et al., 2023). School teaching materials often emphasize knowledge competencies without integrating spiritual skills (Devitasari et al., 2023). Observations at a Madrasah Aliyah (Islamic senior high school) in Sleman Regency revealed that chemistry instruction primarily targeted cognitive development, neglecting the affective domain. This imbalance inadvertently undermined students' character development, particularly their environmental consciousness. A notable issue was students' lack of environmental awareness, evidenced by their tendency to litter and improperly segregate waste, mixing organic and inorganic materials. This phenomenon highlights the need for schools to instill positive environmental values in students.

As agents of change (Damayanti et al., 2021), teachers play a crucial role in shaping environmentally conscious students by incorporating environment-based learning activities into the curriculum

(Rezkita & Wardani, 2018). Chemistry instruction that integrates environmental education can address the problem of environmental awareness (Perkasa, 2020). Numerous chemistry concepts directly relate to the environment, fostering students' creativity and innovation in addressing local environmental issues (Perkasa, 2017). Utilizing the environment as a learning resource can enhance education (Irwandi & Fajeriadi, 2020). By engaging with learning materials from their surroundings and daily life, students can better understand concepts through practical, relatable experiences (Kristyowati & Purwanto, 2019).

The elements of local wisdom can be taught through an ethnoscience approach (Aulia et al., 2021) that connects science and indigenous culture to shape students' character and bring them closer to their surrounding environment (Andayani et al., 2021). Integrating ethnoscience into long-term learning will enhance students' awareness of utilizing science and technology to provide solutions and protect the environment (Putri et al., 2022). Sayakti (in Pertiwi & Firdausi (2019)) explains that learning using a local cultural approach and the surrounding environment, or an ethnoscience approach, is essential and serves as a valuable resource to make the learning process more meaningful for students. The integration of ethnoscience into the learning process can be achieved by developing learning media and teaching materials that reflect the local conditions around the school (Damayanti et al., 2017).

Teachers must be creative in designing learning media and utilizing technology to facilitate the learning process and adapt to the times (Effendi & Wahidy, 2019). Engaging learning media can stimulate students' motivation and enhance their learning experience (Hapsari & Zulherman, 2021). In this context, the electronic worksheet is one interactive and practical learning medium that can boost students' enthusiasm for learning (Sari & Suryanti, 2022). E-worksheets make it easy for students to complete assignments anytime and anywhere (Lestari, 2022). In addition, they offer advantages over printed versions, such as the ability to display sound and image animations, making the material more engaging and helping learners visualize abstract concepts (Suparwati et al., 2023). Currently, some Islamic senior high schools in Sleman Regency still use printed worksheets that are opaque and colorless. Teachers often have limited time to create more engaging worksheets, so they rely on the available teaching materials.

A chemistry teacher at an Islamic senior high school in Sleman Regency reported that most students were less enthusiastic about the chemistry learning process. This was because the chemistry materials contained many abstract and mathematical concepts, including buffer solutions (Andriani et al., 2019). Students' cognitive abilities in chemistry were classified as moderate. This was supported by data on students' daily assessment results, which were below the passing grade (KKM) set at 75. The percentage of students who scored below the passing grade on the buffer solutions material was 60%. Furthermore, the students tend to memorize the concept of buffer solutions, leading to quicker forgetting of the material. They relied solely on the teacher in class, and their involvement in learning activities was minimal, resulting in less meaningful chemistry learning. One of the internal factors that can improve student motivation and learning outcomes is teacher creativity in utilizing learning media (Rasam & Sari, 2018). The selection of e-worksheets based on an ethnoscience approach to buffer solutions material can be an alternative solution to these problems.

Several previous researchers have developed ethnoscience e-worksheet innovations in chemistry materials. First, Junita (2022) developed an ethnoscience-based e-worksheet on membrane transport material. This approach received a student response rate of 94%, aided by activities that addressed real-life problems in chemistry learning, thereby increasing students' knowledge and motivation. Second, Suparwati et al. (2023) developed an ethnoscience-based e-worksheet on reaction rate material. This e-worksheet effectively

assisted teachers and improved students' understanding of chemistry mental models. Third, Idrus (2022) reviewed articles on integrating ethnoscience with the STEM approach to learning, concluding that such integration could be applied to all materials with positive results.

The Prophet exemplified the cultivation of good character values through the guidance of the Quran and Hadith (Sholihah & Maulida, 2020). Integrating science and religion is also essential in Islam, as it is an open religion, with its teachings serving as inspiration for various branches of science (Sari & Vebrianto, 2017). Developing teaching materials integrating Islam and science aims to guide students towards positive attitudes in everyday life (Suprianingsih et al., 2022). An analysis of the availability of teaching materials in an Islamic senior high school in Sleman Regency revealed that the teaching materials primarily contained general science content and lacked Islamic values. The emphasis has been on cognitive achievement, with less attention to affective values. Therefore, integrating Islamic values into ethnoscience-based e-worksheets on buffer solutions material is necessary to strengthen student character.

Integrating Islamic values into learning can be effectively achieved through chemistry teaching materials. This integration is evident in the materials and assignments, which present issues from an Islamic perspective without altering the essential competencies outlined in the established curriculum. Buffer solutions, a key chemistry topic, can be linked with Islamic values. The concept of buffer solutions, which maintain pH stability, can be analogous to students defending and protecting the environment from harm. Educators can shape students' character towards environmental awareness by providing analogies between chemical concepts and Islamic values. According to Riyanto (2020), every individual must cultivate an attitude of caring for the environment to preserve its quality. Instilling this character trait helps build students' character by reinforcing their understanding of chemical concepts and deepening their insight into Islamic values. One such chemistry topic that can be integrated with Islamic insights through the content of the Quran is the buffer solution, particularly through the e-worksheet.

This e-worksheet can serve as a medium to address environmental awareness. Through an ethnoscience approach, students can indirectly experience the practical application of science within their communities. In addition, integrating Islamic values can enhance students' understanding of their religious teachings and how they relate to environmental preservation. This approach aligns with research conducted by Aziz et al. (2023), which found that integrating Islamic values into learning could develop students' character. This incorporation has proven effective, significantly increasing students' caring attitudes towards the environment. Specifically, the present study aimed to assess the quality of the e-worksheet and students' responses to it.

Method

This research followed the Research and Development (R&D) methodology using the 4D model. According to Sugiyono (2019), R&D is a research method aimed at developing a product and testing its efficacy. The 4D model consists of four main stages: Define, Design, Develop, and Disseminate (Winaryati et al., 2021). However, this study was limited to the Develop stage.

The Define stage involved analyzing needs, availability, curriculum, and materials. In the Design stage, the following steps were undertaken: selecting learning media, preparing the format, collecting references, preparing data collection instruments, and creating a product design. The Develop stage involved testing and refining the product, specifically the ethnoscience e-worksheet integrated with Islamic values for buffer solutions material.

The instruments used in this study included an interview sheet for chemistry teachers, a Likert scale product quality assessment questionnaire for material

experts, media experts, and reviewers (senior high school chemistry teachers), and a Guttman scale questionnaire for student responses. Data analysis involved converting the qualitative assessments from material experts, media experts, and reviewers into the quantitative data. The data processing was based on a Likert scale with the following categories: excellent (5), good (4), fair (3), poor (2), and bad (1). The scores obtained were then averaged for all aspects and each individual aspect of the assessment using the formula (1). The scores were converted back into qualitative data based on the ideal assessment criteria in Table 1. Finally, the ideal percentage of the product as a whole and for each aspect was calculated using the formula (2).

$$\overline{X} = \frac{\Sigma x}{n} \quad (1)$$

$\overline{X}$ = average score
$\sum$ Score = total score
n = number of experts

Table 1
Ideal assessment criteria

No	Quantitative score range (i)	Qualitative Category
1	Xi + 1.8 SBi < X	Excellent
2	Xi + 0.6 SBi < X ≤ Xi + 1.8 SBi	Good
3	Xi – 0.6 SBi < X ≤ Xi + 0.60 SBi	Fair
4	Xi– 1.80 SBi < X ≤ Xi – 0.60 SBi	Poor
5	X ≤ Xi – 1.80 SBi	Bad

$$\text{Ideal percentage} = \frac{\text{obtained score}}{\text{maximum ideal score}} \text{x } 100\% \quad (2)$$

The data analysis of student responses was converted into quantitative data using the Guttman scale. Positive statements were assigned a score of 1, while negative statements received 0. The average value for all aspects was then calculated using the formula (1). Subsequently, the percentage of product ideality, both overall and for each individual aspect, was calculated using the formula (2).

Results and Discussion

This Research and Development (R&D) study produced an ethnoscience e-worksheet integrated with Islamic values for buffer solutions material, adhering to the 4D model development steps. The 4D model consists of four main stages: Define, Design, Develop, and Disseminate. However, this research was limited to the Develop stage. Specifically, the research stages carried out are as follows:

Define

At the Define stage, the researchers conducted a needs analysis and curriculum analysis. The needs analysis was conducted through interviews and observations at several Islamic senior high schools in Sleman Regency. This analysis identified several issues, including the fact that existing teaching materials, such as textbooks and student worksheets, did not adequately support the teaching and learning process. Students rarely used the provided textbooks due to their limited availability in the library. The textbooks and worksheets were too formal and lacked content to strengthen student character, a key aspect of the Merdeka Curriculum. Moreover, the worksheets were still print-based, with opaque and colorless paper.

Furthermore, teachers had never utilized ethnoscience-integrated worksheets with Islamic character values as teaching resources to buffer solutions material. This condition was mainly due to the teacher's limited time to create such materials. Another issue identified was the moderate cognitive abilities of students in chemistry subjects, with students often showing a lack of enthusiasm for learning chemistry. Data from students' daily test results, which were below the passing grade (KKM), indicated that 60% of students scored below the passing grade on buffer solutions material. In this regard, students tend to memorize the

concept of buffer solutions, leading to quicker forgetting of the material. Additionally, they relied heavily on the teacher in class and were not very active in their learning process. These conditions prompted the development of the e-worksheet integrated with ethnoscience and Islamic values for buffer solutions material. The developed e-worksheet aimed to determine the validity and gather student responses.

Design

The Design stage involved creating the initial product outline (Draft I) using Canva and Microsoft Word software. The various features available in Canva allow for easy and attractive designs, making the learning media more communicative and engaging (Wulandari & Mudinillah, 2022). The e-worksheet design included an initial framework divided into four parts: the cover page, the initial section, the content section, and the closing section. The initial part of the e-worksheet comprised a preface, table of contents, instructions for use, learning outcomes, and learning objectives. The content section included integrated chemistry material on ethnoscience and Islamic values, along with activity sheets. In the closing section, evaluations were provided, containing practice questions to enhance understanding of the material, a bibliography, appendices, and answer keys. The e-worksheet was converted into digital worksheets using the Heyzine Flipbooks website and connected to the LiveWorksheets web application, allowing students to fill in the answers directly. This web application is also beneficial for teachers, saving time and reducing paper use. In addition, it is more interactive, motivating students to learn (Fuada & Fajriati, 2021).

The final product developed can be accessed through the link: https://heyzine.com/flip-book/9c73fc8b0e.html. The developed media featured character education based on Islamic values. This is evident in the e-worksheet content, which presents buffer solutions material associated with verses from the Quran. The performance of the buffer solution is analogous to the concept of self-control, reflecting a person's ability to remain stable and controlled amidst environmental changes. Relevant verses include Q.S Al-A'raf: 31, Q.S Al-Baqarah: 205, and Q.S Al-Mudatsir: 2, which emphasize not damaging the environment and not using natural resources excessively. Umami (2014) asserts that the Quran provides many teachings about self-care and environmental control. Thus, students can learn the values of environmental care, social responsibility, and conscientiousness. In contrast to previous research by Asmaranti and Pratama (2018), which identified five character values in teaching materials—religiosity, curiosity, conscientiousness, independence, and honesty—this product focused on environmental care, social care, and responsibility. The product specifications can be seen in Figures 1 and 2.

Develop

The third stage was the Develop stage. After the product (Draft I) was revised based on expert feedback and input, a revised product I (Draft II) was produced. Draft II was then reviewed by four peer reviewers and validated by a material expert and a media expert. Feedback and input from these peer reviewers and experts were used for revision II, further improving the product. Subsequently, the revised product II (Draft III) was assessed by five reviewers (senior high school chemistry teachers) and responded to by 30 students to obtain data and input for revision III, resulting in the final product.

Figure 1
Integrated Chemistry Material on Ethnoscience and Islamic Values

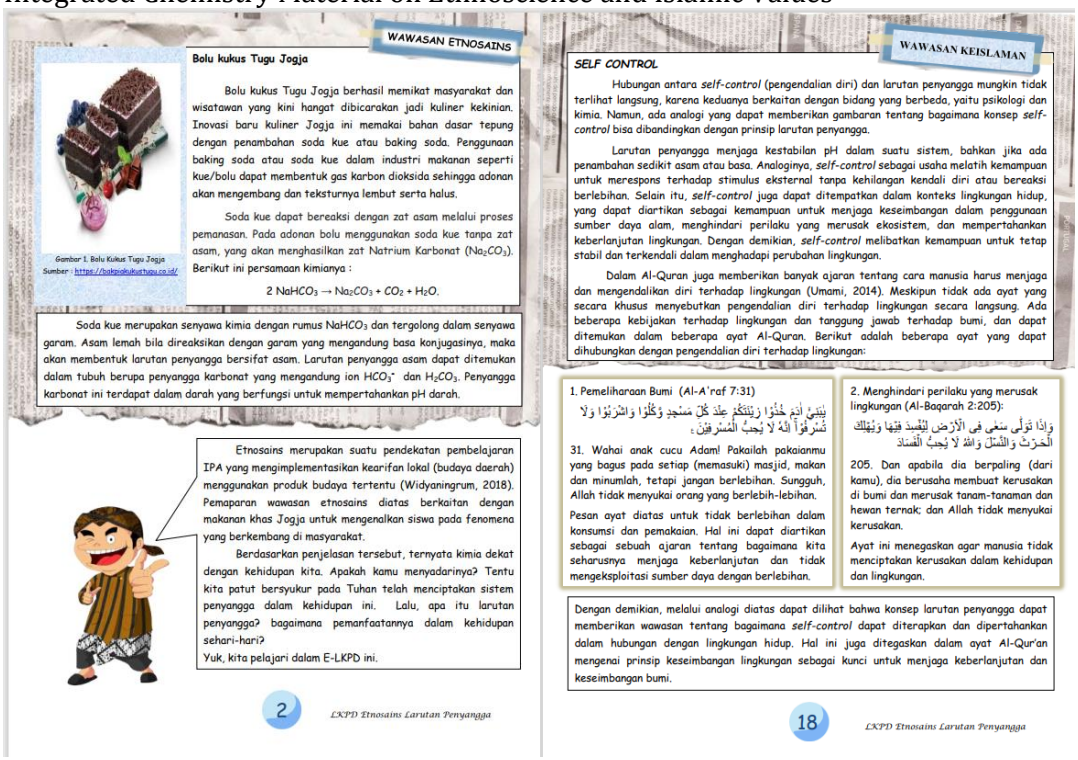
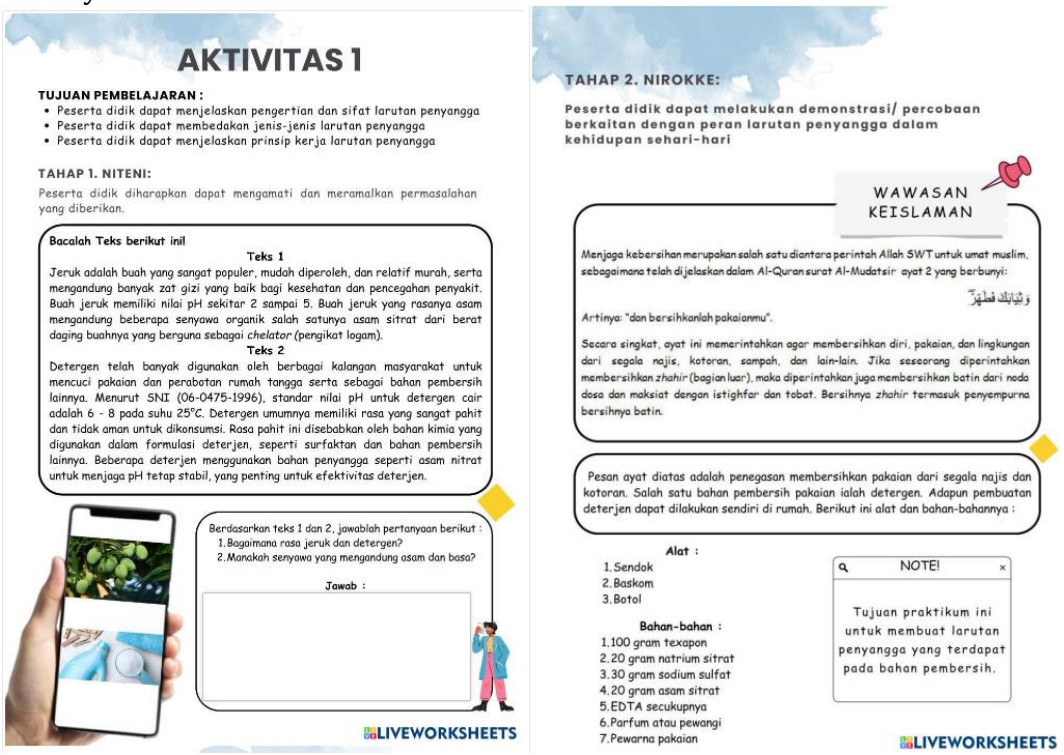


Figure 2
Activity Sheets



Product Validation and Assessment

The validation by media experts achieved an ideal percentage of 95% in the "excellent" category, though with some recommended revisions. The media expert suggested providing titles and reference sources for images/tables, ensuring consistency in letter sizes, improving the bibliography by arranging it alphabetically, and modifying question number nine.

Based on the results of the reviewers' assessment, the percentage was 87%, with an average score ($\bar{X}$) of 65.4 and an ideal maximum score of 75, placing it in the "excellent" category. The reviewers suggested adding more questions, incorporating insights into Islamic values before the material description, and including the structure of chemical compounds on the cover design. Not all suggestions were adopted; insights into Islamic values were integrated into the sub-material on the benefits of buffer solutions, and the cover design already featured a picture of a chemical solution, aligning with the topic of buffer solutions.

The final media was responded to by 30 students, who provided positive feedback. They enjoyed the electronic worksheet, finding it attractive and varied in appearance. The worksheet included comics, animated images, and videos related to the material, which enhanced students' enthusiasm for learning. The integration of ethnoscientific insights and Islamic values also helped in understanding the concept of buffer solutions in everyday life. However, some students noted the lack of background sound in the electronic worksheet, leading to improvements in the flipbook audio settings.

The students gave a total score of 315, with an ideal percentage of 87.50%, categorized as "excellent." Table 3 displays the data on the results of validation, assessment, and student responses.

Table 3
Review of Product Quality and Student Responses

Subject	Review aspect	∑Score	∑ Max Ideal score	Ideal Percentage	Category
Material Experts	Contents	13	15	84.4 %	Excellent
	Language	9	10		
	Ethnoscience	8	10		
	Islamic Values	8	10		
Media Experts	Presentation	14	15	95%	Excellent
	Graphics	14	15		
	Ethnoscience	5	5		
	Islamic Values	5	5		
Reviewers	Contents	68	15	87%	Excellent
	Language	44	10		
	Presentation	68	15		
	Graphics	67	15		
	Ethnoscience	38	10		
	Islamic Values	42	10		
Students' Responses	Contents	50	60	87.5%	Excellent
	Language	50	60		
	Presentation	54	60		
	Graphics	55	60		
	Ethnoscience	49	60		
	Islamic Values	57	60		

Data analysis demonstrates that the content quality of this product was categorized as "excellent." Regarding content aspect validity, the electronic worksheet fulfilled the principles of material depth, conceptual accuracy, and clarity of the questions, as indicated by the research of Damayanti et al. Focusing on these aspects

makes the content well-prepared, making it easier for students to understand the subject matter (Zepyra et al., 2023). The material presented was also consistent with the cited literature, ensuring that the validation of the material in this e-worksheet was reliable and could be used as a valid reference. In addition, Khoiriah and Kholiq (2020) support this finding by emphasizing that the feasibility of material content must align with the suitability of the questions with indicators and answer keys and the material content with learning objectives.

The language aspect of the developed product was categorized as "excellent" and met the criteria for communicativeness and accuracy of sentence structure. Indicators met according to the rubric included effective sentences, consistent terminology, appropriate punctuation, and adherence to PUEBI (General Guidelines for Indonesian Spelling). This is consistent with Pratama and Saregar (2019), who state that teaching materials with communicative grammar facilitates an easier understanding of the material's content. Accurate punctuation and clear sentence structure in teaching materials provide information that is easily understood by readers (Anggun et al., 2023).

The feasibility aspect of the product presentation was categorized as "excellent" per the criteria, including presentation completeness, presentation techniques, and presentation support. The product consistently displayed teaching materials, including the front cover, preface, instructions for use, table of contents, learning outcomes, learning objectives, material descriptions, activity sheets, evaluation questions, bibliography, appendices, answer keys, and back cover. The presentation of the material was adapted to the Merdeka Curriculum, with explanations that were easy for students to understand and supported by videos, engaging pictures, and example practice questions. The resulting product aligns with the research by Indriani et al. (2022), which notes that the presentation of e-worksheet must include easily readable text, attractive images, and clear videos. Additionally, the inclusion of practice questions and practicum activities in the e-worksheet offers students opportunities to practice and makes learning more enjoyable (Kirana et al., 2022).

The results demonstrated that the graphical aspects of the developed product were categorized as "excellent," including images, illustrations, fonts, color selection, and overall design, all of which made the e-worksheet attractive. The developed product aligns with the research of Novia et al. (2021), corroborating that the design must be visually appealing, with colors suited to the developmental level of students and a cover that reflects the learning material. The teaching materials must also feature an engaging cover with bright colors and a readable font size to encourage student enthusiasm (Nareswari et al., 2021).

The ethnoscience aspect encompasses the characteristics and role of ethnoscience. Data analysis indicated that this aspect was also categorized as "excellent." For instance, in learning about buffer solutions, students considered the properties of one of Jogja's specialty foods, such as the components of a buffer solution found in "Jogja Tugu" steamed sponge cake. This integration of local culture with science increases interest in local culture and makes learning more engaging (Woro et al., 2021). This study supports Khasanah's (2021) findings that teaching materials incorporating real-world concepts enhance student interest and motivation while fostering knowledge of local culture. This is consistent with Wiyanto et al. (2017), who found that ethnoscience learning can stimulate student curiosity, facilitate the learning of scientific processes, and provide opportunities for students to make observations and draw conclusions based on their findings.

The results also indicated that the Islamic values aspect of the developed product was categorized as "excellent," incorporating insights related to Islamic values. The indicators included the accurate selection of Quranic verses and their relevance to the material. Sastrawan and Yenti (2020) support this research by

emphasizing the need for clarity in writing Quranic verses, consistency in Arabic lettering, and the ability to connect Quranic content with chemical material, which helps students apply spiritual attitudes in everyday life. The selection of Quranic verses allows students to explore their meanings and applications in everyday contexts (Herman et al., 2022).

Conclusion

An ethnoscience e-worksheet on buffer solutions material, incorporating character education based on Islamic values, was developed using the 4D model. This e-worksheet could be an alternative self-learning tool easily accessed through electronic devices. The product met the eligibility criteria for content, language, presentation, graphics, ethnoscience, and Islamic values. It received an "excellent" rating from both media and material experts. Teachers' assessments also rated it as "excellent," indicating its effectiveness in learning environment. Students' responses mirrored these assessments, further supporting the e-worksheet's potential. Therefore, the ethnoscience e-worksheet, integrated with Islamic values on buffer solutions material, demonstrated significant potential as a quality teaching material to enhance students' understanding of both the subject matter and Islamic values. To maximize the benefits of this electronic worksheet, students need to have a stable internet connection. Future research should focus on developing similar electronic worksheets that incorporate ethnoscience and Islamic values for other topics.

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