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# Development of E-Modules Based Science, Environment, Technology, and Society (SETS) on Buffer Solution Material for Class XI Senior High School

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**Abstract:** This study aims to describe the characteristics, validity results, practicality, and student responses to SETS-based E-Modules on buffer solution material that was developed. The research uses a Research and Development (R&D) method with the 4D model, which has four stages, namely define, design, development, and disseminate. This study examined six high school chemistry teachers and 32 12th-grade students who had studied buffer solutions. The instrument used is a product quality assessment sheet, including validation sheets for material experts, media, and practitioners, as well as student responses. The data analysis technique was carried out by converting qualitative data from media experts, material experts, and chemistry teachers into quantitative data using a Likert scale and the student responses using the Guttman scale. The results showed that the SETS-based E-Module was of excellent quality and suitable for teaching on the topic of buffer solutions. This is evidenced by validation calculations performed by material and media experts, practicality tests conducted by chemistry teachers, and student responses, which yielded scores of 89%, 94%, 83%, and 80%, respectively.

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## Introduction

Technological developments in the world of education have created media that can help the learning process become more effective and efficient (Lai & Bower, 2020). Therefore, teachers and educational institutions must continue to develop technological competencies to create relevant, competitive learning environments in the global era (Liu *et al*., 2022). The use of information technology in the teaching and learning process can be seen from the existence of e-learning-based learning in schools (Jamun, 2016). The existence of e-learning can facilitate the learning process because it is carried out without being hindered by space and time (Ulyawati, 2022). In addition, e-learning can also be used to provide a variety of learning resources and media so that students have an enjoyable learning experience (Asmiyunda *et al*., 2018). E-learning works well for many subjects, including chemistry subjects (Safitri & Sari, 2022).

Learning media needs to be selected after an analysis of user needs in order to provide maximum benefits and results (Mahartika *et al*., 2020). Therefore, it is necessary to develop technology-based teaching materials that are effective, interesting, can help facilitate the learning process, and can be used anywhere and anytime (Safitri & Sari, 2022). These

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materials can take the form of e-modules. E-modules are digital modules consisting of text and/or images containing material focused on specific topics, accompanied by suitable simulations for learning (Herawati & Ali, 2018; Rahayu & Solihatin, 2019). E-modules are considered to have several advantages over other printed teaching materials. Using e-modules makes learning more efficient, effective, and relevant (Saputri & Syuhada, 2022). Additionally, the selection of e-modules is motivated by the fact that, in the 21st century, students and teachers must possess the skills necessary to master developments in information technology (Wulansari *et al*., 2018).

Based on interviews with several teachers at SMAN Tasikmalaya Jawa Barat, it was found that teaching materials were limited to printed books. However, printed books are considered ineffective as independent teaching materials because teachers play a crucial role in explaining each subject (Saputri & Syuhada, 2022). Students' enthusiasm for chemistry is also relatively low, resulting in declining learning outcomes. Additionally, the school does not use interactive or electronic teaching materials during learning activities. Teachers usually take advantage of the learning atmosphere outside the classroom to avoid boredom. Teachers have never used a specific approach with teaching materials during the chemistry learning process. Students at SMA Negeri 6 Tasikmalaya are allowed to bring smartphones and other electronic devices, and the school provides internet access to support students' learning.

Chemistry has specific characteristics that differentiate it from other science subjects. Its concepts are hierarchical, meaning they progress from simple to complex (Yanti *et al*., 2024). Students often struggle with chemistry due to the extensive memorization required and the subject's inherent confusion, especially given its limited application in everyday life (Syahri *et al*., 2017). One chemistry topic that students often struggle with is buffer solutions (Luthfiyah, 2020). Students have difficulty learning about buffer solutions due to a lack of in-depth understanding of the concepts. This is because buffer solutions are related to prerequisite topics, such as chemical equilibrium and acids and bases (Luthfiyah, 2020). According to research by Alighiri *et al*., (2018) 31.05% of students did not understand buffer solutions well, 12.96% had misconceptions about them, and 10.46% did not understand them at all. In addition, Harpiyani *et al.*, (2021) found that teachers rarely relate everyday events or applications to buffer solution material, particularly the subtopic of creating a buffer solution with a specific pH. Meanwhile, interviews with students revealed that they better understand and remember chemistry material when it is related to everyday life problems and events.

The SETS (Science, Environment, Technology, and Society) approach is one suitable method for supporting students in the learning process (Harpiyani *et al.*, 2021). According to Riwu *et al.*, (2018), the SETS approach helps students connect science with technology, the environment, and society in the chemistry learning process. The SETS approach has several advantages. It makes students more aware of the uses of technology that can be linked to scientific concepts and their impact on the environment and society (Warlinda *et al*., 2022; Widiastuti & Purnawijaya, 2021): Students will have a better understanding of science, and it can improve their critical thinking skills (Yerimadesi *et al*., 2022); Additionally, it fosters creativity and provides an interesting and enjoyable learning environment that motivates students to learn (Putri & Rusmini, 2021).

Research on the development of SETS-based modules has been conducted by Muniroh, (2024) which found that SETS-based E-Modules for science on the subject of additives and addictive substances are suitable for use in learning and have been proven effective in improving science literacy and environmental awareness. Additionally, Rahmah

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*et al*., (2017) conducted research that examined SETS (Science, Environment, Technology, Society) based modules integrated with Islamic Values in Chemical Bonding Material from the aspects of material, presentation, language, and graphics and obtained percentages of 85.9%, 85.8%, 85.4%, and 86.03% respectively. These percentages are categorized as very good for chemistry learning. However, SETS-based electronic modules have not been widely adopted for chemistry learning. Therefore, this study aims to describe the characteristics, validity, practicality and student responses to SETS-based electronic modules on buffer solutions.

## Research Method

The method of research used is research and development (R&D), a scientific approach involving the research, analysis, design, and production of media, as well as testing the effectiveness of the final product. The model used in this research adapts the 4D model, which consists of define, design, evelop, and disseminate (Thiagarajan *et al*., 1976).

The definition stage identifies and analyzes the needs of the learning process through interviews with chemistry teachers and observations. The design stage is the process of planning the media to be created, which includes several steps such as preparing the instruments used, choosing the type of product, determining the appropriate format, and creating an initial design. The development stage produces SETS-based E-Module products based on previous designs. These products are then validated by subject matter and media experts. The instrument used is a product quality assessment sheet, including validation sheets for material experts, media, and practitioners, as well as student responses. The validation results, in the form of suggestions and comments, are used to improve and perfect the developed E-Module. Product that have been revised and assessed by experts are the assessed by chemistry teachers and student responses by students in grade XII who have studied the buffer solution material.

The data analysis technique was carried out by converting qualitative data from media experts, material experts, and chemistry teachers into quantitative data using a Likert scale and the student responses data using the Guttman scale in score form. Furthermore, the average value for each aspect and the overall assessment is calculated based on the score obtained. The formula used to calculate the average value is as follows:

$$\bar{x} = \frac{\sum x}{n}$$

$\bar{x}$ = average score
$\sum x$ = total score
$n$ = number of validators/rate

The the percentage of product ideality is calculated using the formula:

$$\text{Percentage of result} = \frac{\text{total score obtained}}{\text{total max score}} \times 100\%$$

The scores obtained are then converted into qualitative values following the reference as in Table 1 (Kurniawan *et al*., 2018).

**Table 1. Media Feasibility Category**

| Percentage | Criteria |
|---|---|
| 81-100 | Very Feasible |
| 61-80 | Feasible |
| 41-60 | Feasible Enough |

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| | |
|---|---|
| 21-40 | Less Feasible |
| >21 | Very Unfeasible |

**Results and Discussion**

This research began with the Define stage. This stage aimed to gather preliminary information related to the product being developed. Activities carried out at this stage included a literature review of scientific journals discussing chemistry education and direct observation through interviews with several chemistry teachers. Four chemistry teachers from SMAN 2 Tasikmalaya, SMAN 6 Tasikmalaya, and SMAN 1 Ciawi were interviewed and observed. The interview results revealed that technology and interactive media were not used optimally, resulting in a chemistry learning experience that was neither interesting nor easy to understand. Teachers used learning media in the form of printed books, PowerPoint presentations, and student worksheets (LKPD) adapted to the Merdeka Curriculum syllabus.

The results of the student questionnaire analysis show that many students find chemistry difficult and tend to be passive learners. Therefore, they need teaching materials containing animations and videos, as well as explanations linked to relevant real-life phenomena. Using animation and video in teaching materials has been proven to improve students' understanding, engagement, and motivation to learn (Timamah *et al*., 2025). Next, a task analysis was conducted to outline the main student tasks, consisting of curriculum and concept analyses. The curriculum analysis was based on learning outcomes (CP) according to the independent curriculum. The concept analysis identified ways to integrate everyday phenomena to broaden students' understanding of buffer solutions and their role. Thus, the developed E-Module contained LKPD with a discovery learning model and buffer solution material with SETS (Science, Environment, Technology, and Society) contexts. Implementing SETS-based discovery learning with chemistry e-modules has been proven to significantly improve students' ability to generate new ideas, solve problems, and conduct scientific exploration compared to conventional models (Yerimadesi *et al*., 2022).

The design stage is based on the results of the analysis and forms the basis for preparing instruments, selecting formats, and creating initial product designs. Instruments are prepared based on feasibility criteria, including material and media expert validation sheets, practicality sheets from chemistry teachers, and student response questionnaires. he E-Module is created in a flipbook format and can be accessed via a link on a mobile phone or laptop. The initial E-Module design is an A4-size layout created using Web Canva. The final product is an SETS-based e-module in PDF format that is converted into a flipbook using the www.heyzine.com platform. The developed e-module contains a cover, table of contents, instructions for use, concept map (CP), ATP, and SET-based discovery learning worksheets. These can be accessed anywhere and at any time using an internet connection. The layout, font type and size, icon selection, and design are as attractive as possible, as shown in Figure 1.

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**Figure 1. Cover E-Modul Based on SETS**

The developed e-module contains material on buffer solutions divided into three learning activities. Each activity covers a subchapter of the material, including the definition and properties of buffer solutions, the components of buffer solutions, the principles of buffer solutions, the calculation of the pH and pOH of buffer solutions, the effects of adding a small amount of acid or base and dilution on buffer solutions, and the role and benefits of buffer solutions in everyday life. Students will study the three activities based on the discovery learning stage. Learning begins with examining discourse related to science, the environment, technology, and society in real life to prepare students for the lesson. Learning that begins with discourse involves various forms of interaction and engagement between students and teachers, which significantly impacts the learning process (Liyanage *et al*., 2021). The appearance of discourse in the E-Module can be seen in Figure 2.

**Figure 2. Discourse Display on the E-Module**

Other interactive features in the e-book include instructional videos, a discussion of buffer solution examples, and paperless worksheets. These interactive elements, such as videos that visualize complex concepts, can motivate students to engage actively in the learning process. This supports students' understanding, especially those who find chemistry difficult (Yulhendri *et al*., 2022). The instructional videos and sample questions can be seen in Figure 3.

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**Figure 3. The instructional Videos and Sample Questions on E-Modul**

The E-Module's concept consolidation consists of material containing SETS aspects. One of these aspects is covered in Learning Activity 3: The Role and Benefits of Buffer Solutions in Everyday Life. The display of buffer solution material in the E-Module can be seen in Figure 4.

**Figure 4. Display of Material on the Role of SETS Charged Buffer Solutions**

The next stage is the development stage. During this stage, the e-module will be validated by subject matter and media experts. Through this process, teaching materials can be evaluated for accuracy, alignment with learning objectives, practicality, and level of engagement (Hendriko & Iryani, 2022). The results of the validation, along with any suggestions and comments, will be used to improve and perfect the developed E-Module. The results of the material experts' assessment can be seen in Table 2.

**Table 2. The Result of Material Expert Validation**

| Aspect | Percentage (%) | Category |
|---|---|---|
| Content Suitability | 92 | Highly Valid |
| Accuracy of Material | 87 | Highly Valid |
| Construction | 88 | Highly Valid |
| Average Number of Validations | 89 | Highly Valid |

The result of validation by material experts has 3 indicators yielded a suitability percentage of 89%, which can be categorized as “highly valid” for use as learning media. The results of the media expert assessment can be seen in Table 3.

**Table 3. The Result of Media Expert Validation**

| Aspect | Percentage (%) | Category |
|---|---|---|
| Software Engineering | 93 | Highly Valid |
| Learning Design | 98 | Highly Valid |
| Visual Communication | 91 | Highly Valid |
| Average Number of Validations | 94 | Highly Valid |

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The results of validation by media experts using three indicators yielded a feasibility percentage of 94% and were categorized as highly valid. Therefore, based on expert validation, the E-Module product that has been developed is declared feasible for field testing.

After the validation was completed, the product feasibility test was carried out through practicality and readability tests. The product's practicality was assessed by six chemistry teachers from public high schools and public Islamic high schools in the Tasikmalaya area. The aim was to determine the ease of use, ease of access, and suitability of the product to the needs of the teaching and learning process. The readability test was conducted through responses from 32 12th-grade students to measure the extent to which e-books can attract interest, be understood, and be used effectively. The results of product quality assessment can be seen in Table 4.

**Table 4. Result of Product Quality Assessment**

| Product Quality Assessment | Aspect | Percentage (%) | Category |
|---|---|---|---|
| Practitioner (Chemistry Teacher) | Construction<br>Software Engineering<br>Learning Design<br>Visual Communication<br>Media Display<br>Ease of Use | 83 | Very Feasible |
| Student Response | Language<br>Material<br>Construction<br>Software Engineering<br>Kebermanfaatan | 80 | Very Feasible |

The assessment of chemistry teachers received a rating of very good with a percentage of 83%. Teacher assessment of learning media is essential to ensuring the effectiveness, relevance, and success of the teaching and learning process (Mansur & Utama, 2021). Learning media developed must be at least good to proceed to the trial stage with students. The results of the student response test were then categorized as highly feasible with a percentage of 80%. Positive responses to the E-Module suggest that using E-Modules can significantly boost student motivation, engagement, and learning outcomes (Rahman *et al*., 2023). According to Lafifa* *et al*., 2022; and Putra *et al*., (2022) readability testing is important for describing student responses to the E-Module and proving that it can be clearly and easily understood, making it suitable for use in the learning process.

Based on expert validation, practicality tests, and readability tests, it can be concluded that the SETS-based e-module on buffer solutions is a suitable alternative learning medium for the classroom. The module provides an integrated learning experience involving science, technology, the environment, and society, with material presented in videos, audio, and images to help students understand the content. This is supported by Widiastuti & Purnawijaya, (2021), who stated that the SETS approach connects science concepts with the environment, technology, and society, making learning more meaningful, relevant, and contextual for students. Rahmawati *et al*., (2022) stated that the SETS approach effectively improves critical thinking, problem-solving, communication, collaboration, and science process skills at all education levels. Muniroh, (2024) conducted research on the development of SETS-based teaching materials and found that SETS-based E-Module science products on

additives and addictive substances are suitable for learning and effective in improving science literacy and environmental awareness. Additionally, Seftianingsih, (2021) research shows that SETS-based physics modules are feasible for use, with media and material feasibility scores of 3.88 and 3.89, respectively, and a student readability score of 3.28. These E-modules are effective in increasing student interest and mastery of the material.

However, the development and implementation of SETS-based E-Modules is not without challenges. Researchers' limited time in designing learning that is integrated with the SETS approach and the need for training to maximize the use of multimedia features in E-Modules are some of the obstacles that need to be anticipated. On the other hand, the flexibility of this E-Module opens up great opportunities for adaptation to other subjects, such as Chemistry on the topic of acids and bases or Biology on the subject of environmental pollution, which are naturally closely related to science, environment, technology, and society. In fact, with local context adjustments, similar E-Modules have the potential to be applied in various educational environments, such as Islamic boarding schools or other communities, thereby expanding the practical impact of this learning innovation.

## Conclusion

The results showed that the SETS-based E-Module was of excellent quality and suitable for teaching on the topic of buffer solutions. This is evidenced by validation calculations performed by material and media experts, practicality tests conducted by chemistry teachers, and student responses, which yielded scores of 89%, 94%, 83%, and 80%, respectively.

## Recommendation

Based on the learning challenges identified, especially in the student analysis and the Merdeka Belajar curriculum learning that emphasizes technology and the development of student abilities, researchers recommend; school policy,where there is training of teachers' skills in making technology-based media. Teachers are also advised to utilise the SETS-based e-modules developed in this study, particularly for the material on buffer solutions. Due to time constraints, this study did not include an effectiveness test in the dissemination phase. Therefore, further research is recommended to test the effectiveness of the e-modules by considering the learning schedule between classes and non-teaching days, to ensure optimal implementation. Using SETS-based e-modules is expected to improve students' conceptual understanding, reduce paper usage and contribute to environmental conservation efforts by minimising negative impacts on nature.

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