JPPIPA 10(9) (2024)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

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

Development of The E-Module on Colloid System with Contextual Teaching and Learning (CTL) Oriented Toward Chemo-Entrepreneurship (CEP) to Enhance Students' Critical Thinking Ability

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Received: May 22, 2024
Revised: July 16, 2024
Accepted: September 25, 2024
Published: September 30, 2024

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DOI: 10.29303/jppipa.v10i9.8546

Abstract: The high unemployment rate among high school graduates and the low critical thinking ability of high school students motivated the author to develop electronic teaching materials based on a contextual approach and oriented toward entrepreneurship. This study aims to determine the validity, practicality, and effectiveness of the e-Module on colloid system with Contextual Teaching and Learning (CTL) oriented toward Chemo-Entrepreneurship (CEP) to enhance students' critical thinking ability. The research method employed is Research and Development (R&D) using the Plomp model, which consists of the preliminary research phase, development or prototyping phase, and assessment phase. The research instruments used include validity questionnaires, practicality questionnaires and critical thinking ability test. The e-Module was validated by three lecturers from the Chemistry Department at UNP and two chemistry teachers from SMAN 6 Solok Selatan. Practicality testing was conducted with two chemistry teachers and 30 eleventh-grade students from SMAN 6 Solok Selatan. Data obtained from the validity and practicality tests were analyzed using Aiken's V formula and practicality percentages. The validity test results showed a V value of 0.92, indicating a valid category. The analysis of the teacher practicality questionnaire showed an 86% score, categorized as very practical, while the student practicality questionnaire showed an 81% score, categorized as practical. The t-test yielded a sig (2-tailed) value of 0.026. Based on these results, it can be concluded that the developed e-Module is valid, practical, and effective in enhancing students' critical thinking skills.

Keywords: Chemo-Entrepreneurship (CEP); Colloid Systems; Contextual Teaching and Learning (CTL); Critical Thinking AbilitY; E-Module, Plomp's Model

Introduction

High School is an institution aimed at preparing students to continue their education to a higher level. However, not all high school graduates can proceed to higher education. The Deputy of the Coordinating Ministry for Human Development and Culture (Kemenko PMK) revealed that the reasons they do not continue to college include economic constraints and limited university seats, resulting in less fortunate high

How to Cite:
Andrean, M. D., Zainul, R., Nizar, U. K., & Kurniawati, D. (2024). Development of The E-Module on Colloid System with Contextual Teaching and Learning (CTL) Oriented Toward Chemo-Entrepreneurship (CEP) to Enhance Students' Critical Thinking Ability. *Jurnal Penelitian Pendidikan IPA*, *10*(9), 6638–6646. https://doi.org/10.29303/jppipa.v10i9.8546

school graduates entering the workforce without having maximized their skill sets. (Detik.com, 2021). As a result, they face difficulties in finding employment and are at risk of becoming unemployed. According to data from the Central Statistics Agency (BPS), the unemployment rate in Indonesia as of August 2023 was 5.32%, or 7.86 million people. The open unemployment rate for high school graduates is 8.15% (BPS, 2023).

One of the efforts to prepare students for the job market is to equip high school students with entrepreneurial skills (Kissi, 2020; Ukah & Atah, 2021; Mas, 2021). The goal is to shift students' mindset from being employee-oriented to being willing and able to become entrepreneurs (Rodriguez & Lieber, 2020; Blesia, 2021; Blimpo & Pugatch, 2021). This can be achieved by integrating entrepreneurship education into various subjects taught at school.

Chemistry is one subject that has the potential to be developed into entrepreneurship. Various applications of chemistry can be found in everyday life, such as colloid systems. Generally, many products we consume daily are in colloidal form. For instance, milk, which is commonly consumed by people across different social strata, is an emulsion colloid known for its high nutritional value. It can be sourced from animals or made from plant materials like corn and legumes. This dairy product can be marketed as a business opportunity (Andrean, 2019).

The entrepreneurial approach in chemistry is known as the Chemo-Entrepreneurship (CEP) approach. The CEP approach allows students to learn the process of converting materials into valuable, economically beneficial products and fosters entrepreneurial spirit (Andrean, 2019). Using the CEP approach in chemistry can enhance students' ability to apply abstract chemical knowledge to real-world applications by producing economically valuable products, thus encouraging them to become entrepreneurs (Saibu, 2024).

According to interviews with chemistry teachers at SMAN 6 Solok Selatan, many students perceive chemistry as a difficult subject. Students often struggle to understand chemistry concepts because they are abstract and complex, requiring a deep understanding to learn. Specifically, in the topic of colloid systems, students frequently face learning difficulties because they tend to rely on memorization. Students who only memorize without truly understanding the material result in untrained critical thinking ability, leading to incomplete concept mastery (Elder & Paul, 2020; Leasa, 2021; Karonen, 2021).

Contextual Teaching and Learning (CTL) is one instructional model that can help students improve their critical thinking ability (Hyun, 2020; Bag & Gürsoy, 2021; Haddar, 2023). The CTL model is a learning concept that helps teachers connect teaching material with students' real-life situations (Lin, 2020; Tapingkae, 2020; Kelana & Wardani, 2021). Students are guided to explain real-world phenomena and solve everyday problems by mastering concepts they have built themselves, leading to comprehensive concept mastery and improved critical thinking ability (Kosassy, 2019).

To implement a learning process that enhances students' critical thinking ability through contextual and CEP-oriented learning, educational materials in the form of e-modules can be used. An e-module is a form of self-study material systematically arranged into specific learning units and presented in an electronic format (Lukitoyo & Wirianti, 2020; Arnila, 2021; Wegner, 2023). Each learning activity within the e-module is linked with navigational links to make students more interactive with the program, supplemented with video tutorials, animations, and audio to enrich the learning experience (Suyatna, 2020; Delita, 2022; Prabu, 2023).

Previous research by Rosyadi and Fauzana (2019) indicated that CEP-oriented colloid system modules are effective in improving students' learning outcomes. Prayitno's (2022) research on the effectiveness of CEP-based chemistry learning in relation to students' life skills showed that CEP-based chemistry learning effectively enhances students' life skills in communication, teamwork, and work skills. Additionally, Nur's (2022) research found that interactive e-LKPD assisted by linktree on colloid materials with the Contextual Teaching and Learning model effectively improved students' critical thinking skills, as evidenced by an increase in N-Gain scores from 0.40 to 0.71 based on pretest and posttest assessments.

Based on the above description, the development of contextual-based teaching materials oriented toward CEP is titled "Development of an E-Module on Colloid Systems Using Contextual Teaching and Learning (CTL) Oriented Toward Chemo-Entrepreneurship (CEP) to Enhance Students' Critical Thinking Ability".

Method

The type of research used is Research and Development (R&D). The research and development method is employed to produce a product and test its effectiveness (Sugiyono, 2020). The research subjects include three chemistry lecturers from Universitas Negeri Padang (UNP), two chemistry teachers from senior high schools, and 30 eleventh-grade science track students from SMAN 6 Solok Selatan. The object of this research is the e-module on colloidal systems with Contextual Teaching and Learning (CTL) oriented towards Chemo-Entrepreneurship (CEP) to enhance students' critical thinking ability. The development model used is the Plomp & Nieveen model (2013), which consists of preliminary research, development or prototyping phase, and assessment phase. Evaluation is based on formative evaluation proposed by Tessmer within the framework of Plomp & Nieveen (2013), as depicted in the following diagram.

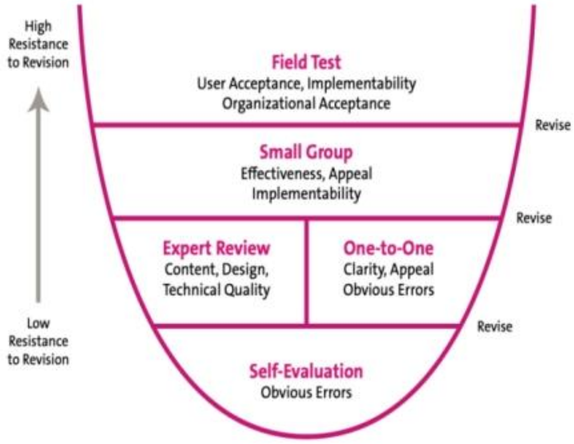

Figure 1. Evaluation in the Plomp Development Model

The data collection instruments used in this study are validation questionnaires and practicality questionnaires, and pretest and posttest questions for critical thinking ability. The validation questionnaires were analyzed using Aiken's V formula, which is as follows:

$$V = \frac{\sum s}{n\,(c-1)} \quad (1)$$
$$S = r - l_0$$

Explanation:
r : the value given by the validator
c : highest validity score (in this case = 5)
l_0 : lowest validity score (in this case = 1)
n : number of expert validators

Table 1. Criteria for Validation Questionnaire

Mean Score	Criteria
V > 0.8	Valid
0.4 < V ≤ 0.8	Moderate
V ≤ 0.4	Poor

(Aiken, 1985)

The practicality questionnaire is analyzed using the percentage of practicality with Formula 2.

$$NP = \frac{R}{SM} \times 100\% \quad (2)$$

Explanation:
NP : final score
R : obtained score
SM : maximum score

Table 2. Criteria for Practicality Questionnaire

Mean Score (%)	Criteria
86 – 100	Very Practical
76 – 85	Practical
60 – 75	Moderately Practical
55 – 59	Less Practical
≤ 54	Not Practical

(Prastowo, 2020)

The improvement in students' critical thinking skills is measured by calculating the N-Gain value from the pretest and posttest scores obtained using Formula 3.

$$\text{N} - \text{Gain} = \frac{\text{Posttest score} - \text{Pretest score}}{\text{Maximum score} - \text{Pretest score}} \quad (3)$$

Next, the average N-Gain value of the students is calculated using Formula 4

$$\text{Average N} - \text{Gain} = \frac{\sum \text{N} - \text{Gain for students}}{\text{Number of students}} \quad (4)$$

Table 3. Classification of N-Gain

N-Gain Score (g)	Clasification
g ≥ 0.7	High
0.7 > g ≥ 0.3	Medium
0.3 > g	Low

(Hake, 1999)

The N-Gain value will be statistically tested to determine its significant improvement using SPSS software.

Result and Discussion

Preliminary Research
Needs Analysis

Based on data from the Indonesian Central Statistics Agency (BPS), the unemployment rate in Indonesia in August 2023 was 5.32%, equivalent to 7.86 million people, with the unemployment rate among high school graduates standing at 8.15%. The analysis of this data indicates that high school graduates are not adequately prepared for the job market and lack entrepreneurial spirit. Subsequently, interviews were conducted with chemistry teachers at SMAN 6 Solok Selatan. Based on these interviews, it was found that many students perceive chemistry as a difficult subject. Particularly in the topic of colloidal systems, students often face learning difficulties because they tend to rely on memorization. As a result, students easily forget the concepts they have learned. Students who only memorize without truly understanding the material lack trained critical thinking abilities, leading to incomplete mastery of concepts. One effort to address these issues is integrating entrepreneurship into learning through contextual-based e-module instructional materials.

Curriculum Analysis

According to the Merdeka Curriculum, colloidal systems are a core topic in high school chemistry studied in Phase F. The learning outcomes that students must achieve by the end of Phase F include explaining the application of various chemical concepts in daily life and demonstrating that the development of chemistry results in various innovations. Based on these learning outcomes, the indicators that students must achieve are: 1) Classifying mixtures into solutions, colloids, and suspensions; 2) Grouping types of colloids based on dispersed phase and dispersing medium; 3) Describing the properties of colloids (optical properties, kinetic properties, adsorption, coagulation, and electrical properties); 4) Explaining lyophilic and lyophobic sols; 5) Describing the methods of colloid formation (dispersion method and condensation method); 6) Creating innovative colloidal products of economic value in daily life; 7) Marketing the colloidal products created to generate profit.

Based on the indicators above, the learning objectives of colloidal systems can be formulated as follows: 1) Students can explain the definition of colloids; 2) Students can distinguish between solutions, colloids, and suspensions; 3) Students can explain the types of colloids based on dispersed phase and dispersing medium using examples from daily life; 4) Students can describe the properties of colloids based on examples from daily life; 5) Students can differentiate between lyophilic and lyophobic sols; 6) Students can differentiate between the methods of colloid formation (dispersion and condensation); 7) Students can create innovative colloidal products of economic value in daily life; 8) Students are expected to be able to market the colloidal products they have created with the aim of generating profit.

Students Analysis

Based on the questionnaire distributed to students, it is known that: 1) students prefer learning materials that include many examples, have attractive, illustrated, and colorful designs, and 2) all students have smartphones that they frequently use for learning and searching for study materials on the internet. The analysis of these student characteristics is taken into consideration in developing contextual-based teaching materials in the form of an e-module oriented towards Chemo-Entrepreneurship (CEP). This e-module is electronic-based and accessible to students via their smartphones.

Concept Analysis

According to the Merdeka Curriculum, colloid system is a core chemistry subject studied in Phase F of senior high school. The colloid system material encompasses several key concepts: 1) Definition of colloid system, 2) Types of colloids, 3) Properties of colloids, 4) Lyophilic and lyophobic colloids, and 5) Colloid production. The concept analysis conducted yielded a concept analysis table used to create a concept map.

Development or Prototyping Phase

Based on the analysis conducted in the initial investigation phase, the next step is to design an e-module on colloid systems based on CTL oriented CEP. This e-module is structured based on the components of e-modules according to Kemendikbud (2017), which have been modified. The developed components of the e-module include cover, user instructions, learning outcomes, learning objectives, learning flow, introduction, concept map, activity sheets, CEP News!, "Ayo Membuat!" activities, self-assessment, motivation column, test sheets, answer key, and discussion. The design of the e-module on colloid systems based on CTL oriented CEP was then realized into a product, resulting in Prototype 1. Subsequently, Prototype 1 underwent formative evaluation as follows.

Self-Evaluation

Self-evaluation is conducted using a checklist against the essential components that should be included in the e-module. Additionally, based on the self-evaluation results, several typographical errors were identified within the e-module and subsequently corrected.

Expert Reviews

Expert assessment was conducted by requesting validation from 3 chemistry lecturers and 2 chemistry teachers from SMAN 6 Solok Selatan to evaluate Prototype 1. Based on the data analysis of the validation questionnaire, the validity level of the developed e-module can be determined as shown in Table 3. The colloid system e-module based on CTL oriented towards CEP that is deemed valid is referred to as Prototype 2.

Table 4. Validation Results of the E-Module

Components	V Score	Category
Content	0.88	Valid
Language	0.93	Valid
Presentation	0.92	Valid
Graphic	0.97	Valid
Average	0.92	Valid

Based on Table 4, the components of validity of the developed colloid system e-module have an average V value of 0.88, categorized as valid. This indicates that the developed e-module is valid in terms of content suitability, confirming that it adheres to the principles of knowledge and is based on the curriculum or developed from appropriate materials and theories. According to Rochmad (2012), content validity signifies that the instructional material is aligned with a strong theoretical rationale or curriculum.

The average V value for the language component of the developed e-module is 0.93, categorized as valid. This implies that the language used in the developed e-module conforms to the rules of proper Indonesian language, is communicative, and easily understandable. Depdiknas (2008) states that good e-modules use simple sentences to ensure clear communication and user-friendly information presentation. Communicative and simple language enhances understanding of concepts and increases students' learning interest (Fadhillah & Andromeda, 2020).

The average V value for the presentation component of the developed e-module is 0.92, categorized as valid. This score indicates that the developed e-module is systematically presented and adheres to the components of e-module development. Moreover, the e-module guides students to engage in activities aligned with the syntax of the CTL learning model. One of the principles of e-module development is to ensure it is packaged for effective use in the learning process (Kemendikbud, 2017).

The average V value for the graphic design component of the developed e-module is 0.97, categorized as valid. This score indicates that the e-module has a clear layout, appropriate illustrations, images, appealing design, and readable font size. An e-module should be designed to be visually engaging to maintain students' interest and motivation in learning (Latif & Talib, 2021). Including images in the e-module can enhance students' engagement as it prevents monotony from reading text alone (Priantini & Widiastuti, 2021).

Overall, the validity of the developed module across each component is categorized as valid. However, there are still some e-module components that need improvement based on the feedback from validators, necessitating revisions before proceeding to practicality testing.

One-to-One Evaluation

The One-to-One Evaluation was conducted by interviewing three students from twelfth-grade students (science program) SMAN 6 Solok Selatan with varying learning abilities (high, medium, and low). Based on the interviews, it was found that the cover design of the e-module is already good and tidy, the color scheme and overall appearance of the e-module are attractive, and the language and terminology used are easy to understand. Additionally, the images and illustrations within the e-module are engaging and assist students in comprehending the material, the instructions for using the e-module are clear and easily understood, no typographical errors were found in the e-module, the sentences are well-structured and easy to comprehend, and the phases of the learning activities effectively help students in completing the exercises within the e-module. However, there are still some questions that are not fully comprehensible.

Based on the One-to-One Evaluation, improvements were made to the developed e-module to achieve an even better version. The revised e-module on colloid systems based on CTL with CEP orientation is referred to as Prototype 3.

Small Group Evaluation

This stage begins with conducting a learning session using e-module (prototype 3) in the classroom for one session. The learning takes place outside regular class hours, with the researcher acting as the teacher. The learning activities are designed to resemble classroom teaching. After the session ends, six students from twelfth-grade students (science program) SMAN 6 Solok Selatan with different learning abilities (high, medium, and low) were asked to fill out a practicality questionnaire regarding the use of the e-Module in the conducted learning process. The results of the practicality questionnaire assessment in the Small Group Evaluation phase can be seen in Table 5.

Table 5. Small Group Evaluation Practicality Results

Aspect	NP Score (%)	Category
Ease of use	91	Very Practical
Time Efficiency	82	Practical
Utility	86	Very Practical
Average	86	Very Practical

Based on Table 5, it can be concluded that Prototype 3 falls under the category of very high practicality with an average *NP* score of 86. The colloid system e-module based on CTL oriented towards CEP that has proven practical in small group evaluation is referred to as Prototype 5.

Field Test

Prototype 4, which has proven practical, is continued to the assessment phase. Prototype 4 is tested with teachers and students of the eleventh grade (science program) at SMAN 6 Solok Selatan.

Assessment Phase

Practicality Test

Practicality was evaluated based on product usability in a limited field trial regarding the feasibility and implementation of the prototype 4 in the field.

Practicality data were obtained from the analysis of questionnaire responses from 2 chemistry teachers and 30 students of the eleventh grade (science program) at SMAN 6 Solok Selatan. Based on the analysis of practicality questionnaire data, the level of practicality of the developed e-module can be determined as shown in Table 6.

Table 6. Results of Practicality Testing

Aspect	Average NP Score (%)	
	Teachers	Students
Ease of use	87	88
Time Efficiency	80	77
Utility	91	79
Average	86	81
Category	Very Practical	Practical

Based on Table 6, it can be observed that the average practicality test results for the usability assessment of the developed e-module obtained from questionnaire responses of teachers and students are 87% and 88%, respectively, both categorized as highly practical. This indicates that the developed e-module is easy to use in learning activities. The use of e-Module in teaching enhances students' interest in understanding the provided materials. Students can access learning materials within the e-module anytime using their mobile phones (Priantini & Widiastuti, 2021).

Furthermore, the average practicality test results for the efficiency of time usage of the e-module in teaching obtained from questionnaire responses of teachers and students, which are 80% and 77% respectively, both categorized as practical. This demonstrates that the developed e-module is efficient in terms of time for use in teaching. An e-module serves as instructional material containing learning objectives or competencies in each learning activity, materials, summaries, and systematic evaluations. The e-module facilitates students to learn independently, in groups, or conventionally. It is presented with self-learning instructions so that students can learn at their own pace (Delita, 2022).

Moreover, the average practicality test results for the benefits of using the e-module in teaching obtained from teacher questionnaire responses are 91%, categorized as highly practical. Meanwhile, the average practicality test results from student questionnaire responses are 79%, categorized as practical. The positive practicality test results from both teachers and students indicate that the developed e-module assists teachers in delivering teaching materials and aids students in understanding the learning materials, as well as motivating them for entrepreneurship. Delita (2022) explains that an e-module is electronically presented instructional material designed to support active learning. It helps teachers deliver materials to students effectively and makes learning more engaging, aligning with current technological advancements. The e-module can enhance learning effectiveness, self-directed learning, confidence, motivation, performance, and student learning outcomes. Furthermore, Supartono (2009) explains that chemistry learning oriented towards CEP activates students to construct their own concepts and knowledge, leading to better retention of knowledge in students' memory and easier understanding of concepts. Moreover, students are trained to produce marketable products, which can serve as preparation for entrepreneurship.

N-Gain Test

The gain score is obtained from the relationship between the pretest and posttest scores of students' critical thinking ability before and after using the e-Module on colloid systems with CTL oriented toward CEP. The results of the pretest and posttest scores for students in the control and experimental classes can be seen in Table 7.

Table 7. The Result of The N-Gain Analysis of Students’ Pretest and Posttest Scores

Class	Average N-Gain	Categori
Experiment	0.534	Moderate
Control	0.476	Moderate

Based on Table 7, the average N-Gain for the experimental class is 0.534, which is higher than the N-Gain of 0.476 for the control class. This data indicates that the critical thinking ability of students in the experimental class is higher compared to that of students in the control class.

Normality Test

Normality testing aims to determine whether the data is normally distributed. The normality test data is obtained using the Shapiro-Wilk test. The decision criteria are based on the significance value (sig): if sig > 0.05, the data is normally distributed, and if sig ≤ 0.05, the data is not normally distributed. The results of the normality test analysis can be seen in Table 8.

Table 8. Result of the Normality Test

Class	α	Significance (sig)	Decision
Experiment	0.05	0.101	Normally distributed

The significance values obtained were 0.101 for the experimental class and 0.273 for the control class. Since the significance values for both classes are greater than 0.05, it can be concluded that the pretest and posttest scores for both classes are normally distributed.

Homogeneity Test

Homogeneity testing aims to determine whether the data has homogeneous variances. The decision criteria are based on the significance value (sig): if sig > 0.05, the data has homogeneous variances. The data for the homogeneity test is obtained through the homogeneity of variance test. The results of the homogeneity test analysis can be seen in Table 9.

Table 9. Result of the Homogeneity Test

Class	α	Significance (sig)	Decision
Experiment Control	0.05	0.472	Homogen

The significance value for both classes was 0.472. Since this value is greater than 0.05, it can be concluded that the pretest and posttest scores for both classes have homogeneous variances.

Hypothesis Test

Hypothesis test data is obtained through an independent sample t-test. The results of the hypothesis test analysis can be seen in Table 10.

Table 8. Result of the Hypothesis Test

Class	Significance (sig)	Decision
Experiment	0.026	H_0: Rejected H_1: Accepted

The significance value obtained was 0.026. This value is less than 0.05, meaning H_0 is rejected and H_1 is accepted. Based on this, it can be concluded that the critical thinking ability of the class using the developed e-Module on colloid systems (experimental class) is higher than that of the class not using the developed e-Module (control class). Therefore, the e-Module on colloid systems with CTL oriented toward CEP is effective in enhancing students' critical thinking ability. Through the CTL model, students are guided to explain real-world phenomena and solve everyday problems by mastering concepts they have constructed themselves rather than merely memorizing facts. This leads to comprehensive concept mastery and improved critical thinking ability (Kosassy, 2019). Meanwhile, CEP is a contextual-based chemistry learning approach linked to real-world objects, allowing students to learn the process of transforming materials into useful, economically valuable products, and fostering an entrepreneurial spirit (Andrean, 2019).

Conclusion

Based on the research results and discussion, it can be concluded that the e-Module on colloid systems with Contextual Teaching and Learning (CTL) oriented toward Chemo-Entrepreneurship (CEP) has a validity score of 0.92, categorized as valid. Furthermore, the practicality level assessed by teachers is 86, categorized as very practical, while the practicality level assessed by students is 81, categorized as practical. The use of the e-Module is also effective in enhancing students' critical thinking ability, as evidenced by the N-Gain value for the experimental class (0.534) being higher than the N-Gain value for the control class (0.476).

Acknowledgments

Thank you to the thesis advisor for guiding the research and writing of this article to completion. Thank you to SMAN 6 Solok Selatan for the assistance and permission during the research process. Thank you to the editors who reviewed and studied this article. Thank you to my parents for their moral and material support. And thanks to all those who have helped and cannot be mentioned one by one.

Author Contributions

Maifil Dwi Andrean contributed to conducting research, developing the product, analyzing data, and writing the article. Rahadian Zainul served as the advisor in the research and writing activities. Umar Kalmar Nizar and Desy Kurniawati served as product validators.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

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