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Development of E-LKM on Colloid Materials Based on Science Technology and Society to Improve Creative Thinking Skills

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Abstract: This study aims to develop E-LKM based on Science Technology Society (STS) on colloid material and analyze its validity and practicality in improving students' creative thinking skills. The method used in this research is Research and Development (R&D) with the 4D model, but this research is limited only to the development stage, namely validity and practicality tests. The define stage was carried out by analyzing student needs, curriculum, and relevant colloid concepts. At the design stage, the E-LKM was designed by integrating the STS model. The develop stage includes validation by a team of five experts and practicality testing by two lecturers and Chemistry Education students. The research instruments consisted of interviews, questionnaires, validation sheets, and practicality instruments. The results of the validity test using Aiken's V in terms of material and media obtained 0.89 and 0.93 in the valid category. The results of the practicality test conducted by lecturers and students were 90.15% and 92% with a very practical category. The assessment was carried out based on four aspects of creative thinking: fluency, flexibility, originality, and elaboration, which showed an increase after the use of E-LKM. The results of this study prove that the STS-based E-LKM on colloid material is valid and practical and has the potential to improve students' creative thinking skills. Further research can examine its effectiveness in understanding chemical concepts and its application to other topics.

Keywords: Colloids; Creative thinking ability; E-LKM; Science technology society

Introduction

In the era of globalization, the ability to think creatively is one of the important skills that must be possessed by every individual, especially in the field of education. Education is a fundamental aspect of human life. Without education, personal and community development can be hampered, which ultimately results in underdevelopment. As the main pillar in the progress of a nation, the level of education plays an important role in determining the welfare and development of a country (Ridwan et al., 2024). The main purpose of education is to create change and guide students in improving the quality of life (Rahayu et al., 2019). Education is a fundamental need for every individual, where the increasingly high demands in the world of education encourage educators and students to play an active role in various developments. The quality and impact of education is strongly influenced by the effectiveness of learning. Therefore, efforts to improve quality of learning must be carried out continuously, starting from primary and secondary education to higher education (Gusta et al., 2020).

One of the goals to be achieved in education in Indonesia is to develop the potential of students to become human beings who are able to think creatively, namely skills in finding new relationships, seeing a problem from a different perspective, and combining

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previously learned concepts (Manurung et al., 2023). According to Dewi et al. (2019) the ability to think creatively can be known from expertise analyzing a data, as well as providing varied problem solving responses. Indicators of creative thinking include five indicators, namely 1) thinking smoothly, the achievement of this indicator students can find answer ideas to solve problems; 2) flexible thinking, the achievement of this indicator students can provide varied solutions (from all angles); 3) original thinking, the achievement of this indicator students can produce unique answers (using their own language or words that are easy to understand); and 4) elaboration skills, the achievement of this indicator students can expand an idea or describe in detail an answer.

This study uses the science technology society (STS) learning model that links the learning process with everyday life which can make students think comprehensively and creatively in finding solutions and ideas in solving problems and will affect students' abilities (Wulandari et al., 2024). Learning with STS makes students more interested in learning chemistry, and provides learning how to keep up with technological developments, and their contribution to society and predict the possible damage that will be caused. In addition, it also eliminates the gap between chemistry learning with technology, and society (Junanto et al., 2023).

One of the chemical concepts that is closely related to the elements of Science Technology Society is colloidal material. This material requires the ability to connect chemical concepts with various phenomena in everyday life (Sari et al., 2022). And colloidal material is not new to students because it has been studied in high school so that learning will be easier. However, in general, students have not fully mastered the concepts given at school. This can be due to learning conditions in schools dominated by teacher activities, as well as less supportive school facilities (Diamora et al., 2022). In addition, sometimes teachers play a dominant role in the classroom or use the lecture method, making students less active in class and unable to build their own understanding of learning (Modeong et al., 2022). So that this has an impact on higher education, students become passive and less motivated in the learning process.

Based on the results of interviews conducted with lecturers, it can be concluded that lecturers use discussion methods when teaching, but they often face challenges in ensuring active participation from all students. Some lecturers also mentioned that the limited time in one lecture session made the discussion unable to run in depth. Therefore, assignments are given independently in the form of papers. And questionnaire results from students show that as many as 83.3% of students have difficulty in connecting colloid concepts with problems faced by society. In addition, as many as 70% of students have not been able to solve colloidal problems with various solution methods.

Then, as many as 63.3% of students did not carry out independent learning both for the material being studied and that had been studied previously. As many as 93.3% stated that the teaching materials used tended to be ineffective in increasing students' interest in learning. This problem has an impact on physical chemistry courses, because the depth and difficulty of colloidal material will be increasingly difficult plus a lack of understanding of the concept. Based on this, media is needed which is expected to improve students' creative thinking skills in learning activities.

Learning media functions as an intermediary tool that conveys messages or information with instructional purposes, thus supporting the process of delivering material from the source to the recipient (Arsyad, 2011). One of the media used is e-lkm. E-LKM is one of the learning media designed to guide students in the learning process (Patresia et al., 2020). The use of appropriate teaching materials can support active and enjoyable chemistry learning (Hanifah et al., 2024). E-LKM is expected to support students in solving problems or cases related to the material studied. Thus, e-lkm is expected to be able to increase student activeness and participation in the learning process. In addition, the use of e-LKM supports more effective and efficient learning. This is because students can understand lecture material independently without having to wait for delivery from lecturers (Syam et al., 2020). One of the applications used in making e-lkm is using Flip PDF Professional.

Flip PDF Professional is software used to create teaching materials in the form of e-books with 3D effects (Seruni et al., 2019). This application is an application that can create interactive learning media content with various supporting features such as audio, animation, video, and flash which are displayed in the form of a flipbook or can be flipped like a 3D book (Febrianti, 2021). some research on the use of Flip PDF Professional which states that Flip PDF Professional software is better than other software such as Kvisoft Flipbook Maker. Both are in the excellent category, namely Flip PDF Professional with a percentage of 93.75% (Arini et al., 2017) and Kvisoft Flipbook Maker with a percentage of 87% (Apsari et al., 2017). In addition, Flip PDF Professional is more compatible on laptops and mobile devices. Thus, Flip PDF Professional can be used to develop e-lkm to improve students' creative thinking skills on colloidal material.

The development of community technology science-based e-lkm on colloidal material is one of the

teaching materials that has the potential to be developed in increasing creative thinking skills and is expected to make students more active. Previous research conducted by Nurhamidah et al. (2022) examined the "Development of E-modules Based on Creative Thinking Ability Using Flip PDF Professional on Colloid Material at SMAN 4 Bengkulu City". The conclusion of the results of this study showed that the assessment of material experts and media experts amounted to 4.25 and 4.57 which included a very feasible category because it was in the Liker scale range of 4.2 < V < 5. Student response based on student assessment shows that students are very interested in learning with e-modules with an average score of 4.35 including a very interesting category.

This research aims to produce Electronic Student Worksheets (E-LKM) based on Science Technology Society (STS) on colloidal material, as well as analyze the validity, and practicality in improving students' creative thinking skills.

Method

The type of research used is development research (Research and Development) which uses the development model from Thiagarajan, namely 4D (Sugiyono, 2019). 4D model is a development model developed by Thiagarajan which has four stages, namely the defining, designing, developing, and disseminating stages (Izzania et al., 2024). In the Define stage, it is carried out by identifying problems found in lecturers and students in the learning process and analyzing the teaching materials used, especially identifying needs based on front-end analysis, analysis of student characteristics, analysis of concepts and learning outcomes (Putra et al., 2021). Furthermore, the Design stage focuses on the preparation of an e-lkm learning model based on science technology and society withinitial design that includes structure, content, and interactive design. After the design is complete, the Develop stage is carried out by realizing the e-lkm according to the design, followed by testing the validity, and practicality. This research was only conducted up to the development stage.

The validity test was conducted to assess the quality of the content and media of the e-LKM which consisted of two aspects, namely material validity and media validity. The validity test was conducted by 5 lecturers consisting of 3 lecturers of Chemistry Education of Padang State University, 1 lecturer of Chemistry Education of Riau University, and 1 lecturer of Chemistry Education of Sultan Syarif Kasim Riau State Islamic University. The assessment from the validators was analyzed using Aiken's V formula. Meanwhile, the practicality test was carried out through distributing questionnaires to two lecturers and students to assess the aspects of content, user-friendliness, efficient learning time and the benefits of using e-LKM. Data from the practicality questionnaire was analyzed quantitatively to determine the level of practicality of the developed e-lkm. The following assessments given by validators on each statement were analyzed using Aiken's V formula. The formula proposed by Aiken's in equation 1.

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

Description:
r = scores given by validators
c = highest validity score
lo= lowest validity value
s = r- Io
n = number of expert validators

The developed e-lkm can be determined based on Aiken's criteria (Table 1).

Table 1. Criteria for Level of Validity (Aiken, 1985)

Scale	Criteria
V< 0.87	Medium
V≥ 0.87	Valid

Meanwhile, the data analysis technique on practicality is obtained from the questionnaire responses from lecturers and students which are analyzed by using the formula in equation 2.

$$p = \frac{f}{N} \times 100\% \quad (2)$$

Description:
P = Final Grade
f = Score acquisition
N = Maximum Score

Table 2. Criteria for Practicality Level (Elisyah et al., 2024)

Scale	Criteria
81% - 100%	Very practical
61%-80%	Practical
41%- 60%	Practical enough
21%- 40%	Less practical
0-20%	Not practical

Results and Discussion

The process of developing E-LKM based on Science Technology Society (STS) for basic chemistry courses consists of three stages, namely define, design, and

develop. The results of each stage of the e-lkm preparation are described as follows:

Define

The defining stage aims to obtain an overview of the learning conditions in higher education, especially in chemistry courses at Riau University. Based on the results of the front end analysis, it was found that the teaching materials used in lectures were still limited to the main textbook and PowerPoint presentations, which were less able to support students in applying concepts contextually. The main difficulty faced by students in colloidal material is the tendency of the material to be presented only in the form of memorization without real application, thus not developing creative thinking skills. This finding is in line with research from Awaliyah et al. (2023), which revealed that students have difficulty in understanding colloidal concepts in depth due to teaching materials that are less interactive and lack of involvement in exploration-based learning. In addition, student analysis shows that most students have difficulty in connecting colloidal concepts with everyday life and lack the initiative to learn independently. Permata et al. (2022) emphasized that problem-solving-based learning models can improve creative thinking skills and help students understand the material in a more applicable manner. Therefore, innovation is needed in teaching materials that are able to connect chemical concepts with real situations to improve student understanding and involvement.

The results of task and concept analysis show that colloid learning at the tertiary level needs to be adjusted to the learning outcomes that have been set, especially in linking the material to the real context. Students are expected not only to understand the colloidal system theoretically, but also to be able to apply it in various situations through a Science Technology Society (STS) based learning model. In addition, survey results show that most students are interested in the use of STS-based e-lkm that can be accessed flexibly via the internet. Therefore, this research aims to develop STS-based e-lkm that not only supports learning outcomes but is also designed interactively with technology integration to increase students' interest and creative thinking skills.

Design

The design stage in the development of Science, Technology, and Society (STS)-based e-lkm includes three main aspects, namely media selection, format selection, and initial design. The media selection process is based on needs analysis and relevance to the independent curriculum. In this case, Microsoft Publisher and Flip PDF Professional were used to design a more interactive e-lkm, equipped with digital quizzes and learning videos related to the concept of colloids, so that students can more easily understand the material contextually. Furthermore, the format selection stage aims to adjust the learning model used with the characteristics of the material. This e-lkm is developed based on the STS approach, which includes the initiation stage as an initial introduction to issues or phenomena related to colloids, the concept formation stage to explore theoretical understanding, the concept application stage to apply the material in everyday life, the concept consolidation stage to strengthen understanding, and the assessment stage as an evaluation of learning achievement.

The initial design resulted in an e-lkm framework consisting of several main components, such as title, student and lecturer identity, instructions for use, introduction, learning activities, evaluation, and reference list. The development of this e-lkm in this study is designed to be more flexible, interactive, and based on real problem solving, so that it can increase students' understanding in applying colloid concepts in various situations. The following e-lkm cover can be seen in Figure 1, while an example of learning activities in Activity 1 is shown in Figure 2.

Figure 1. E-LKM cover view

Figure 2. Learning activities

The curriculum requires students to be more active, creative and innovative in problem solving. Basically,

the ultimate goal of learning is to produce students who have the knowledge and skills to solve problems that will be faced in social life, and technology. The learning model is expected to lead students to be active in So that learning is centered on students, one of them is the Science Technology Society (STS) model.

The (STS) model is a learning approach that integrates science concepts with technology, environment and society to create a more contextual and applicable learning experience. This model has a synthesis, namely there is an initiation stage, concept formation stage, concept application, concept stabilization and evaluation (Poejiadi, 2010). Damayanti et al. (2022) showed that the application of STS-based learning models can improve students' critical thinking skills by involving them in deeper exploration of concepts and their application in real life.

The STS model has a syntax consisting of an initiation stage to arouse curiosity, concept formation through investigation activities to understand concepts more deeply, application is linked to real life, and understanding test as a learning evaluation stage. The STS model aims to connect theory with problem solving in a social and technological context. This model plays an important role in improving creative thinking skills, because it requires students to connect concepts with real-world phenomena, explore various solutions to problems, and develop innovations based on science and technology.

And the development of this e-lkm emphasizes the process of creative thinking skills and the relationship between concepts that foster students' ability to search and investigate systematically, critically, logically, and analytically in the community technology science model through the use of Flip PDF Professional software (Hasanah et al., 2023). And this e-lkm can facilitate students in learning and can be accessed anywhere and anytime. And learning with the community technology science model (STS) is one of the solutions in packaging learning optimally which is expected to optimize the quality of education (Minasari et al., 2020).

Develop

The development stage is the stage of realizing the planning results of all components at the design stage carried out previously. Products that have been conceptualized are then developed according to the material, student needs, image illustrations and so on with the aim of producing development products in the form of colloid e-lkm based on science technology society (STS) to improve students' creative thinking skills. The feasibility of using teaching materials such as e-lkm is determined based on several aspects of assessment activities (Lestari et al., 2019). The results of the analysis of material and media validation sheets on STS-based colloid e-lkm are presented in tables 3 and 4.

The Colloid E-LKM that has been produced is validated by 5 validators. Validators in this validity test consisted of 5 chemistry lecturers from 3 Padang State University chemistry lecturers, 1 Riau University chemistry lecturer and 1 UIN Suska Riau chemistry lecturer. Processing of validation results is done using Aiken's V formula. Based on the table above, the material validity analysis carried out obtained the results of the V value = 0.89 in the valid category, it can be concluded that the colloid e-lkm developed is valid in terms of material, meaning that this e-lkm is suitable for use as a subject matter. According to Tegeh et al. (2019) Proper and valid learning media must be in accordance with the feasibility of the content of the learning material to be achieved.

Table 3. Material Validity Analysis Results

Assessed Aspect	Value V	Category of Validity
Content feasibility	0.93	Valid
Feasibility model characteristics (STS)	0.86	Medium
Linguistics	0.93	Valid
Presentation feasibility	0.88	Valid
Graphics feasibility	0.88	Valid
Ability creative thinking	0.88	Valid
Average V value	0.89	Valid

Table 4. Media Validity Analysis Results

Assessed Aspect	Value V	Category of Validity
Size e-lkm	0.96	Valid
Cover design e-lkm	0.91	Valid
Content design e-lkm	0.92	Valid
Average V value	0.93	Valid

Media validation consists of the suitability of e-lkm content with STS syntax and the suitability of e-lkm content with chemistry. Based on the analysis of media validity conducted, the value of V = 0.93 was obtained in the valid category. Learning media must be supported by material that is in accordance with the concept, presented systematically, consistently, sequentially, and clearly so that it is easy to understand and effective in supporting the learning process (Susanti, 2021). It can be concluded that the colloid e-lkm developed is valid in terms of media and can be continued to the practicality stage.

Learning practicality aims to assess the implementation of learning by using products that have been developed in accordance with learning syntax on various aspects of assessment (Masruhah et al., 2022). The practicality of the e-lkm that has been developed is obtained through: 1) the results of the assessment of 39 students of the 3rd semester of chemistry education at Riau University on the e-lkm that has been developed,

and 2) the results of the lecturer's response to the e-lkm developed. The results of the data processing of the colloid e-lkm practicality questionnaire on students and teachers can be seen in Table 5.

Table 5. Practicality Analysis Results of Lecturers and Students

Assessed Aspect	Lecturer	Student	Practicality Category
Content Aspect	87.5%	-	Very Practical
User-friendliness	87.5%	95%	Very Practical
Efficient Study Time	100%	90%	Very Practical
Benefits	85.6%	92%	Very Practical
Average value	90.15%	92%	Very Practical

According to Arikunto (2021), practicality in education and learning media refers to the ease of preparing, using, interpreting the results, and storing them, so that they can support the effectiveness of the learning process. Based on Table 5, it is obtained that the average value of the practicality of colloid e-lkm by lecturers and students is 90.15% and 92% with a very practical category. These results indicate that the colloid e-lkm developed was responded positively by students and lecturers. And science technology and society-based learning can improve students' creative thinking skills. STS-based e-lkm on colloidal material is effective in learning because it is equipped with images, learning videos, and evaluations that support understanding of the material can be a breakthrough to realize a more practical and efficient learning process (Aldresti et al., 2021). This finding is in line with Wardatun et al. (2024), which states that teaching materials that contain phenomena in everyday life have great potential in developing students' creative thinking skills.

Conclusion

Science Technology Society (STS) based colloid e-lkm was developed through research and development with the 4D model to improve the quality of learning for Chemistry Education students. The results showed that this e-lkm has been declared valid with a material validity level of 0.89 and media validity of 0.93. The results of the practicality test conducted by lecturers and students showed a percentage of practicality of 90.15% and 92%, which is included in the very practical category. The use of e-lkm shows that this media can be used effectively in STS-based chemistry learning. The high validity and practicality results show that e-lkm has the potential to be applied in learning to improve students' concept understanding. In addition, the application of e-lkm in chemistry learning shows positive results in supporting a more interactive and contextual learning process. These findings provide a basis for further development so that e-lkm can be further optimized in improving the quality of chemistry learning at the university level.

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Author Contributions

Creating research instruments, guiding the research process, and writing articles, M. S. and O. S.; Validating the E-LKM, A. D. K., B. Y. F., D. F. and Y. K.

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