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Development of Electronic Teaching Materials Based on Contextual Teaching and Learning (CTL) Approach to Improve High School Students' Mathematical Problem Solving Skills

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Abstract: The aim of this research is to develop approach-based electronic teaching materials Contextual Teaching and Learning (CTL) on systems of equations and linear inequalities to improve high school students' valid and practical mathematical problem solving abilities. This research method uses research and development with a 4D model. Data was collected using questionnaires, observations and interviews. The data analysis technique used is quantitative descriptive analysis. Teaching materials are said to be valid and practical if the score obtained is more than 70%. The results of this research show that electronic teaching materials are based The CTL approach was developed to increase mathematical problem solving abilities for high school students get score *mean* 89% with very valid category. The results of student responses in the limited trial obtained a score of 90.28% in the very practical category. The student response results in the field trial were 90.35% with very practical criteria. The teacher response results were 94.14% with the very practical category and the observation sheet 90.6% with the very practical criteria. From the results of validity and practicality, it can be seen that the teaching materials developed are suitable for use as learning resources.

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Introduction

The independent curriculum contains the term learning outcomes which contains five skills that students should have in learning mathematics, including mathematical problem solving abilities (Kemendikbudristek, 2022). At every level of education, the aim of mathematics lessons is for students to be skilled in identifying problems, designing strategies, completing strategies and concluding the solutions found (Kemendikbudristek, 2022). The results of research by Hermaini & Nurdin (2020) found that the average student mathematical problem solving abilities was 65.44%. Another research also conducted by Damayanti & Kartini (2022) at SMA Nurul Falah Pekanbaru found that the student mathematical problem solving abilities percentage was 31.6%, which means it is relatively low.

Researchers carried out a preliminary study to look at the mathematical problem solving abilities of students at MA Muhammadiyah Pekanbaru who had implemented the independent curriculum. Based on the mathematical problem solving abilities test results, it was found that each mathematical problem solving abilities category was still relatively low. The low mathematical problem solving abilities of students when studying mathematics is influenced by students' lack of enthusiasm when studying, doing routine practice questions and memorizing formulas is still a student habit, as well as the lack of adequate teaching materials that can train mathematical problem solving abilities . Teaching materials are one of

Vol. 11 No. 3 : July 2024
E-ISSN: 2722-4627
pp. 637-646

the factors that have an impact on students' mathematical problem solving abilities. Next, the researcher gave a questionnaire to find out students' assessments of the material presented in the teaching materials, namely the independent curriculum book that had been prepared by the government. The results of the questionnaire showed that 72.72% of students did not agree that the material presented in the independent curriculum teaching materials was easy to understand. Researchers also interviewed mathematics teachers, it was discovered that the independent curriculum teaching materials still contained concepts that were not yet in depth so that students could understand the teaching material and not all practice questions could facilitate students' mathematical problem solving abilities .

The development of teaching materials is one of the stages that can be implemented and is expected to facilitate students' mathematical problem solving abilities. Teaching materials are used using the CTL approach because students are invited to look for problems, plan strategies, and find solutions to problems (Amirin, 2020). Today's era demands learning that combines technology with teaching materials through the development of electronic teaching materials. Electronic teaching materials are developed with software applications that can be used, namely *Flip PDF Professional.* This software is common in making *e-book* shaped *flipbook* animation and unification *file pdf* with pictures and learning videos (Aini & Puspasari, 2022). Based on previous research, the results showed that students responded positively to the development of using teaching materials *flip pdf professional* (Sari et al., 2021) and meets the valid category from all aspects of appropriateness of content, language and presentation and meets practical criteria (Elvadiningsih & Jazwinarti, 2021).

Teaching materials that will be developed on systems of linear equations and inequalities consisting of concepts and solutions for Systems of Linear Equations with Three Variables (SPLTV) as well as concepts and solutions for Systems of Linear Inequalities with Two Variables (SPtLDV) for Phase E students of class X SMA/MA in the independent curriculum. Various difficulties faced by students in studying SPLTV material include the inability to understand information to be converted into mathematical models and being careless in the calculation process (Dewi & Kartini, 2021). Errors in indicators for planning problem solving, namely errors in writing information into a mathematical model and student errors in indicators mathematical problem solving abilities carries out problem solving, namely errors in the calculation process. Based on the description of the problem, the aim of this research is to develop approach-based electronic teaching materials Contextual Teaching and Learning (CTL) on systems of equations and linear inequalities to improve high school students' valid and practical mathematical problem solving abilities

Research Method

This research uses research and development methods with a 4D model, namely 1) Definition (define), 2) Planning (design), 3) Development (develop), 4) Spread (disseminate) (Mulyatiningsih, 2014). The description of each stage is as follows: Stage define namely 1) beginning-end analysis; 2) student analysis; 3) competency analysis. At the design stage, choose the format, media and initial design (prototype). At the level of development developed teaching materials, validated with validators, tested product readability on 3 students, 12 students for limited trials, and ended with field trials. Development stage carried out by providing teaching materials to schools, upload to accredited journals, as well as seminars on research results.

Validation sheets, response questionnaires and observation sheets were used as data collection instruments. Electronic teaching materials were validated by 2 mathematics

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Vol. 11 No. 3 : July 2024
E-ISSN: 2722-4627
pp. 637-646

education lecturers and 1 mathematics teacher. The aspects on the validation sheet are aspects of language, graphics, appropriateness of electronic media, content, presentation and aspects of mathematical problem solving skills. The validation results from the validator are analyzed and revised according to suggestions. The next stage was a product readability test on 3 class XI IPS MA Muhammadiyah Pekanbaru students to find out the obstacles when using the product being developed. The revised electronic teaching materials were tested on 12 students of class XI Science MA Muhammadiyah Pekanbaru during a limited trial. After that, the electronic teaching materials were tested and then analyzed using quantitative descriptive data analysis techniques. Teaching materials are said to be valid and practical if the score obtained is more than 70%.

Results and Discussion

At the definition stage, namely the beginning-to-end analysis step, it was discovered that the school was using an independent curriculum, students' mathematical problem solving abilitieS was low, and teaching materials that could facilitate students' mathematical problem solving abilities were still not available. The results of the analysis steps are that students like studying independently and using learning videos and students' mathematical problem solving abilities is still low. The researcher gave questions on systems of linear equations and inequalities to see students' mathematical problem solving abilities, obtained the results in Table 1. Below;

Table 1. Student mathematical problem solving abilities Success

Mathematical Problem Solving Abilities Indicator	Percentage
Understand the problem	25,6 %
Plan problem solving	37,2 %
Implement problem solving	30,2 %
Double check the correctness of the results	7%

Table 1 shows that students' mathematical problem solving abilities is very low. The low mathematical problem solving abilities of students is due to the unavailability of teaching materials that can facilitate mathematical problem solving abilities so one solution is to provide electronic teaching materials based on the CTL approach. The CTL approach was chosen because the contextual approach can help improve students' mathematical problem solving abilities because it is able to make students achieve mathematical problem solving abilities indicators in the form of identifying problems, planning strategies, carrying out problem solving and providing conclusions from problem solving (Rangkuti, 2018). Meanwhile, Polya (1957) said there are four main steps in solving mathematical problems, namely *understanding the problem, devising a plan, carrying out the plan, looking back.* Based on the results of the analysis carried out, it is known that there is a need to develop electronic teaching materials using the CTL approach which can facilitate students' mathematical problem solving abilities. Next, a competency analysis is carried out by referring to Learning Outcomes (CP) that are suitable for students' mathematical problem solving abilities. The researcher chose learning outcomes in the algebra content and functions of Phase E. The author limited the research to students being able to solve problems related to three-variable linear equation systems and two-variable linear inequality systems.

Activities at stage design namely to calculate the validity and practicality of electronic teaching materials by preparing instruments. The next activity is that the media chosen is video which suits the characteristics of students who like to learn through picture and video

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Vol. 11 No. 3 : July 2024
E-ISSN: 2722-4627
pp. 637-646

media because they are easy to understand and can watch them again if there is material they don't understand. Research (Widyasari et al., 2021) states that learning videos create learning that is easy to understand and interesting and can increase learning motivation. The next activity is the initial design of teaching materials consisting of pages *cover*, foreword, table of contents page, instructions for use page, learning outcomes, learning objectives, introduction to material, material/content, example questions, exercises and answer key, summary, end-of-chapter exercises and answer key, glossary/list of terms, list of references, and accompanying sheet. The components of teaching materials are based on Septora (2017) which states that teaching materials consist of an introduction, subject objectives, learning activities, exercises, summaries and tests and formative answer keys (evaluation). The teaching materials are designed in two sub-chapters, namely a three-variable linear equation system consisting of the general form and mathematical model of SPLTV, solving SPLTV using substitution, elimination and mixed methods (elimination-substitution). The second sub-chapter is the general form, mathematical model and solution of SPtLDV.

Development step activities include developing electronic teaching materials, product validation and product revision as well as conducting product trials. Electronic teaching materials are developed based on an initial design that is in accordance with the components of the teaching materials. Teaching materials are made through *Microsoft Word* and kept in shape *PDF*. Teaching materials in form *PDF* which will be used as electronic teaching materials using assistance *Flip PDF Professional*. The manufacturing process begins with carrying out a process *install* application, after that open the application and click the button *new project* and select the uploaded file in HTML 5 form as in Figure 1.

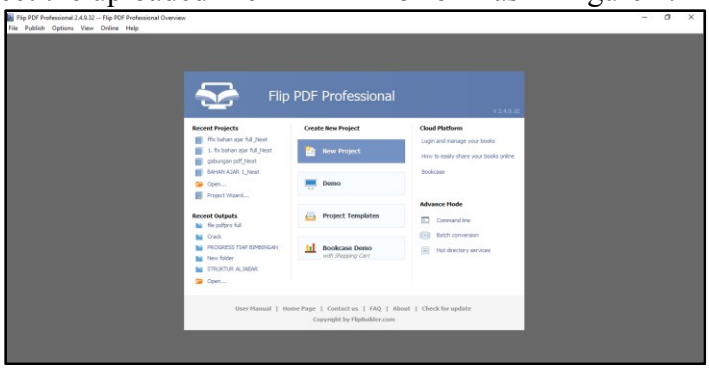

Figure 1. Initial appearance of the application

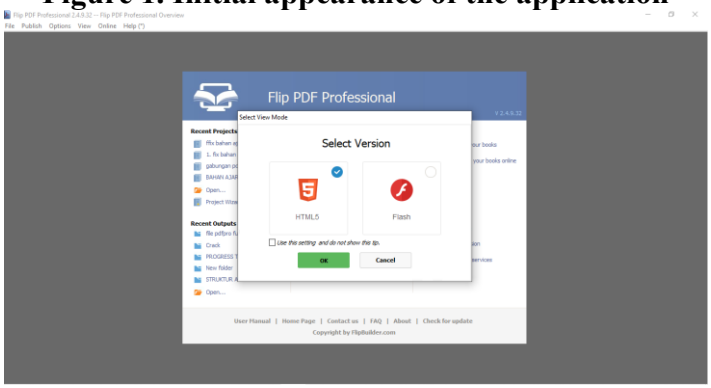

Figure 2. Version Selection Display in the Application

The next step is to choose *file* which will be in *input* Open the application and make edits to the page you want to add images or videos to. Appearance *input file* in Figure 3. and display *edit pages* in Figure 4.

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Vol. 11 No. 3 : July 2024
E-ISSN: 2722-4627
pp. 637-646

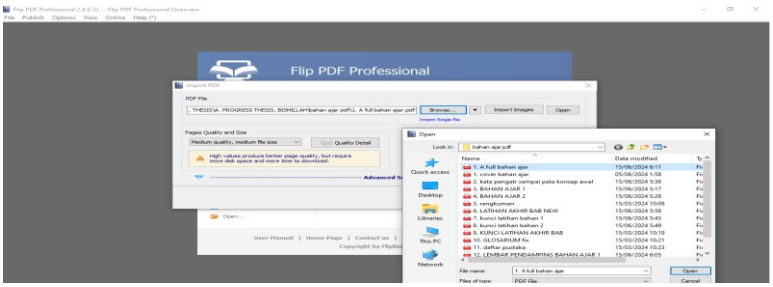

Figure 3. Display *Input File* on the Application

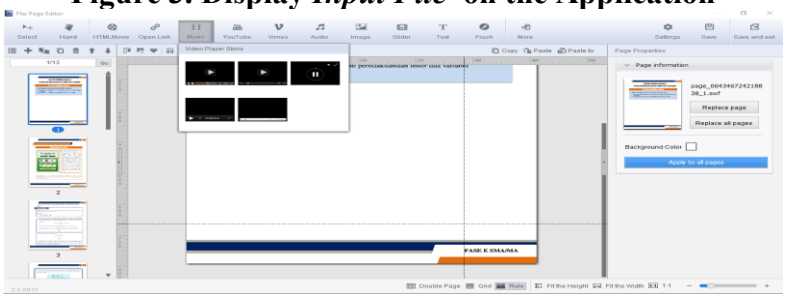

Figure 4. Display *Edit Pages* on the Application

Teaching materials that are deemed suitable *upload online* so as to obtain *link* or *barcode* to access electronic teaching materials. Like Figure 5.

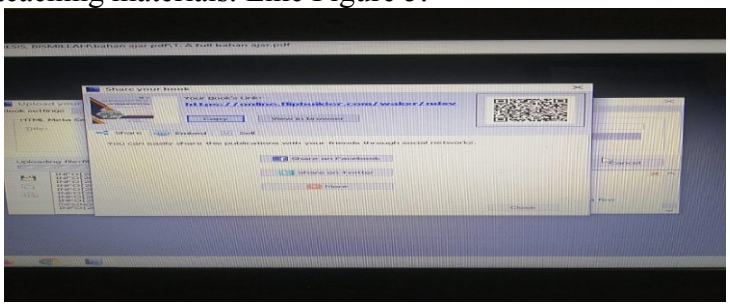

Figure 5 Display *Link* and *Barcode* Teaching Materials

Students who have successfully accessed electronic teaching materials using a link or barcode will enter the display *cover*. *Cover* electronic teaching materials as in Figure 6.

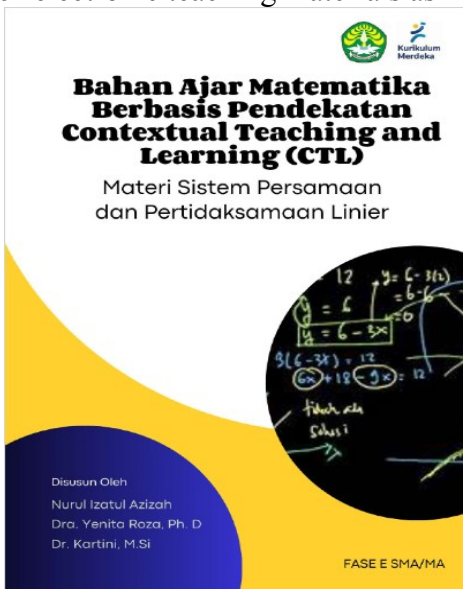

Figure 6. Cover Electronic Teaching Materials

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Vol. 11 No. 3 : July 2024
E-ISSN: 2722-4627
pp. 637-646

The Electronic Teaching Materials that had been created were discussed with the supervisor and continued with validation by 2 mathematics education lecturers and 1 mathematics teacher. The validity of teaching materials is the level of accuracy of the teaching materials developed (Saputri et al., 2023). Validating teaching materials aims to determine the accuracy of teaching materials that are suitable for use as learning resources through validation sheets. Ilyas Ramdani (2014) stated that graphics, language, presentation and content are aspects in developing teaching materials. The validation sheet in this study is divided into six assessment aspects, namely appropriateness of content (11 questions), presentation (8 questions), language (4 questions), graphics (6 questions), electronic media (4 questions), mathematical problem solving abilities (5 questions). The results of product validation by 3 validators are presented in Table 2.

Table 2. Validation Results of Teaching Materials

No	Aspect	Third Value of Members			*Mean*	Category
		1	2	3		
1	Graphics	75	83	88	82	Valid
2	Language	96	92	96	94	Very Valid
3	Eligibility of Electronic Media	88	94	88	90	
4	Presentation	78	97	97	91	
5	Head	80	91	93	88	
6	Mathematical Problem Solving Skills	80	85	95	87	
	Rate Rate	82	91	93	89	

Validation results show that electronic teaching materials with *mean* 89% with very valid criteria. Score *mean* from experts it is found to be valid if it exceeds a score of 70% (Alawiyah et al., 2021). The suggestions from the validator were typing errors in the teaching materials and improving the way of writing the prices in the questions. The validator also suggested changing the cover because the title was too big so it filled the page. *cover* and replace supporting images. Revision *cover* in Figure 7.

Figure 7. Revision *Cover* Electronic Teaching Materials

The next step was to test the readability of the product to see the obstacles to using electronic teaching materials which was carried out on 3 students of class XI IPS MA Muhammadiyah Pekanbaru. The students' response to electronic teaching materials was that students looked enthusiastic and enthusiastic when using the electronic teaching materials that researchers provided and helped students to understand the material on systems of linear equations and inequalities. The input from students in the modeling step should be that the writing of fruit,

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Vol. 11 No. 3 : July 2024
E-ISSN: 2722-4627
pp. 637-646

for example, should be arranged downwards and the fruit images should be the same size on each page. Students are also confused about the sentences used in the steps for solving SPLTV, so they provide input to separate the steps for solving SPLTV in general and the examples carried out that are in accordance with the example questions given. Students also suggested that the exercises and answer keys need to be given clear titles so that students do not make mistakes in matching the existing exercises and answer keys. After being revised, it was tested on 12 students of class XI Science MA Muhammadiyah Pekanbaru. In the limited trial, it was obtained that the student response questionnaire results met the practical criteria as shown in Figure 8.

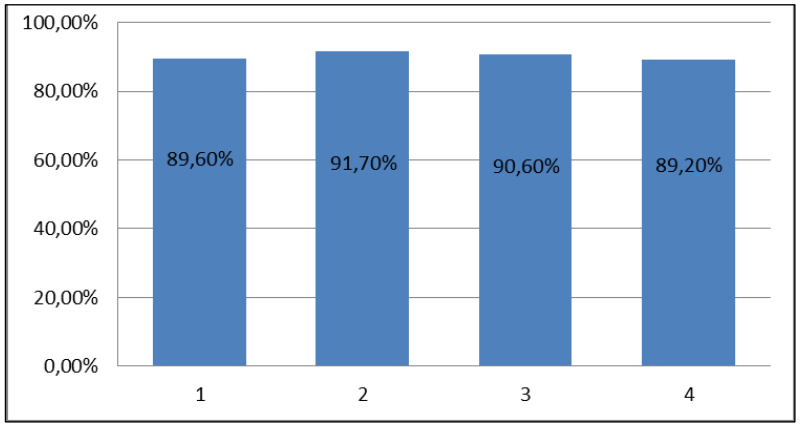

Figure 8. Results of Student Responses at the Limited Trial Stage

The revised teaching materials were at the limited trial stage, then tested in field trials conducted with class X.2 MA Muhammadiyah Pekanbaru during 4 meetings. Students were given a response questionnaire to determine the practicality of electronic teaching materials. According to Walker & Hess in Dessy Kristianto (2014) Practical aspects of teaching materials include appearance, subject matter, and language. This research student response questionnaire uses aspects of appearance (2 questions), content (8 questions) and language (2 questions). %. According to In (2020) that teaching materials are said to be practical if they reach the criteria ≥ 70%. The results of the student response questionnaire at the field trial stage were 90.35% in the very practical category. Details of each meeting are as in Figure 9.

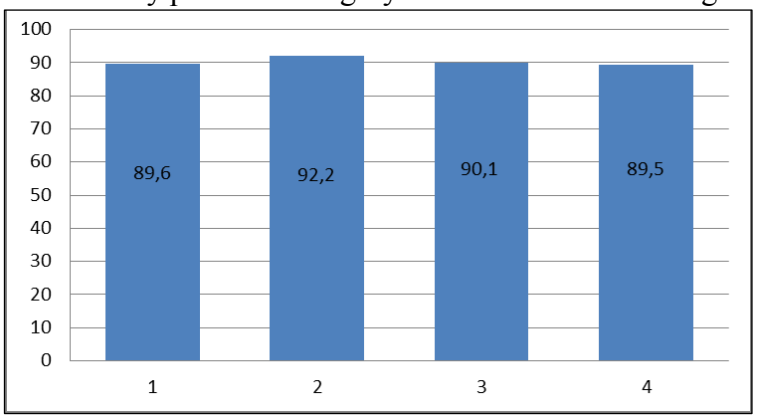

Figure 9. Results of Student Responses at the Field Trial Stage

Teachers were also given a teacher response questionnaire to see the practicality of the electronic teaching materials used when studying. The assessment aspect of the student response questionnaire consists of appearance (3 questions), material (4 questions) and

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Vol. 11 No. 3 : July 2024
E-ISSN: 2722-4627
pp. 637-646

presentation (9 questions). The teacher response questionnaire results of 94.14% at the field trial stage met the very practical criteria and can be observed in Figure 10.

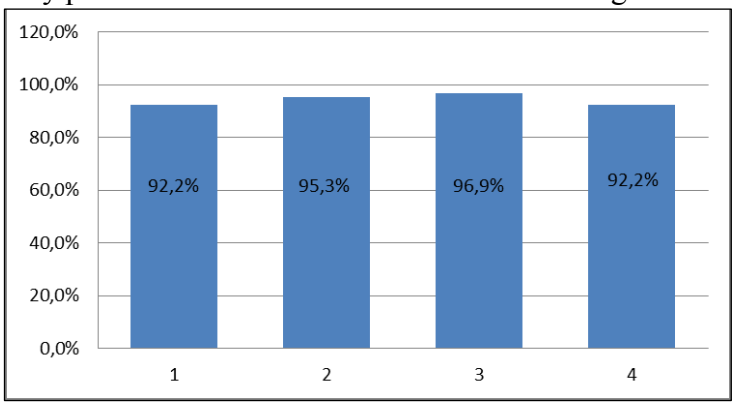

Figure 10. Results of Teacher Responses at the Field Trial Stage

Teachers as observers in the field trial stage are given observation sheets to assess learning using electronic teaching materials and response questionnaires to determine the practicality of electronic teaching materials. The observation sheet assesses the opening, main and closing activities. The details of the number of questions on the observation sheet are 7 questions for the opening activity, 4 main questions, and 5 questions for the closing activity. This was also said by Rahdiyanta, (2016) that observation sheets were used simultaneously when practical learning activities were being carried out.

The results of the teacher's observation sheet show that the electronic teaching materials that were tested were implemented well and the electronic teaching materials met the criteria of being very practical. Details of each meeting can be seen in Figure 11.

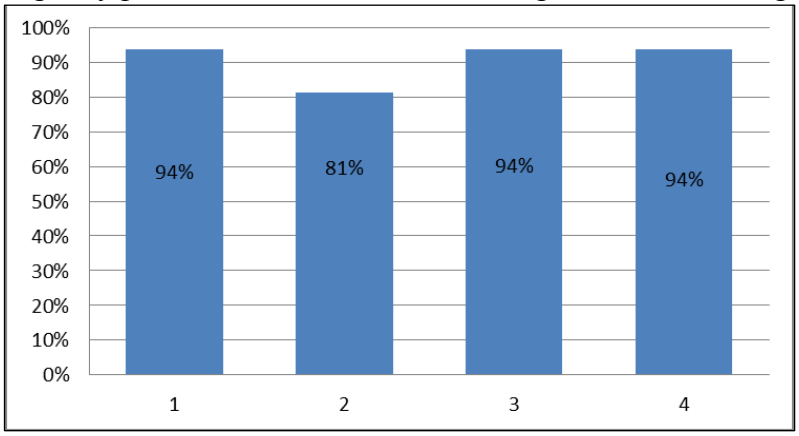

Figure 11. Results of Observation Sheet at the Field Trial Stage

Some of the findings during the field trials include, students said that the electronic teaching materials developed helped them to understand systems material starting from discovering concepts and solving problems of systems of linear equations and inequalities because the exposure to material in electronic teaching materials was close to students' daily lives and it was easy for students to understand the examples. question. In electronic teaching materials there are also exercises so that students can measure their understanding of the material on systems of linear equations and inequalities. Students think that electronic teaching materials can motivate students to learn independently because the choice of color and appearance of electronic teaching materials is attractive so that it makes students interested in studying

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Vol. 11 No. 3 : July 2024
E-ISSN: 2722-4627
pp. 637-646

them. There is an increase in student learning motivation because the teaching materials created are interesting and easy to understand (Lasmiyati & Harta, 2014).

Students said that the use of sentences and language in electronic teaching materials was clear and easy to understand. Students also said that the instructions in the electronic teaching materials were clear, making it easier for students to learn the electronic teaching materials. The results of the teacher response questionnaire also showed that the instructions in the electronic teaching materials provided were clear. The results of the teacher's response to the material in electronic teaching materials are systematic material and follow the learning objectives of systems of linear equations and inequalities.

Based on the results of validation, limited trials and field trials, it was concluded that the electronic teaching materials for systems of linear equations and inequalities based on the CTL approach that were developed included valid and practical criteria. Electronic teaching materials that are valid and practical are continued to the distribution stage. According to Mulyatiningsih (2014) the dissemination stage is carried out by distributing electronic teaching materials developed for students and teachers, and disseminated to a wider target audience. In this research electronic teaching materials which have been valid and practical written in articles and uploaded to accredited journals, as well as providing electronic teaching materials to the schools that contributed to this research.

Conclusion

The conclusion obtained from the results of this research is that the electronic teaching materials developed are based on CTL approach to facilitate mathematical problem solving abilities for SMA/MA students get score *mean* 89% with very valid category. The results of student responses in the limited trial of 12 students obtained a score of 90.28% in the very practical category. The student response results in the field trial were 90.35% with very practical criteria. The teacher response results were 94.14% with the very practical category and the observation sheet 90.6% with the very practical criteria. From the results of validity and practicality, it can be seen that the teaching materials developed are suitable for use as learning resources.

Recommendation

Recommendations for further research are that teachers train students by giving problem solving questions and can develop teaching materials that increase mathematical problem solving abilities in other materials and the resulting teaching materials can be used as references in developing teaching materials in other learning materials.

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