DEVELOPMENT OF AN SCT-MODEL-BASED CHEMICAL BONDING E-MAGAZINE TO ENHANCE STUDENTS' CRITICAL THINKING SKILLS AND KNOWLEDGE LEARNING OUTCOMES

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Abstract. *Critical thinking skills and knowledge learning outcomes are very important for students in today's chemistry learning. However, the results of the PISA test, preliminary studies, and previous research indicate that both aspects still need to be improved. This study uses an R & D approach utilizing the ADDIE model to create a chemical bond e-magazine based on the SCT model that is valid, practical, and effective in enhancing critical thinking skills and knowledge learning outcomes. This study involved five expert validators and 66 grade XI students of SMA Negeri 8 Banjarmasin. The data were gathered through questionnaires, observation sheets, and tests, and then analyzed descriptively. The findings revealed that (1) the e-magazine produced demonstrated a high level of validity (90%) in terms of content, presentation, language, and media, (2) practical with an average score of 88%, and (3) effective with an N-Gain of 0.71 (critical thinking) and 0.75 (knowledge) categorized as high, with an average achievement score of 83%.*

Keywords: *Chemical bonds, critical thinking skills, e-magazine, learning outcomes knowledge, SCT model.*

INTRODUCTION

Critical thinking skills involve the ability to reason and reflect carefully when determining what to accept as true and what actions to take [1,2]. Critical thinking is a structured process within oneself that allows students to carry out analysis, evaluate facts and draw conclusions regarding solutions to problems that have been analyzed [3,4]. Basri et al. [5] The study stated that the analysis showed six sub-skills of critical thinking, with the interpretation sub-skill ranking low because more than 60% of students were unable to interpret effectively. The interpretation sub-skill received a low assessment because more than 60% of students were not able to interpret well. Critical thinking skills play a crucial role in enhancing students' learning outcomes. If students have high critical thinking skills, they can analyze a question well and then answer it correctly. Critical Thinking Skills (CTS) and Knowledge Learning Outcomes (KLO) are important for producing quality students [6].

Data from PISA indicate that learners in Indonesia are still quite weak in answering questions that refer to problem-solving skills, critical thinking, and logic [7]. This is corroborated by the research performed by Ramadhani. [8] that the post-test results from the control class showed less critical average results with an achievement level of 51.23% at SMA Negeri 8 Banjarmasin.

CTS, KLO, and the demands of 21st-century learning activities call for innovation in teaching and learning practices. Innovation in learning is a renewal of previous learning, then packaged with new ideas [9]. Susanti et al. [10] stated that innovation in learning can improve the quality of learning activities, making them more effective and efficient, and adapting to current developments in science and technology. Learning innovation requires learning models that support active student

learning and innovative learning media that can attract student interest [11].

One suitable learning model for improving CTS and KLO is the SCT (Scientific Critical Thinking) learning model. The SCT model was constructed as a further development of the PBL (Problem Based Learning) and Inquiry learning models [12,13]. The SCT learning model, which is based on a constructivist approach, can be implemented to improve critical thinking, self-efficacy, and communication skills in students [14].

A good learning model must be accompanied by engaging learning media to increase student motivation. This learning motivation is necessary so students can understand and understand the importance of learning. Engaging learning media can be achieved by being as creative as possible and containing content relevant to everyday life. E-magazine are a form of media that can attract students' interest while also facilitating their understanding in the learning process [15].

*E-magazine*is a medium for conveying electronic-based information so that it is easy to use and not monotonous in writing [16]. Being digital files that can be accessed online, e-magazines eliminate the need for paper. E-magazines have the advantage of being able to be used on electronic devices and have supporting features such as adding videos, images, audio, and quizzes, thus stimulating desire and interest in the learning process [17,18]. E-magazine also has a different structure from the book. E-magazine contains more pictures, explanations use more concise and clear language, thus providing learning that is memorable, long-lasting, quickly remembered and understood [19]. This media is suitable as learning material for material that is quite complex and considered difficult for students, such as learning chemistry.

Chemistry is often regarded as a difficult subject by students, as it requires mastering concepts that are both complex and abstractconcepts [20]. This statement is supported by Nurillah et al. [21] Through observations conducted at MA Al Muhtadi, 80% of students stated that chemical bonding was difficult to understand. These two statements were also proven by research by Sariwati [22] 68% of students have not yet achieved the Minimum Competency for chemical bonds. One of the factors that makes chemical bonds difficult is their relatively abstract nature. Therefore, chemical bonds are often considered difficult. Chemical bonding is a physical process that allows an attractive force to occur between two or more atoms, thus forming a stable diatomic or polyatomic compound [23]. The concept of chemical bonds can be connected to activities around where we live facilitate the understand of the material [24]. Chemical bonding material can be a tool to measure critical thinking skills and students' learning outcomes due to its characteristics. 1) At the macroscopic level, substances exhibit properties that can be seen, handled, and detected by smell; 2) submicroscopic level that relates to atoms, ions, molecules, and structures; 3) formulas, equations, symbols, and graphs constitute the symbolic level and are essential concepts that learners need to grasp to comprehend other areas of chemistry [25,26,27]. Therefore, the development of educational media is necessary to facilitate the availability of the three characteristics of chemical bonds and can attract interest and help students understand the material on chemical bonds concisely.

Previous studies have extensively investigated the development of engaging chemistry learning e-magazines including the study carried out by Umamah et al. [28] this demonstrates the development of e-magazines as a learning resource for chemistry. The outcomes of the study reveal that the e-magazine is effective in enhancing students' CTS, achieving a validation score of 91.65%. Furthermore, the effectiveness is reflected in the average N-gain score of 0.91 for the experimental class, with the highest score being 1.00 and the lowest being 0.66. In the experimental class, 8 students achieved the high N-gain category, and 6 students were in the medium category. Meanwhile, the control class had an average N-gain of 0.44, with the highest score being 0.88 and the lowest being 0.33. Based on the facts obtained from interviews with teachers at SMA Negeri 8 Banjarmasin, which became the sample school, students achieved a mastery of 25% in each class on the topic of chemical bonds. This research demonstrates novelty related to the development of an e-magazine that can enhance CTS and students' KLO in detail. The results of these factual descriptions lead to this research being conducted by developing a learning

media in the form of an e-magazine SCT model to improve CTS and students' KLO.

METHOD

This study employs a Research and Development (R&D) approach. The R&D process involves a series of organized steps, starting with problem or opportunity identification, research planning, data collection, analysis, and the development of new solutions or products [29]. This research uses the ADDIE model. The ADDIE is a development model that involves systematic, clear, and precise stages to produce a product, and this model is specifically designed for multimedia learning [30]. ADDIE Modelas in Figure 1.

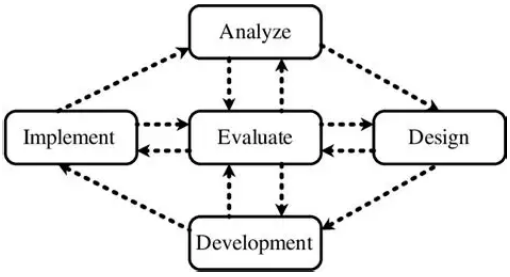

Figure 1. ADDIE development model

The validity, practicality, and effectiveness of the e-magazine were tested using two types of data collection techniques, including tests and non-tests, which were analyzed descriptively. The data analyzed to test the validity of the e-magazine used the following formula:

$$\text{Validity } E-magazine = \frac{\text{total score required}}{\text{total score(overall)}} \times 100$$

The values obtained from the validator were tabulated and categorized based on the validation criteria stated by Mawarni et al. [31] as in Table 1.

Table 1. Criteria for e-magazine validation results

Percentage Interval	Validation category	Information
85.01 – 100.00%	Very valid	Can be used without revision
70.01 – 85.00%	Quite valid	Can be used with minor revisions
50.01 – 70.00%	Less valid	Not used because it needs a lot of revision
x ≤ 50.00%	Invalid	Not to be used

Practicality data analysis was obtained from the e-magazine readability questionnaire, the response questionnaire (teachers and students) regarding the media, the ability to use the e-magazine and the implementation of learning. The data analyzed in testing the practicality of the e-magazine used the following formula:

$$\text{Practicality of E-magazine} = \frac{\text{total score required}}{\text{total score(overall)}} \times 100$$

Practicality criteria according to Wahyudi et al. [32] are presented in Table 2.

Table 2. Criteria for practicality of e-magazines

Mark	Validation category	Information
81.00-100%	Very practical	Can be used without revision
61.00-80%	Practical	Can be used with minor revisions
41.00-60%	Quite practical	It is recommended not to use
21.00-40%	Not practical	Can not be used
00.00-20%	Very impractical	Can not be used

The analysis of the e-magazine's effectiveness was conducted by evaluating students' CTS and KLO through assessments administered prior to the implementation (pre-test) and following the implementation (post-test) of the e-magazine. These assessments employed a test instrument consisting of six descriptive questions designed to measure CTS and ten multiple-choice questions aimed at assessing KLO. The results obtained were subsequently analyzed using an established calculation formula.

$$\text{CTS} = \frac{\text{Required Score}}{\text{Maximum Score}} \times 100$$

$$\text{KLO} = \frac{\sum \text{Required Score}}{\text{total Score}} \times 100$$

The criteria for the results of CTS assessment according to Musahrain et al. [33] and the results of KLO according to Djamarah & Zain [34] that students obtain in studying chemical bonding material are presented in Table 3 and Table 4.

Table 3. Criteria for critical thinking skills

Interval	Category
81 < x ≤ 100	Very High
61 < x < 80	High
41 < x < 60	Medium
20 < x < 40	Low
0 < x < 20	Very Low

Table 4. Criteria for knowledge learning outcomes

Mark	Category
92-100%	Very good
83-91%	Good
75-82%	Enough
<75%	Not enough

The test scores obtained were then further analyzed using normalized gain (N-Gain). N-gain analysis aims to evaluate the improvement of variables and measure the effectiveness of the developed e-magazine and the use of e-magazines in chemistry learning [35]. N-gain values are computed by applying the formula below.

$$N\ Gain = \frac{S_f - S_i}{I_s - S_i}$$

Information:

N Gain = Test valuegain normality
Sf = Post-test score
Si = Pre-test score
Is = Scoreideal maximum

The obtained scores are subsequently interpreted according to the N-Gain criteria established by Hakke [36] in Table 5 below.

Table 5 N-Gain value criteria

N-Gain	Category
(g) > 0.7	High
0.3 ≤ (g) ≤ 0.7	Medium
(g) < 0.3	Low

RESULTS AND DISCUSSION

Study produced an e-magazine designed for learning chemical bonding, along with data regarding its validity, practicality, and effectiveness. The first stage of the ADDIE development model is the analysis stage.

Analysis Stage

The analysis stage was conducted by analyzing the needs of students, curriculum, teaching media used, and students' learning environment. The results showed that the ongoing learning was quite interactive between teachers and students, but was still not supported by electronic learning media. This analysis stage is important to identify the issues arising in the learning process and analyze the need for development, feasibility, and criteria for developing new teaching materials. The analysis stage was conducted by implementing literature studies and field studies. One of the analysis results from observations conducted with students showed that students felt bored with teaching materials in the form of printed books. Based on the results of distributing questionnaires to determine students' needs for E-Magazine learning media, display in Figure 2 below.

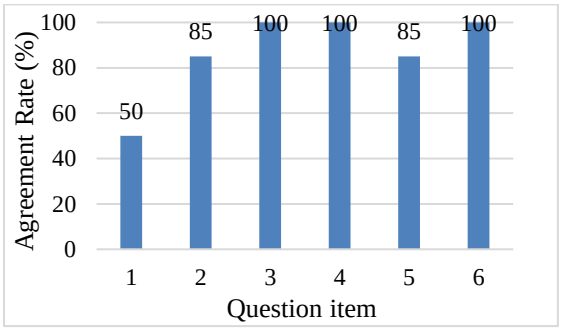

Figure 2. Graph of the results of the e-magazine development needs questionnaire

Question item:

1. I have never used electronic media to study chemistry.
2. I'm unable to learn chemical bonding material using only printed textbooks.
3. I'm more interested in studying chemical bonding through e-magazines.
4. I need learning media that connects the material to everyday life.
5. I find chemical bonding material difficult.
6. I feel enthusiastic about learning chemistry through engaging electronic media.

According to the data presented in Figure 2, question items 3, 4, and 6 recorded the highest score of 100%, whereas the lowest score recorded was 50%, and the remaining items scored 85%. Based on data taken from 66 students, it shows that students need interesting learning media with electronic support and implementation of learning materials in everyday life to support learning to make it

more interesting and easier to understand, especially in chemical bonding material which they find difficult.

Design Stage

The design phase entails the preparation of the e-magazine media concept to be implemented in development. The product of this development is systematically structured with the following two components, (1) Using the syntax of the SCT learning model, (2) Loading content related to material connected to events in everyday life in the student orientation section. This e-magazine contains material, images, and videos that can foster students' enthusiasm for learning it [37]. This e-magazine consists of a front cover page, a home page, a content page, and a final page. The appearance contents of the e-magazine is presented in Figure 3.

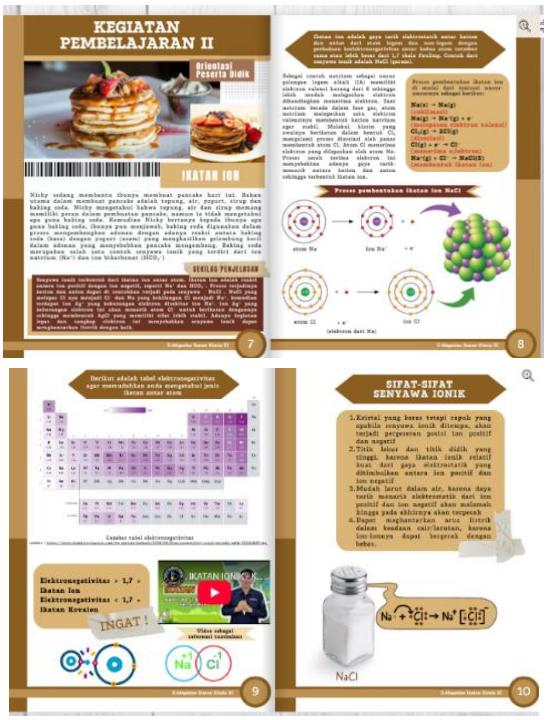

Figure 3. Screenshot of e-magazine

Development Stage

The e-magazine media was developed with the help of *website* Heyzine flipbooks allow the product to be converted into a swipeable book that can be easily accessed via a link or QR code scan on an electronic device. The product development results can be accessed via the QR code in Figure 4.

Figure 4 e-magazine QR Code

Validation

During the development stage, product feasibility testing was also conducted. The product trial phase involved two steps: expert assessment and development trial. The first test was conducted by five expert and experienced validators to assess the feasibility of the developed e-magazine and the 16-item CTS and KLO test instruments used in this study. The media validation results are presented in Table 7 below.

Table 7 Results of e-magazine validation test

Aspect	Average	(%)	Category
Contents	36	90	Very Valid
Presentation	17.6	88	Very Valid
Linguistics	18.8	94	Very Valid
Media	26.6	88	Very Valid
Amount	24.7	360	Very Valid
Average	90	90	

The data presented in Table 7, the e-magazine as a whole is categorized as very valid. This proves that the e-magazine can be advanced to the next stage.

The second test was conducted by testing the readability of the e-magazine. The readability test was conducted 3 times. First, an individual test was conducted on 5 students of class XII 1 SMAN 8 Banjarmasin with a score of 82% in the “Very Practical” with revisions to the font that was difficult to read and the color was less suitable. Second, a small group test was conducted on 10 students of class XII 1 SMAN 8 Banjarmasin with a score of 87% in the “Very Practical”. This test was conducted after the e-magazine was revised based on the suggestions from the individual test. The revisions given from the small group test were the neatness of the writing.

Implementation Stage

Practicality

E-magazine the revised version was based on validator and student feedback during individual and small group trials and was then used in classroom learning. In implementing e-magazines in the classroom, 66 students were selected as samples for the limited group e-magazine readability trial. The results were categorized as "Very Practical" with a score of 91%. The suggestions given by students after learning with *e-magazine*is to add more interactive elements such as quizzes or short videos. Suggestions and comments at this stage serve as an evaluation for improving the e-magazine to produce a practical, readable e-magazine that can be widely disseminated and used in chemistry learning.

Students also responded to the e-magazine after using it in class. The findings indicated that 91% of students responded with the "Very Practical". Student evaluate after using the e-magazine were positive, such as finding it significantly helpful in understanding due to the more concise material and easy-to-understand language.

At the implementation stage it also produces teacher responses, results observations of teachers' ability to use e-magazines, and observations of learning implementation as data for testing the practicality of e-magazines. The results obtained from teacher responses to e-magazines were 91% with the category "Very Practical". Comments and suggestions given by teachers regarding e-magazines are that it should be accessible both offline and online, optimize the accessibility of flipbooks on all devices, and add features to record students' answers to critical thinking tasks."

Observations of teachers' ability to use e-magazines scored 83%, categorized as "Very Practical." Observations of learning implementation scored 85%, categorized as "Very Practical." These results indicate that e-magazines are practical, as assessed by the results of the practicality test. Observations of teacher activities in the classroom are crucial for optimal learning [38].

The results of the recapitulation of the analysis of the practicality of e-magazines that have been tested based on several assessment components such as readability trials (individual, small group, limited group), student responses, teacher responses, results of observations of teachers' abilities to use e-magazines, and results of observations of the implementation of learning are presented in Table 8.

Table 8. Recapitulation of E-magazine Practicality

Component	Evaluation(%)	Criteria
Legibility	87	Very Practical
Student Response	91	Very Practical
Teacher Response	94	Very Practical
Teachers' ability to use e-magazines	83	Very Practical
Implementation of Learning	85	Very Practical
Average	88	Very Practical

Effectiveness

E-magazine those that have passed the validation stage are then tested for their effectiveness. This testing was carried out by implementing the e-magazine to students in learning. The implementation was carried out on 66 grade XI students at SMA Negeri 8 Banjarmasin. Before being used in learning, students were first given 16 questions in the form of 6 essay questions and 10 multiple-choice questions as a pre-test. The pre-test was administered to evaluate students' baseline abilities prior to the implementation of the e-magazine. At the conclusion of the learning process, the same set of questions was administered as a post-test to evaluate students' CTS and KLO. The findings from the analysis of the effectiveness of students' CTS and KLO are presented as follows.

1) Critical thinking skills (CTS)

The scores obtained for the CTS test are presented in Table 9 below.

Table 9. Pre-test and post-test scores of CTS

Test	Lowest Value	The highest score	Average
Pre-test	7	43	25
Post-test	40	93	78

Based on Table 9, students' CTS showed an increase from average score increased from

25, which was classified as "Not Good," to 78, which fell into the "Good", after the implementation of e-magazines the SCT model on chemical bonding material in the learning process. The effectiveness test data can be processed into a data distribution to determine the frequency of students in certain categories. The distribution of results from the pre-test and post-test is shown in Table 10.

Table 10. Distribution of CTS test results

Mark	Category	Frequency	
		Pre-test	*Post-test*
76-100	Good	0	47
56-75	Pretty good	0	14
41-55	Not good	1	4
0-40	Bad	65	1

Table 10 shows that, in the pre-test, 65 students had CTS in the "Bad" on chemical bonding material, 1 student was in the "Not Good" and no one students were in the "Pretty Good" and "Good". After implementing learning through an e-magazine, a post-test was subsequently conducted. The results indicated that 47 students demonstrated CTS in the "Good", 14 students in the pretty "Good", 4 students in the "Not good", and 1 student in the "Bad".

Students' progress in CTS can be assessed using the Normalized Gain (N-Gain). This improvement presented in Table 11 below.

Table 11. N-gain values of CTS test

N-gain	Category	Frequency
$(g) > 0.7$	Hight	38
$0.3 \leq (g) \leq 0.7$	Medium	28
$(g) < 0.3$	Low	0

Based on Table 11, 38 students demonstrated an improvement in CTS classified as "High", while 28 students showed an enhancement in the "Medium".

2) Knowledge Learning Outcomes (KLO)

Data on students' KLO, based on the average pre-test and post-test scores in the limited trial class, outcomes are shown in Table 13.

Table 13. Pre-test and post-test values of KLO

Mark	Completeness	Frequency	
		Pre-test	*Post-test*
76-100	Completed	1	55
1-75	Not Completed	65	11

Based on the results presented in Table 13, in the pre-test, there were 65 students who did not complete the test and 1 student who completed it, whereas in the post-test, 55 students completed the test and 11 students did not. The data on students' KLO were categorized based on the applicable completion value. The Minimum Completion Criteria (MCC) applicable at SMA Negeri 8 Banjarmasin for grade XI chemistry students is 75. Based on these provisions, students with scores below 75 are said to have not completed the course and scores above 75 are said to have completed the course.

There were 65 students who did not complete the pre-test and 1 student who completed it, resulting in a completion rate of 2% in the pre-test. Meanwhile, 11 students did not complete the post-test, resulting in a completion rate of 83%. This indicates a very significant increase in the completion aspect of KLO. These scores are also categorized by level in Table 14.

Table 14. Pre-test and post-test values of KLO based on level criteria

Mark	Category	Frequency	
		Pre-test	*Post-test*
92-100	Very good	0	19
83-91	Good	0	18
76-82	Enough	1	18
1-75	Not enough	65	11

The highest and lowest scores in the pre-test of knowledge learning outcomes were 80 and 10, respectively. The average score obtained in the pre-test was 41. The highest and lowest scores of students' KLO in the post-test were 100 and 50, respectively, with an average score of 86.

The knowledge test data obtained from the pre-test and post-test were then processed into N-Gain data to measure how much the students' understanding has improved knowledge increased after participating in learning using the e-magazine that had been developed with chemical bonding material. The N-Gain data from the students' knowledge test are presented in Table 15 below.

Table 15. N-gain values of KLO tests

N-gain	Category	Frequency
$(g) > 0.7$	High	46
$0.3 \leq (g) \leq 0.7$	Medium	20
$(g) < 0.3$	Low	0

Based on Table 15, The N-gain results indicate 46 students “High” and 20 “Medium”. Based on the calculations, it is known that there was an increase in students' knowledge scores between the pre-test and post-test, as seen from the average N-Gain obtained of 0.75, which falls within the “High”.

Evaluation Stage

The evaluation stage is the stage carried out at the end of each previous stage. In other words, at each stage of development, an evaluation is conducted to improve the product. In the previous development stage, validation tests were conducted with validators and readability tests with students, who were then given scores, comments, and suggestions to improve the e-magazine product.

An evaluation phase was also conducted upon the completion of the research and all stages of the process. The goal was to refine the e-magazine, which had been piloted on a single sample, and then further develop it for wider distribution and continued use in chemistry learning going forward.

CONCLUSIONS AND SUGGESTIONS

E-magazine chemical bonding based on the SCT model is provenis very valid, practical, and effective in advancing CTS and KLO of students. Validity reached 90%, practicality 88%, and effectiveness is shown by an increase in CTS achieved an N-Gain of 0.71 “High” and KLO with an N-Gain of 0.75 “High” and an average completion rate of 83%.

Suggestions for future researchers who want to conduct research on e-magazine development are to make e-magazines accessible offline, optimize the accessibility of flipbooks on all devices and add features to record students' answers to critical thinking tasks.

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