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Developing Android-Based Chemistry Learning Media Using the Inquiry Model to Improve Students' Learning Outcomes and Critical Thinking Ability

Meydia Afrina
SMAN 9 Bengkulu Selatan, Bengkulu, Indonesia
afrinameydia@gmail.com

Jumiati Siska
Universitas Dehasen, Bengkulu, Indonesia
jesiskaalghazali@gmail.com

Sudarwan Danim
Universitas Bengkulu, Bengkulu, Indonesia
sudarwandanim@unib.ac.id

Abstract: *Students' critical thinking and their ability to learn outcomes depend on the learning design and student activities. Most of the students use their free time by playing gadgets. Students learn faster with the features contained in gadgets than learning from sources in the form of textbooks. This phenomenon is the background for researchers to develop android-based chemical media which has several menus that can be explored by students in learning. Android-based chemical media was developed using the Smart Apps Creator application. This study aims to develop a digital media that is compatible with the android system. In this study the media is used to improve cognitive learning and critical thinking. In addition, it also aims to evaluate the responses of students in learning chemistry through the topic of Oxidation Reduction Reactions. The development of this media was adapted from the procedure of the interactive mobile learning development process. The collection of evaluation data models that are applied are pre-test and post-test in the test class. Based on the results of the development carried out, it can be concluded that the developed android-based chemical media has met the appropriate criteria. This media can help educators in the learning process effectively and optimally and make students interested in learning chemistry.*

Keywords: *Android Media; Critical Thinking; Learning Outcomes; Question*

INTRODUCTION

Currently, information and technology are developing markedly by advances in knowledge, known as the 21st century. The hallmark of the 21st century is the speed at which information and technology are interconnected, thus creating synergy. The context of the use of information and communication technology in education is evidenced by the fusion of "space and time" to determine the speed and success of science by mankind. The 21st century is marked by the expansion of (1) information that is available anywhere and can be accessed at any time; (2) faster computing; (3) automation that

replaces routine work; and (4) communication that can be done from anywhere and anywhere (Ipa, Pembelajaran, & Berbantuan, 2014).

In facing the current era, students are expected to have 21st century skills so that they can help students to learn and adapt to all forms of changes that occur from time to time (Komalasari, 2011). These changes are related to global economic networks, ecosystems, and politics. This condition requires students to learn how to communicate, cooperate, and solve problems with people around the world. Students need seven survival skills including: critical thinking and problem solving, leadership and cooperation, agility and adaptability, initiative and entrepreneurial spirit, ability to communicate effectively both verbally and in writing, easy access to information and analysis of information, imagination and curiosity (Komalasari, 2011). In order to compete with foreign nations, students should have a 21st century learning framework. Students are required to have skills, knowledge and skills in the fields of technology, media and information, learning and innovation skills as well as life and career skills. This framework also describes the skills, knowledge and expertise that must be mastered in order for students to be successful in life and work. In line with that, the 21st century learning paradigm emphasizes the ability of students to want to learn starting from finding out from various sources, formulating problems, and carrying out analytical thinking and collaboration and collaboration in solving problems. In addition, every student must have critical thinking skills, knowledge and skills of digital literacy, information literacy, media literacy and mastering information and communication technology to face learning in the 21st century (Liberna, n.d.).

One of the 21st century skills that students must have been the ability to think critically. Critical thinking is a skill related to disposition. Like creative thinking, critical thinking becomes a thinker who not only has certain cognitive skills, but also the willingness to critically assess and evaluate information, emphasizing problem identification analysis and assumptions. An analysis of how arguments and thoughts are constructed so as to produce a formulation or conclusion is needed in the practice of critical thinking (Marni, Suyono, & Roekhan, 2019).

Critical thinking is thinking seriously, actively, and accurately in analyzing all information received with rational reasons. Critical thinking is used in making informed judgments and explaining the reasons for solving problems (Medium, 2017). Critical thinking has an important role in making decisions and solving problems during the learning process and in everyday life (Effectiveness et al., 2016). In dealing with the problems faced in life, critical thinking is needed. By thinking critically, a person can manage his thoughts so that he can

act more appropriately. A critical thinker is a person who is good at analyzing, a critical thinker uses his reasoning as the basis of his thinking (*Ennis.Pdf*, n.d.).

Critical thinking will be easier to teach to students if it is included in the subject, compared to practicing critical thinking independently. Critical thinking skills are very important for students to be able to more easily understand abstract chemical concepts. To understand and master the concept of chemistry, students are expected to think critically in order to translate abstract concepts into concrete ones. In chemistry learning, teachers can improve students' critical thinking skills by enriching students' meaningful experiences. The experience can be an opportunity to express opinions orally or in writing like a scientist [8]. Research and development that has been carried out by states that the development of a respiration module based on critical thinking indicators can improve critical thinking skills and student learning outcomes [8]. The process of critical thinking skills is developed through inquiry learning. This is because in the inquiry process, students receive information, they will think, prioritize information, and look for correlations before looking for supporting reasons that refer to the new knowledge. Furthermore, they will develop various learning plans and activities then stimulate them, and ask questions to improve brain thinking skills is an inquiry learning process.

Chemistry learning can be meaningful by using the inquiry learning model. Chemistry is one of the science subjects that is closely related to everyday life (Weaver, Samoshin, Lewis, & Gainer, 2016). One of the chemistry materials taught in high school related to everyday life is redox reaction material. This material is material whose application is close to the real life of the community. Monotonous and teacher-centered learning activities will cause boredom and result in low student learning outcomes. Several studies have been conducted in the development of mobile learning to support the teaching of 21st century basic skills.

According to research (Sumbawati et al., 2018) learning media can motivate students to learn more about chemistry because according to students media is interesting, attractive, and makes learning more meaningful. Therefore, learning using android that has been developed is feasible to be used as a learning medium and in accordance with the needs of students. Another research conducted by (Solikhin & Wijanarko, 2021) shows that: (1) android-based chemistry learning media has characteristics, namely attractive, practical and flexible visualization and evaluation of varied questions, (2) android-based chemistry learning media is considered suitable for use in learning, in terms of material aspects, media aspects and test results of students, and (3) there is a significant increase between learning motivation and cognitive achievement of

students who take part in learning using android-based chemistry learning media with conventional learning.

The approach to using digital technology as a learning medium has a better and more effective impact than other approaches. For this reason, it is necessary to support interesting and interactive learning media to increase student interest in learning. The results of the study (Puspitarini & Hanif, 2019) show that the media design and content validity are very feasible with 80% feasibility percentage. Practitioners and students responded very well with 82.22% and 86.35% mean percentage eligibility respectively. The effectiveness of this media on the growth of student literacy is evidenced by the N-gain value of 0.65% in the medium category. It can be concluded that the android-based chemistry learning media that was developed is highly qualified for chemistry learning applications and grows students' scientific literacy on redox reactions and electrochemistry subject matter effectively (Khasanah & Widoretno, 2017).

Learning using inquiry can motivate students to become thinkers, foster curiosity, train cooperation and solve problems. According to (Perkuliahan, 2010) the stages of inquiry that must be carried out are as follows:

1. Problem Identification and Clarification

The first step is to determine the problem to be explored or solved using the inquiry method. Questions can be prepared or delivered by the teacher. The nature of classroom problems so that they can be thought about, experienced, and solved by students. Problems need to be identified and clarified. If the problem is determined by the teacher, it should be noted that the problem must be real, can be done by students, and in accordance with the abilities of students. The issue is in accordance with the level of life and circumstances of the students.

2. Formulate hypotheses

The next step, students are asked to propose temporary answers about the problem. This is called a hypothesis. The student's hypothesis is evaluated by the teacher if it is not precise and clear then the teacher helps correct it by clarifying its purpose. The wrong hypothesis will later be proven after data collection and data analysis is obtained.

3. Collecting data

The next step, students search and collect data to prove whether their hypothesis is true or not. One way to collect data can be done by practicum.

4. Analyzing the data

The collected data must be analyzed to be able to prove whether the hypothesis is true or not. To make it easier to analyze, data must be organized, grouped, and managed so that it can be analyzed easily. Data is usually arranged in tables for easy reading and analysis. Here sometimes the teacher needs to intervene because of the large amount of data so that students are sometimes confused about determining the next step. In analyzing, it is often necessary to use computational tools such as mathematical formulas and statistics that allow students to make decisions or make generalizations.

5. Drawing conclusions

From the data that has been grouped and analyzed, conclusions are drawn with generalizations. After drawing conclusions, it is then matched with the initial hypothesis, to see whether our hypothesis is accepted or rejected.

The inquiry process begins with formulating problems, developing hypotheses, collecting evidence, testing hypotheses, and drawing tentative conclusions, examining temporary conclusions to get conclusions that are to some extent believed by students (Wardani, 2017). The android-based chemistry learning media that will be developed is in the form of audiovisual media. This media was developed because it was based on an initial assessment carried out to meet the students' learning styles, which were generally audio-visual. The media developed is one of the media that can create an interactive learning environment that provides a positive response to student learning needs by preparing active learning activities to ensure independent learning occurs (Rasmawan, n.d.).

The interactive concept in a computer-based learning environment follows three elements, namely (1) customizable instructional sequences; (2) responses or answers to student work; and (3) customizable feedback. Learning using interactive media has a positive impact on learning. The use of computer-based learning media in addition to improving learning outcomes also increases the role and knowledge skills of students (Widowati, Nurohman, & Anjarsari, 2017). The learning media used also affects students' ability to seek and investigate new knowledge (Hasnunidah & Lampung, 2007).

Critical thinking is an organized and clear process used in mental activities such as problem solving, decision making, persuading, analyzing assumptions, and conducting scientific research. Critical thinking allows students to systematically study problems, face many challenges in an organized manner, formulate innovative questions, and design solutions. Critical thinking is a systematic process that allows students to formulate their reasoning. Critical

thinking is an organized process that allows students to evaluate the evidence, assumptions, logic and language underlying the statements of others. Critical thinking also means thinking right, and contemplating the thought process is part of right thinking (Hasnunidah & Lampung, 2007). Critical thinking is grouped into five main activities as follows:

a. Provide a simple explanation, which contains; focusing questions, analyzing questions and asking questions, and answering questions about explanations or statements.
b. Building basic skills, which consist of; considers whether the source is reliable or not and regarding and considers observation reports.
c. Summarizing which consists of subtraction activities or considering the results of subtraction, induction or considering the results of induction, and making and determining the value of the consideration.
d. Provide further explanation consisting of identifying terms and definitions of considerations and dimensions, and identifying assumptions.
e. Establish strategies and techniques consisting of determining actions and interacting with others.

RESEARCH METHOD

Research and development of android-based chemistry learning media was carried out at SMA Negeri 9 Bengkulu Selatan. The research location was chosen at SMA Negeri 9 Bengkulu Selatan because from the results of observations and empirical data as a teacher at school it was found that the use of learning media as a learning resource was rarely used. Based on observations and interviews with students' needs, students need learning media that are interactive, interesting, easily accessible from anywhere (Arsyad, Azhar, 2011).

Preliminary research was conducted in the early stages of research by conducting observations and interviews with teachers and students as well as parents as the school committee. After compiling an interactive media development design that has been validated by experts, the researchers conducted a small-scale trial. The product trial was carried out on class XII-IPA students with redox reaction material in the odd semester of the 2021-2022 academic year. This research was conducted on July 25, 2021 until September 30, 2021.

There are two different types of trials with different scores in one school. A small-scale trial was conducted on 10 students of class XII-IPA2 who

were taken randomly. A large-scale trial was conducted on 20 students of class XII-IPA1 as many as 20 students.

This research is a Research and Development (R&D) research conducted to develop android-based chemistry learning media [20]. Where the application of this media is combined with the inquiry learning model, in chemistry subjects. The material for the odd semester of class XII is redox reactions. Sources of research and development data came from research subjects, namely students of class XII-IPA SMA Negeri 9 Bengkulu Selatan class XII-IPA1 and XII-IPA2, as well as chemistry subject teachers who played a role in the learning process at the research school and outside school consisting of 5 people as reviewers.

Table 1. Data form, Data Collecting Method, and Instrument

Data	Data Collecting Method	Instrument
The potential identification and the validation of android-based chemistry learning media	Interview for teacher and students Product validation by the experts and chemistry teacher of SMAN 9 South of Bengkulu	Interview guideline Validation sheet
The use of learning media in small-scale test and large-scale test	Assessment of test abd observation of critical thinking ability	Observation sheet and evaluation test
The assessment of product effectiveness	Response questionnaire for students, teacher, and experts	Questionnaire sheets on the use of interactive learning media

RESULT AND DISCUSSION

This R & D research results are presented in the following data. The results of the trial validation can be seen in table 2 below.

Table 2. The Validation Result of Test Item Trial

Validation	Number of Test Item	Total of Test Item
Valid	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15,	47

Validation	Number of Test Item	Total of Test Item
	16, 17, 18, 19, 20, 21, 22, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 49, 50	
Invalid	23, 36, 48	3
Total		50

The result of item difficulty trial can be seen in the table 3 below.

Table 3. The Result of Item Difficulty Trial

Difficulty Level	Number of Test Item	Total of Test Item
Easy	15, 32	2
Moderate	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 29, 30, 31, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 49, 50	45
Hard	16, 28, 48	3
Total		50

The result of item distraction trial can be seen in table 4 below.

Table 4. The Result of Item Distraction Trial

Distraction Level	Number of Test Item	Total of Test Item
Excellent	3, 47, 49	3
Good	11, 13, 25, 26, 30, 41, 50	7
Adequate	1, 2, 5, 6, 7, 8, 9, 14, 15, 16, 18, 19, 24, 27, 31, 32, 33, 35, 37, 38, 39, 40, 42, 43, 44, 45, 46	27
Bad	4, 10, 12, 17, 20, 21, 22, 28, 29, 34	10
Very Bad	23, 36, 48	3
Total		50

From the overall analysis of the above trial test items then the number of the test items that can be used for the next test is 47 test items. All these number will be used for trials using android-based chemistry learning media, the number of test items mentioned are the test items number 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 49, 50.

The Result Of Android-Based Chemistry Learning Media Implementation/Making

This study has developed android-based chemistry learning media and instruments as a means for testing the validity and effectiveness of the media. Learning sets resulted from development include syllabus, lesson plan, android-based chemistry learning media, the media developed with inquiry approach and critical thinking (Hidayat, Milama, & Muslim, 2020).

The Development of Android-Based Chemistry Learning Media

The next process is to create the finished form of the product in the form of educational media. It did without coding program. An overview of the design and appearance can be seen on the story board in the attachment. The media uses smart apps creator. The media make the output Apk.extention. The media can run well on android.

The material content developed in some part for class XII of senior high school such as material, video, game, developer, references. This material is divided into several subs of Oxidation Reduction Reaction. The media contains visual, audio and animation elements (Akhlis & Dewi, 2014).

Figure 1. The Starting Appearance of the Media

Figure 2. Media Board

The Result of Validation and Revision towards the Learning Media

It has been stated that the tools developed include syllabus, lesson plans, and educational games as well as inquiry-based and critical thinking worksheets. The results of the validation of learning tools by several validators are presented in Table 5. It has been stated that the learning sets developed include syllabus, lesson plan, and educational game and student's worksheet which are based on inquiry and critical thinking. The validation results of the learning sets by some validators are presented in Table. 5

Table 5. The Validation Analysis Sheet of Media

Instrument of the study	Assessment Average in Per- centage (%)
Syllabus Validation	83.33
Lesson Plan Validation	83.33
Media Validation (material)	78.33
Media Validation (language)	83.33
Learning design	84.25
Visual communication design	80
The validation average of media and learning sets	81.67

Table 5 shows the average validation score of the experts with percentage of 81.67%. The score indicates that the assessment from the experts has valid criteria, so it can be concluded that the research instrument can be used as a means of data collection in research.

Android-based chemistry learning media testing was done by material validators to analyze the content of chemistry material. Validation results show that chemistry materials are adapted to the independence curriculum by using a scientific approach in the learning and taking contextual examples in the students' life so that the students' inquiry and cri tical thinking skills will increase. The validation result is a summary of the three validators and the recapitulation result of the substance of the material listed in Table 5.

Table 6. The Recapitulation Result of The Material Substance Validation

Assessment Aspect of Educational Game	Average Score of The Three Validators	Category
Feasibility of con- tent/material	3.27	Very valid
Language of the material	3.33	Very valid
Learning design	3.37	Very valid
Visual communication design	3.2	Very valid

The Effectiveness of Android-Based Mobile Learning to Improve Students' Critical Thinking Ability

Data analysis to determine the effectiveness of android-based mobile learning was carried out using the N-gain test. N-gain test to determine the increase in students' scientific literacy after being taught using android-based learning media on colloid system material. From the results obtained when testing students' initial abilities by being given pre-test questions in the form of reasoned multiple-choice questions as many as 10 items, the average score of students was 17.52, while after students received learning using android-based learning media, they were then given a post evaluation. -Test in the form of multiple-choice questions with reasoned as many as 10 items obtained the average score of students is 69.53. From the data from the students' pre-test and post-test results, then the N-gain test was calculated to determine the effectiveness of using android-based chemistry learning media to improve students' critical thinking ability on oxidation reduction reactions material. After conducting the N-gain test, the average score of student acquisition was 0.62 in the medium category (Toprac, 2008). The following is a graph of students' pre-test and post-test learning outcomes in table 1.

Figure 3. Graph of Student Learning Outcomes

Thus, it is said that android-based mobile learning to improve students' critical thinking ability on oxidation reduction reactions material can be used to support student learning activities. Students are given the opportunity to practice developing thinking skills, be scientific, and be able to make a connection between the knowledge possessed and its application in everyday life (Nazar, Rusman, Puspita, & Yaqin, 2022)

CONCLUSION

Based on the results and discussion, it can be concluded that the characteristics of android-based learning of chemistry media to improve students' critical thinking ability on oxidation reduction reactions materials use smart application creator software. This media is in the Apk. extension, which is installed and displayed in an android. This mobile learning also affects the activeness of students in studying oxidation reduction reactions material which is indicated by the high student response. The effectiveness of the developed media is effective to use, this is based on the average N-gain score in the medium category (Setiawaty, Rezkia Lukman, Imanda, & Putra, 2023).

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