Jurnal Pendidikan IPA Indonesia

THE DEVELOPMENT OF INQUIRY BY USING ANDROID-SYSTEM-BASED CHEMISTRY BOARD GAME TO IMPROVE LEARNING OUTCOME AND CRITICAL THINKING ABILITY

S. Wardani[1], L. Lindawati[2]*, S. B. W. Kusuma[3]

[1]Chemistry Department, Faculty of Mathematics and Natural Science, Universitas Negeri Semarang, Indonesia
[2]SMA-IT Al Irsyad Al Islamiyyah, Indonesia
[3]Chemistry Department, Kanazawa University, Japan

ABSTRACT

Student's critical thinking and their learning result depend on learning design and student's activity. Most students use their spare time with playing game. Students are more challenged by the difficulty in playing game rather than facing the difficulty in understanding the lesson. This phenomenon is the basic reason of the researchers to develop a game that has the essence of the subject matter, namely Chemistry Board Game (CBG) or we can call it with Al Chemist Knight. This research aims to develop a suitable digital game based on android system. In this research media was used to improve the cognitive learning and critical thinking. It also has purpose to evaluate the response of learners in learning chemistry through alkane derived compound topic. The development of this game was adapted from the procedure of game development process in mobile 3D presentation. The collection of evaluation data model applied was pre test and post test in trial class. The result showed that in the pretest the learning result average was 34.35 with classical target of 5%. While the posttest learning result average was 80.51 with classical target of 85%. The n-gain factor was 0.703. Based on the result of the students questionnaire data analysis, 3.025 of students responded positively to the implementation of CBG. A CBG media makes an assessment of critical thinking, in which the indicator of critical thinking which are focusing on questions get 3,1 point, giving arguments get 2.95, asking and answering questions get 3.0, making decision get 3.05, and the average score of critical thinking indicator is 3.025 which belongs to good category. Based on the students' response questionnaire, we get the average score of 3.3 or 82.5% which is classified in good category.

INTRODUCTION

The 21st century is a century of knowledge, where information is scattered and technology evolves. The characteristic of the 21st century is the increasingly interconnected world of science, so that the synergy between them becomes faster. The context of the utilization of information and communication technology in education is evidenced by the melting factor of "space and time" has been a determinant aspect of the speed and success of science by mankind. The 21st century is marked with the abundance of (1) information available anywhere and accessible at any time; (2) faster computing; (3) automation that replaces routine jobs; and (4) communication that can be done from anywhere and everywhere.

The 21st century skills can help students to learn and adapt to all forms of change that takes place over time (Ongardwanich et al., 2015). The change is related to global economic, ecosystem and political networks. This condition requires students to learn how to communicate, cooperate, and solve problems with people all over the world. Students need seven survival skills including: critical thinking and problem solving,

*Address Correspondence:
E-mail: lia.lindawati@gmail.com

leadership and cooperation, agility and adaptability, full of initiative and enterprener spirit, ability to communicate effectively both oral and written, easy access to information and information analysis, imagination and curiosity (Saavedra & Opfer, 2012).

A 21st century learning framework that requires learners to have the skills, knowledge and skills in technology, media and information, learning and innovation skills as well as life and career skills. This framework also explains the skills, knowledge and expertise that must be mastered so that learners can be successful in life and work. In line with that, the 21st century learning paradigm emphasizes on the learners' ability to find out from various sources, formu- late problems, and do analytical thinking and cooperation as well as collaboration in solving problems. To deal with learning in the 21st century, everyone must have critical thinking skills, digital literacy knowledge and skills, information literacy, media literacy and master information and communication technologies (Jagodziski & Wolski, 2015).

The mastery of the 21st century is supported by students' critical thinking skills. Critical thinking is a skill that deals with disposition. Critical thinking as well as creative thinking, being a critical thinker not only has a certain cognitive, but also a willingness to assess and evaluate information critically. Critical thinking generally involves the identification analysis of issues and assumptions. The practice of critical thinking requires an analysis on how arguments and thoughts are constructed so as to produce a formula or conclusion (Vellalba, 2011).

Critical thinking is to think seriously, ac- tively, and accurately in doing the analysis of all information received with a rational reason. (Liberna, 2011). Critical thinking is used in making judgments of information and explaining the reasons for problem solving (Thomas, 2011). Critical thinking has an important role in determining decisions and overcoming problems during the learning process and in everyday life (Snyder & Snyder, 2008). Critical thinking is necessary to address the problems faced in life. By thinking critically, one can organize, adjust, change, or fix his mind so that he can act more appropriately. A critical thinker is a man of skillful reasoning, a critical thinker uses his reasoning as his rationale (Ka- timi, 2012).

Critical thinking will be easier to teach to students if it is included in the course, as opposed to practicing critical thinking independently through critical thinking courses (Ennis, 2016). Critical thinking skills are very impor- tant to de-

velop because learners can more easily understand the concept, sensitive to problems that occur so as to understand and solve prob- lems, and able to apply the concept in different situations. Critical thinking learned in the science class also affects learners' lives long after they lea- ve formal education by providing tools that can be used to analyze many issues they face in their daily lives. Critical thinking can be developed in learning by enriching meaningful learners' ex- periences. The experiences can be in form of an opportunity to argue verbally or in writing like a scientist (Frydenberg, & Andone, 2011).

The research and development that had been done by (Khasanah et al., 2017) stated that student's critical thinking skills increased by using the respiration module which was developed based on the critical thinking indicators so that student's learning outcome improved. The process of critical thinking skills is developed through inquiry learning. This is be- cause in the process of inquiry, learners receive information, they will think, prioritize the infor- mation, and search for its correlation before loo- king for supportive reasons that refer to the new knowledge. Subsequently they will be drawing up learning plans and diverse activities then stimula- ting them, and asking questions to improve brain thinking skills is an inquiry learning process (Lle- wellyn, 2002).

Inquiry learning is applied to chemistry subject. Chemistry is a science subject in which its application is close to everyday life (Bailin, 2002). One of the chemistry materials taught in senior high school related to the utilization of chemicals in everyday life is the alkane derived compounds material. This material is the basic material of organic chemistry in which its development and application is so vast and related to real life of society. Alkana derived compounds are memorizing material with abstract concepts. The learning activities are monotonous, which leads to boredom and results in low student scores.

Several studies have committed in the development of educational games to support the teaching of basic 21st century skills (Boyle et al., 2014). Game based learning describes an environment that contains materials game and a game of knowledge and skills to gain score in which this game activity involves problem solving skills and challenges to students with a bit of disappointment (Kirriemuir & Mcfarlane, 2004).

The use of Chemkarta games in chemistry learning increases the knowledge and learning outcomes of students on the functional group material (Knudtson, 2015). The study states that

the use of games in chemistry learning will help students in learning the material, so that students learn with fun and increased understanding.

The current review analyzes the impact of the use of Game Based Learning (GBL) on the development of 21st century learning skills in depth and reveals that the effectiveness of GBL relies on game design. In particular, game design featuring the mixing of learning theories with game design elements proved to be successful (Libema, 2015). The game industry leads to effective learning. Game and learning materials design based games tend to work better than just games that contain educational or entertaining matches only. In summary, this study demonstrates the reason for optimism about the potential for using game based learning as an approach to promote the development of 21st century skills in the future (Qian & Clark, 2016).

The approach of digital technology using as a learning medium has a better and more effective impact than other approaches. To increase students' interest in learning, an interesting learning media support is needed. The use of gaming applications as learning media can increase learning outcomes (Adnan et al., 2017).

From the results of interviews conducted, it can be seen that nearly 90% of learners spend their spare time by playing games on their android phone. The potential for playing game liking can be utilized for learning process through making android based chemistry board game. Learning methods and media applied by teachers so far have not accommodated the potential of learners in playing the game. Therefore, there are still many learners who are supposed to take more time to study only waste their time. The integration of inquiry method in learning using games has not been developed so the researchers try to combine inquiry method with android-based game media. This merging of method and media is expected to provide an alternative in teaching chemistry to learners.

The purpose of this research is to 1) Knowing the level of validity of interactive media android base Chemistry Board Game on alkane derived compound material; 2) Knowing and describing the effectiveness of Chemistry Board Game media which can be used to improve the critical thinking ability of class XII-IPA students; and 3) Knowing and describing changes in mastery level of learners' material which is seen from the learners' learning outcome on alkana derived compound material after using this media.

The approach used is inquiry. The Inquiry approach teaches students how scientists work.

This approach can motivate students to become thinkers, grow curiosity, train in cooperation and solve problems (Widowati et al., 2017)

According Gulo (2002) explains the inquiry stages to be done as follows:

a.   Identification and clarification of problem

The first step is determining problem to be explored or solved by inquiry method. Issues can be prepared or submitted by the teacher. The nature of the class problem so that can be thought, experienced, and solved by students. Issues need to be identified and clarified. If the problem is determined by teachers, it needs to be noted that the problem should be real, can be done by students, and in accordance with the ability of students. The issue corresponds to the level of life and state of the student.

b.   Formulating hypothesis

The next step, students are asked to submit a temporary answer about the issue. This is called the hypothesis. Student hypothesis is evaluated by the teacher if it is not appropriate and clear then the teacher helps to correct it by clarifying the purpose only. A false hypothesis will later be evident after data collection and analysis of data obtained.

c.   Collecting data

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

d.   Analyzing data

The data collected should be analyzed to be able to prove whether the hypothesis is true or not. To make it easier to analyze, data should be organized, grouped, and managed so that it can be analyzed easily. The data are sually arranged in a table for easy reading and analysis. Here sometimes teachers need to intervene because of there are lots of data that students are sometimes confused to determine the next step. In analyzing, it is often necessary to use calculation tools such as mathematical formulas and statistics that allow students to make decisions or take generalizations.

e.   Drawing conclusion

From the data that have been grouped and analyzed, the the conclusion is drawn with the generalization. After drawing conclusion, it is then matched to the original hypothesis, to see whether our hypothesis is accepted or rejected.

The inquiry process begins with formulating problems, developing hypotheses, gathering evidence, testing hypotheses, and drawing temporary conclusions, examining temporary conclu- sions to get conclusions that to some extent are believed by students (Hasnunidah, 2012). Chemistry board game learning media to be developed in the form of audiovisual media is a set of tools that can project moving and voi- cing images. The combination between image and sound shapes characters equal to their origi- nal form. Computer based chemistry board game learning media is one of the media that can create an interactive teaching environment that provides an active response to the learning needs of students by preparing effective learning activities to ensure the occurrence of independent learning (Arsyad, 2011).

Interactive concepts in a computer-based learning environment follow three elements, namely (1) adjustable instructional sequences; (2) student work responses or answers; and (3) adjustable feedback. Learning using this interactive media has a positive impact on learning. The use of computer-based learning media in addition to improve learning outcomes, it also increases the role and skills of students' knowledge (Sadiman, 2010). The learning media used also affects the ability of students to search and investigate new knowledge (Akhlis & Dewi, 2014).

Critical thinking is a well-directed 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 the problem, face a multitude of challenges in an organized way, formulate innovative questions, and design solutions (Kartimi, 2012).

Critical thinking is a systematic process that allows students to formulate and evaluate their own beliefs and opinions. Critical thinking is an organized process that allows students to evaluate evidence, assumptions, logic and language that underlies others' statements. Critical thinking is also thinking well, and contemplating the thought process is part of thinking well (Fitriawati, 2010).

Critical thinking is grouped into five main activities as follows:
a) Providing a simple explanation, which contains; focusing questions, analyzing questions and asking questions, and answering questions about an explanation or statement.
b) Building basic skills, which consists; considering whether the source is trustworthy or not and regarding and considering an observation report.

c) Concluding which consists of deducting activities or considering the results of deductions, inducing or considering induction results, and making and determining the value of consideration.
d) Providing a further explanation which consists of identifying terms and definitions of considerations as well as dimensions, and identifying assumptions.
e) Setting strategies and techniques which consists of determining actions and interacting with others (Ennis, 2016).

METHODS

Research and development of interactive learning media Chemistry Board Game or also called Al Chemist Knight was done in SMA-IT Al Irsyad Al Islamiyyah Purwokerto. The location of the research was chosen in SMA-IT Al Irsyad Al Islamiyyah Purwokerto because the result of observation and experience as a teacher in the school found that the use of learning media as a source of learning is rarely used while it is based on observation and interview of students' needs then the students need an easily accessible learning media from anywhere.

Preliminary research was conducted in the early stages of the study by doing observations and interviews on teach- ers and students as well as school management, especially the vice principal of the curriculum field. After developing an interactive media deve- lopment design that has been validated by the ex- perts, the researchers conducted small-scale test. Product trials were conducted to the students of class XII-IPA with alkane derived compound material in the odd semester of the academic year 2016-2017. This research was planned to begin on July 25, 2016 up to September 30, 2016.

There were two different types of trials with different grades in one school. Small-scale trial was done to the students of XII-IPA1 class as many as 10 students that were taken randomly. Large-scale trial was done to the students of XII-IPA2 as many as 20 students.

This research is a Research and Development (R & D) study conducted to develop learning media Chemistry Board Game (CBG) named Al Chemist Knight in which the application of this media is combined with inquiry learning model, on chemistry subject by taking the specification of organic chemistry material, a functional group of alkane derived compounds (the material of XII class of senior high school). The development procedure of the Game Development Process on mobile 3D presentation from Perdue Uni-

versity was later translated into detailed research procedures.

  Data sources of this research and development are derived from the research subjects which are students of XII-IPA Class of SMA-IT Al Irsyad Al Islamiyyah especially class XII-IPA1 and XII-IPA2, as well as the chemistry subject teacher who plays a role in the learning process at school. Not to mention, the Principal and Administrative staff who permit and assist the ongoing research.

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

Data	Data Collecting Method	Instrument
The potential identification and the validation of *chemistry board game*	Interview for teacher and students	Interview guideline
	Product validation by the experts and chemistry teacher of SMA-IT Al Irsyad Al Islamiyyah Purwokerto	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

RESULTS AND DISCUSSION

  This R & D research results are presented in the following data:

The Validation Result of Test Item Trial
Table 2. The Validation Result of Test Item Trial

Validation	Number of Test Item	Total of
Valid	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,	48
Invalid	23, 36	2
Total		50

The Result of Item Difficulty Trial
Table 3. The Result of Item Difficulty Trial

Difficulty Level	Number of Test Item	Total of Test Item
Easy	15, 32, 48	3
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	2
Total		50

The Result of Item Distraction Trial
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, 48	28
Bad	4, 10, 12, 17, 20, 21, 22, 28, 29, 34	10
Very Bad	23, 36	2
Total		50

  From the overall analysis of the above trial test items then the number of test items that can be used for the next test is 48 test items. All these numbers will be used for trials using CBG games, 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, 48, 49, and 50.

The Result of CBG Implementation/Making

  This study has developed CBG 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 educational game (hereinafter referred to as CBG), game developed

with inquiry approach and critical thinking.

The Development of Carbonil Board Game (CBG)/Al Chemist Knight

The next process is to do the programming or coding so as to create the finished form of the product in the form of educational game. An overview of the design and appearance can be seen on the story board in the attachment. The game is a computer game created with the help of Adobe Flash CS6 software with action script 3.0 language. This game can run well on computers with minimum specifications Intel® Pentium® 1.6 GHz processor, 1024MB memory, equipped with sound card and VGA graphic card. Games can run under the operating system of Windows me, XP, Vista, Windows 7, Windows 8 and Android. For the android operating system, it has to go through the installation process of the file android installer (apk).

The material content developed in the game is the alkane derived compound ma- terial for class XII of senior high school. This ma- terial is divided into several subs which are included in stage game. The game consists of two stages and each stage consists of 2 settings. The initial display design (main page) of the game can be seen in Figure 1.
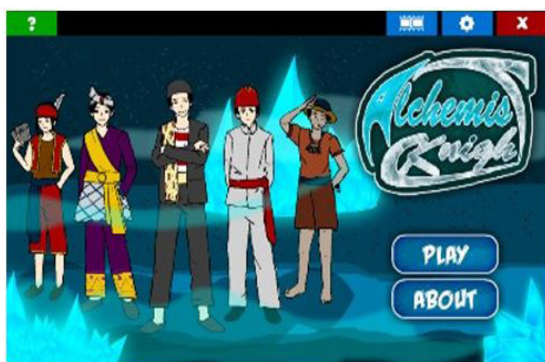

Figure 1. The Starting Appearance of the Game

The game called Chemistry Board Game or Al Chemist Knight is an educational game in the form of board game. On this board the lear- ners will get the material and practicum as well as exercise questions that are appropriate with the material. Learners win the game if they have makee a straight/vertical/horizontal line on the board and they create at least three intercon- nected lines. This is the rule of the game to be follo- wed. Game board images are presented in Figure

Figure 2. The Game Board of *Chemistry Board Game / Al Chemist Knight*

The Result of Validation and Revision towards the Learning Set

Telah disampaikan bahw perangkat yang dikembangkan meliputi silabus, RPP, dan *educa- tional game* serta LKS yang berbasis inkuiri dan berfikir kritis. Hasil validasi perangkat pembe- lajaran oleh beberapa validator disajikan dalam Table 5. It has been stated that the learning sets developed include syllabus, lesson plan, and edu- cational game and student's worksheet which are based on inquiry and critical thinking. The vali- dation results of the learning sets by some valida- tors are presented in Table 5.

Table 5. The Validation Analysis Sheet of Me- dia and Learning Sets

Instrument of The study	Assessment Average in Per- centage (%)
Syllabus Validation	83.33
Lesson Plan Validation	83.33
Game Validation (material)	78.33
Game Validation (language)	83.33
Game Validation (learning design)	84.25
Game Validation (software engi- neering)	79.16
Game Validation (visual commu- nication 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 ex-

perts has valid criteria, so it can be concluded that the research instrument can be used as a means of data collection in research.

Educational game testing was done by material validators to analyze the content of chemistry material. Validation results show that CBG chemistry materials are adapted to the 2013 curriculum by using a scientific approach in the learning and taking contextual examples in the students' life so that the students' inquiry and critical 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 content/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

Critical Thinking Ability

One of the goals of science learning is developing students' critical thinking skills (Bailin, 2002). The following table shows the ave- rage score of critical thinking skills in the experi- mental class.

Table 7. The Average Score of Critical Thinking Ability in the Experimental Class

Aspect	Average score	Criteria
Focusing the ques- tions	3.1	Good
Analyzing arguments	2.95	Good
Asking and answering questions	3.0	Good
Determining actions	3.05	Good
Indicator average	3.025	Good

From the data, it is known that inquiry learning using CBG game and student's worksheet aided will develop students' critical thinking ability on a good scale in terms of four indicators of critical thinking ability, ie focusing questions, analyzing arguments, asking questions and answering questions, determining an action. Among the four indicators, learners have a balanced ability which is evidenced by the difference in scores between indicators that are not much different (Liliasari, 2003).

Discussion
The Development of CBG Media

The development of learning program is a matter that is necessary especially in class XII chemistry material. With the limited time of class XII and the material is a lot and abstract, it is necessary to develop game media that will help learners' understanding. Based on the interviews, it is known that the needs of teachers and students of SMA-IT Al Irsyad is the development of media. By looking at the habits of learners in using their free time in which they more often play games on their android phone, then the researchers developed educational games that are expected to help the understanding of learners in alkane derived compound material.

CBG is a computer game that can now be used in learning. By using CBG with inquiry approach, it will improve learners' critical thinking skills. CBG development by utilizing adobe flash CS6 allows learners to learn wherever and whenever. CBG with features equipped with materials, exercise questions and practicum animation will deepen the concept of learners about alkane derived compound material. In line with the research (Jagodzinski & Jagodzin'ski, 2015) stated that the virtual experimental assessment model has been developed by utilizing NUI technology, kinetic sensor technology used in android based smartphones, the application of practicum assessment using NUI will provide motivation to learn and deepen understanding of learners on the chemistry practicum competence.

In this research the development of CBG is developed in an effort to give understanding of cultural and character education and train the students in the ability of creative thinking. The learning sets developed in addition to CBG are syllabus and lesson plan. All the completeness of the set is made with the aim to improve learning outcomes of learners and foster the values of the nation's character that includes creative, curiosity, independent and honest.

Learning set that will be used in the previous data collection is validated by the validators based on the assessment then the average score above 3 or if it is stated in percentage will be more than 70%. The figure indicates that the developed instrument is valid although there are some that need to be revised or developed further.

The development of syllabus and lesson plan in this research focuses on the application of inquiry characterized media and applying critical thinking indicator, applied to chemistry learning process of alkane derived compound material, the material is visualized in the form of game level which must be completed by the students. The results show CBG games can increase the enthusiasm of learners in studying chemistry. Good enthusiasm correlates with the increased learning outcomes of learners' cognition. Learners can be motivated to complete the game in line with improving their understanding of the alkane derived compound material. After completing the game, learners get reward from the teacher. In addition to rewards, another positive thing that learners get is that they volunteered to learn to understand the material. A good understanding of alkane derived compound material then correlates with the ability of learners in solving posttest test items.

In addition to the enthusiasm of learners, another thing that stands out during the research is the emergence of motivation to compete. In line with the opinion of (Toprac, 2008) which states that the motivation of learners can increase with the educational game, this research also raises the spirit of competing well among the students. They learn and strive to be the fastest in completing educational games. The advantage for teachers is that learners do not need to be reminded to study chemistry. Chemistry becomes something fun because learners can learn chemistry while playing games just like an online game.

The Effect of CBG Media Development Learning Completeness

Learning completeness is measured by using the pretest given at the beginning of the research and posttest provided at the end of the study. The success of the class can be seen from at least 85% of the number of students in the class who has reached the completeness of the individual (Mulyana, 2004). From the calculation results, it was obtained learning completeness of 85%, while the completeness before treatment of 5%, with the increase in n-gain 0.703 in the high category.

The existence of students' learning completeness can be defined that CBG game was de-

veloped effectively and successfully. Actually, many factors affect the learning outcomes. One of them is the learning strategy that is pursued in the presentation of teaching and learning process. Presentation of games leads learners to be more interactive and fun so they can build their own knowledge. This can increase the ability of students to master the concepts they learn. In accordance with the statement of (Komalasari, 2010), learners need interactive activities to improve their motivation and effectiveness of their learning.

In addition to learning completeness, from the results of the posttest score, it also shows the enhancement mastery of the concept of alkane derived compound material. From the test results, it is known that the pretest score of 34.35 and posttest score of 80.51. Significant score increases indicate that CBG media or games are able to clarify alkane derived material and improve student's learning achievement.

The increase in student's score by using android games is in line with the results of research by (Jagodzin'ski, 2015) which states that the use of kinetic sensor based virtual laboratory in chemistry praticum will improve student's learning outcomes and foster self-confidence in practicum in the laboratory. Meanwhile (Akhlis & Dewi, 2014) has created an inquiry-based learning set by using ICT (e-learning) to develop student's character, the research results prove significant influence on the student's character by using e-learning ICT.

The use of CBG games in learning is done with inquiry approach which is embodied in the CBG game stage. At each level learners are presented with a problem then learners must complete it in order to reach the stage board game al chemist. When the learner stage has reached al chemist then learners should solve the problem in the box of al chemist available where in the box presented a problem and its solution. This corresponds to the inquiry stage which is the phase of formulating the hypothesis, testing the hypothesis and drawing conclusions (Klisch et al., 2012) stated in his journal report that learning with inquiry setiing on a virtual laboratory game enhances student's knowledge and literacy of the science regarding the pollutants that enter the body by inhalation.

Meanwhile, learning with inquiry setting will stimulate learners to develop their critical thinking ability. Measurement of critical thinking ability of learners is done by making observations during learning by using CBG. Indicator of critical thinking is used on the problem created for

CBG games. Therefore, when students play the CBG/Al Chemist game, their critical thinking skills will increase, this is due to the integration of critical thinking indicators with the game problem. Indi- cators used include the ability to focus the ques- tions, analyze arguments, ask questions and ans- wer questions, and determine an action.

The use of respiratory module by applying critical thinking indicator proved to be effective in improving student's learning outcomes (Khasanah et al., 2017). Adnan et al. (2017) stated that the use of Bana Game in junior high school students in Situbondo was able to improve students' critical thinking skills. Critical thinking, problem solving and analysis skills of middle school students increased by using inquiry based learning in the provision of organic pharmaceutical-based chemical based projects (Weaver, 2016). The results of Hairida (2016) stated that inquiry-based learning modules with authentic assessment on additive materials was proven to be effective to improve student's inquiry ability and critical thinking skills. While Cahyani et al. (2014) stated that multimedia-based inquiry learning simply improves students' cognitive ability with N Gain achievement of 0.31.

CONCLUSION

According to the results and discussion, the researchers draw some conclusions as follows: The validity test towards the android based CBG games interactive media on the alkane de- rived compound material results in very valid ca- tegory for all tests including material feasibility, language, visual communication design, and learning design, each of them gain the score of 3.27, 3.33, 3.2, and 3.37.

CBG games media improves learners' critical thinking skills on the effective category which is proven through the observations which show scale of three or good category. This category consists of 4 aspects of learners' critical thinking skills which include focusing questions, analyzing arguments, asking and answering questions, and determining actions.

CBG games media can improve learners' conceptual understanding especially on the alkane derived compound material. After using CBG, students got better score. In pretest, students got the average score of 34.35 and the learning completeness of 5%, while in posttest they got the average score of 80.51 and learning completeness of 85%. In addition, the N-gain factor value reaches 0.703 in the high category.

REFERENCES

Adnan, F., Prasetyo, B., & Nuriman, N. (2017). Usability Testing Analysis on The Bana Game as Education Game Design References on Junior High School. *Jurnal Pendidikan IPA Indonesia*, *6*(1), 88-94.

Akhlis, I., & Dewi, N. R. (2014). Pengembangan Perangkat Pembelajaran Science Berorientasi Cultural Deviance Solution Berbasis Inkuiri Menggunakan ICT untuk Mengembangkan Karakter Peserta Didik. *Jurnal Pendidikan IPA Indonesia*, *3*(1), 86-94.

Arsyad, Azhar. (2011). *Media Pembelajaran*. Jakarta: PT Raja Grafindo Persada.

Bailin, S. (2002). Critical Thinking and Science Education. *Science & Education*, *11*(4), 361-375.

Boyle, E. A., MacArthur, E. W, Connolly, T. M., Hainey, T., Manea, M., Karki, A. (2014). A narrative literature review of games, animations and simulations to teach research methods and statistics. *Computers & Education, 74,* 1-14.

Cahyani, R., Rustaman, N. Y., Arifin, M., & Hendriani, Y. (2014). Kemampuan Kognisi, Kerja Ilmiah dan Sikap Mahasiswa Non IPA Melalui Pembelajaran Inkuiri Berbantuan Multimedia. *Jurnal Pendidikan IPA Indonesia*, *3*(1), 1-4.

Ennis, R. H. (2016). *Critical Thinking Across the Curriculum: A Vision*. Springer Science Business Media Dordrecht.

Frydenberg, M., & Andone, D. (2011). *Learning for 21st Century Skills*. London.

Gulo, W. (2002). *Metode Penelitian*. Jakarta: PT. Grasindo.

Hairida, H. (2016). The Effectiveness Using Inquiry Based Natural Science Module with Authentic Assessment to Improve the Critical Thinking and Inquiry Skills of Junior High School Students. *Jurnal Pendidikan IPA Indonesia*, *5*(2), 209-215.

Hasnunidah, N. (2012). Keterampilan Berpikir Kritis Siswa SMP Pada Pembelajaran Ekosistem Berbasis Konstruktivisme Menggunakan Media Maket. *Jurnal Pendidikan MIPA*, *13*(1), 64-74.

Jagodzinski, P., & Wolski, R. (2015). Assessment of Application Technology of Natural User Interfaces in The Creation of a Virtual Chemical Laboratory. *Journal of Science Education and Technology*, *24*(1), 16-28.

Kartimi, K. (2012). Pengembangan Alat Ukur Berpikir Kritis Pada Konsep Termokimia untuk Siswa SMA. *Scientiae Educatia: Jurnal Pendidikan Sains*, *1*(1), 1-14.

Khasanah, A. N., Widoretno, S., & Sajidan, S. (2017). Effectiveness of Critical Thinking Indicator-Based Module in Empowering Student's Learning Outcome in Respiratory System Study Material. *Jurnal Pendidikan IPA Indonesia*, *6*(1), 187-195.

Kirriemuir, J., & McFarlane, A. (2004). Literature Review in Games and Learning. Bristol, UK: Futurelab

Klisch, Y., Miller, L. M., Wang, S., & Epstein, J. (2012). The Impact of a Science Education Game on Students' Learning and Perception of Inhalants as Body Pollutants. *Journal of Science Education and Technology*, *21*(2), 295-303.

Knudtson, C. A. (2015). ChemKarta: A Card Game for Teaching Functional Groups in Undergraduate Organic Chemistry. *Journal of Chemical Education*, *92*(9), 1514-1517.

Komalasari, K. (2010). *Pembelajaran Kontekstual Konsep dan Aplikasi*. Bandung: PT Refika Aditama.

Liberna, H. (2015). Peningkatan Kemampuan Berpikir Kritis Matematis Siswa melalui Penggunaan Metode Improve pada Materi Sistem Persamaan Linear Dua Variabel. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, *2*(3), 190-197.

Liliasari, (2003). Pengembangan Ketrampilan Berfikir Tingkat Tinggi Mahasiswa Calon Guru melalui Model Pembelajaran Kimia. *Jurnal Pendidikan, 2*(1), 7-14.

Mulyana. (2004). *Metodologi Penelitian Kualitatif*. Bandung: PT Remaja Rosdakarya.

Ongardwanich, N., Kanjanawasee, S., & Tuipae, C. (2015). Development of 21st Century Skill Scales as Perceived by Students. *Procedia - Social and Behavioral Sciences*, *191*, 737–741.

Qian, M., & Clark, K. R. (2016). Game-based Learning and 21st Century Skills: A Review of Recent Research. *Computers in Human Behavior*, *63*, 50-58.

Saavedra, A. R., & Opfer, V. D. (2012). Learning 21st Century skills requires 21st Century Teaching. *Phi Delta Kappan*, *94*(2), 8-13.

Sadiman, A. (2010). *Media Pendidikan*. Jakarta: Raja Grapindo Persada.

Snyder, Gueldenzoph, Snyder & Mark J. (2008). Teaching Critical Thinking and Problem Solving Skills. *The Journal of Research in Business Education 5*(2), 7-14.

Thomas, T. A. (2011). Developing First Year Students' Critical Thinking Skills. *Asian Social Science*, *7*(4), 26-35.

Toprac, P. K. (2008). *The Effects of a Problem-based Learning Digital Game on Continuing Motivation to Learn Science*. The University of Texas at Austin.

Weaver, M. G., Samoshin, A. V., Lewis, R. B., & Gainer, M. J. (2016). Developing Students' Critical Thinking, Problem Solving, and Analysis Skills in an Inquiry-Based Synthetic Organic Laboratory Course. *Journal of Chemical Education*, *93*(5), 847-851.

Widowati, A., Nurohman, S., & Anjarsari, P. (2017). Developing Science Learning Material with Authentic Inquiry Learning Approach to Improve Problem Solving and Scientific Attitude. *Jurnal Pendidikan IPA Indonesia*, *6*(1), 32-40.