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THE CHEMISTRY TRIANGLE-BASED MULTIMEDIA TO BUILD A GOOD IMPRESSION: A DESIGN-BASED RESEARCH

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Abstract: Science teachers need to pay attention when introducing chemistry to junior high school students hence they don't have low perceptions of chemistry. Multimedia which based on the chemistry triangle can be a solution in helping teachers explains the relationships among macroscopic, sub-microscopic, and symbolic level of chemistry so students can understand the scientific contents better and have a good perceptions. This research aimed to develop a chemistry triangle-based multimedia to build a good impression on junior high school students about chemistry. The design of chemistry triangle-based multimedia was developed through a design-based research (DBR). The participants in the research were three schools of seventh-grade students in Pekalongan Regency, Indonesia. The data were collected through interviews, observations, questionnaires, and tests. The results of this research were in the form of the complete cycles of DBR carried out to produce a chemistry triangle-based multimedia that meets the criteria in helping teachers introduce chemistry in a way that is more easily accepted by students and gives a positive impression about chemistry. This article describes the four phases of the DBR process in the development of chemistry triangle-based multimedia.

Keywords: Chemistry triangle, DBR, junior high school students, multimedia.

INTRODUCTION

Chemistry learning in schools has functions and learning objectives summarized in the core competence of the 2013 curriculum (Ministry of Education and Culture, 2016). Learning chemistry is important because it connects other sciences (Taber, 2002) but the results of the research describe chemistry as an unpopular subject among students (Hofstein et al., 2011) due to several factors, such as many terms to be memorized (Woldeamanuel et al., 2014), the need for visualization media while the teacher rarely facilitates them and the students do not understand the benefits of learning chemistry for life now or in the future (Sirhan, 2007). Another research reveals the difficulty of learning chemistry is the inability of students to show a good understanding of the very basic concepts of the subject (Ali, 2012), visualize structures

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and processes in sub-microscopic and connect with other levels of chemical representation (Treagust et al., 2003; Treagust & Chittleborough, 2007). The fact that the characteristics of the chemistry subject are difficult makes students claim and justify that chemistry is difficult beforehand even though they have not had time to study it deeper.

The bad perception as the impact of delivering content without preparation will make students stay away from chemistry. The teachers must appropriately introduce chemistry so that students have positive judgment and a good impression. In the case of building a good impression, multimedia that contains a variety of colours and shapes can be used by teachers because target-specific characteristics such as the physical appearance of the perceived are one of the three major characteristics that influence impression (Quick & Nelson, 1997). Multimedia also could enhance chemistry learning with support constructing, developing, and evaluating students' mental representation of chemistry at three levels (Gilbert & Treagust, 2009).

The development of learning media has been carried out such as learning media for the kinetic theory of gases sing the ADDIE model (Gusmida & Islami, 2017) and instructional media E-Learning based on blended learning using the Research & Development of Borg and Gall (Kristanto et al., 2017). From some of the development research methodologies, the collaborative process of researchers and teachers has not received more attention even though this is very important considering the teacher is a subject that is directly related to problems in the classroom. In the development research model of Reeves (2006), Design-based research (DBR), there is four-step which one of them is an analysis of practical problems by researchers and practitioners in collaboration. DBR is development research that focuses on solving broad-based complex, real-world problems that are critical to education while at the same time maintaining a commitment to theory construction and explanationz (Herrington et al., 2007). DBR is used as an approach in the development of educational products such as meaningful online discussions in undergraduate field experience courses (Johnson et al., 2017), a multimedia environment to support language learning (Hung, 2011).

The research on introducing chemistry as part of science to beginners, especially junior high school (JHS) students, is still rarely done. Innovations in introducing chemistry to beginners can be done through multimedia where physical appearance and chemical multiple representations are the main concerns. This is carried out to build a good impression for JHS students on chemistry which will have a positive impact on chemistry learning at the senior high school level. Therefore, it is important to develop the chemistry triangle-based multimedia which considers multiple chemical representations through several types of media that support one another. This research aimed to develop chemistry triangle-based multimedia that can be used by teachers in introducing chemistry so that students have better understand of chemistry and build a good impression. The chemistry triangle-based multimedia is expected to be a media of introducing the right chemistry for teachers and assisting teachers in preparing meaningful learning.

METHOD

Research Design

A design-based research (DBR) framework referring to the theory Reeves (2006) was used for this research. The design was used to develop the chemistry triangle-based multimedia in introducing chemistry to JHS students. There are four phases in DBR, analysis of practical problems by researchers and practitioners in collaboration, development of solutionsin formed by existing design principles and technological innovations, iterative cycles of testing and refinement of solutions in practice, and reflection to produce "design principles" and enhance solution.

Participants

The participants who came from JHS students were the seventh-grade students from three different schools in Pekalongan Regency selected based on stratified random sampling using national exam scores (UN).

Table 1. The Number of Participants

Phases of DBR	Participants	
Analysis of practical problems by researchers and practitioners in collaboration	1. The 8th and 9th JHS students from three schools (A, B, and C category) 2. 120 SHS students from 16 schools in Central Java	
Iterative cycles of testing and refinement of solutions in practice	Iterative 1	Two 7th JHS students from each school (A, B, and C-category)
	Iterative 2	One 7th class from each school (A, B, and C-category)
	Iterative 3	Two 7th class from each school (A, B, and C-category)

The three schools selected were of the A Category (schools with high UN scores), B Category (schools with moderate UN scores) and C Category (schools with low UN scores). Table 1 presents the number of participants in phases of DBR.

Data Collections

Data collection was carried out using observation, questionnaires, interviews, Think Aloud of Protocol (TAP), impression questionnaires, and cognitive tests. To find out the feasibility and effectiveness of the integrated learning media, the data analysis was carried out using a qualitative approach with TAP, interviews and quantitative approaches through Aiken's validity test and 1 tailed t-tes.

RESULT AND DISCUSSION

The four phases of DBR in developing triangle-based multimedia chemistry to introduce chemistry to junior high school students are explained below.

Phase 1: Analysis of Practical Problem by Researchers and Practitioners in Collaboration

In the problem analysis phase, we began by analyzing facts in the field, innovations made to overcome the problem and reviewing the relevant literature. Collaboration with related parties such as teachers and education practitioners was conducted because it can provide advice and shape a better understanding of the educational problems (Anderson & Shattuck, 2012). The results of the analyses of chemistry learning problems are shown in Table 2. Based on Tabel 2 JHS students need media that helps to imagine chemistry abstract contents and understanding the Table 2. JHS students need media that helps to imagine chemistry abstract contents and understanding the interconnection of chemistry triangle. Perception of chemistry can caused anxiety among students resulting in negative attitudes toward chemistry (Kaya & Yildirim, 2014). There is a similar perception of chemistry in junior and senior high schools. Even, there is a decrease in students' attitudes towards chemistry from junior high school to senior high school levels (Cheung, 2009). This indicates that bad perceptions of chemistry can persist and even increase over time because of the increasingly difficult material.

Teachers and experts suggest developing chemistry triangle-based multimedia to overcome this problem. Learning media is one of the appropriate variables in reflecting chemistry in the learning process area (Barke et al., 2012).

Phase 2: Development Solution

The chemistry triangle-based multimedia was developed on the topic of classification of matter and its changes which was given to the seventh-grade students in the odd semester. The multimedia develops based on factor media that can bring up the chemistry triangle in learning. Johnstone (1991) stated that there is a triangle of levels of representations in chemistry, macroscopic, sub-microscopic, and symbolic terms. The chemistry triangle-based multimedia introduces all three levels of chemical representations through three types of media, namely podcasts, molymod-like and Macromedia Flash, all of which are mutually sustainable. The students can easily understand a concept starting from the macroscopic level through podcasts connected to the sub-microscopic level through molymod-like and finally theintroduction of symbols with Macromedia Flash. Science teachers might consider using multiple representational tasks combined with discussion and collaborative work because it is more efficacious in promoting a scientific understanding (Yakmaci-Guzel & Adadan, 2013). Product characteristics of the chemistry triangle-based multimedia promotes types of media such as molymod-like (hands-on) that requires teacher creativity and time in making it with simple materials to facilitate the students' understanding of the sub-microscopic level of chemistry in the learning proces.

Table 2. Analysis of Chemistry Learning Problems

Method	**Subject**	**Results**
Observation	Science learning in A, B, and C category schools	Science learning facilities, such as laboratory materials, are inadequate, especially for B- and C-category schools The learning media used have not varied. Textbooks and worksheets are the main teaching resources used. The textbooks and the worksheets do not yet contain an explanation of the three levels of chemical representations.
Interview and questionnaire	1. The 7th and 8th JHS students of A, B, and C categories schools 2. Science teachers of A, B, and C category schools 3. SHS students using Google form	The teachers lack time in preparing science learning. The introduction to chemistry to students is less optimal. Science teachers are less able to present all three levels of chemical representations in learning. JHS students have a low perception of chemistry materials. JHS students have difficulties imagining abstract content like atoms and molecules SHS students stated that chemistry is not a favourite subject because it is difficult.

Teachers need to prepare a variety of media in chemistry learning to increase motivation ((Ljubojevic et al., 2014; Reiser, 2001; Wegner, Homann, & Strehlke, 2014) and build a good impression of students (Haber & Tesoriero, 2018; Samudra et al., 2016) using interesting and more realistic subjects. Innovations to improve the efficiency of the use of media in the learning process can be done by integrating several types of learning media (Papo, 2001).

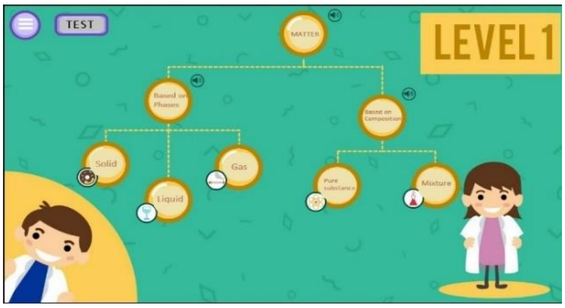

Figure 1. Concept Maps of Chemistry Triangle-Based Multimedia

Figure 2. Podcast Manuscript of Chemistry Triangle-Based Multimedia

Figure 3. Digital Simulation of Chemistry Triangle-Based Multimedia

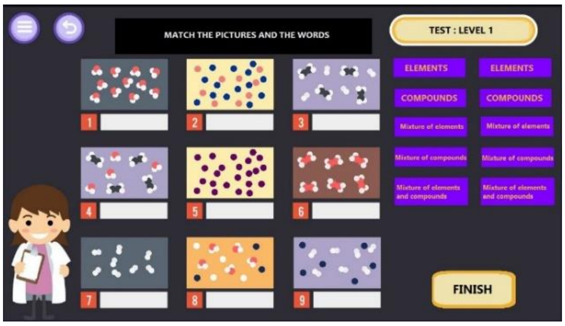

Figure 4. İnteractive Test of Chemistry Triangle-Based Multimedia

The macromedia flash format developed includes podcasts (dialogs/monologs) accompanied by manuscripts, concept maps in each subtopic with symbols/ images, animations and digital simulations in the form of sub-microscopic level and interactive experiments and interactive tests that can be seen in Figure 1-4.

Phase 3: Evaluation and Testing of Solution

To find out the quality of the chemistry triangle-based multimedia, three iterative were carried out. The first iterative aimed to determine the comprehension and readability of learning media through the Think Aloud of Protocol (TAP) procedure. The procedure for implementing the TAP method began in the selection of representative users by taking two students from the A-, B-and C-category schools. The six students were given instructions to use the chemistry triangle-based multimedia and could comment on the quality, material readability and questions, and ease of use. During the TAP session, all the students' comments were recorded to be reviewed.

The second iterative was carried out to find out the feasibility of the chemistry triangle-based multimedia in the classroom after passing through the revision. At the end of the second iterative, each student was given a questionnaire containing the characteristics and aspects to be assessed. The implementation of the third iterative aimed to find out how effective the chemistry triangle-based multimedia is used in the process of introducing chemistry to JHS students. This iterative was carried out on two classes (1 experimental class (EC) and 1 control class (CC)) in all three schools.

The effectiveness test was conducted to find out the difference in the use of the chemistry triangle-based multimedia in EC which aimed to build a good impression of chemistry and the use of common learning media in the form of printed books in CC. The product effectiveness test was analysed using SPSS 21 IMB software based on students' responses to the impression questionnaire and cognitive test scores. The results of the product effectiveness test from the three schools can be seen in Table 3.

The assessment of the three schools shows the appearance of the chemistry triangle-based multimedia is the main factor that causes students to give a positive appreciation of chemistry so that a good impression is formed. The varied and bright colours, the shape of the molecular models that are unique to them, and the animations and digital simulations they see make them happy in the learning activities of the substance classification and their changes.

Table 3. Results of The Chemistry Triangle-Based Multimedia Effectiveness Test

School	Effectiveness Test	Testing Technique	Sig. Value	Remark
A-category school	Impression		0.043	EC students have a better impression.
	Cognitive Test		0.67	There is no difference understanding conception between EC and CC students.
B-category school	Impression	*Independent t-test 1-tailed*	0.000	EC students have a better impression.
	Cognitive Test		0.037	EC students have a better understanding conception
C-category school	Impression		0,001	EC students have a better impression.
	Cognitive Test		0.023	EC students have a better understanding conception

Colour is proven to effectively affect students' attention in learning (Dzulkifli & Mustafar, 2013) because their emotional reactions to bright colours increase in the positive direction (Kurt & Osueke, 2014; Pope et al., 2012). The right colour selection can contribute to a longer span of concentration in learning, improve performance and influence emotions and positive perceptions (Jalil et al., 2012). Wu & Shah (2004) indicate that students prefer to represent chemical entities in certain ways and visuospatial abilities play an important role in chemistry learning.

The chemistry triangle-based multimedia design takes students' preferences and visuospatial abilities into consideration so that the media supports all students in learning about the relations of the three chemical representations. The side effects of a positive assessment of these students make learning not boring and increase students' questioning activities. Choosing the right learning strategy can increase the level of learning motivation (Kotryakhov et al., 2019)

Phase 4: Documentation and Reflection

The impression that was built by students after chemistry was introduced through the chemistry triangle-based multimedia as shown through the expression, response, and answers of the interview summarized in Table 4. The students in the EC gave positive assessments on the dimensions of the impression of chemistry seen in their expressions and emotions when learning activities took place.

Table 4. Summary of Students' Responses to Chemistry Learning

Dimension of Impression	Observation Result	Interview Result
Student assumption to chemistry	The students showed a familiar attitude towards chemistry by asking questions related to chemistry.	At first, they tend to think that chemistry is associated with harmful drugs and substances. Now, this thinking is replaced by the new information they received that all substances and the energy interactions in these substances are chemistry.
Physical appearance of chemistry	The students looked unfamiliar with molecular pictures and started discussing with their classmates about the meaning of the pictures.	Molecular pictures that looked strange to students arouse their curiosity to understand their function and relationship to the composition of substances.
	The students were enthusiastic to make pictures of particles	They had not yet understood in depth about the purpose of the pictures they were working on, but they felt happy when asked to make a visualization of these particles.
Verbal/nonverbal communication	Based on the students' expressions, it seemed that they were trying to adapt in using the media to learn chemical terms through the chemistry triangle-based multimedia, audio (podcasts and digital simulation explanations) and visuals.	They liked to use the chemistry triangle-based multimedia because they were free to try clicking on the button in the media. They prefer to listen and see digital simulations than to read the material.
Learning environment	They enjoyed the teacher's way of explaining the material	They liked it because the teacher taught in a way that is different from what is normally done like games and digital simulations.

Presentation of the three levels of representations contributes to an increase in the level of understanding of students proven in Table 3 which states the learning achievement of EC students (classes that use integrated learning media) is better than CC students.

Assessment at the classroom level is important because it has an impact on students by shaping learning behaviour, self-concept, and self-efficacy, enabling self-adjustment, increasing academic motivation, and organizing and securing the storage of knowledge and skills through practices carried out by the teacher (Alkharusi, 2008; Rodriguez, 2004). The teacher reviews the test results in various formats and evaluates the answers of students (Alkharusi, 2015). In the application of the chemistry triangle-based multimedia, students are asked to resolve cases about substances and their changes given through podcasts, conduct simple experiments and interactive experiments, and then observe them to answer questions from the student worksheets. At the end of the meeting, each student takes an evaluation test in the form of an interactive test or a multiple-choice test to measure their understanding of each subtopic. A variety of assessment instruments in the chemistry triangle-based multimedia is given to increase the students' experience and make evaluation activities not boring so they are challenged to complete the test (Crooks, 1988; Judd & Keith, 2015).

CONCLUSION

The development of the chemistry triangle-based multimedia was carried out using four phases of the design-based research. The chemistry triangle-based multimedia is proven to be able to build a good impression of chemistry and improve students' learning achievement so that teachers can use the multimedia as an appropriate way of introducing chemistry at the initial level in the junior high school. A good impression is essential for students because it affects the perception of chemistry at higher levels such as senior high school and university. The chemistry triangle-based multimedia is developed through the collaboration with expert teachers and lecturers to overcome the problems in the field through appropriate solutions from the suggestions of experts and practitioners.

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