Development Interactive Multimedia Using 3D Virtual Modelling on Intermolecular Forces Matter

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ABSTRACT: One of characteristic in chemistry is its abstractness concept thus, the models or analogies to represent its microscopic and symbolic representation which not able seen by eyes are needed. Intermolecular forces lesson is one of chemistry concept that needs microscopic and symbolic representation. Modelling for microscopic and symbolic representation can be used to facilitate students for a better learning experience. Related to the problem background, the aim of this study is to know the validity of interactive multimedia using 3D modelling. The interactive multimedia using 3D virtual modelling will contain intermolecular forces explanation and equipped with 3D illustration, animation, and text to describe microscopic and symbolic representation. This study used R&D method by Thiagarajan and the data gathering section conducted in SMA Negeri 1 Waru Sidoarjo. The instruments to assess the validities of multimedia are content validity sheet and construct validity sheet which assessed by 3 academics and practitioners. The validity average scores obtain 86.66% for content validity and 85.78% for construct validity which both categorize as "Very Valid".

Keywords: Interactive Multimedia, 3D Virtual Modelling, Intermolecular Forces

INTRODUCTION

Chemistry is the scientific discipline which learns about substances' properties, compositions, structures, and changes during reaction with other substance[1]. As a knowledge, chemistry involves an abstract concept which unseen by vision sense. This abstractness feature made chemistry be one of difficult subjects for some high school students because this concepst can not be actualized, and must be drawn in to scheme or model[2]. Thus, to ease in learning chemistry needs multiple representations to visualize the abstractness concept. Multiple representations separated into three forms[3]. First macroscopic representation, this form can be done with real observations of a phenomenon using the fifth sense. For example, when observed water it will look colourless liquid. Second microscopic representation, this form described in particle level of molecules which build a matter. For example, in microscopic representation, water contains one oxygen and two hydrogens. Third symbolic representation, in this form, can be done by quantitatively and qualitatively to observe macroscopic phenomenon using the chemical equation, calculation, graph, mechanism, or analogies. Thus, symbolic representation of water can be drawn as a bent molecule and produce by reacted H_2 gas and O_2 gas.

One of the chemistry lessons in Indonesia high school is intermolecular forces. This lesson included in tenth-grade competence. According to the Minister Education and Culture Regulation on 9th attachment states that, intermolecular forces lesson comprised: ionic, atoms, and molecule interactions and its physical properties. All of the molecules interactions and its properties are not able to observe barely, thus need a model. When learning intermolecular forces, students will able to know about london force, dipole-induced force, dipole-dipole force, and hydrogen bond [4]. Intermolecular forces classify as a dynamic concept because it involved mechanism of molecules interaction [5]. When learning microscopic and symbolic representation which not able seen by eyes needs a model to visualize the abstract concept. The modelling also can be used in the learning process for better students' learning experience [6][7].

The model can be divided into virtually and realistic. Realistic models usually used printed poster, mannequin, or in chemistry learning use molymod to visualize the molecular geometry. Virtually model use computer-integrated to combine all or some 3D and 2D illustration, animation, video, audio, and text as media components. Following the learning principles written in the Minister of Education and Culture

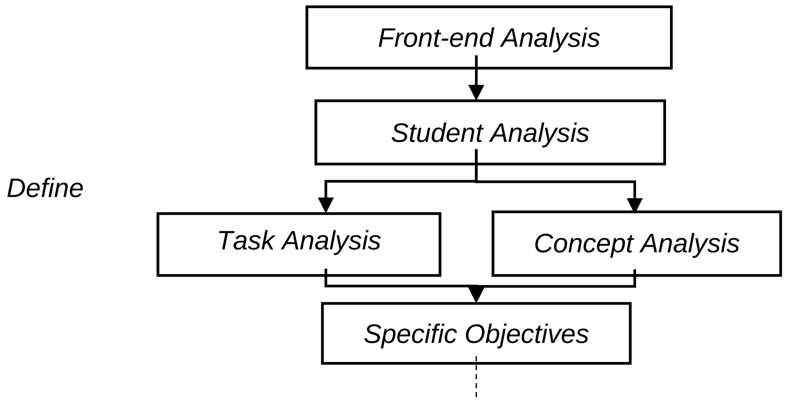
Regulation No. 22 of 2016 concerning standards of the primary and secondary education process state that using media and other learning resources based on IT can be used to support the learning process to be more effective and efficient [8]. Moreover, best learning media be able to follow the era of existing technological developments because it will greatly support the educational process in the era of the industrial revolution 4.0. The use of technology media can increase the effectiveness of learning if supported by interactive learning[9]. Modelling of material with symbolic representation can use a device with multiple senses involved in multimedia. Through using IT-based multimedia can be used to bridge multiple representations of chemical materials and as an effort to improve students' comprehend.

Prior pre-experiment studies shown that 89% tenth-grade students state that they claimed to have difficulty in learning symbolic concepts such as chemical bonds and hydrocarbons. They also state that confuse to differentiate whether intermolecular forces or intramolecular bond. Using 3D realistic media such as molymod or related is not conducted because of constrained means and limited time. Chemical software has been widely circulated on the internet, for example, MolView, ChemDoodle3D, and ChemOffice. The features in the application include conversion of chemical formulas to molecular formulas to 3D molecular shapes, data on the physical properties of compounds, and their spectroscopy. The purpose of using these applications according to the description available on the website of the application developer is for students and professional researchers who need help in the data processing.

METHOD

Study design

This study using R&D research design by Thiagarajan which consisting of 4 stages, there are define, design, develop, and disseminate[10]. In this study, the stage limited to the develop stage on the expert appraisal. In define stage, involved some steps which are front-end analysis, students analysis, concept analysis, and task analysis. This stage intends to know the requirements in the learning process. In the design stage, involves criterion test construction, media selection, format selection, and initial design. The construction and selection in the design stage are based on the data in the define stage. In the develop stage, the result from the design stage will be assessed by an expert according to some components. The stages in this study can be briefly below.



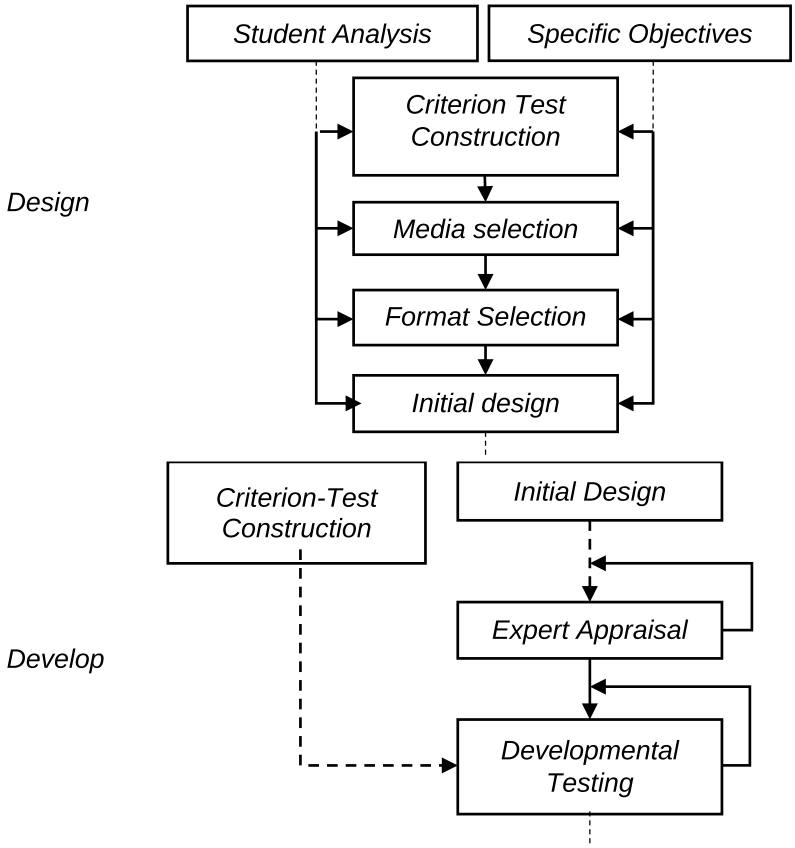


FIGURE 1. Research and Development Design by Thagarajan [10].

Place, Time and Subject Study

This study was conducted in SMA Negeri 1 Waru Sidorajo with 25 tenth grade students in mathematics and natural sciences class in even semester of 2019-2020.

Data Gathering

To gather the data, this study use validity sheets which will be assessed by three expert academics and practitioners. There is two validity sheets, first is content validity and second is construct validity.

Study instruments

The instruments that used is validity sheets which already established and modifies by Sadiman, Munadi, and Nieven to assess the multimedia validity[11][12][13]. The assessment points are written in the table below.

TABLE 1. Assessment Indicators for Interactive Multimedia Using 3D Modelling

NO.	Aspects	NO.	Assessment Indicators	Source
			Content Validity	
1	Suitability matter with curriculum	1.1	The suitability of the development of interactive multimedia with intermolecular force material.	Multimedia format
		1.2	Conformity of learning objectives with SK / KD / Curriculum.	Material and questions in multimedia

NO.	Aspects	NO.	Assessment Indicators	Source
		1.3	The suitability of the material in interactive multimedia with the learning objectives.	Material and questions in multimedia
2	Suitability matter substance with learning matter	2.1	The breadth of intermolecular force material in multimedia.	Material and questions in multimedia
		2.2	The depth of intermolecular force matter in multimedia	Material and questions in multimedia
		2.3	The accuracy of concepts and definitions.	Material and questions in multimedia
			Construct Validity	
1	Media as multimedia	1.1	Clarity of learning objectives to be achieved.	Questions in multimedia
		1.2	The illustrations or images presented are relevant to intermolecular force material.	During the process of answering questions in sections 1 through section 4 and the material section
		1.3	Quality of static media (2D images and 3D models).	During the process of answering questions in sections 1 through section 4 and the material section
		1.4	Quality of dynamic media (animation).	During the process of answering questions in sections 1 through section 4 and the material section
		1.5	The layout of illustrations, images, videos and text in multimedia is appropriate.	Overall part in multimedia
2	Interactivity	2.1	A multimedia design able to facilitate students in understanding the material.	Overall part in multimedia
		2.2	The phenomena presented in multimedia correspond to intermolecular force material.	Phenomenon part 1 to part 4
		2.3	Accuracy in providing stimulus and interaction in multimedia.	During the process of answering questions in sections 1 through section 4 and the material section
		2.4	Ease of operation (usability).	Overall part in multimedia

Data Analysis

Data validation results from 3 academics and practitioners to interactive multimedia using 3D modelling on intramolecular forces matter were analyse in descriptive quantitatively. The analysis was carried out by giving a presentation of research on multimedia with a percentage of the scores obtained from the validation sheets. The percentage of the data is obtained based on the Linkert scale.

TABLE 2. Assessment Scale Category

Category	Scale
Very Good	5
Good	4
Medium	3
Not Good	2
Not Very Good	1

The total score that obtained based on the Linkert scale then calculates using the formula below:

$$\%=\frac{\text{Score total all validator for each criteria}}{\text{Criterion score}}\times 100\%$$

The values that obtained are based on the above calculation, will be interpreted according to the following Linkert Scale table.

TABLE 3. Linkert Scale Table

Category	Scale
Very Valid	81-100%
Valid	61-80%
Medium	41-60%
Not Valid	15-40%
Not Very Valid	0-24%

Multimedia states as valid if every aspect obtain the percentage of ≥61% with a valid category and percentage ≥81% with a very valid category[14].

RESULTS AND DISCUSSION

The result from this study is valid interactive multimedia using 3D virtual modelling on intermolecular forces matter. The multimedia involve illustration, 3D object, animation, and explanation about the geometrical molecule, its interaction, and its physical properties to visualize the microscopic and symbolic representation.

Define

The first stage is defined which includes front-end analysis. In the introduction already written that the background in this study is to know the validity of interactive multimedia using 3D virtual modelling on intermolecular forces matter. Front-end analysis includes concept analysis, student analysis, and task analysis. When analyzing the concept, obtain that intermolecular forces is one of an abstract concept and have dynamic feature because involve the steps how to molecules interact. When analyzing the students, obtain that students need media to understand concept abstractness in chemistry. Additionally, students in age 15-16 years old can think abstractly. When analyzing the task, obtain intermolecular forces is one of the chemical bonding lessons. This lesson including in even semester for tenth-grade science high schoolers.

Design

The second stage is the design which including constructing criterion tests, media selection, format selection, and initial design. In constructing a criterion test, obtain a validity sheet to assess the validity of interactive multimedia that already developed. In media, selection obtains Articulate Storyline 2.0 to develop the 3D multimedia. In format selection, is describe what are the component in multimedia that developed. In the initial design, will describe in detail about development in format selection. In this multimedia involve microscopic and symbolic representation which visualize in 2D illustration and 3D object for better students' comprehend in learning intermolecular forces. The multimedia also completed by the 3D animation of intramolecular interaction to know how the mechanism the molecules interact. This animation will help students to understand and differentiate the intramolecular bond and intermolecular forces. Multimedia conducted as concept building thus, students have to answer the questions to obtain the concept. While answering questions, students will stimulate by animation and illustration for better understanding in intermolecular concept [2][7].

Develop

The third stage is developed which including expert appraisal. The expert appraisal is conducted to obtain assessments regarding the media that have been developed. This stage aims to determine the validity of interactive multimedia using 3D modelling on intermolecular forces in terms of the validator's assessment. Validator consists of two chemistry lecturers and one chemistry teacher by assessing the instruments. The validity of a media in terms of content is then called the content validity and the construct is then called the construct validity. Content validity is related to the assessment of the suitability of the contents of the material in the media with the curriculum used at school. The content validity consists of two aspects, namely the suitability of the material in the media with the applicable curriculum and the suitability of the substance of the learning material with the literature. While the construct validity is related to the quality of the developed media design. Construct validity consists of two aspects, namely media as multimedia and media interactivity. The result of validity assessment is written below.

TABLE 4. Validity Result: Percentage and Criteria

No	Assessment	Percentage and Criteria
1	**Content Validity**	
	The suitability of the material with the curriculum	88,89% (Very Valid)
	The suitability of the substance of learning material	80,00% (Valid)
2	**Construct Validity**	
	Media as Multimedia	89,33% (Very Valid)
	Interactivity Media	88,33% (Very Valid)

According to the validity, it states that the scores from average aspect obtained obtain 86.66% for content validity and 85.78% for construct validity which ≥81% and categorize as very valid. However, this multimedia still need more revised for further improvement.

The material in the media must be by the curriculum to be in line with the learning objectives of the Ministry of Education and Culture. The suitability of the material in multimedia is viewed from several components including the suitability of the development of interactive multimedia with intermolecular force materials, the suitability of learning objectives with SK / KD / Curriculum, and the suitability of the material contained in interactive multimedia with learning objectives. In general, the suitability of the material in the media with the applicable curriculum scores 88.89% which is categorized as very valid. The following chart shows the details of the validity score of the suitability of the material with the curriculum.

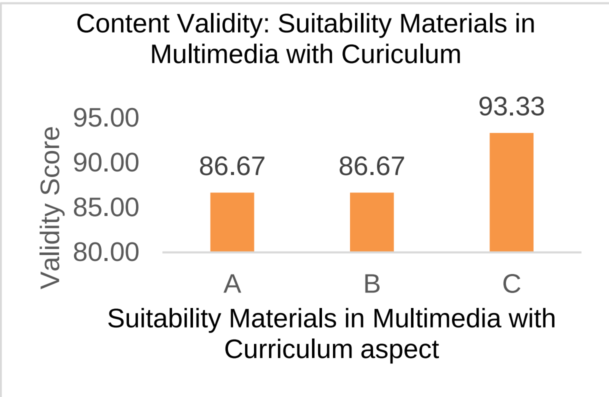


FIGURE 2. Suitability Materials in Multimedia with Curriculum Chart

Explanation:
A= The suitability of the development of interactive multimedia with intermolecular force material
B= Conformity of learning objectives with SK / KD / Curriculum
C= The suitability of the material in interactive multimedia with the learning objectives

Aspects of the suitability of the substance of learning materials are used to assess the suitability of the substance of the material in multimedia developed with the literature. The literature used is the 2016 revised 2013 curriculum chemistry syllabus, university basic chemistry books, and high school / equivalent chemistry books. Components of this aspect include the breadth of the material, the depth of the material, and the accuracy of the concepts and definitions. The following diagram shows the breakdown of the suitability aspect score of the learning material.

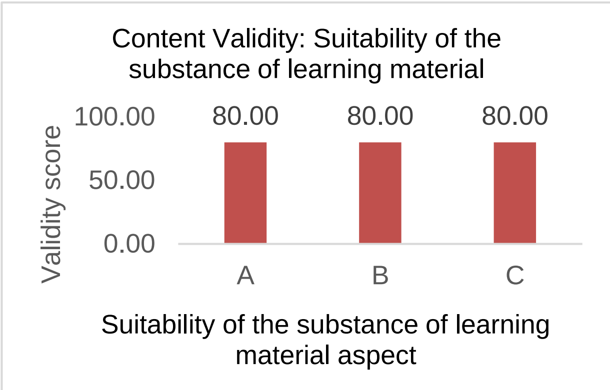


FIGURE 3. Suitability of the Substance of Learning Material Chart

Explanation:
A= The breadth of intermolecular force material in multimedia
B= The depth of intermolecular force matter in multimedia
C= The accuracy of concepts and definitions

Construct validity is used to get an assessment of the harmony of the developed multimedia design. The construct validation assessment is reviewed from several aspects that characterize the multimedia development being carried out. In this multimedia, construct validity assessment includes media criteria as multimedia and media interactivity.

Reddi & Mishra states that multimedia is a combination of several media elements (audio, video, graphics, text, animation, etc.) into a system that is synergistic and able to provide benefits to users [15]. Based on the description of the media components as multimedia in this study include the clarity of the learning objectives achieved, the relevance of illustrations to the material, the quality of static objects, the quality of dynamic objects, and the layout of each multimedia component. In general, the validity score obtained for this aspect can be seen in the diagram below.

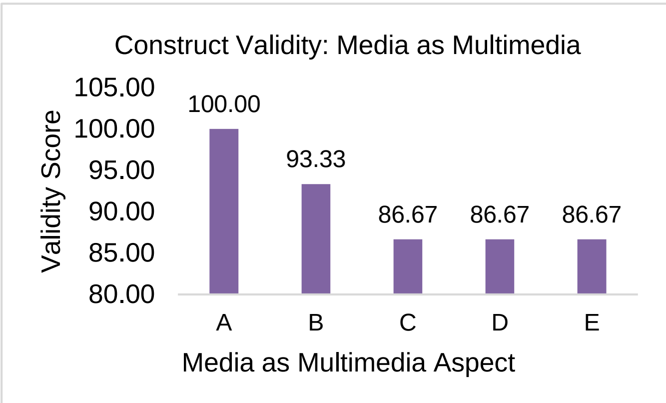


FIGURE 4. Construct Validity: Media as Multimedia Chart

Explanation:
A= Clarity of learning objectives to be achieved
B= The illustrations or images presented are relevant to intermolecular force material
C= Quality of static media (2D images and 3D models)
D= Quality of dynamic media (animation)
E= The layout of illustrations, images, videos and text in multimedia is appropriate

Mishra & Sharma states that the interactivity of multimedia includes the use of technology, gives users control over multimedia to complete tasks, there are stimulus and response back, and is easy to use [16]. Moreover, good interactive multimedia be able to reinforce students learning experience by higlighting main topic of subject[7]. Based on these descriptions, the assessment of multimedia interactivity in terms of multimedia design can facilitate students in understanding the material, the phenomena presented in multimedia by intermolecular force material, the accuracy of stimulus delivery and interaction in multimedia, and ease of operation. In general, the following diagram regarding the multimedia interactivity validation score developed.

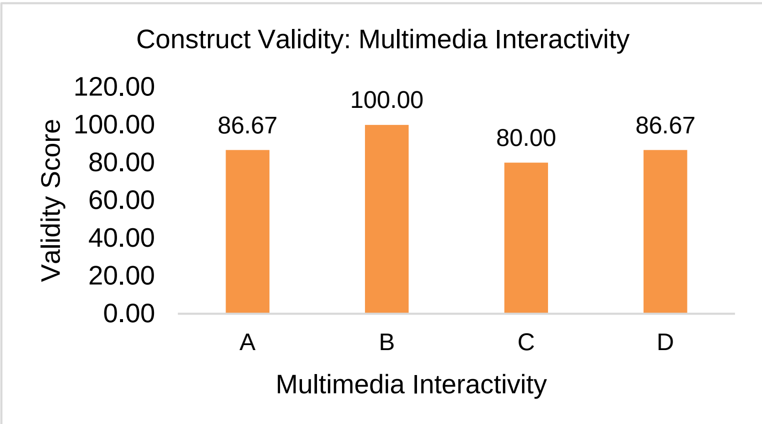


FIGURE 5. Construct Validity: Multimedia Interactivity Chart

Explanation:
A= Multimedia design able to facilitate students in understanding the material
B= The phenomena presented in multimedia correspond to intermolecular force material
C= Accuracy in providing stimulus and interaction in multimedia
D= Ease of operation (usability)

CONCLUSION

This study aims to know the validity of interactive multimedia using 3D modelling. According to the expert appraisal, the multimedia that developed obtain average scores obtain 86,66% for content validity and 85,78% for construct validity which both categorize as "Very Valid".

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