Virtual media simulation technology on mathematical representation of sound waves

D R Darman¹, F C Wibowo¹, A Suhandi², W Setiawan², H Abizar¹, S Nurhaji¹, L Nulhakim¹ and A Istiandaru³

¹Universitas Sultan Ageng Tirtayasa, Jl. Raya Jakarta KM 4 Serang, Banten, Indonesia
²Universitas Pendidikan Indonesian, Jl. Dr. Setiabudhi No. 229, Bandung, Indonesia
³Universitas Ahmad Dahlan, Jl. Ringroad Selatan, Tamanan, Bantul, Indonesia

E-mail: dina_rd@untirta.ac.id

Abstract. This research aims to develop Virtual Media Simulation (VMS) for learning physics oriented conceptual level in the mathematical representation of sound waves. Facts on the ground show that there are still many students who are found experiencing misconceptions in physics concept so that it is necessary to learn VMS assisted conceptual change. The research uses Quantitative study design used is one-group pre-test post-test design. Research subjects at one of the state universities in the Serang City, Banten Province, Indonesia. The construction of the conception of the data that will be obtained from both groups is searched for the Level of Understanding of Each Wave and Sound Concept. The result of the research shows that the highest mathematical representation of Level of Understanding divided into Complete Understanding (CU) is 78%, Partial Understanding (PU) is 14%, Wrong Understanding (WO) is 7%, Not Understanding (NU) of 2% and the lowest the No Answer (NA) 0%. The conclusions of VMS can be used in the mathematical representation of physics learning because of the quantity of the level comprehensively understood in the category of "good" and effective facilitating concentration control of sound wave concept of students.

1. Introduction

The universe becomes an object that is very important in human life because it is a part of a complete system that cannot be separated from human life. Humans as one of the living creatures of the inhabitants of the universe should have learned and learned various natural secrets. The understanding of the universe, humans will get ease in navigating their lives and easier to overcome the problems faced in their lives. Physics is part of Natural Sciences specifically studying natural phenomena that are not alive or material in the sphere of time and space. Natural phenomena are formed when there is an interaction between matter and energy. So actually physics is studying the matter, energy, and interaction between the two. As an example in everyday life, there is an observed phenomenon that is the increase in the temperature of the substance when heated. This event is an interaction between substances with heat energy that affect increasing the temperature of the substance [1].

The results of the empirical investigation show that several factors influence the high and low-temperature rises of substances when heated, such as the mass of substances, the heat of the type of substance, and the amount of heat given. Macroscopically this situation can be understood because it is based on the results of observations of measured quantities [2]. When there is a question why the mass of a substance, the heat of the type of substance, and the amount of heat given affects the temperature
rise of the object when heated, the observational data cannot provide an adequate explanation because what is learned is the macroscopic level. To be able to answer the questions above, a more fundamental study is needed at the microscopic level of objects. "The microscopic system can easily help macroscopic systems" [3]. Facing the 4.0 industrial revolution is certainly not easy. Some things need to be prepared, for example by changing the learning method in the world of education that exists today. One of them is virtual learning by the demands of the 21st century, namely ICT literacy where the empowerment of virtual learning has an impact on Mathematical Representation.

Physics learning is held at various levels of formal education as a means to learn concepts, principles, laws and principles and the interrelationship between concepts that occur in a physical phenomenon that is observed which leads to the construction of conceptions in the minds of students' minds. The quality of conception that is formed in the minds of students' minds is very dependent on the learning process experienced. Verbal learning will not produce a scientific conception in the minds of students' minds. Instead, it can lead to a misconception called misconception. If the student has a certain conception and the conception is different from the scientific conception, it is said that the student experiences misconceptions [4, 5].

During this time, lecture learning is only verbal information and has not facilitated students to construct or comprehend physics concepts, especially microscopic physical concepts. A simulation or visualization media is needed that can model microscopic phenomena that are invisible. For example, the temperature of a substance is microscopically represented by the rate of motion of the constituent particles. The higher the temperature of an object, the faster the constituent particles move. Because the particle size of the constituent substances is very small and cannot be observed by the sense of sight, the movement cannot be observed, let alone understood. If the movement of substance particles can be visualized, the phenomenon will be more easily understood. An instructional simulation often involves the representation of concrete and abstract objects [6]. Learning physics by using virtual simulations can visualize abstract objects as if they were real [7].

Meanwhile, from the explanation above, the idea emerged to innovate in the development of virtual simulations. The availability of virtual media related to abstract and microscopic phenomena is believed to be very helpful in the process of construction and reconstruction of conceptions in physics learning, especially for microscopic teaching methods, therefore researchers are interested in developing virtual media that other researchers have not developed in the hope of contributing real in improving the quality of physics learning at various levels of high school and college level through the provision of one of the supporting tools for physics learning in the form of virtual media. Finally, this research activity was entitled Development of Technology Virtual Media Simulation (VMS) on Mathematical Representation of Sound Waves for Level Construction Conception.

2. Virtual Media Simulation (VMS)

Computer simulation is a computer program that contains a particular system model and that can be executed, after the execution of the output can be analysed [3]. Computer simulations usually model abstract concepts and involve mathematical models. Computer simulations have become an important part of mathematical modelling and natural systems, social systems, and technological systems. Simulation modelling is usually done with the aim of modelling visuals that become more real and realistic. The benefits of simulation are to make the abstract system into a concrete system, or a graphical representation of an abstract system.

Virtual simulations are also used in the aviation world to test a pilot before flying a plane, or the driver to get a SIM must be tested using a simulation. Because the simulation has a broad meaning, so the virtual simulation area in this study is modelling of an abstract object that becomes more real. The microscopic properties are defined as properties that are not observed by the eye (abstract) and occur in very small (micro) material. Microscopic phenomena are events of an unobserved existence by the eye (abstract) and occur in very small (micro) material. A microscopic example in physics is the size of particles that make up water on a micro scale and the movement of water particles that cannot be observed by the sense of sight [1, 2].

2
The development of simulation in learning must be done carefully so that the media produced is by the needs in learning. The three are some basic steps in creating simulation media, namely:

1. Determine the system and describe theories that determine changes in the system.
2. Determine the free (independent) parameters that will be changed by the user.
3. Determine the dependent variables be presented to the user in response to the parameters entered.
4. Develop mathematical approaches and algorithms to evaluate and present change.
5. Determine the method in the interface if you want to exit the simulation or continue the simulation.
6. Administer a test, get feedback, and improve.

3. Level Construction Conception
The level of students’ understanding of the concept of physics after participating in the learning process will vary, some understand it in its entirety, some understand some, some even misunderstand. Categorize the level of students’ understanding of the concept [8]. To measure the level of depth of understanding in the construction of the concept of microscopic phenomena using virtual simulations using an understanding test and the results are categorized into a level of understanding following Table 1.

| Level of Understanding | Criteria                                      |
|------------------------|-----------------------------------------------|
| [0] Not Answering (TMJ)| Do not answer any question                     |
| [1] Not Understanding (TMH)| Answer all questions, but the answer is not appropriate (irrelevant) with the question |
| [2] Understanding Erroneously (MSK)| Answer all questions but the answer is unclear, or the answer is wrong |
| [3] Understanding Some (MSB)| Correctly answer some questions             |
| [4] Understanding Whole (MSU)| Answer all the questions correctly |

In addition to the level of understanding, after participating in learning, students will also have an understanding model of the VSM. Saglam and Devecioglu share their finding of student understanding models and their characteristics as shown in Table 2 [8].

| Model Understanding | Characteristic                                      |
|---------------------|-----------------------------------------------------|
| Optimal Model (MO)  | Students correctly define, use, and model something theoretical knowledge correctly |
| Non-Creative Model  | Students correctly define the use and something of theoretical knowledge but fail to exemplify it |
| Theoretical Model (MT) | Students determine and define something theoretical knowledge but fail to apply and exemplify it |
| Practical Model (MP) | Students correctly apply and model each part of theoretical knowledge but fail to define and define |
| Memorize Model (MM) | Students define a theoretical knowledge, books correctly but fail to use, apply and exemplify |
| Not Having a Model (TKM) | Students fail to define, utilize, apply and exemplify from a theoretical knowledge |
4. Method
The purpose of the present study is to describe the level of understanding of the students using Virtual Media Simulation (VMS) technology on Mathematical representation of sound waves for level construction conception. The research uses one group post-test only design [9]. Tests of understanding the concept of the experimental class applied using one group post-test only design as shown in Figure 1.

![Figure 1. Design one group post-test only](image)

where:

O: The conceptual test understanding of sound waves for level construction conception
X: Treatment in the form of VMS experimental group.

The respondents involved in this study were 78 students of senior high school. The sample was randomly selected from second-year student undertaking an introductory physics course. A few groups of these students have already studied VMS of senior high school in Banten Province, Indonesia.

5. Analysis

5.1. Virtual Media Simulation Technology
Virtual Media Simulation development stage that is done in this study included the analysis phase, the planning or design, production, and evaluation [5]. Analysis of curriculum successfully selected thermal expansion of solids material with consideration of the material contains some abstract concept, so that very precise when made interactive multimedia that can simulate events that are difficult to observe by students and can simulate the sound wave. Result it showed that the use of virtual media could change the conception of learners who have a conceptual understanding through the level of understanding [4].

The preparation stage is carried out by analysing the study of media needs to be developed. The results of this need study is an in-depth exploration phase of the issues being studied. This activity aims to get an overview of the problems and reliable solutions to overcome these problems. The needs study phase consists of literature studies and analysis of the availability of virtual media simulations on wave and sound material. A literature study was conducted to determine the problem to be studied; researchers conducted a study of literature studies on research reports relating to students' understanding of the concept of waves and sounds, construction learning concepts of conception, virtual simulations, and concept characteristics of waves and sounds.

The results of the analysis of the research report on understanding and misconceptions in the concept of wave and sound concepts found that students were still less comprehensive in their understanding. From several research, we obtained information about understanding the wave and sound material [10-13]. Based on the findings of the research, the researcher sets the level of understanding that will be remediated through the development of virtual simulation media for physics learning that is oriented to conception construction, carried out on wave material and sound in the concept:

(1) Resonance
(2) The relationship between the amplitude of the sound with the loudness of the sound
(3) The relationship between sound frequency and high and low tone of voice
(4) The relationship of sound propagation with medium density
(5) The relationship between size of energy received and distance between receiver and sound source.
(6) Relationship of sound amplitude with material stiffness properties.

Based on the results of preliminary studies that have been carried out, it can be concluded that the majority of students understanding the concept do not understand the concept of physics as a whole. So it takes the effort to construct a scientific conception using Macromedia Flash 8.0 virtual simulation. The simulation makes continued at the development stage. Analysis of the availability of simulation media on wave and sound material is shown in Table 3.
| Display of wave simulation and sound | Source | Description |
|------------------------------------|--------|-------------|
| http://bit.ly/sound colorado       | This simulation does not display microscopic sound physical processes; it has not facilitated the manipulation of the model so that it still allows misconceptions. |
| http://bit.ly/wave-simulator        | This simulation has indeed shown microscopic physical processes of sound and waves, not yet showing the constituent particles |
| http://bit.ly/javaoscillation       | This simulation does not display the physical process of the wave microscopically, tends to simulate the occurrence of waves. |
| http://bit.ly/gluon waves           | This simulation has not been shown microscopically by the transverse wave physical process and has not shown microscopic symptoms of particle movement so that it still allows student misconception. |
6

| Display of wave simulation and sound | Source | Description |
|-------------------------------------|--------|-------------|
| ![Wave Simulation](http://bit.ly/graymotion) | This simulation has indeed shown the propagation process in the medium microscopically does not accommodate and counter student understanding of wave and sound material. |

Based on the findings in the preparation or study needs phase, the media was designed to obtain virtual simulation products to change students’ conceptual understanding of wave and sound material. At the design stage, virtual simulation media are designed in the form of storyboards by adjusting to students’ pre-defined misconceptions. The example is presented in Figure 2.

![Microscopic of the sound wave](image)

**Figure 2.** Microscopic of the sound wave

5.2. Level of Understanding

The information is obtained that on average the level of understanding from high to low after the application of the construction concept of physics conception by using virtual simulations of microscopic phenomena on the wave and sound material.

![Percentage of average level of understanding](image)

**Figure 3.** Percentage of the average level of understanding on wave and sound material
Based on Figure 4, it was obtained information that on average the level of understanding from high to low after the application of the construction of physics conception learning by using a virtual simulation of microscopic phenomena on the wave and sound material. The result of the research shows that the highest mathematical representation of Level of Understanding divided into Complete Understanding (CU) is 78%, Partial Understanding (PU) is 14%, Wrong Understanding (WO) is 7%, Not Understanding (NU) of 2% and the lowest the No Answer (NA) 0%.

6. Conclusion
The conclusions of VMS can be used in the mathematical representation of physics learning because of the quantity of the level comprehensively understood in the category of "good" and effective facilitating concentration control of sound wave concept of students. The recommendations are a strategic alternative in the development of for digital mathematics representation learning. Based on the results of research of the conclusions of this research are the results presented here show that students effective with VMS significantly for level of understanding.

7. Acknowledgements
The research was funded by research grant from the Research and Community Service Institution (LPPM), Universitas Sultan Ageng Tirtayasa, in 2018.

References
[1] Wibowo F C, Suhandi A, Rusdiana D, Darman D R, Ruhiat Y, Denny Y R, Suherman and Fatah A 2016 Microscopic virtual media (MVM) in physics learning: Case study on students understanding of heat transfer J. Phys.: Conf. Ser. 739 012044
[2] Wibowo F C and Suhandi A 2013 The Implementation of Model Project Creative Learning (PCL) for Developing Creative Thingking Skill Concept of Electricity Magnet Jurnal Pendidikan Fisika Indonesia 9 144
[3] Wibowo F C, Suhandi A, Rusdiana D, Samsudin A, Darman D R, Faizin M N, Wiyanto, Supriyatman, Permanasari A, Kaniawati I, Setiawan W, Karyanto Y, Linuwih S, Fatah A, Subali B, Hasani A and Hidayat S 2017 Effectiveness of Dry Cell Microscopic Simulation (DCMS) to Promote Conceptual Understanding about Battery Journal of Physics: Conf. Series 877 012009
[4] Kartal T, Ozturk N and Yalvac H G 2011 Misconceptions of Sciences Teacher Candidats about Heat and Temperature Procedia Social and Behavioral Sciences 15 2758
[5] Wibowo F C, Suhandi A, Rusdiana D, Ruhiat Y and Darman D R 2016 Microscopic Virtual Media (MVM) in Physics Learning to Build a Scientific Conception and Reduce Misconceptions: A Case Study on Students’ Understanding of the Thermal Expansion of Solids International Conference on Innovation in Engineering and Vocational Education (Paris: Atlantis Press) pp 239-44
[6] Wibowo F C, Suhandi A, Rusdiana D, Ruhiat Y, Darman D R and Samsudin A 2017 Effectiveness of Microscopic Virtual Simulation (MVS) for Conceptualizing Students’ Conceptions on Phase Transitions Advanced Science Letters 23 839
[7] Wibowo F C, Suhandi A, Samsudin A, Darman D R, Suherli Z, Hasani A, Leksono S M, Hendrayana A, Hidayat S, Hamdani D and Coştu B 2017 Virtual Microscopic Simulation (VMS) to promote students’ conceptual change: A case study of heat transfer Asia-Pacific Forum on Science Learning and Teaching 18 1
[8] Saglam-Arslan A and Deveciogle Y 2010 Student teachers' levels of understanding and model of understanding about Newton's laws of motion Asia-pacific Forum on Science Learning & Teaching 11 1
[9] Cresswell J 2017 Research design: qualitative, quantitative and mixed methods approach (London: Sage Publication, Inc)
[10] Çalış M, Okur M and Taylor N 2011 A Comparison of Different Conceptual Change Pedagogies Employed Within the Topic of “Sound Propagation” Journal of Science Education and Technology 20 729

[11] Bohigas A, Jee’ n X and Periago C 2012 Misconceptions About Sound Among Engineering Students J Sci Educ Technol 21 669

[12] Fish D, Anderson T R, Aalih S and Pelaez. N 2014 Sound Misconceptions (Pretoria: South African Institute of Physics)

[13] Witmanna M, Steinberg R N and Redishc E F 2003 Understanding and affecting student reasoning about sound waves International Journal of Science Education 25 991