Microscopic Virtual Media (MVM) in Physics Learning: Case Study on Students Understanding of Heat Transfer

F C Wibowo¹², A Suhandi¹, D Rusdiana¹, D R Darman², Y Ruhiat², Y R Denny², Suherman², A Fatah²

¹ Universitas Pendidikan Indonesia, Indonesia
² Universitas Sultan Ageng Tirtayasa, Indonesia

E-mail: firmanulcaturwibowo@untirta.ac.id

Abstract. A Study area in physics learning is purposeful on the effects of various types of learning interventions to help students construct the basic of scientific conception about physics. Microscopic Virtual Media (MVM) are applications for physics learning to support powerful modelling microscopic involving physics concepts and processes. In this study groups (experimental) of 18±20 years old, students were studied to determine the role of MVM in the development of functional understanding of the concepts of thermal expansion in heat transfer. The experimental group used MVM in learning process. The results show that students who learned with virtual media exhibited significantly higher scores in the research tasks. Our findings proved that the MVM may be used as an alternative instructional tool, in order to help students to confront and constructed their basic of scientific conception and developed their understanding.

1. Introduction

The universe is an integral part of the system that can not be separated. The universe as a whole must be studied because knowledge of human nature will increase the strength to resolve the problems. Humans have a curiosity about the nature sciences itself. The purpose of finding the way out that realized in the form of asking and thinking systematically. So that the Natural Sciences is not just curiosity or mastering of knowledge in the form of a bunch of the facts, concepts, or principles but also a process of discovery [1].

Physics is part of the Natural Sciences that contained about the natural sciences which is expected to become a vehicle for students to learn about themselves and around of nature. Learning Physics emphasizes to providing direct experience to develop the competence of learners to be able to explore and understand about universe around scientifically. Constructive learning of science as a dynamic process to building, organizing, and elaborating knowledge of natural word [2].

Physics is the knowledge that studies the basic nature of matter and energy and their interactions. Studying the properties of objects is done by observation, understanding and prediction of natural phenomena. Specifically, Physics tries to answer fundamental questions about the nature of universe and all of the principles. For example in daily lives when using the stove to cooking water is a part of physics learning about materials and energy. Physical layout as material in the water and the temperature is an energy properties. By the time the water is heated water particles move by convection process, to observe the movement of water particles when heated is very difficult to
observe with the naked eye. So, we need a visualization of the movement of the water particles that are microscopic. Visualization of the movement of the water particles will make learners more easily to understand and more meaningful.

Characteristic of physics consists of microscopic properties and macroscopic. In physics is defined as a concept that can be observed with the eye and measured. Examples of macroscopic physics is electrical current, strong electric current can be measured using ammeters but the electric current can not be off is but can be felt (electrocuted). The simplest example of a macroscopic is condensed phase that solids and liquids, which can be observed with the eye and the can was measured using the measuring instrument. but we cannot observe the constituent particles of solid phase and liquid and, limitation is called the microscopic properties.

Construction concept in physics involving macroscopic aspects (observable traits), and microscopic aspects (particles making up matter). Learning Physics that prioritizing microscopic aspects would be not effective if presented by means of a lecture or class discussion without the support of the physical processes that occur in the form of impressions or visual. For example, learning solid expansion, movement and distance related constituent particles (collisions between particles) and the temperature. This learning involves a dynamic aspect of particle motion that cannot be explained by drawing on the blackboard. When explained directly in front of the classes that just use the help whiteboard, learning is not effective because the study of solid expansion involves microscopic dynamic aspect. This is what will lead to misconceptions experienced by learners.

Mastery of the basic concepts are still low by learners, this is one of things which can lead to misconceptions. Because the materials of physics are microscopic, so the learners difficult to absorb all the matter well. Moreover, many basic concepts that require visualization to helps facilitate understanding of the concept of heat transfer.

A study was obtained that if the learning only listened (lecture or teacher) without doing the other things such as write a notes, mastery of the matter contributed by 5 %. Followed by reading, mastery of the matter contributed by 10 % and when studied with the help of audio visual mastery of the matter contributed by 30 % [3]. So that when the matter of physics are microscopic, it can be visualized using a media conception of physics, the construction of concept can be formed. Based on the description that has been stated above, the formulation of the problem in general is: "How Microscopic Development of Virtual Media (MVM) Effective For The Physics Learning to Construct The Concept Orientation In Characteristic of Matter Microscopic on the concept of heat transfer ?"

2. Virtual Simulations in Physics Learning

School's widespread access to Information and Communications Technologies (ICT) pose tremendous challenges to physics teaching and learning. Physics is one of the first areas where the possibilities that computers may offer for the employment of new teaching methods have been and are still explored. A variety of computer applications have been developed and used in teaching Physics, such as spreadsheets [5], computer-based laboratories [4], multimedia [6] [7], simulations [8], exploratory environments [9] and intelligent tutors [10]. Furthermore, research has often been employed to direct design and development about educational software as well as educational evaluation software. Among the various ICT applications, computer simulations are of special importance in Physics teaching and learning. Simulations to educational environments, which aim to enhance teachers' instructional potentialities and to facilitate students' active engagement. Computer simulations offer a great variety of opportunities for modeling concepts and processes. Simulations provide a bridge between students’ prior knowledge and the learning of new physical concepts, helping students develop scientific understanding through an active reformulation of their misconceptions [11]. Specially, they are open learning environments that provide students with the opportunity to:

1. Develop their understanding about phenomena and physical laws through a process of hypothesis making, and testing of ideas;
2. Isolate and manipulate parameters and therefore helping them to develop an understanding of the relationships between physical concepts, variables and phenomena;
3. Employ a variety of representations (pictures, animation, graphs, vectors and numerical data displays) which are helpful in understanding the underlying concepts, relations and processes;
4. Express their representations and mental models about the physical world; and
5. Investigate phenomena which are difficult to experience in a classroom or lab setting because it is extremely complex, technically difficult or dangerous, money-consuming or time-consuming, or happen too fast.

The constructivist perspective in physics teaching argues that knowledge is not discovered but it is achieved by constructing models of physical phenomena. According to [12] we can done two types of models:

1. Mental models, are representations of the physical phenomena constructed in the minds of students and contain a set of information about what students know (either that's correct or incorrect); and
2. Conceptual models, which originate from mental models and are created by the cooperative activities of scientists. They are objective representations in the sense that they are free from influence of anyone. Students’ active is important to overcome their conceptual obstacles and reach the scientific conceptual models.

![Figure 1. Microscopic Virtual Media (MVM) in Physics Learning concept of thermal expansion in heat transfer](image)

We can distinguish between two types of computer models in physics [12]:
1. Exploratory models, which are constructed by experts to represent domain knowledge. Usually they are micro worlds that simulate physical processes and laws. Such micro-worlds encourage students explore and interact with them, handle parameters and observe their results; and
2. Expressive models, which allow students express their own ideas on a domain. They provide learners with tools to student relationships between concepts, explore the consequences of those student relationships and learn through an active process of representing their own models.

### 3. Understanding of the Concepts (Consistency Conception)
Consistency conceptions of the students in this study include the pattern of student answers using the same concept models in answering a series of questions. This data was obtained through the test of consistency conception instruments tested by asking questions with the same concept more than once. Build the necessary concepts of harmony between the facts and the basic concepts owned learners so that the concept can be systematically formed. However, the harmony between the basic concepts owned learners are often influenced by the initial understanding obtained by learners before entering the class when obtain teaching under the guidance of a teacher. It is as stated by [2] states that "Research of data collected over more than three Decades has shown that the majority of students
come to science classes with pre-instructional knowledge or beliefs about phenomena and concepts to be taught ...". The preliminary understanding is often at odds with the concept put forward by scientists. This condition is known as misconceptions (Alternative conceptions). As noted by [14] that "These students construct sensible and coherent understandings of phenomena and concepts as seen through Reviews their own eyes that do not match the views that are Universally accepted by the scientific community." Among the misconceptions found the matter waves is the sound wave propagation speed depends on the frequency of sound waves [16] the only wave interference is constructive, does not apply to the destructive [17], and sounds including transverse waves [15]. Various of studies have tried to resolve misconceptions experienced by learners through open questions (open-ended questions), to explore the basic concepts used as an excuse by the students to answer questions. Development of the concept of measuring instruments (diagnostic instruments) continue to be made in order to document how much misconceptions experienced by learners in a variety of topics. This is done to prepare a study that is capable of changing misconceptions owned learners into appropriate understanding of the scientific conception, as expressed by Driver [17] that "... documenting all the alternative conceptions held by students Contribute to lecturers could "conceptual ability to effect change, as well as the benefits and inform science curriculum planning, Generally". By knowing misconceptions of learners, teachers can plan a learning process that is more planned and directed, in order to support the concept development process.

4. Method
The sample total of 40 students attending the first year of student of physics education (18±20 years old) participated in the research. The students on sample were coming from a variety of social-economic backgrounds, Most of them (70%) had computer experience. The students were grouped in the experimental group. Our research was carried out during the academic year 2013±2014 and took the time about 4 months after students had received school teaching on thermal expansion in heat transfer concepts. Heat transfer teaching topic described in the Physics Curriculum university. experimental group activities took place in the Physics laboratory.

5. Analysis
Our educational intervention took place approximately two weeks after students in the experimental group had received traditional class teaching on the relevant topics. All students from the experimental group were offered two lessons in the computer lab. During the first lesson the teacher, with the collaboration of a researcher, used Microscopic Virtual Media (MVM) to display simple heat transfer phenomena and analyze. From these results obtained the two groups of data that is data pre-test and data post-test. Data from this study in the form of students' conceptions profile, decrease misconceptions students, students' conceptual change and effectiveness Microscopic application of Virtual Media (MVM) to remediate misconceptions students. The data collection using the instrument in the form 15 multiple choice questions with 3 possible answers along with the reasons. Most of the students' initial conceptions still have misconceptions. This is shown in profile before learning those students' conceptions on the concept of a good heat-absorbing color. The total of 40 (80%) students says that the white color cannot absorb heat. This statement contradicts the conception of scientists who claimed that the white color is a good heat reflector. After learning using Microscopic Virtual Media (MVM), students are given a post-test to determine the final conception of students. Based on post-test results, the concept of a good heat-absorbing color changing students' conceptions positive profile of 65%. Partially students already stated that the white color is a reflector of heat good or a bad heat absorbent. A decrease in student misconceptions is the average percentage difference misconceptions students between before and after remediation using Microscopic Virtual Media (MVM). A decrease in student misconceptions can be presented in figure 2.
Based on Figure 2 is known that the average value decrease misconceptions students on concept of heat transfer in amount of 32%. Reduction misconceptions can be calculated by the formula:

\[ P = S_0 - S_t \]

Description:
- \( P \) = Decreased misconceptions students (%)
- \( S_0 \) = The number of students who have misconceptions on the pre-test (%)
- \( S_t \) = The number of students who have misconceptions on the post-test (%)

Students are given conceptual change after remediation with Microscopic Virtual Media (MVM) can be analyzed using McNemar Test. McNemar Test calculations showed that there significant conceptual change after being given remediation using MVM. With an average value \( X^2_{\text{count}} \) (4.17) is greater than \( X^2_{\text{table}} \) (3.84) of \( \alpha = 5\% \). This shows that students' conceptual changes in significant heat transfer between before and after remediation with MVM.

Based on the results of pre-test and post-test, we get the result of conception that obtained by students before and after remediation using MVM on the concept of heat transfer. The concept of displacement Heat consists of seven concepts, namely conduction, conductors, insulators, convection, radiation, heat-absorbing color is good and less good, as well as the workings of a thermos. On The concept, almost all the students still have misconceptions. For conduction concept, many students assume that conduction is heat transfer is accompanied by displacement of constituent particles. This statement contrary to the conception of scientists who claimed that conduction a heat transfer without transfer of the constituent particles.

In this study, it also known that some students cannot differentiate the concept of heat transfer. Many of them confused about concept between conduction and convection. For the concept of radiation, some students have selected the correct answer choice but students cannot provide the right reasons. Students simply rewrite the answer choice about that.

Based on the results of the study, the percentage of misconceptions students during pretest by 80%. This indicates that the student's mastery heat transfer is relatively low, so misconception is high. Having given remediation using MVM, the percentage of student’s misconception changed to 65%. This concept showed that misconceptions experienced by students decreased of 32%. The decrease is due at the time of learning to use MVM, students can find out a conception that corresponds to the conception of scientists. Students are need visualization about concept of heat transfer. With visualization, each student can develop thinking ability to understand the material displacement heat.

![Figure 2. Decrease of student misconceptions can be presented](image.png)
6. Summary
Based on the results of research and discussion, show that the students who learned with virtual media exhibited significantly higher scores. Our findings strongly support that MVM used as an alternative instructional tool, in order to help students confront their scientific conception construct and develop functional understanding of physics.

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