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Discovery Learning Assisted E-Learning to Improve Student Conceptual Understanding About Heat and Its Application

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Abstract

Synchronizing the concepts of heat and heat transfer explicitly on the competency of expertise in vocational schools still needs further research. This research focuses on the impact of discovery learning assisted by e-learning in improving student understanding about the concept of heat, its transfer, and its application. Through the one-group, pre-test – post-test design with 36 subjects of computer and network engineering students, Al Munawwariyyah Vocational School, this research was applied. The results showed an increase in conceptual understanding with n-gain values of 0.79 (high) and a d-effect size of 3.01 (very high). This value indicates that discovery learning assisted by e-learning has a positive impact on increasing students' conceptual understanding from an average pre-test of 39.9 to an average post-test of 84.1. Students' skills in troubleshooting the Central Processing Unit (CPU) problems increase significantly after learning. Most students can explain the heat transfer by conduction, convection, and radiation that occurs on the CPU along with the impact and benefits of competency expertise.

Keywords: Discovery learning, E-Learning, Conceptual Understanding, Heat and Transfer

Introduction

The rapid development of technology has brought various changes in various sectors, including the education sector. The monotonous teaching model with the lecture system is no longer in its era to be applied. There has been a massive shift from teacher-centred learning patterns to student-centred as the main characteristic. This is evidenced by the increasingly widespread, applications supporting the assessment of learning in the classroom and outside the classroom, such as Quizizz (Nanda et al., 2018), Kahoot (Rafnis, 2018), Plickers (Yulanda & Zafri, 2019), and other applications. In addition to assessment-based supporting applications, there is also Learning Management System (LMS) application such as Moodle (Mustofa, 2019) and virtual home learning classes (Waskita, 2019) owned by Centre for Data and Information (Pusdatin), Ministry of Education, Culture, Research, and Technology of Indonesia.

Various developments in education-based applications have brought significant changes in improving the quality of learning. This nuance gave rise to various learning innovations that were quite diverse. Some of them involve interactive multimedia such as PhET and interactive PowerPoints (Mustofa, 2016; Mustofa, 2018), online-based assessment, to distance learning such as MOCC (massive open online course) (Ismail et al., 2018) as applied in developed countries.

On the other hand, vocational education has greater challenges than just integrating learning with information technology. This is because vocational education at the secondary level has competency standards for graduates (SKL) that are different from secondary education in general. In accordance with Ministerial of Education and Culture regulation No. 34 Year 2018 (Permendikbud No. 34/2018), the purpose of this level of education is to master science and technology and have productive abilities according to their competency. This means students need to be facilitated to not only understand globalization and its changes, but also the concepts of knowledge that link and match with the competencies of their expertise. Hopefully after they graduate, they can be filtered into the world of work in accordance with their competence.

Physics as the basic subject in the field of competence has an irreplaceable role in supporting the achievement of competencies in engineering majors to balance theory and practice. Computer and network engineering majors are closely related to physics. This is in accordance with National Work Competence Standard (SKKNI 2016-285, Ministry of Manpower, 2016) which states that one of the competencies that must be mastered by graduates of this department is the ability to check CPU processor coolers. This expertise is not only related to practice but more specifically explained that students must understand the various processes that support the cooling system. In physics, related studies are explained in the concept of heat and transfer. Collaboration between basic computer science and physics is necessary. According to Santoso (2015), the procedure of installing a cooling fan in a precise position is very important, because it is closely related to efforts to maintain a stable processor temperature by flowing heat through the system.

Exposing the importance of heat material and its transfer does not seem to be followed by a good understanding of the concept of heat in general. This is consistent with reports from various journals stating that most students experience misconceptions in explaining the concept of heat and its transfer (Kartal et al., 2011; Alwan, 2011; Soeharto et al., 2019). Misconceptions like this should not happen especially to students, because the wrong concept will have fatal consequences in the practice of their expertise.

Based on these problems, a related solution is necessary. Surely the solution taken must be nuanced learning according to the era, that is based on information technology and the cultivation of appropriate concepts that can be collaborated with expertise. One learning that can facilitate these needs is discovery learning. Discovery learning is a learning model that emphasizes the discovery of basic concepts (Wenning, 2011). E-learning is an internet-based or intranet vehicle that is useful for facilitating more interactive learning (El-Seoud et al., 2014).

Based on the explanation of these advantages, this research focuses on the application of discovery learning assisted by e-learning. The aim is to find out how far the effect of discovery learning assisted by e-learning can improve the understanding of the concept of heat, its transfer, and its application in the field of computer engineering in physics subject.

Methods: Research Design

This study used pre-experimental research. It applied a one-group pre-test – post-test design (Gall et al., 2003). The subjects of the study were 36 students of class X Computer and Network Engineering (TKJ) Academic Year 2018/2019, Al Munawwariyyah Vocational School, Bululawang, Malang Regency.

In accordance with the research plan, this study consisted of two stages, namely learning design and learning implementation. The learning design focused on analysing the material needs of students majoring in computer and network engineering as well as the preparation of e-learning media as a support for discovery learning. Material

requirements analysis was adjusted to SKKNI published by the Indonesian Manpower Office and Physics Curriculum for Vocational Computer and Network Engineering. Specifically, this research focuses on the heat and transfer material which is useful in understanding the processor cooling system and heat flow inside the CPU which is very beneficial for increasing student skills.

The preparation of e-learning media as a discovery learning platform was prepared by the teacher independently. This media was developed from Moodle managed by a LAN network (only accessible in a school environment). This was adjusted to the conditions and school rules in the boarding school environment but still facilitates learning based on controlled information technology.

The next activity was making Lesson Plan according to KI 3 and KI 4. The lesson plan was developed with discovery learning models assisted by e-learning media. Practice-based learning activities were carried out in the classroom and the Computer Disassembly Laboratory (CDL), while discussion activities, questions and answers, and materials were integrated with e-learning in the classroom that can be accessed only in the school environment. Through these e-learning activities such as assessment of learning (formative), discussion forums, questions and answers, and data sharing can be done freely and controlled.

After the planning was complete, the results of the design were implemented in learning. This stage consisted of three parts, namely pre-test (initial understanding test), implementation of the learning plan, and post-test (final understanding test). Pre-test and post-test questions were used to measure the understanding of the concept of heat and its transfer. Pre-test and post-test instruments consisted of 14 multiple-choice questions. The instrument was validated by 61 students who had studied the material temperature and heat. The results stated that the instrument is valid and reliable with a reliability coefficient of 0.79 which is included in the reliable category. This means that the instrument on the understanding of concepts is ready to be used to measure validly and consistently.

Data analysis related to the implementation of the design was carried out quantitatively and qualitatively. Pre-test and post-test results were quantitative data and analysed using descriptive statistical tests and followed by paired t-tests to find out whether there are differences between the students' understanding of concepts before and after treatment. Furthermore, further analysis using the average N-gain and effect size were carried out to find out how much it affects to students' understanding toward the concepts. Qualitative analysis was carried out using observation and documentation techniques to reinforce the results of the quantitative analysis conducted primarily concerning students' skills in applying the concept of heat and its transfer in the computer field. Through observation also, students' difficulties related to the concept of heat and transfer can be resolved during learning process. It can be explored more to support quantitative data obtained from the results of the post-test.

Findings and Discussion

Increased Understanding of the Concept of Heat and Transfer

The results of the pre-test and post-test had done in descriptive statistical analysis. The results of the analysis are presented in Table 1. It shows that the average post-test (84.1) is higher than the pre-test value (39.9). Based on the skewness value of the two groups of data, the values are between -1 and 1, meaning that the data are normally distributed so that the different tests can be performed using parametric analysis (Morgan et al., 2004). Through the paired-sample t-test, a significance value of p = 0,000 was obtained. These results indicate that there are significant differences between the post-test and the pre-test significantly. Calculation of the average n-gain obtained 0.79 which included in the medium-high

category (Hake, 1998; Mustofa & Asmichatin, 2018). This means that discovery learning assisted by e-learning can significantly improve students' understanding of the concepts in heat material and its transfer and application. Effect size calculation results obtained valued d= 3.01 in the category of very high. This means that discovery learning assisted by e-learning has a very positive effect on the understanding of the concept of heat and its transfer to computer and network engineering students.

Aspect	Pre-test	Post-test
N	36	36
Average	39,9	84,1
Minimum	7,1	42,8
Maximum	71,4	100
Std. Dev	14,18	15,19
Skewness	-0,135	-0,844

Table 1. The Result of Statistic Descriptive Analysis

Improving students' understanding of concepts causes students to be actively involved. They are invited to find out the concept of a phenomenon or problem that they encounter. They were also invited to find problems, predict signs of problems, and find solutions based on these signs. According to Jean Piaget's theory of cognitive development, learning that facilitates students to find concepts independently can trigger the development of their schemata. Triggering the development of this schemata can produce a new balance that is more mature so that the concepts possessed are stronger (Slavin, 2006). The results of this study support several studies stating that discovery learning assisted by e-learning can improve students' understanding of concepts. Mustofa (2019) found that discovery learning that is integrated with e-learning media can improve students' understanding of concepts in solution concentration and its application material. Through this learning as well, the ability of students' scientific literacy increases so that the quality of concepts mastered by students becomes like the experts.

Students' Skills in Applying the Concept of Heat and Its Transfer in Computer Science

Students' skills in applying this concept can be accessed during learning and after learning process ends. At the practical session on the material of heat and its transfer, each group of students was asked to disassemble the computer and analyse the CPU cooling system. Besides, students were asked to test the effect of pasta processors with different prices on the ability to transfer heat to maintain a stable processor temperature when working in both standby and heavy work conditions such as rendering videos and playing games.

Student activities while in the laboratory could be seen in Figure 1. Students per group were given one computer and a set of assembled and disassembled computers to clean the inside of the CPU. After finishing cleaning and observing the CPU cooling system, then students were asked to reassemble. After testing, it turns out there was one group reporting that the computer suddenly shut down when turned on. Learning heat transfer begins with giving problems in the scope of the computer that is when the initial button on the CPU is turned on suddenly the computer off by itself. Armed with troubleshooting material, some students gave responses, ranging from problematic power supplies, hard drives that

did not fit into their positions, hot processors, applications that did not support, resulting in the death of the computer itself.

The teacher did not answer directly to the problems. Then the teacher instructed students to disassemble the CPU again and looked for the cause of the problem. They found that the cooling fan did not turn on and the heatsink was not tight, resulting in the processor became hot.

Figure 1. Practical Disassemble CPU

The findings of existing problems were reported in front of the class. The results are emphasized by the group of students experiencing problems and explained various causes. After the discussion in class, it was concluded that one of the causes was the shutdown of the cooling system. Therefore, all students understand the science of troubleshooting a problem related to computers. Not quite so, the teacher continues to invite students to test the ability of a cheap and expensive pasta processor. They were asked to test the difference between the quality of the two ingredients in transferring heat from the processor to the heatsink to keep the processor temperature stable. One of the students' activities in the second practicum was shown in Figure 1 (left). The result is that the quality of the expensive pasta processor has a better heat transfer capability in maintaining processor temperature both during standby, normal use, and heavy use such as when playing games or rendering the video.

After learning is finished, the teacher provided a post-test. Based on the results of the post-test, most students can answer the questions related to heat and transfer applied to the computer.


Perhatikan gambar sirkulasi udara dalam CPU berikut ini

Berdasarkan konsep aliran udara tersebut, panas akan berpindah secara … yang dipengaruhi beberapa factor antara lain suhu di luar CPU. Apabila suhu di luar CPU lebih dingin (Ruangan Ber-AC) maka, suhu CPU akan cenderung … sehingga kondisi CPU relative lebih stabil.

A. Konduksi, rendah
B. Konduksi, tinggi
C. Konveksi, rendah
D. Konveksi, tinggi
E. Radiasi, tinggi.

Figure 2. Problem to access the concept of heat transfer

The problem to access student understanding related to heat transfer that occurs on the computer is presented in Figure 2. Based on the results of students' answers at the post-test, it was found that there were 28 students out of 36 students (77.8%) able to answer correctly. This means that most students understand correctly that the concept of heat flow is heat transfer by convection from the system to the environment. This understanding indirectly influences the mindset of students related to the system and environment in explaining the concept of energy flow as discussed by Mustofa & Asmichatin (2018). While other factors that can affect CPU performance are room or place factors. With this kind of understanding, students are expected to have an idea of how to prepare for computer installation while working in the future.

Questions to access how the concept of heat and transfer can support the competency abilities of their expertise are presented in Figure 3. Through these problems, students were asked to analyse various problems. This is closely related to the science of troubleshooting that is practically learned in competency subjects. Based on the results of

the post-test, it was found that there were 32 out of 36 students who answered correctly. Based on the results of a hypothetical analysis such as done by Mustofa (2018) when making a choice shows that a large number of students are already able to master the concept of heat applied in the computer field with the following explanation: (1) they do not choose option (A), meaning they assume that if the thermal paste is dry, the ability to conduct heat conduction from the processor to the heatsink is not optimal, so the processor temperature tends to be less stable or hot; (2) They do not answer option B, which means that practically they understand the concept of convection heat flow on the CPU so that the temperature inside the CPU remains stable; (3) They do not choose options C and D, which means they have two abilities, namely first understanding that the installation must be thorough, and secondly, they understand that the air cavity is not a good conductor for rapid transfer of heat from the processor to the heatsink.

Salah satu permasalahan yang ada pada perangkat computer adalah computer off sendiri secara langsung saat pertama kali dinyalakan atau tiba-tiba computer melakukan restart. Menurut ilmu troubleshooting permasalahan yang terjadi adalah sebagai berikut … (kecuali)
A. Pasta thermal kering
B. Kipas angin dibagian depan computer yang mengalirkan udara dingin mati
C. Pengunci heatsink kurang rapat, sehingga rongga antara heatsink dan processor tidak tertutup
D. Kipas diatas processor dan dibagian luar mati
E. Design casing CPU yang digunakan terlalu banyak celah

Figure 3. Problem to access the synchronization of physics and science troubleshooting

Conclusions and Sugestions

Based on the discussion, it can be concluded that discovery learning assisted by e-learning can improve the understanding of the concept of heat and its transfer. Through this learning, the improvement of students' conceptual understanding is obtained high, with an n-gain of 0.79 and a d-effect size of 3.09 which shows that learning has a very positive effect on students' conceptual understanding. Through this learning as well, students' skills in troubleshooting computer problems related to the concept of heat and transfer increase. Most students can explain in detail the effects and benefits of heat transfer by conduction, convection, and radiation that occur on the CPU that supports the competence of their expertise. The success of discovery learning assisted by e-learning can be an option for further research with different materials.

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