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EFFECTIVENESS OF SCIENCE LEARNING ON NERVOUS SYSTEM MATERIAL USING INTERNET OF THINGS (IOT)-BASED VIRTUAL LABORATORY

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Abstract: This study aims to examine the effectiveness of an Internet of Things (IoT)-based virtual science laboratory on nervous system material in science lectures. The method used in this study was an experiment with the research subjects of A3 and A4 class students who were randomly selected in the Universitas PGRI Yogyakarta PGSD study program taking Science courses. Data collection was carried out by giving a pre-test and post-test and measuring n-gain to determine the increase in concept understanding after using a virtual science laboratory. Data analysis was carried out using the t-test to test the significant difference between the pre-test and post-test results, as well as the n-gain test to measure the effectiveness of virtual science laboratories in improving student concept understanding. The results showed that the IoT-based virtual science laboratory was effective in improving students' concept understanding with an n-gain of 0.7, which indicates a moderate to high increase in concept understanding. In addition, the t-test results showed a significant difference between the pre-test and post-test results. This research is expected to contribute to the development of educational technology that can improve the quality of learning and provide empirical evidence regarding the effectiveness of IoT-based virtual science laboratories.

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Introduction

Research on learning using IOT-based virtual science laboratories on nervous system material is related to the importance of developing more innovative and effective learning methods in improving student understanding of the material taught. In addition, in the context of the COVID-19 pandemic, online learning or distance learning through internet media is the main

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choice to minimize the risk of spreading the virus (Aurelia, 2021; Prabandari & Sumarni, 2020). The utilization of Internet of Things (IoT) technology in virtual science laboratories is expected to be an effective alternative in distance learning (Handayani & Alfina, 2021; Prihatmoko, 2016). The IoT-based virtual science laboratory allows students to conduct experiments and observations with the help of technology so that they can gain a better understanding of the concepts taught. (Pongoh & Budiman, 2022; Ramadiani, Silvianti, Putra, & Agustina, 2022).

Several recent studies have demonstrated the advantages of learning using IoT-based virtual science laboratories. Research (Leisenberg & Stoponat, 2019) developed an IoT demonstrator for distance learning purposes based on well-known specialized filter and classification algorithms and a practically available open cloud platform. In addition, research (Cîmpanu, Lupu, & Ungureanu, 2019) consider the software and hardware deployment criteria of a virtual laboratory used for educational purposes. In 2020 there was also research (Benesha, Lee, James, & White, 2020) which engineered a virtual lab for sports science using wearables and IoT, demonstrating the design and construction of experiments, along with prototyping software solutions that can all be operated remotely using a web-based client. The last research is (ABEKIRI et al., 2023) who developed a low-cost platform called LABERSIME that is installed in the cloud (LMS, IDE) and equipped with embedded systems to drive real laboratory equipment and conduct experiments qualitatively more efficiently compared to the face-to-face mode. In this context, research on learning using IoT-based virtual science laboratories, especially on nervous system material is very important to be developed and implemented.

In education, advances in new technologies, the rise of artificial intelligence, and IoT have transformed the learning environment from traditional-based learning to digital-based learning (Alhazmi, Kaed, Al-Hammadi, Alsakkaf, & Al-Hammadi, 2023). By utilizing IoT technology in virtual science laboratories, it is expected that students can more easily understand the concepts taught and gain better practical experience. In addition, learning using IoT-based virtual science laboratories can also help teachers in developing more effective and efficient learning methods in the digital era. Science learning is important in education because it provides a deeper understanding of science concepts.

A science laboratory is a place where students can learn and experiment directly with science concepts, thus improving their understanding of the subject matter. However, not all schools or universities have adequate and complete science laboratories to support learning. In addition, the COVID-19 pandemic has disrupted teaching and learning activities and forced many educational institutions to shift to distance learning. In this case, a virtual science laboratory based on the Internet of Things (IoT) is one alternative to help students understand science concepts without having to come to a physical laboratory. The IoT-based virtual science laboratory utilizes Internet of Things (IoT) technology that allows laboratory equipment to be connected to the Internet and can be accessed by students remotely through an online platform. Students can conduct experiments and observations through videos, images, and data provided by the virtual science laboratory.

The utilization of this technology can provide a more interactive and enjoyable learning experience for students, while providing convenience and efficiency in learning. Many studies have been conducted to evaluate the effectiveness of IoT-based virtual science laboratories in

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science learning, including on nervous system material. One of the studies conducted (Ilyas, Liu, & Sara, 2022) showed that the virtual laboratory based on science process skills integrated with zoom meetings was effective in improving students' concept understanding. In addition, other research conducted by (Gaffar & Sugandi, 2019) stated that the virtual laboratory in the experimental class was more effective than the conventional practicum in the classroom so that the application of virtual practicum learning devices could improve the science process skills of high school students on invertebrate material.

This is supported by the survey results which show that most students feel more motivated and have greater interest in learning through virtual science laboratories. (Alatas & Fachrunisa, 2019; Bahtiar & Azmar, 2022; Bortnik, Stozhko, Pervukhina, Tchernysheva, & Belysheva, 2017; Hadi & Hermansyah, 2021; Raini, 2020; Rusliati & Retnowati, 2019; Susdarwati, Agnafia, & Dimas, 2021; Trisnawati & Yetri, 2019). However, it should be noted that the effectiveness of IoT-based virtual science labs in science learning is still a matter of debate among academics. Some studies show positive results, while others show less significant results. For example, research conducted by (Sarah, 2018) showed that there was no significant difference in investigation ability and chemistry learning achievement between students who participated in virtual lab-based practicum activities and students who participated in real lab-based practicum activities. Therefore, this study will analyze the effectiveness of Science Learning of Nervous System Material Using a Virtual Laboratory Based on the Internet of Things (IoT).

Method

This study aims to evaluate the effectiveness of an IoT-based virtual science laboratory on nervous system material. The research method design used was an experiment with a pretest-posttest control group design. The research subjects were A3 and A4 class students in the Universitas PGRI Yogyakarta PGSD study program who were randomly selected from students taking Science courses. The research subjects will be divided into two groups, namely the experimental group and the control group. The experimental group will use an IoT-based virtual science laboratory on nervous system material, while the control group will use conventional learning methods without using an IoT-based virtual science laboratory. Before the implementation of the treatment, a pretest will be conducted on both groups to measure students' understanding of the nervous system material. After that, the experimental group will be given treatment in the form of learning using an IoT-based virtual science laboratory on nervous system material for four weeks, while the control group will be given treatment in the form of conventional learning using textbooks and blackboards. After the learning period is complete, a posttest will be conducted on both groups to measure students' understanding of the nervous system material after the treatment. In addition, a questionnaire will also be conducted to measure student satisfaction with the use of an IoT-based virtual science laboratory on nervous system material. The data obtained will be analyzed using descriptive and inferential statistical analysis. Descriptive analysis is used to describe sample characteristics and questionnaire results, while inferential analysis is used to test differences in student understanding between the experimental group and the control group using an independent t-test. In addition, correlation analysis will also be conducted to determine the relationship between student satisfaction with the use of IoT-based virtual science

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laboratories and student understanding of nervous system material. In this study, ethical and security aspects will also be considered in the use of IoT-based virtual science laboratories, such as the use of student personal data and internet network security.

Results and Discussion

Internet of Things (IoT)-based virtual science laboratory on nervous system material is an educational technology innovation that utilizes the internet and IoT devices to provide a more interactive and effective learning experience for students. This virtual science laboratory can be accessed through the internet network and allows students to conduct experiments and simulations about the nervous system virtually. In this IoT-based virtual science laboratory, there are IoT devices connected to the internet and integrated with the learning system. These devices can provide accurate and real-time information and data to students when conducting experiments and simulations in the virtual science laboratory. In learning about the nervous system, the IoT-based virtual science laboratory can show visualizations of the nervous system and allow students to learn how the nervous system works in the human body. In addition, this virtual science laboratory can also provide simulations of how the nervous system responds to stimuli from the external environment and how these stimuli are interpreted by the nervous system. The IoT-based virtual science laboratory on nervous system material has several advantages. First, students can access the virtual science laboratory from anywhere and anytime, thus facilitating the learning process. Second, this virtual science laboratory can provide a more interactive learning experience and improve students' concept understanding. Third, this virtual science laboratory can reduce the cost and time to conduct experiments in a physical laboratory. An overview of the IoT-based science laboratory design on nervous system material can be seen in Figure 1.

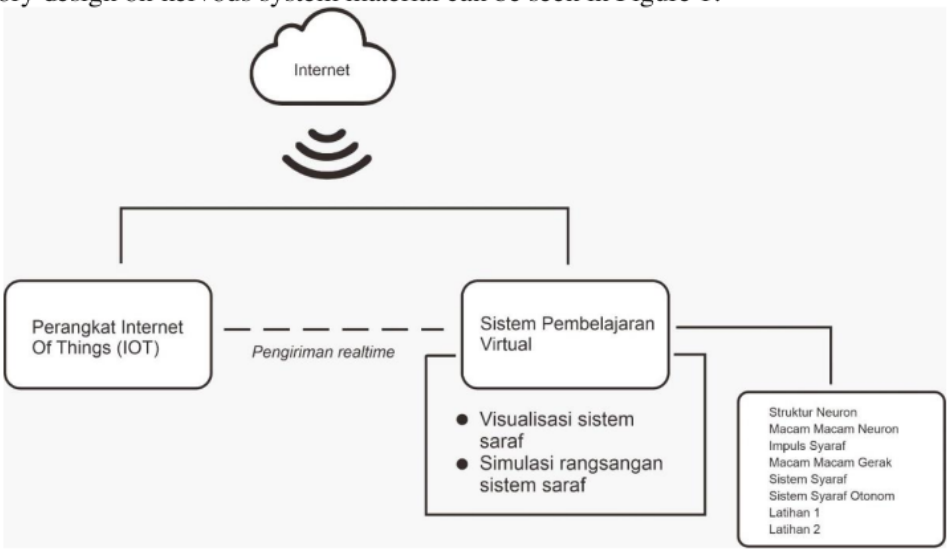

Figure 1: IoT-Based Science Laboratory Design on Nervous System Materials

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As for the laboratory display on the device (laptop, PC and cellphone) can be seen in Figures 2, 3, and 4 as follows.

Figure 2. Initial view

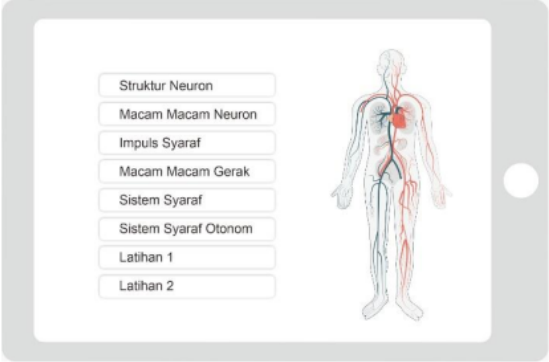

Figure 3. Material Page

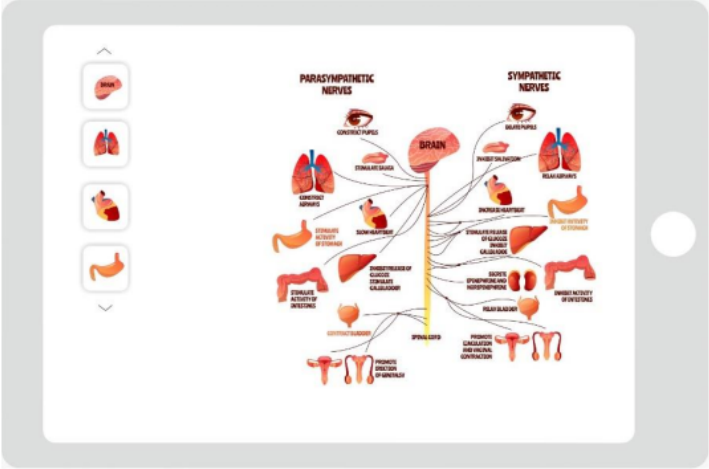

Figure 4. Practicum page

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According to Figures 2, 3 and 4, it is known that by using an IoT-based virtual science laboratory on nervous system material, it is expected to increase student interest and motivation in learning and improve student understanding and mastery of concepts on nervous system material. Internet of Things (IoT)-based virtual science laboratory on nervous system material is an interesting concept in the development of educational technology. The results showed that the IoT-based virtual science laboratory on nervous system material was effective in improving student learning outcomes, as evidenced by the higher average post-test score compared to the average pre-test score. In addition, this study also shows that the IoT-based virtual science laboratory can help students understand the material better and increase their interest in learning.

The results of the t-test research data analysis showed that there was a significant difference between the pretest and posttest results in the group using the IOT-based virtual science laboratory on nervous system material (significance value <0.05). This shows that the use of IOT-based virtual science laboratories in nervous system material can improve student understanding of the material. In addition, the n gain results show that the use of IOT-based virtual science laboratories on nervous system material provides a high increase in student understanding. The average increase in n gain in the group using the IOT-based virtual science laboratory was 0.8, which showed a significant increase in understanding. In terms of student responses to learning using an IOT-based virtual science laboratory on nervous system material, the majority of students gave a positive response to the use of the virtual science laboratory. Students find it easier to understand the concepts in the nervous system material through the use of virtual science laboratories, and feel more interested and motivated to learn.

Learning using an IOT-based virtual science laboratory on nervous system material has several advantages over conventional learning conducted in a physical laboratory. Some of these advantages include the ability to conduct difficult or dangerous experiments virtually without safety risks and high costs, the use of technology that appeals to students, and greater flexibility of time and place. The use of virtual technology in learning has been shown to increase students' motivation and interest in learning science. (Gaol, 2015; Hadi & Hermansyah, 2021; Suarja & Aswadi, 2016; Yuniarti, Dewi, & Susanti, 2012). In addition, virtual science laboratories can provide a more fun and engaging learning experience, which can increase student participation and improve learning outcomes. In the context of learning about the nervous system, IOT-based virtual science laboratories can provide a more immersive experience and help students better understand the concept of the nervous system. Students can learn about different parts of the nervous system and observe the interactions between them virtually, which can improve their understanding of complex concepts.

Research on learning using IoT-based virtual science laboratories on nervous system material is a topic that continues to grow and attract attention in the field of science education. The position of this research lies in the effort to improve the effectiveness of science learning through the use of evolving technologies, namely the Internet of Things (IoT) and virtual science laboratories. In several previous studies, it has been proven that the use of technology in science learning can improve students' understanding and their engagement in learning. One of the advantages of learning using an IoT-based virtual science laboratory on nervous system material is the ability to combine theoretical concepts with practical experiences that are directly involved

through interactive simulations. In addition, the virtual science laboratory also allows students to conduct experiments that are not possible in a physical laboratory, such as visualizing how neural signals work in real-time through interactive simulations.

In this study, students were tested with several case studies that required problem solving and critical thinking about the concept of the nervous system, and the results showed that students who used the IoT-based virtual science laboratory had better abilities than students who used the physical laboratory. Thus, the position of research on learning using IoT-based virtual science laboratories on nervous system material is as an effort to increase the effectiveness of science learning through the use of technology that continues to grow, as well as overcome the limitations that may exist in physical laboratories. This research provides an alternative solution that can enrich students' learning experience and increase their involvement in science learning.

Research on learning using IOT-based virtual science laboratories on nervous system material has several differences with previous similar studies. Previously, several similar studies were conducted using simulation or animation-based learning methods, but in this study, a virtual laboratory-based learning method with Internet of Things (IOT) technology was used. This research also emphasizes the use of IOT technology as a support for virtual laboratory learning, which allows students to conduct experiments independently and respond to data in real-time. This is different from previous studies that only rely on simulations or animations that tend to be more static and less interactive. In addition, this research also pays attention to the factor of student involvement in learning, by integrating game features and competition elements in learning. This can increase students' motivation and encourage them to be more active in learning. Thus, research on learning using IOT-based virtual science laboratories on nervous system material has advantages in the use of technology that is more interactive, real-time, and able to increase student involvement in learning. These differences can be used as a basis for developing more effective and innovative learning approaches in the future.

Conclusion

Berdasarkan hasil penelitian, dapat disimpulkan bahwa laboratorium sains virtual berbasis Internet of Things (IoT) pada materi sistem syaraf efektif dalam meningkatkan pemahaman konsep mahasiswa. Hal ini terlihat dari hasil n-gain rata-rata sebesar 0,70 pada kelompok eksperimen yang menunjukkan peningkatan pemahaman konsep yang sedang hingga tinggi. Hasil uji-t menunjukkan perbedaan signifikan antara kelompok kontrol dan eksperimen dalam hal efektivitas laboratorium sains virtual berbasis IoT pada materi sistem syaraf. Oleh karena itu, dapat disimpulkan bahwa laboratorium sains virtual berbasis IoT merupakan alternatif yang baik dalam pembelajaran materi sistem syaraf karena dapat meningkatkan pemahaman konsep mahasiswa dengan baik. Penelitian ini diharapkan dapat memberikan kontribusi dalam pengembangan teknologi pendidikan yang dapat meningkatkan kualitas pembelajaran.

Recommendation

The research is limited to the use of IOT-based virtual science laboratories on nervous system material. Virtual laboratory-based learning with Internet of Things (IOT) technology can be further developed in other science materials to conduct science experiments or the like that

contain high hazards so that students can conduct experiments independently and respond to real-time data in cyberspace.

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