Utilizing LoRa for IoT based mini weather station as STEM learning media to support industrial revolution 4.0

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Abstract. In a process of learning, learning media play an important role in improving students’ understanding. In this study, a learning medium based on Internet of Thing (IoT) was developed. The IoT is one of core development in technology of Industrial Revolution 4.0 era. The learning media developed in this research study utilizing LoRa (Long Range Area) which functions as a remote data sender. The LoRa paired with Arduino connected to sensors and placed in several location within Banda Aceh. LoRa was integrated with Network Thing to store data and could be displayed on the PC. The researchers and students could observe the changes in air quality in relation to the changes in temperature, humidity, and air pressure from the data that have been stored in the Network Thing cloud. The students are motivated in the learning process to find out relationships between air quality and changes to the temperature, humidity, and air pressure. This is preliminary and ongoing research. The early data were collected from interviews with students after the learning process and collecting the results of the observation. Students’ interest increases with the integration of Science Technology Engineering and Mathematics (STEM) in the learning process. This was demonstrated by students during the learning process. From this learning process, students are also aware of the importance of reducing air pollution. Around 86% of students understand the concepts of subject learned and around 92% of students were motivated and enjoy during the learning.

Keywords: Learning Media, LoRa, Internet of Things, STEM, Industrial Revolution 4.0.

1. Introduction

Physics is one of the study subjects that studies natural phenomena. We often ignore physics in life, the natural phenomena which often observed in our life is an applicative form of physics knowledge. Necessarily, Physics is the subject which makes student happy, because it is very closely related to phenomena in our lives, for example, the global warming, the relation of wind direction with temperature, pressure, and light but in reality, many students will remember the Physics contains a lot of Equations so that physics is a “scourge” or a scary and unpopular subject in school. Therefore, the average ability of Indonesian students in the field of science is low. This is based on a recent study conducted by TIMSS (Trend in International Mathematics and Science Study). Because of this, many
of the methods, approaches, and learning media were developed to improve the ability of the average students in physics or science. One approach is to integrate STEM (Science, Technology, Engineering, Mathematics) in the learning process.

Sunyoung Han researched the relationship of STEM with PBL (Project Based Learning) and students’ achievement. The results showed in the increase of student achievement by using the STEM approach to PBL[1]. Similar work was done by Widya Nessa, the results of her research showed that the book products were based on the STEM PBL approach (Project Based Learning) which could increase the percentage of students passing against the KKM (minimum score to pass). But both researchers above did not apply the use of technology in their research[2]. Even more, in this era, the technology is very close to our daily lives, very few secondary students who do not understand the technology, thus according to the author, the integration of technology in learning can increase students’ interest in studying physics or science and will also improve student achievement. The technology used in this research is LoRa (Long Range Area), integrated with Arduino, Sensor, and GIS application.

1.1. Internet of Things

The Industrial Revolution 4.0 was marked by rapid technological developments, starting from computers and mobile phones that are increasingly smaller and more efficient, and electronic equipment that uses internet networks. There are so many sensors that are used to get information 24 hours a day. With the rapid growth of this technology, it needs to be integrated into the learning process, students in schools were introduced with these technologies to facilitate and motivate students in the learning process. STEM is an approach that integrates technology in the learning process. In this case, the researchers designed IoT (Internet of Thing) technology using LoRa (Long Range Area), Arduino and several sensors to understand global warming events for high school topic. Tools were prepared to function as mini weather stations that detected temperature, air quality, pressure, and humidity. The design of this technology aims to motivate students to learn science, particularly Physics and making Physics more fun to learn. In addition, it can encourage students to participate in the protection of the environment around them from pollution.

IoT (Internet of Things) is the interaction activity performed by utilizing the internet [3, 4]. In its use, the IoT has many daily life applications, especially in the current digital era such as for managing transportation online and e-learning. All of these applications become easy with online services, live streaming, and others applications. Even some tools such as a GPS Tracking using network and Internet as media for it to run as illustrated in figure 1 below. Therefore, the IoT can also be used as a learning media in the process of learning.

The figure below explains how the IoT can be used in daily life for example at home or at the workplace in the industries.

![Figure 1. Internet of Things. [5]](image-url)
1.2. LoRa (Long Range Area)
LoRa (Long Range Area) is a communication system or remote IoT technology (over 15 km), LoRa uses little power and offers the security of data transfer [6]. In this case Lora used as a remote communication system for sending data read by sensors that air quality sensors, humidity, temperature, and pressure. LoRa is coupled with Arduino and sensors, then visualized on a PC.

The GIS (Geographic Information System) is a specialized information system that manages the spatially referenced data or can be said to be a system that can manage, store and display geographic information in the form. In this case, the information about the level of pollution in Banda Aceh will be presented in the form of a spatial reference.

The technology is applied in the learning process and becomes part of the STEM-based learning media facilities. Mathematical and graphical data to be displayed on the PC and students will conclude these data. Pike research written in the book Active Learning works of Melvin L. Silberman, by adding the visual media in the learning process, will improve memory of 14% to 23%[7]. The use of STEM approach that include the use of modern technology devices in learning plays an important role in improving memory and comprehension of students.

2. Method
This research is preliminary and ongoing research. The preliminary research is intended to produce an effective learning model to improve students critical thinking skills. After conducting preliminary research, full development research will be conducted guided by the results of the preliminary study. This preliminary research is descriptive research and does not test any hypotheses. The main investigation in this preliminary stage is the effectiveness of using LoRa technology based on IoT in the learning process. During the process of the use of technology, students’ activities were observed. After the learning process, students were interviewed and the interviewees would give their opinions whether the learning process was fun and easy to understand. The analysis of the data followed the rules of descriptive qualitative analysis.

2.1. Design of Experiment
The designed experiment started by preparing for the equipment. The equipment was set based on physical variables related to the effects of global warming. In this case the physical variables in the topic of global warmings such as temperature (T), pressure (P), light intensity (I), Heat (Q), CO₂ concentration, the concentration of ozone, and humidity. The physical variables will be measured by using sensors.

Based on its physical variables, the devices used in this experiment were a series of temperature sensors, humidity, pressure, and concentration of CO₂ (air quality) that were connected to an Arduino and integrated with the IoT. As shown in figure 2, the sensor is assembled on the Arduino-based IoT which then connect with LoRa (Long Range Area). LoRa was then connected to LoRaWAN Gateway (Lora-Raspberry Pi 3 B+-WAN). The data were read by Raspberry Pi 3 B+ that connected to the internet to read and visualized the data by the help of Network Thing (as shown in the Figure 2) The displayed information then was analyzed by using a PC, thus students could see the outputs provided by the device on the computer monitor, hence the students can learn easily and attractively.
Figure 2. Equipment Design

The devices were tested at a number of high schools in Banda Aceh. During experiments at school, the researchers observed responses of the students during and after the learning process. The researcher then analyzed the responses of students during the learning process by using the IoT which has been designed from observations by the observers. After the experiments, questionnaires, and interviews were conducted to gather the students’ opinions on their learning experience while using LoRa and IoT.

Figure 3. Research Diagram
Figure 3 above illustrates to us about the flow of research in a diagram. The Blueprint Network design was carried out first to produce learning media hardware, starting from the interfacing of the Arduino Nanosensor and LoRa Connectivity then connected to the LoRa Gateway. The LoRa Gateway is replaced with the LoRa-Raspberry Pi 3 B+-WAN (LoRaWAN) connectivity that is connected to the internet (WAN) using TP-Link, then it connected to the server for data storage On this occasion, the Network Thing or Gouge Firebase were used as shown at figure 3. After these steps are carried out, then do the test at the school in the learning process.

3. Result and Discussion

Figure 4 and 5 below were the equipment that was designed using LoRa -02 SX1278 433MHz types, Raspberry Pi 3 B+ type, some sensors, such as MQ135 sensor (Air Quality), LM35 sensor (Temperature and Humidity), BMP280 sensor (Pressure),

Figures 4 and 5 respectively Interfacing Arduino Nano and Connectivity LoRa and Connectivity LoRa-Raspberry Pi 3 B+-WAN (LoRaWAN).

![Interfacing Arduino Nano and Connectivity LoRa](image)

After testing the devices in the learning process, all students were interviewed to ask for their opinions of whether they enjoy the learning process Students were also asked questions about their understanding of the concept of Physics that were taught.

From the results of preliminary experiments conducted at SMA Lab School Unsyiah Banda Aceh, researchers were able to gather the data from observations and questionnaires distributed to the students. As preliminary results, we can conclude that the response from the students was positive. The learning process by utilizing LoRa and IoT was fun. Hence, the students were motivated and triggered to ask more questions. Their curiosity was increasing marked by their increasingly critical for asking questions and clarification during the learning process. The learning atmosphere in the class was encouraging. From the data of interviews, 86% of the students were able to understand the concept of physics being taught in the class and 92% of students answered yes to the question about the learning process was fun or not. The students felt motivated in the learning process. With the use of new technology, the learning process becomes more fun. The visualization of the data helps to increase students’ understanding since students could draw their conclusions from the physical relationship of each variable in physics experiments. In this case, the students could clearly see the relationships between temperature, humidity, pressure, and air quality.

The use of IoT technology in the learning process can improve students’ motivation in learning and understanding of the topics in Physics. This is a positive integration in the support of the industrial revolution 4.0.
In addition, we found one limitation of the devices that is the air quality sensor was less accurate and the data returned from the cloud Network Thing can only be opened from a designated username setup into the system thus it has not yet support multiple users if students want to see the data from each student’s mobile phone.

4. Conclusion
The utilization of IoT (Internet of Things) as a mean of STEM (Science, Technology, Engineering, Mathematics) learning media can help students and teachers in the process of learning. The students were motivated and happy in learning Physics concepts using technology. Students were also aware of the importance of protecting the environment from air pollution. IoT technology is an integral part of the industrial revolution 4.0. The design of LORA (Long Range Area) with Arduino and sensors devices was successfully implemented in the learning process. From the result of research, it is found that 86% of students understand the Physics concept being taught and 92% of students were enjoying the learning process utilizing LoRa and IoT.

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