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Integration of Internet of Things (IoT) on Web-based Chemistry Learning

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Abstract

The development of science and technology, especially the development of the internet is very rapid today. The world of education, needs to develop learning innovations involving the internet. Internet of Things is one of the innovative technologies that can connect a device or object into a large data base so as to speed up the information process through the power of the internet network. The application of the Internet of Things in high school chemistry learning, especially in the concentration cell potentiometry method, can be used in practicum in school laboratories. The results showed that the combined method of concentration cell potentiometry integrated with the Internet of Things (Pot-IoT) has been proven effective (n-gain = 0.7208) to be used as a learning medium for the practicum of measuring Pb metal in water samples at school.

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Abstrak (Indonesian)

Perkembangan ilmu pengetahuan dan teknologi khususnya perkembangan internet sangat pesat saat ini. Dunia pendidikan perlu mengembangkan inovasi pembelajaran melibatkan internet. Internet of Things salah satu teknologi inovatif yang dapat menghubungkan suatu perangkat atau objek ke dalam suatu data base besar sehingga dapat mempercepat proses informasi melalui kekuatan jaringan internet. Penerapan Internet of Things dalam pembelajaran kimia SMA khususnya pada metode potensiometri sel konsentrasi dapat digunakan dalam praktikum di laboratorium sekolah. Hasil penelitian menunjukkan bahwa gabungan metode Potensiometri sel konsentrasi terintegrasi Internet of Things (Pot-IoT) telah terbukti efektif (n-gain= 0.7208) digunakan sebagai media pembelajaran untuk praktikum pengukuran logam Pb pada sampel air di sekolah.

Kata Kunci: Internet of Things (IoT), Media Pembelajaran, Potensiometri

INTRODUCTION

Internet of Things (IoT) is an innovative technology that is growing rapidly with various applications, functions, and services so that it can be applied in everyday life [1]. IoT is a combination of a number of technologies such as the internet, sensors, and wireless communication [2]. The Internet of Things (IoT) can connect the physical world with the digital world that allows these devices to be accessed by every user without being hindered by distance and time [3]. The Internet of Things (IoT) can be developed to connect a device or object into an extensive network or large data base so as to speed up the information process through the power of the internet network. The Internet of Things (IoT) is defined as an integrated system that can enable data exchange [4].

The Internet of Things (IoT) has been widely developed and implemented, one of which is the most recognized at this time is the smart home using the Internet of Things [5]. In addition to smart homes, the Internet of Things has also been used in organizing customer management [6]. The industrial field has also utilized the Internet of Things to monitor wastewater treatment plants [7]. The electronic world has also used IoT for the material capabilities and performance of electronic devices [8] and the use of IoT as a temperature sensor on robots [9]. In agriculture, a monitoring system for temperature, humidity, and gas in cowsheds based on IoT technology has been developed [10].

The development of the Internet of Things (IoT) system in the world of education is very necessary, especially in learning chemistry at school. Internet of Things (IoT) can be connected to several devices via the internet network so that learning, especially practicum which is usually done in the laboratory, can be monitored remotely via the internet and practicum data can be calculated, processed, analyzed further so that it is faster and more accurate.

The Pot-IoT method was developed based on a website by utilizing google suite for education features such as google spreadsheets and google doc in a website so that students can work in groups or individually in processing the results of practicum with the potentiometer tool developed more effectively. The purpose of this research is the integration of concentration cell potentiometry method and Internet of Things (Pot-IoT) and its application as a practicum learning media in schools.

MATERIALS AND METHODS

Materials

The tools used in this research are glassware, Hantek 365F multimeter, Windows 10 computer, PHP (Hypertext Preprocessor) and C programming language. The materials used are Pb metal electrode, Demin water, Pb acetate standard solution 10^{-6} M, sample water, and KCl salt bridge. Making the salt bridge was done by dissolving KCl (0.5 M) as much as 3.725 g in 100 mL with demin water. Then the solution was added with agar as much as 2 grams and heated to boiling. After boiling the KCl solution was put into a U pipe and then cooled.

Methods

Potentiometric circuit of Internet of Things (Pot-IoT) integrated concentration cell as shown in **Figure 2**. In the cell circuit, there are two half cells consisting of a half-cell of 10^{-6} M Pb acetate standard solution and the tested water sample. The potentiometric circuit is connected to a Hantek multimeter connected to a laptop and the Pot-IoT website. The internet of Things design on website-based chemistry learning is integrated into a database connected to the user's device so that the measurement data with the potentiometer tool will be accessible on the Pot-IoT website and processed further so that the learning process runs more effectively.

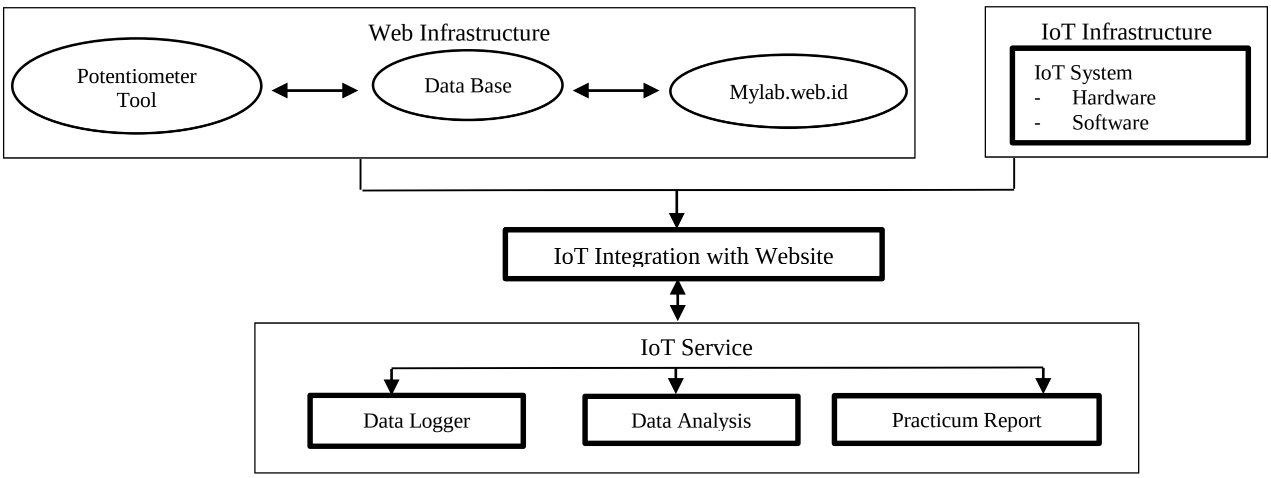

Figure 1. Website-based Internet of Things Design [3]

Figure 2. Potentiometer Circuit

Nernst Equation [11]:

$$E\ cell = E° - \frac{RT}{nF} x \ln \frac{[C_{standard}]}{[C_{sample}]} \quad (1)$$

Description:

E cell : cell potential
E° : standard reduction potential (volt)
R : constant (J. K^{-1}.mol^{-1})
T : temperature (K)
C : concentration (mol. L^{-1})
n : number of moles
F : Faraday constant (96.500 C)

.

Analysis of Student test data (Effectiveness of Web usage) [12].

$$< g > = \frac{<\%S_f> - <\%S_i>}{(100 - <\%S_i>)} \quad (2)$$

Description:

g : average normalized gain score

Sf : final score (*Post-test*)

Si : initial score (*Pre-test*)

100 : maximum score

RESULTS AND DISCUSSION

Internet of Things for Potentiometric Metal Measurement

Potentiometric concentration cell integrated Internet of Things (Pot-IoT) is developed through a framework namely CodeIgniter where the PHP and C programming languages are used to develop a website that will connect potentiometry with the Internet of Things (IoT). The website page can be accessed via the internet or WIFI network. Students can use laptop equipment, smartphones, and also cellphones as a medium to access learning [13].

On the Pot-IoT website, there are 4 main menus, namely instructions, Hantek testing or data logger, data analysis, and practicum reports. Students can read instructions or practicum work procedures, then can do practicum by selecting the Hantek testing menu as shown in **Figure 1**.

In a series of potentiometer devices, cell potential data is sent which is read through a computer, the data appears on the website in real time through the PHP programming language, stored in the Cloud data base, and can be used and processed by users in real time. Website display and display when going to do practicum as shown in **Figure 3** and **Figure 4**.

The results of cell potential measurements will be further analyzed using the Internet of Things (IoT) by utilizing google suite for education features such as google sheets (data analysis to determine the level of Pb metal in the sample as shown in **Figure 5**) and google doc (practicum report as shown in **Figure 6**) on a website so that students can work in groups or individually in processing the results of practicum with the potentiometer tool developed. Measurement data can be processed into a standard regression curve. The cell potential data obtained can be processed to determine Pb metal levels through the Nernst equation [14].

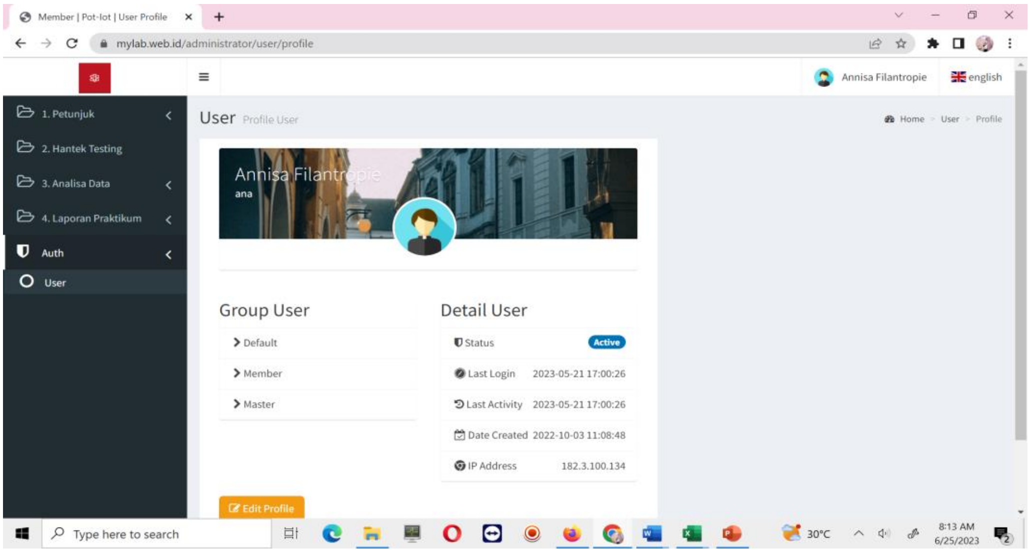

Figure 3. Website display Pot-IoT

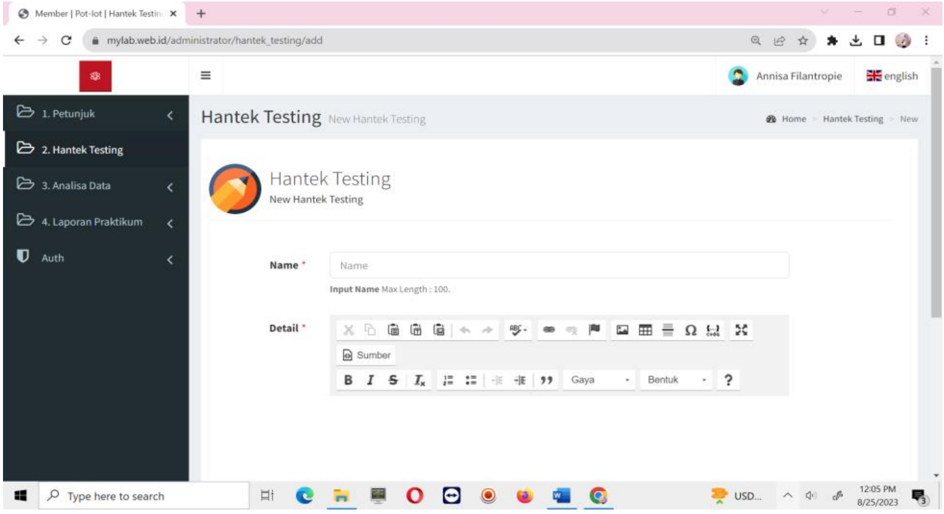

Figure 4. Display when going to do Practicum

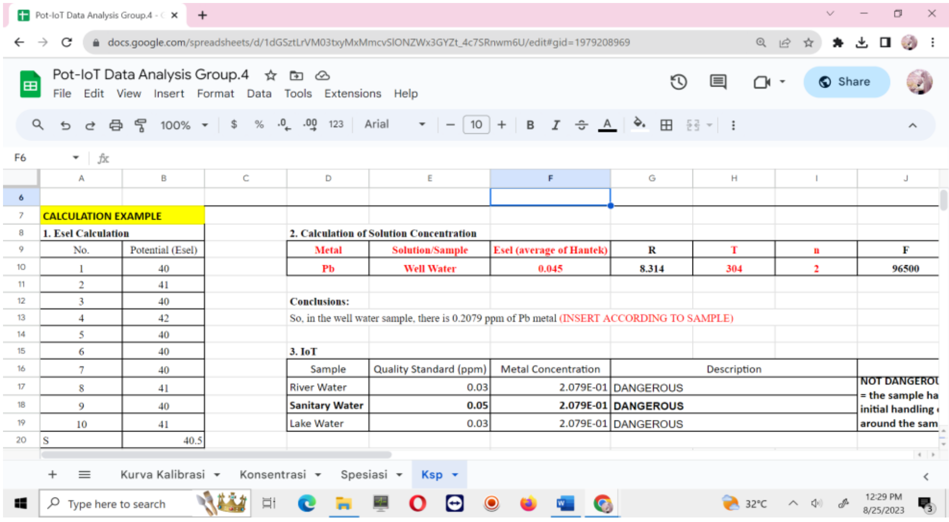

Figure 5. Website display to determine the level of Pb metal in the sample

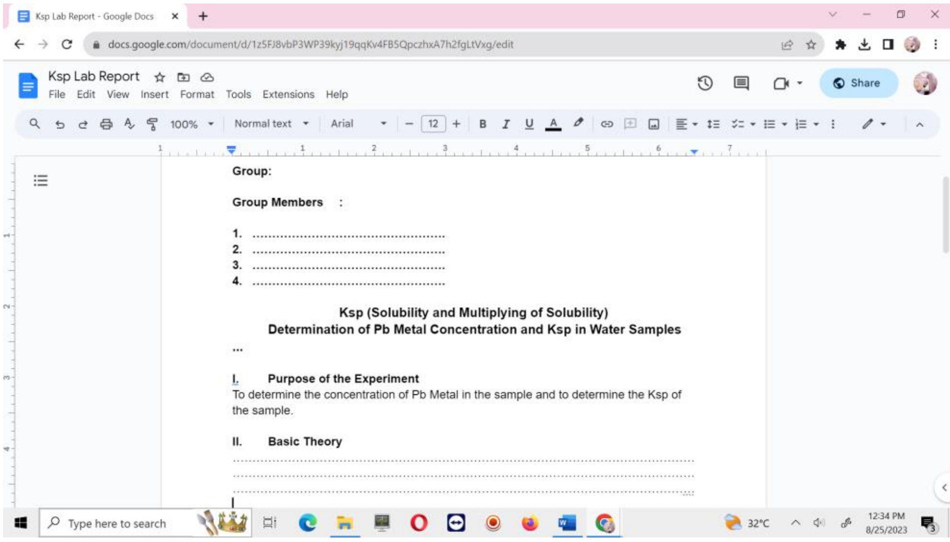

Figure 6. Display of Practicum Report with IoT in the form of Google Doc

Application of Internet of Things for Chemistry Learning at School

The utilization of Internet of Things (Pot-IoT) integrated concentration cell potentiometry is used for the practicum of heavy metal measurement in water samples at school. The use of the Pot-IoT website can make measurements easier and faster so that the learning process becomes more efficient. The Internet of Things (IoT) is very potential to improve students' learning experience. IoT affects the education sector directly and indirectly. Primarily, it facilitates overall work and improves the quality of education. This affects the teaching and learning process to a large extent [15].

In addition, the effectiveness of using the PoT-IoT website has been tested by conducting pre and post-test, before and after learning conducted in the control class and experimental class. In the control class, the practicum was carried out by processing data manually, while in the experimental class the data was processed through the PoT-IoT website developed. In the control class and the experimental class, after conducting the pre-test and post-test, the n-gain value in the control class was 0.2736 and the experimental class was 0.7208. The n-gain value shows the effectiveness of using the developed media. Based on the table above, the use of PoT-IoT website media connected to a potentiometer device for heavy metal measurements in water samples has high effectiveness when used as a learning media in schools

Table 1. Criteria for n-gain Score [11]

Score Criteria	Criteria
$g \geq 0.7$	High
$0.3 \leq g \geq 0.7$	Medium
$g < 0.3$	Low

CONCLUSION

The development of the Internet of Things (IoT) integrated concentration cell potentiometer method has high effectiveness (n-gain = 0.7208) so it can be used as a learning media in schools for the practicum of measuring Pb metal in water samples. The Internet of Things (IoT) can improve the quality of education. IoT has the potential to improve students' learning experience through the teaching and learning process.

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