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KPK and FPB Number Value Detection System using DAKOTA based on Internet of Things for Indonesian Fourth Grade Elementary School Students

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Abstract−Dakon Mathematics (Dakota) is a visual media teaching aid for elementary school mathematics (SD) grade IV, which is used to determine the value of the Least Common Multiple (KPK) and the Greatest Common Factor (FPB). Several researchers have built the Dakota props and have tested them. The results state that the Dakota teaching aids can improve students' understanding. In previous studies, Dakota was operated manually without involving information technology. The problem with the manual Dakota tool is in its flexibility and duration in providing accurate feedback to students. Internet of Things (IoT) technology aims to solve flexibility problems and provide real-time and precise feedback to students. The objectives of the research are threefold, namely: (1) Identifying the need for integration of Dakota tools with IoT, (2) Building Dakota systems and tools integrated with IoT, (3) Evaluation of the performance of IoT-based Dakota tools. The first stage carried out is problem identification. It has been carried out to identify development requirements for integrating Dakota tools with IoT at this stage. The results of the system development needs that have been built have been designed to design the system architecture, followed by designing system functionality, designing hardware for IoT, and designing block diagrams on the system that has been built. Research has succeeded in implementing the IoT-based Dakota system. The second stage is that all tool design and implementation activities have been carried out. The third stage evaluates system implementation results based on functionality, feedback accuracy, and delayed response time. All functionality has worked 100% according to the system design that was built, the feedback accuracy according to the system is 100%, and the delay (between the sensor and the microcontroller) for 100 questions is 1 second, for the delay (between the microcontroller and the IoT platform) is 5 seconds.

Keywords: Dakota IoT; Microcontroller; Module Wi-Fi; Sensor; System Performance

1. INTRODUCTION

Mathematics is a compulsory subject for all students starting at the elementary level (Depdiknas,2006) [1]. Fourth-grade elementary school students are at the level of concrete operational cognitive development, meaning that at this stage, students learn a concept with natural objects around them. Therefore, media use for learning is essential to present mathematical ideas for elementary school students (Prayitno & Faizah, 2019) [2]. This Dakota teaching aid is a medium for learning combined with IoT to make learning more exciting and interactive. The workflow of this Dakota teaching aid is that students insert marbles into the Dakota number holes to find the KPK & FPB values. The infrared sensor detects the Dakota holes that contain marbles. Arduino Mega process to determine the KPK & FPB values. Arduino Mega is a microcontroller board based on ATMEGA2560, with 54 digital input or output pins [3]. After Arduino Mega gets an answer for the KPK and FPB value data, the data is sent to the ESP8266 Wi-Fi to send to the firebase database, one of the reasons for choosing the firebase database because it is excellent to use because of its real-time and responsive speed [4]. In addition, the stored data output to an application so that the teacher can see student answers in determining the value of the KPK and FPB, and students can see the answers on the LCD screen. The Dakota props have not yet integrated with IoT based on related studies.

Even though IoT itself is a technology that can bridge between the physical world and the world of information, an example is how to process data from objects through an interface between the user and the equipment itself [5]. Halim Wajdi, Novian Anggis Suwastika wrote another study that uses IoT for education, and Rahmat Yasirandi with the journal title "IoT Architecture That Supports Stimulation of Motoric Development Growing in Children aged 5-6 Years Using DropBox Games". The research is about the DropBox game being an alternative media for teachers and medical staff to assess and develop children's motor skills [6]. Another researcher, written by Rahmanto, Irvan Naufali, Novian Anggis Suwastika & Rahmat Yasirandi, with the journal title "How is IoT Application To Train Gross Motor Skills Through Hopscotch Games ?". This study discusses the implementation of Hopscotch-type games to balance and coordination skills that support motor development in children aged 4-6 years [7]. Crisnapati wrote the following research, Padma Nyoman, Made Agus Suryadarma Prihantana, and I Putu Pebriawan with the journal title "Development of Counting Educational Games as Learning for Early Childhood." The research is about the use of IoT-based games for children aged 6-8 years in learning to count according to the level that has been designed by the system added with some local wisdom from the island of Bali, including Barong and Ogoh-ogoh [8].

Robiatun Nurohmah carried out further research with the journal title "The Effect of Dakota Media on Cooperative Learning on Cognitive Mathematics Learning Outcomes for KPK & FPB Class IV SDN 3 Bendoagung". The third researcher uses the Quasi-Experimental method with the research design of Nonequivalent Control Group Design Sugiyono (2014). The results showed that the pretest results from the

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experimental class obtained an average score of 63.2, and the posttest score was 92. Meanwhile, the pretest in the control class received an average value of 61 and the posttest with a 77 (the increase in value was not significant) [9]. Mei Riska Dwi Ariyanti, Rasiman conducted the following research and Mei Fita Asri Untari with the journal title "The Effectiveness of Problem Based Learning (PBL) Models with Dakota Media on Learning Outcomes of FPB & KPK Materials." The fourth researcher used the One Group Pretest-Posttest Design method with quantitative type experiments. They carried out on students who found 39 people with a standard KKM score of 75. When the pretest was conducted, the study results obtained an average of 57.56, with six students completed and 33 students incomplete. Meanwhile, the post-test results received an average of 86.79 with 34 students completed and five preliminary students, the percentage increase in value from the Pretest and post-test results was 29.23% [10]. Risnawati, Ari Wibowo has also carried out research, and Bahar with the journal title "The Effect of the Use of Mathematics Dakon Media on the Learning Outcomes of Elementary High School Students in Gowa Regency." The method used by the fifth researcher is by taking a quantitative approach and using a True-Experimental Design. The results when the pretest was carried out on 30 students, namely the experimental class, resulted in a "Good" category score of 8 people (26.67%) with a parameter value of 61 to 80 and for the "Enough" category value as many as 22 people (73.33%) with parameter value 41-60. While in the control class, five people (16.67%) scored in the “Good” category, and 25 people (83.33%) achieved in the “Enough” category. The results when the posttest was carried out on 30 students, namely the experimental class, resulted in the "Very Good" category score of 8 people (26.67%) with parameter values of 81 to 100 and for the "Good" category value as many as 22 people (73.33%) with parameter values 61-80. Meanwhile, in the control class, 16 people scored in the "Good" category (53.33%), and 14 people in the "Enough" category scored 46.67% [11]. The results of several studies that use Dakoies show media can affect student learning outcomes with parameters in terms of student scores, increase student interest in learning, and student activity in knowledge. In addition, learning about KPK and FPB material becomes more fun by using the Dakota media. In this study, the development of determining the value of KPK and FPB and storing data automatically by implementing IoT was carried out. According to Ambrose’s learning principles in IoT, there are practice and feedback principles. In practice principles, there is flexibility, so with IoT, teac, hers, and students can practice at any time, while the feedback principle aims to evaluate the system quickly and accurately [12]. This system analyses the performance and functionality of the system based on the accuracy parameters of looking for the KPK and FPB values and calculates the delay response time. This is necessary to adjust the output in terms of speed and accuracy of sensor data to be stored in the firbase database for modelling data displayed on App Inventor as an IoT platform.

2. RESEARCH METHODOLOGY

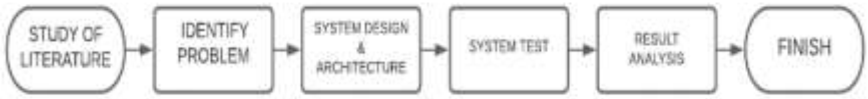

Figure 1. Research Workflow

The workflow of this research can be seen in Figure 1. This study uses quantitative methods for the results. The system calculates the delay response time and the answers' accuracy—figure 1. Research Procedure is a series of research processes from beginning to end. First, the identified problem stage is carried out, aiming to see if there are opportunities for improvement of the tool. The next step is to examine various reference information on journal literature studies related to research that has been done previously to serve as parameters. The next stage is to design the system to be built. The next step is to test the system created then review it from its function, performance, and parameters. The last stage is to analyse the results of the implementation.

The Dakota teaching aid is a tool for combining the traditional game of congklak with mathematics learning which aims to help students determine the KPK and FPB numbers [13]. Teaching aids can be interpreted as tools to assist the learning process so that the message can be well received to run effectively and efficiently [14]. Internet of Things (IoT) is a concept where connectivity can exchange information with the objects around it [15]. Several journals have been found related to research on using DAKOTA tools for learning for fourth-grade elementary school students. Emalia Karti has carried out the research. Albert Supriyanto Manurung, with the journal title "Use of Dakota Teaching Aids to Improve Mathematics Learning Outcomes for KPK and FPB Materials for Class IV Students at Duri Kepa 03 West Jakarta Elementary School," and the researchers used the Class Action Research (CAR) method. The research was conducted in two cycles consisting of the cycle I and cycle II. In the first cycle, the student's average score was 68.71, and the second cycle had an average score of 78.15, so the difference in the increase in the first cycle to the second cycle of 32.26% [16]. IoT has been developed in the field of education. Researchers have already implemented IoT, such as Seiba Shonia, Novian Anggis Suwastika, and Rahmat Yasirardi, with the journal title "Bag Toss Game based on Internet of Education Things (IoET) for the Development of Fine Motors. Stimulation in Children 5-6 Years Old". The application of IoT for educational purposes is known as the Internet of Educational Things (IoET) [17]. Besides that, there is also an example of a well-known traditional game, namely hopscotch, written by Riyan Kuncoro Jati, Novian Anggis

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Suwastika, and Rahmat Yasirardi. Hopscotch is a game that demands high flexibility of foot movements and coordination skills that are scientifically proven to train children's gross motor system. Various types of hopscotch games can improve children's dynamic balance. As a result, IoT-based Hopscotch game with random path successfully imitates hopscotch gameplay with their additional gameplay features, and player subject performance has improved adaptability performance through each level [18]. To date, no Dakota tools have been implemented with IoT.

2.1 Identify Problem

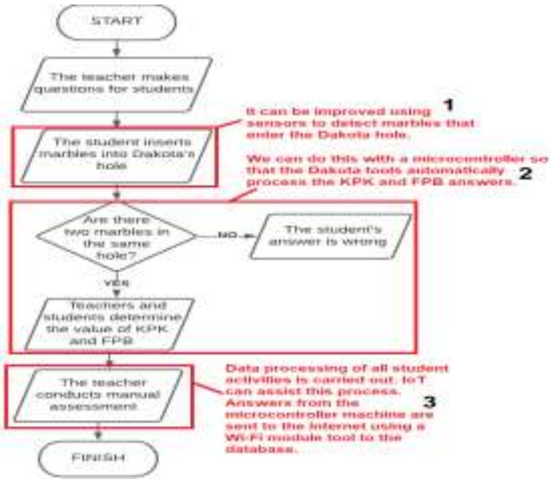

Figure 2. Manual KPK and FPB Search Flowchart

Figure 2 represents the workflow flowchart of the Dakota teaching aid system manually. First, the teacher questions to find the KPK and FPB numbers for students. Then the students put the marbles into the Dakota holes to answer the questions from the teacher. The determination of the KPK and FPB numbers is done manually by students and teachers by looking at the Dakota hole. If there are two marbles in one Dakota hole on the smallest number, that's the KPK's answer. If there are two marbles in one Dakota hole on the most significant digit, then that's FPB's answer. After manual analysis, the teacher recaps student scores manually. The first point in Figure 2 is that students insert marbles into the Dakota hole. At this stage, improvisation can be done on the tool by installing a sensor to detect the marbles that enter the Dakota hole. The second point is the manual process of searching for KPK and FPB carried out by teachers and students by seeing two marbles in the same hole on the Dakota. This can be done by improvising by installing a microcontroller that has been programmed to determine the value of KPK and FPB with the input of 2 numbers. The third point is that the teacher recaps student grades manually. At this stage, improvisation can be done by configuring the IoT using App Inventor to automatically store all student activities through the Wi-Fi module's intermediary. The research goals are to successfully identify requirements and calculate the built tool system's delay response time and accuracy.

2.2 System Design &Architecture

Figure 3 is the architectural system on the Dakota teaching aids for students' learning activities. The architectural design describes the work system flow on students, teachers, Dakota teaching aids, and supporting devices. Each student's answer answers data information sent via the internet using an IoT platform called App Inventor. The data then showed data modelling to the App Inventor teacher.

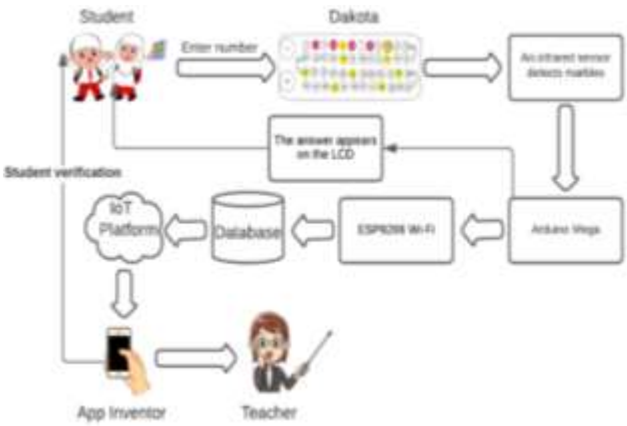

Figure 3. System Architecture

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The function of the tool to build on the device involves several hardware components, as shown in Figure 4.

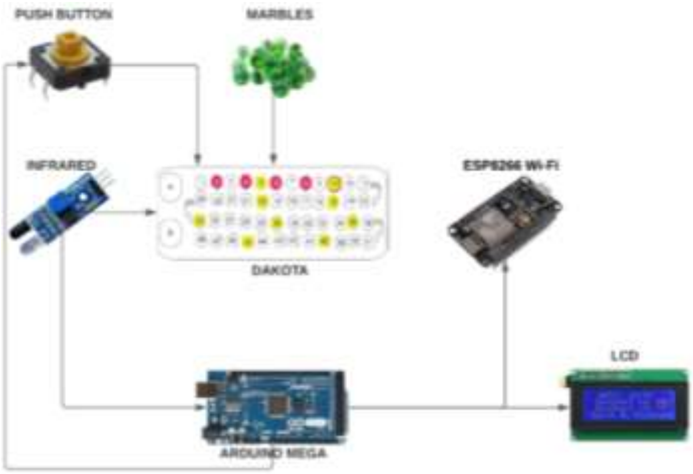

Figure 4. Tool Representation

The infrared sensor installed in the Dakota props detects the marbles inserted by students into the Dakota hole. In addition, Arduino Mega works to validate every marble that has been read by infrared for the process of finding the KPK and FPB values. There are two pushbuttons, reset and finish; the reset button is used if

students want to continue to the next question, while the finish button is used if students have spent working on ten questions. After Arduino Mega processes the answer data, the data is displayed on the LCD so that students know their answers are right or wrong. Then the answer data is saved to the firebase database and then sent to the IoT platform via the internet to the App Inventor, which aims to model student answer data for teachers who need to see their students' performance in class.

2.3 System Test

This study was conducted testing the system functionality on the Dakota props. The functionality focused on hardware components that have their respective functions for testing, as shown in Table 1.

Table 1. System Functionality

Component	Device	Description
Hardware	Arduino Mega	I tested the microcontroller according to the program built with the Dakota props to determine the KPK and FPB values from the infrared sensor detection data.
	Infrared Sensor	It tested the workings of the infrared sensor to detect marbles that fall into the Dakota hole.
	ESP8266 Wi-Fi module	They were testing the Wi-Fi module to send data to the internet.
Software	Database	Receiving student answer data that the microcontroller has processed, sent via the Wi-Fi module.
	App Inventor	An application that presents activity data for student answers to recap grades by the teacher.

The performance of the built system measures the speed of the parameters and the accuracy of reading the sensor, commonly called the delay response time. The rate of the sensor reading data is the duration of the device when it receives instruction and processes it into the input. The level of accuracy was taken from comparing the data from the readings on the Dakota teaching aid system with the actual data.

3. RESULT AND DISCUSSION

This chapter discusses the test results from the data obtained in several experiments. There are two tests, namely, testing the functionality and performance of the system. The research has also conducted an analysis related to the accuracy of the answers from the Dakota visual aid in determining the value of the KPK and FPB and calculating

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the delay response time when marbles are inserted into the Dakota hole that the conclusion stage in the study obtained.

3.1 Requirement

At this stage, the service candidate that has been modelled is built with REST technology using the Express JS framework. Express JS provides all the building blocks needed to create web applications and microservice. Each service on the platform already has its API, registered, and can be searched or found, as shown in Figure 7. The author uses Postman as a design for every existing API to register and use it.

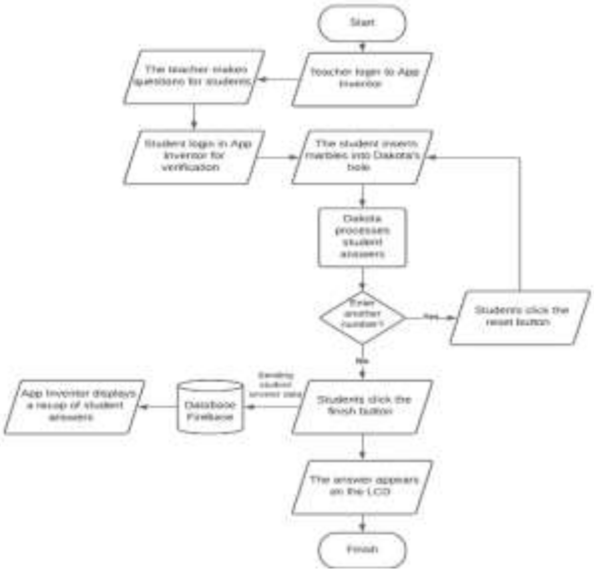

Figure 5. Flowchart of The System Built

Figure 5 represents the workflow flowchart of the DAKOTA teaching aid system automatically that has been integrated with IoT. First, the teacher gives ten questions to students. Students must first log in to App Inventor to verify. The login display can be seen in Figure 6.

Figure 6. Login View

Students answer the question by inserting marbles into the Dakota hole. At this stage, there is an improvisation on the tool, and the Dakota tool has been installed with a sensor to detect the marbles that enter the Dakota hole. The next stage is that the Dakota tool processes the KPK and FPB answers from the scanned marbles that enter the Dakota hole. Then the response is sent to the internet, especially to the firebase database via the Wi-Fi media module. There is also an improvisation because the Dakota tool has a microcontroller installed to automatically process the KPK and FPB answers. If students want to input numbers again, students must press the reset button. Otherwise, if students have finished answering ten questions, students only need to press the finish button, and the answers immediately appear on the LCD. In addition, the system also displays ten student answers in the App Inventor application, an improvisation that previously the teacher did a recap of grades manually. After the Dakota tool is combined with IoT, the teacher does not need a manual summary again because App Inventor has summated student scores. App Inventor is an open-source web application originally developed by Google and currently maintained by the Massachusetts Institute of Technology (MIT) [19]. Teachers used the App Inventor output to see their students' learning performance in the material for finding the KPK and FPB scores. In table 2, there is a list of equipment requirements for the system being built.

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Table 2. System Functionality

Device	Description
Arduino Mega	Make it as a microcontroller for system processes on Dakota props.
Infrared Sensor	Easy to detect the marbles that go into the Dakota hole.
Push Button	As an interface between the student and the Dakota tool (Reset and finish buttons).
ESP8266-01	As a Wi-Fi module that aims to send data to the internet.
LCD	As output answers for students.
Dakota Props	Become a teaching aid to assist in the learning of KPK and FPB.

Several devices can be arranged into a series connected in Figure 7.

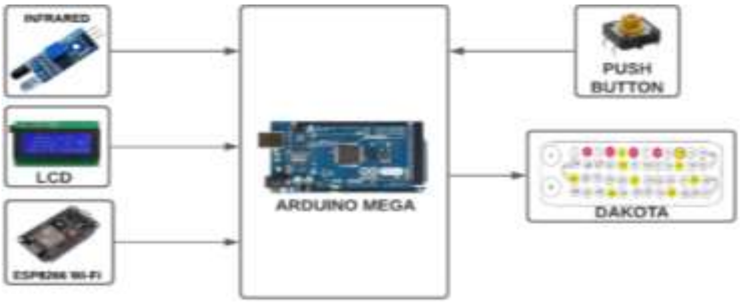

Figure 7. Block Diagrams

3.2 Functionality

This part of the research will test the functionality of the system tools built. The goal is that all functions of the hardware and software tools that have been constructed are fully functional. Three aspects tested for functionality are the microcontroller, sensors, and the IoT Platform (App Inventor).

3.2.1 Microcontroller Functionality

This study uses Arduino Mega as a microcontroller whose role is to be the central controller of the built system. The Arduino Mega system has been programmed only to read two numbers of KPK and FPB values. Figure 8 shows a schematic of the devices connected to the Arduino Mega, such as 20 infrared sensors, ESP 8266, LCD, and push-buttons. In addition, in Figure 6, there is a display of the Dakota props. There are only 20 holes from the Dakota props. Therefore there are 20 infrared sensors installed on the Arduino Mega. The pushbuttons have three buttons. The first is the KPK button which functions for students if they want to find the value of the KPK number, the second button is to find the FPB value, and the third button is for students to go to the next question or to sign that they have finished working on the question.

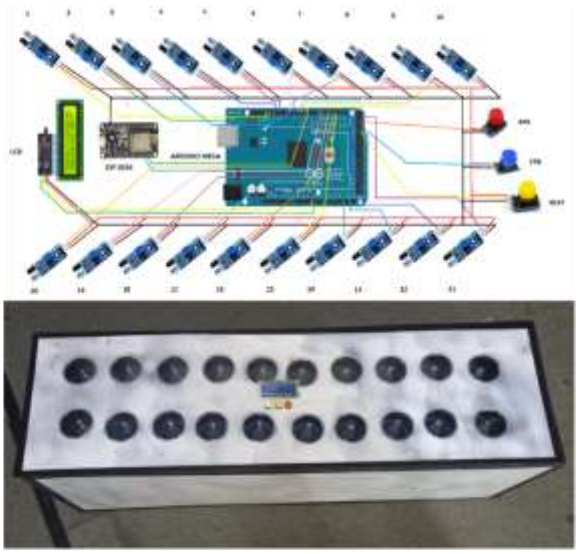

Figure 8. Testing System Arduino Mega

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3.2.2 Infrared Functionality

Figure 9 is proof that the sensor has been tested. The infrared sensor plays a role in detecting the marbles that enter the Dakota hole. Students can do this test to find the value of the KPK and FPB by inserting marbles into the Dakota hole. Arduino Mega answers the marbles detected by the differ-red sensor according to the questions and answers that the previous teacher has arranged. After Arduino Mega finishes processing student answers and teacher answers, the data is sent to ESP 8266 to the firebase database, and solutions for students output on the LCD. In contrast, answers for teachers output in App Inventor.

Figure 9. Infrared Sensor Testing

3.2.3 IoT Platform Functionality

Table 3 shows that the research has designed the questions to be used as parameters and tested against the tool system that has been built. A total of 10 experiments has been conducted, with each experiment containing ten questions.

Table 3. Questions

Number	Question	Enter Number	Results
1	KPK	2,6	6
2	FPB	8,18	2
3	KPK	11,17	187
4	FPB	20,4	4
5	KPK	9,12	36
6	FPB	18,12	6
7	KPK	5,12	60
8	FPB	9,12	3
9	KPK	7,11	91
10	FPB	6,8	2

The ESP 8266 tool acts as a Wi-Fi module to transmit student answer data that infrared sensors have read marbles into the firebase database via the internet. The data is already stored in the firebase database output in the App Inventor. Besides that, in Figure 10, there is a pseudocode for finding the KPK and FPB numbers with two inputs.

KPK PSEUDOCODE ALGORITHM

```
1. Input Num1 and Num2.
2. If Num1 < 2 or Num2 < 2, repeat to line 1.
3. If Num1 = Num2, repeat to row 1.
4. Initialization Kpkbil1 = Num1 and Kpkbil2 = Num2.
5. If Kpkbil1 = Kpkbil2, then jump to line 7.
6. If Kpkbil1 > Kpkbil2 then Kpkbil2 = Kpkbil2 + Bil2,
   if not then Kpkbil1 = Kpkbil1 + Num1.
7. Repeat to row 5.
8. Print the number of KPK = Kpkbil1.
9. Finish.
```

FPB PSEUDOCODE ALGORITHM

```
1. Start.
2. Create variables a, b, c.
3. Input 2 numbers (a,b).
4. Find the remainder of the division of "a" by "b" (c = a mod b).
5. If the value of the modulus sought is 0 (c=0), go to step 8
   If c!=0, then continue step 6.
6. Change the value of "a" to the value of "b",
   and the value of "b" becomes the previously searched modulus value.
7. Repeat step 4.
8. Print FPB number.
9. Finish.
```

Figure 10. Pseudocode KPK & FPB

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In Figure 11, App Inventor shows the overall results of 10 answers, while the output for students is displayed on the LCD with an answering system.

Figure 11. App Inventor and LCD Display

3.3 System Performance Test Results

System performance testing is done by doing several experiments. In one experiment, there were ten questions answered by each student.

3.3.1 Judging Accuracy

Testing the accuracy of assessing the tool in ten trials shows in table 4. The performance test results on the accuracy parameters of calculating the KPK and FPB values were carried out by giving ten questions to students in each experiment, so 100 questions were tried. The test was carried out ten times and resulted in an average accuracy rate of 100%. This test has an important note when inserting marbles into the Dakota hole. You must be careful not to get your hands on the sensor. If you touch the sensor, the sensor read twice.

Table 4. The Results of Assessment Accuracy Test

Trial to	1	2	3	4	5	6	7	8	9	10
1st try	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
2nd try	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
3rd try	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
4th try	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
5th try	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
6th try	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
7th try	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
8th try	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
9th try	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
10th try	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Average					100%					100%

3.3.2 Sensor Reading Speed

The sensor reading speed test results in one experiment can be seen in Table 5. The results of the reading speed test have been carried out, the data obtained an average speed with a value of 5353.5 milliseconds or 5 seconds. In one test, there are ten questions made. Then students have to answer ten questions. The reading speed of the infrared sensor is 1 second. Still, if the infrared sensor data that is read is output to the IoT platform, the speed

Volume 6, Nomor 2, April 2022, Page 848-857
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difference is 5 seconds. This shows that the device's time when it receives instruction becomes an input and sends it to the IoT platform for 5 seconds.

Table 5. Sensor Reading Speed

Trial to	Reading sensor	Display on IoT platform	Difference (Milliseconds)
1st try	00:00:01:003	00:00:06:148	5145
2nd try	00:00:01:012	00:00:06:682	5670
3rd try	00:00:01:052	00:00:06:418	5366
4th try	00:00:01:102	00:00:06:271	5169
5th try	00:00:01:121	00:00:06:502	5381
6th try	00:00:01:167	00:00:06:521	5354
7th try	00:00:01:195	00:00:06:290	5095
8th try	00:00:01:110	00:00:06:792	5682
9th try	00:00:01:169	00:00:06:286	5117
10th try	00:00:01:194	00:00:06:740	5546
		Average	5352.5

4. CONCLUSION

Based on the results of the implementation and analysis of the DAKOTA teaching aid system that uses IoT technology as a medium for assessing KPK and FPB value search activities, it was found that the functional requirements of the system such as sensors, microcontrollers, Wi-Fi modules, App Inventor, student and teacher logins managed to function 100% and successfully integrated with IoT. In the architecture part, the system that has been built has been successful following the activities of using Dakota by students. Based on the parameter assessment of the sensor reading speed for the marbles entered by the students, it is 1 second. In contrast, the sensor reading speed for the IoT platform with an internet speed of 50 Mbps, the average system delay time is 5 seconds. Meanwhile, for the results of the parameter testing, the accuracy of the assessment accuracy is obtained by an average value of 100%, with a note that there are ten trials in which every one test there are ten questions. The following important note is the input from the infrared sensor when the marbles are inserted into the DAKOTA hole, be careful not to hit the sensor when inserting the marbles into the Dakota hole because this can cause the sensor to read twice when normally the infrared sensor should be read the data only once when the marbles are inserted. Besides that, the answers to the KPK and FPB scores for students be output on the LCD, while a recap of the overall responses from students for teachers is output to the App Inventor. The suggestion for further researchers is to develop into five number inputs to find the value of KPK and FPB values because the tools that have been made are only able to input two numbers to find the KPK and FPB values and make interactive video tutorials on how to use the Dakota tool that has been implemented with IoT.

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