Learning how computer’s work with combining CS-Unplugged and Raspberry Pi

S Soviani¹, J Kusnendar² and H W Prabawa²

¹Salman Al Farisi Junior High School, Bandung, Indonesia
²Department of Computer Science Education, Universitas Pendidikan Indonesia, Bandung, Indonesia

*Corresponding author’s email: shinobi.vie@gmail.com

Abstract. Almost from the beginning, computer science was hampered by the perception that computer science exclusively focused on programming. This results in computational-related learning being very limited and minimally taught to students. The widespread use of ICT tools in indirect learning has changed the way students interact with content. This paper presents a different approach, while keeping the teacher at the centre of control of classroom activities but students are given the opportunity to explore the content to be learned by CS-Unplugged and Raspberry Pi. This activity aims to provide basic knowledge about how computers work. One of the activities is a simulation and experimentation on how computers work through the CS Unplugged approach. The basic knowledge formed from the simulation was then used as the basis for assembling a simple computer using Raspberry Pi. Based on the results of observations and interviews conducted, the utilization of CS Unplugged provides a learning experience that builds on the initial concept of how computers work. This is shown by an increase in students' motivation and enthusiasm in learning how the computer works. This experience is what then makes it easy for students to do various computer assembly experiments using Raspberry Pi.

1. Introduction

Almost from the beginning, computer science was hampered by the perception that computer science exclusively focused on programming. This results in computational-related learning being very limited and minimally taught to students. On the other hand, the computer science taught seems to be solitary, disconnected from the relationship and its relevance in solving everyday problems [1]. Ideally students are taught about basic understanding regarding computer science which will not only place students as users of a technology but also be able to take part in the innovation efforts of using computers in order to improve the quality of life [2]. It becomes more important because we live in the digital era, where almost everything is facilitated by the existence of technology.

But then conditions change. Computers as the smallest elements of Information and Communication Technology (ICT) are widespread throughout the world as an integral part of not only intervening in the role of teaching but also other aspects of human life. Computers are not only computerized in terms of material, but also optimizes its role in solving many life problems. According to Iskandarani [3], technological breakthroughs, especially in ICTs have brought unprecedented benefits to economies throughout the world. Furthermore, ICTs have an influence on social practices, especially with regard to information access power [3]. In the context of learning, ICT is referred to as a tool that is needed by students in developing cognitive reasoning and psychomotor abilities [4]. This is also supported by Mohamed and Bakar [5], Bahrudin, et al. [6] which states that computer technology is an important
integral tool in the field of teaching where the use of computer technology is said to be beneficial for students [7] and teachers. From this point on, the concept of computer literacy is growing rapidly while still carrying many problems that have not been resolved completely, one of which is regarding how computer learning should be presented?

There are many types of teaching methods that allow use in classroom learning. In relation to computer learning, the earliest learning theory pertaining to computer learning is the Minimalist Theory revealed by J.M. Carroll [8]. Minimalist theory is developed by basing it on the diversity of ways we learn and interact with computers, including word processing, database and programming applications [8].

The widespread use of ICT tools in indirect learning has changed the way students interact with content [9]. Conventionally, content is delivered orally to students, who at the same time rely more on approaches that tend to be teacher-centred. This paper presents a slightly different approach, while keeping the teacher at the centre of control of classroom activities but students are given the opportunity to explore the content to be learned by: role playing (CS-Unplugged) and conducting a series of experiments (Raspberry Pi). The material chosen in this study is a computer system. An important point in this material is that students must be able to understand the process of computer work, how can a computer process data into information?

This scenario was chosen to solve some learning facts where when the material was presented in class, students tended to look bored because only listening to the teacher explained using the lecture method, besides sitting and listening activities also made some students look saturated. The lack of enthusiasm of students when learning also affects the quality of students' understanding of the material being taught, in addition to some terms that are not understood, abstract data processing is still difficult to understand by students.

One method that can be used in learning computer science is the CS-Unplugged (Computer Science - Unplugged) method. Indeed, CS-Unplugged presents as well as teaches students, a way to expose ideas from computer science without using a computer [10]. CS-Unplugged is developed so that there is no dependency on technology in the learning process and that computer science can be learned easily even by students who are in even lower classes [11].

CS Unplugged has been an example of success in teaching computer science through activities that are very interesting for students. Renate Thies and Jan Vahrenhold of the Technical University of Dortmund in Germany [12] investigated the suitability of CS Unplugged activities for use in space by teaching a group of students. They use CS Unplugged activities to teach some students, and use other alternative media (not CS-Unplugged) for some other students. Their findings showed CS Unplugged activity was as effective in transferring knowledge because there were no significant differences in achievement between groups who studied with Unplugged CS activities and groups that studied with alternative media. In addition, the researchers studied the effects of using CS Unplugged activities at different grade levels, and found that these activities had a significant positive impact when used with high school classes [12,13].

In its development, the presence of CSTA with the issue of Computer Science Standards [14,15] and CS-Unplugged K-12 seems to emphasize that computer learning is not only limited to mastery and ability to use computer applications, but also to understand computers in terms of science (science). This learning method trains students' cognitive thinking skills in understanding the basic concepts and ways of working the computer. The most important thing is that students can understand that the basic concepts of computers are not always related to computers physically [16]. Also, it is important to show students that to understand how computers work requires mathematical thinking and supports computational thinking [16].

Raspberry Pi itself is actually a credit card sized computer designed and produced with the initial intention of providing inexpensive computing devices for education [17]. From the beginning, the existence of Raspberry Pi was intended to activate and revolutionize the teaching of computer science by providing hardware that is accessible and easily accessible [18].

Raspberry Pi is supported by ARM based processors, which operate at 700 MHz - 1.2 GHz, with 256 MB of memory - 1 GB, depending on the model or type used. The main components include HDMI, USB port, Ethernet port and SD card. The default operating system on Raspberry Pi is Raspbian, or
Linux based on Debian. In addition to the main components, Raspberry Pi is equipped with various interfaces to interact with small electronic devices. A serial display (DSI) interface can be used to connect to the touch screen; Camera serial interface (CSI) can be used to take pictures or videos; sensors or/and actuators can be attached to the input/output pin (GPIO) general purpose to monitor and react to environmental changes. The Raspberry Pi advantage is that it provides a common programming environment (for example, Linux) and allows direct control of hardware through the interface.

2. Methods
This learning activity aims to provide students with a foundation of knowledge about how computers work. One of its activities is to provide opportunities for students to conduct simulations and experimentation on how computers work through the collaboration of the Unplugged Role Playing-CS method and the assembly of simple computers using Raspberry Pi. The basic knowledge formed from the Role Playing-CS Unplugged was then used as the basis for assembling a simple computer using Raspberry Pi. An important point that is expected to be understood by students from the Role Playing-CS Unplugged activity is that the computer does not understand what the computer is doing. The computer only follows the instructions given by computer users. While from simple computer assembly activities using Raspberry Pi, students are expected to be able to better understand computer architecture on a simpler scale and can define the role of each computer component according to its division in computer systems.

Student performance data is captured through worksheets. In a simplified computer work process simulation, it is assumed that a computer consists of 3 main components:

- **CPU (Central Processing Unit)**
  This is the part of the computer that is in charge of managing the order and then forwarding it to the other components that are compatible. Students who act as CPUs will be given a program to run and are responsible for telling other components what needs to be done.

- **ALU / Memory (Arithmetic / Logic & Memory Unit)**
  ALU is part of a computer that is responsible for carrying out all mathematical and logical operations. Students who act as ALU / Memory are tasked with recording the current x and y values and performing the mathematical operations requested by the CPU.
  Meanwhile, the memory is responsible for storing information so that it can be called back later.

- **Display**
  Display is a part of the computer that is responsible for presenting the results of a particular computing process. Students who act as Display will respond to the "plot" command of the CPU by plotting x and y values on the display grid (presented in Figure 1)

The main scenario of this learning activity is that the teacher assigns students to take a role in each computer component and gives them a simple case to complete. Students who act as CPU process each instruction in sequence to then pass it on to students who act as ALU / Memory and Display about what they have to do.

This first activity was followed up with the practice of assembling a simple computer using Raspberry Pi, which generally aims to map experience in understanding the role of computer components into actual computer devices. So that in the end, students can distinguish which components belong to the components of input, process, storage and output.
3. Results and Discussion

The study was conducted involving 88 students who were divided into 4 classes. Each class consists of 22 to 24 students who are then divided into seven groups consisting of three students, each group divides tasks and roles into CPU, ALU, and Display each one person, if the group consists of four people then ALU played by 2 people. After dividing the tasks the students make 3 rows according to their roles, namely CPU, ALU, and Display. Every student takes worksheets according to their respective line names and marches neatly.

Students who act as CPU and ALU sit side by side and work on assignments or programs that have been given. After completing all the commands in the ALU program, it gives the calculation table to the Display, then the Display draws the coordinate points that have been calculated by ALU on the provided image media.

The simulation activity is carried out for 2 x 40 minutes. Starting from introductory material, technical explanation of simulation, how to do calculations, how to record data, and how to draw. Students enthusiastically choose the role given, learning takes place with solid activities so that students do not have time to play around. Learning time feels short because all students are active and participate in the simulation eagerly. Some students express feelings of pleasure with the new learning sensation where ICT learning does not only listen to material lectures, listen to tutorials, or practice using applications.

In the first phase of simulation activities, there are several things that should be noted, including:
(a) The response of students begins to emerge because learning requires movement and group coordination, so that the process of student movement and discussion occurs during the learning activities.
(b) The teacher is no longer the main speaker, but plays a role in directing the activities of students to conform to the provisions of the Role Playing simulation being carried out.
(c) Students still have a tendency to be afraid to choose a role that has a heavy task, which is to become ALU because they have to count.
(d) There are still students who do not understand how to calculate the program so that the calculations made produce numbers that are negative (-).
(e) Students have written results repeatedly so that the number of coordinate points resulting from calculations is more than the number of instructions available.
(f) The time needed for the simulation turned out to be quite a lot, especially when explaining how to count, so the time for reflection on learning at the end of the meeting was very little and less effective.

Based on these records, several improvements were made. In learning at this stage, learning activities begin by selecting three students to act as CPU, ALU, Display, and do simulations in front of the class.
observed by other students. Students who become CPUs read the program in a loud voice to be heard by students who are ALU and Display in front of the class and heard by students who are audience, students who become audiences can also do simulations into ALU and Display.

Figure 2. CS-Unplugged 2nd Scenario

The simulation activity is carried out sequentially per each instruction, the CPU reads the command, ALU counts, then the Display immediately draws the coordinate point, after that steps to the next instruction (presented in Figure 2). So on until all instructions have been completed. After completing the simulation, students and teachers reflect on the data processing material on the computer related to the role of the CPU, ALU, and Display on the computer. Students' understanding is strengthened by watching a video show on basic computer components that explains the hardware and software material and the relationship between the two in a computer system. The last activity in this learning was an oral quiz, with questions about what students captured from video shows related to computer system material and computer hardware and software devices, as well as questions about the name and function of computer hardware (hardware).

From the results of interviews, the majority of students liked learning in the form of simulation with the reason: more relaxed, not always serious, and not tense; easier to remember because directly practicing is not only listening. However, there are also some learning conditions that need to be improved, including there are some students who have difficulty in following the simulation rhythm so that they are left behind from class activities. This is more due to changes in learning patterns that are more directed at activating students in constructing the initial concept of learning material. The written test conducted at the end of the learning informs that as many as 67 people out of 88 students were able to exceed the minimum required value, which is 75. Most of the students who scored below the minimum threshold required complained about their confusion in calculating and plotting, because the plot was done differently from what was taught in the math class, starting from the bottom left. While in this learning starts from the top left. 24 of them got a score of $> 90$. In the aspect of the ability to understand the relationship between CPU, ALU, and Display functions on a computer system 46 students were able to achieve good grades, 24 of them reached 100. The ability to count and draw coordinate points increased by 40 the students were able to calculate and draw with a value of 100. While in the simple computer assembly practice activity using Raspberry Pi, it was obtained data that 83 of 88 students were able to exceed the minimum required. Even 55 of them obtained a score of $> 90$. In the aspect of determining the components and functions of each component of the Raspberry Pi device 70 students were able to achieve good grades, 37 of whom achieved a score of 100. Based on the data obtained, 73 students could explain again computer system components and provide examples of each component on different computer units. This shows a positive correlation between increasing motivation, enthusiasm, and the response of students in teaching and learning activities with the level of understanding gained by students.

Interviews conducted on several students explained that changes in the acquisition of value that occurred from the activity sheet was a result of learning habitation which then had an impact on
students' mindset in solving problems. When interviewed about the role of CS-Unplugged and the involvement of Raspberry Pi in learning, some students stated: 'CS-Unplugged helps me understand how computers work'; 'CS-Unplugged makes basic computer learning more exciting ... especially when assembling computers using Raspberry Pi'. Even some students stated that the learning that was done was not felt like the learning in general, but rather like playing and it was very exciting.

4. Conclusion
The basic computer system learning process "How Computer Works" by using a combination of CS-Unplugged and Raspberry Pi affects the ability of students to understand the material. From the results of the study, it is seen that there is a link between learning motivation and an increase in students' understanding. Increased learning motivation can improve students' ability to understand computer science theory material that is being taught or studied.

From the studies we conducted, we learned that the role and creativity of teachers in formulating material into a variety of teaching materials that can facilitate students in learning is very important in learning. The involvement of CS-Unplugged and Raspberry Pi proved to be able to increase students' interest and enthusiasm in learning basic computers. Observations that we did during the learning process took place also indicated the occurrence of growth and development of Computational Thinking in students. Some students assume that the same learning pattern if used in other subjects will certainly have a pretty good impact.

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