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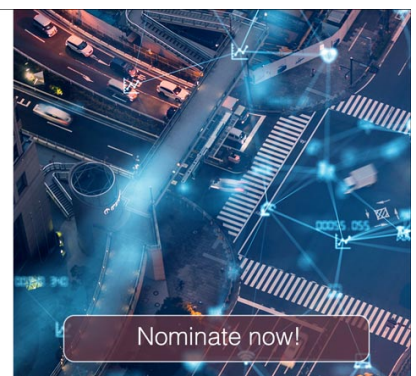# Study on Skill Improvement of Digital Electronics Using Virtual Laboratory With Mobile Virtual Reality

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Abstract. The virtual laboratory of digital electronics using mobile virtual reality technology to save to cost of making real laboratory. Mobile virtual reality can use by student to practice digital electronics skill in their home. This study to finds the skill improvement of student in competency digital electronics using virtual laboratory with mobile virtual reality based. Virtual laboratory can help student to feel the real practice of laboratory in everywhere and every time. The feature of virtual laboratory is: (1) enable to do practice digital electronics in every time and everywhere, (2) student can do experiment like in laboratory using android phone, (3) support with many of android phone series. This study uses the method of research and development with waterfall model that have five stages to develop a software application. The results show that the virtual laboratory can help student to improve their skill of digital electronics because easy feature and real time of virtual laboratory.

1. Introduction

Build a laboratory for student practice in school need much of money. Every school have different need and some school build one laboratory for some competency in same place and go in turns. Laboratory in school also just can be used in school time and it must have a special permission to use laboratory out of school time. School laboratory also need some component for practice and it need another money to buy it. Limited space of school can also be problem when school want to build a new laboratory.

Safety of the laboratory should be highly supervised because it can be danger the student when practice in laboratory. Equipment for practice in laboratory must be maintained, because it can interrupt the practice. Change the equipment and structure of laboratorium can be take a long time because it probability to rebuild the laboratory. Some of the equipment can be broken if it wrong used when practice in laboratory.

Smartphone in this era will be premier needed and everyone must be have a smartphone for social and interaction needs. Operating System (OS) that used in many of smartphone is using an android OS and there was much developer make an application or game on android. The problem is there is only a few application that can be used for education. There are many of student who have a smartphone by themselves but that never be used for education in their school.

One of smartphone technology that can be future technology is a virtual reality program. Virtual reality haven't been used for education and much of the virtual reality application is used in games. The collaboration of laboratory for education and virtual reality must be develop for future education that make a simple, safety, and facilities in education. the collaboration of these can be call by virtual laboratory, that can used in android smartphone.

Digital electronics is an important skill that must be have by the student to face in industrial era 4.0. All of component in era 4.0 using a digital data for communication on machine and operator. Virtual laboratory for digital electronics practice need for student to improve their skill of digital electronics practice. Virtual laboratory for digital electronics can motivate student to do practice more over than using real laboratory.

Almarshoud [1] presented a kind of model of laboratories, the laboratories is a remote laboratory. Remote laboratory in electrical engineering has many type of laboratory, one of them is electronics laboratory. Remote laboratory provide the knowledge to the students with concepts and provide of technical skill by practice with more time by using remote laboratory. It's similarly by using virtual laboratory that can provide the skill of the student by practice with more time everywhere and every time. But on the other hand a real laboratories can provide student with design and problem solving skills and teamwork skills.

Mekonnen [2] describe a characteristic of management of laboratory must have a five goal that named is SMART. It's simple, measurable, achievable, relevant, time bound. Some of SMART characteristic is needed to develop the virtual laboratory because the management of laboratory can be improve the virtual laboratory quality. Quality of laboratories define as accuracy, reliability and timeliness of reported test results [3].

WHO [3] show the 12 quality system of management laboratory, its organization, personnel, equipment, purchasing and inventory, process control, information management, document and record, occurrence management, assessment, process improvement, customer service, facilities and safety. The 12 quality system can be used for virtual laboratory to know the quality as a laboratory.

Bureau [4] describe if every school must have safety management system of laboratory to monitor the standard of laboratory safety, to draw up and implement an emergency plan. Emergency plan including emergency measures, evacuation procedures and escape routes). Another function is conduct inspections and evacuation drills regularly in school. Example for safety management in laboratory is standing committee on laboratory safety, subject panel meetings, laboratory rules, lesson on laboratory safety, safety with experiments, students medical history, laboratory safety inspection, using a science laboratory for purpose of teaching non-science lesson, laboratory safety information/resources, emergency plan. There is need role of teacher technician and student to make laboratory safer [14]. Safety in laboratory very important for student [13].

Persson et al [5] and [12] presented about mobile technology that used for mobile learning. Mobile learning concept has five principal characteristics. It is probability, accessibility, personalized, social connectivity, and increases learning motivation. The characteristic is similar to characteristic for virtual laboratory, because it mobile based using virtual reality.

Zhang et al [6] describe Virtual Reality(VR) is defined as a computer-generated simulation of a 3D environment that users can interact with in a seemingly real or physical way using special electronics equipment, such as a helmet with a screen inside or gloves fitted with sensors. VR is be-coming increasingly popular and it is now widely used in research, education, and training. There are several important categories of VR, including desktop VR, immersive VR, distributed VR and augmented VR. Mobile VR can be a part of categories of VR.

Odeh et al [7] presented a student perception by using virtual laboratory. It is easy to use, easy to understand the concept theory, available for enough time, satisfying the knowledge theory, safety environment, progress new skill, teamwork is encouraged, comfortable physical place, and have much time experimental time.

Lixia et al [8] describe virtual laboratory using virtual reality must possess the following characteristic: 1) physical characteristic of virtual laboratory apparatus must be consistent with laboratory apparatus in real world, as well as the chemical characteristic. 2) Stronger interactive ability. 3) Ability to feedback in real time. 4) Cooperation environment. 5) Virtual scene is similar to true environment. 6) Virtual scene is the can be changed according to needs of user, such as lessen=, magnify, and roaming.

Jaya [9] show the benefit by using virtual laboratory is virtual environment more efficient in budget than physical environment, virtual environment safer than physical environment, interaction in virtual give better experience that can't be get in physical environment, practice on virtual environment can be develop than physical environment, education concept get from experience in virtual. Another benefit is virtual laboratories have the potential to increase pre-laboratory preparation to ensure more confident students and potentially improve progression of the conducted laboratory exercise [10].

Ogungbenro et al [11] describe benefits of using emulator in digital electronics: 1) in emulator system the original look, feel, and behavior of the digital object is maintained, which is just important as the digital data itself. 2) Despite the initial high cost of production of an emulator. 3) Reduce labor hours. 4) Many emulator have already been developed. 5) Emulator allow software exclusive to one system to be used on another. 6) The need for physical component is eradicated thereby reducing cost and experimentation time. 7) Most emulators have large data memory which enhances availability of many emulated electronics component.

2. Research Method

This study use research and development method. In the implementation it is use waterfall model by pressman. It have 5 stage, which is communication, planing, modeling, construction, deployment. Communication stage was done with observation on school and take an interview to teacher, planing was done by provide VR controller and VR box and another equipment for virtual laboratory, modeling is design the model of virtual laboratory from observation in real laboratory, constructing make the program for virtual laboratory so it can be improve skill of the student, deployment is give the virtual laboratory to the teacher to test the skill improvement of student on digital electronics competence.
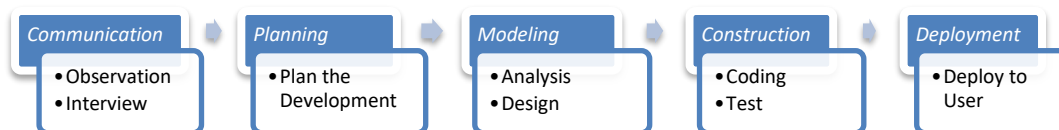
Communication	Planning	Modeling	Construction	Deployment
• Observation • Interview	• Plan the Development	• Analysis • Design	• Coding • Test	• Deploy to User

Figure 1. Diagram Model *Waterfall*
(source: Pressman. 2010:46)

3. The Result and Analysis Prepare

3.1 Communication

This study conducted the communication with 3 school that have digital electronics course for their student. Communication is doing by observation and interview with the teacher. The results is there is no one school that have a laboratory for digital electronics course. But they have a media for digital electronics. The place to do practice is using the general laboratory that can be used by another course. The situation of laboratory and media that their used in one of that school can be sen at Fig. 2 and Fig. 3

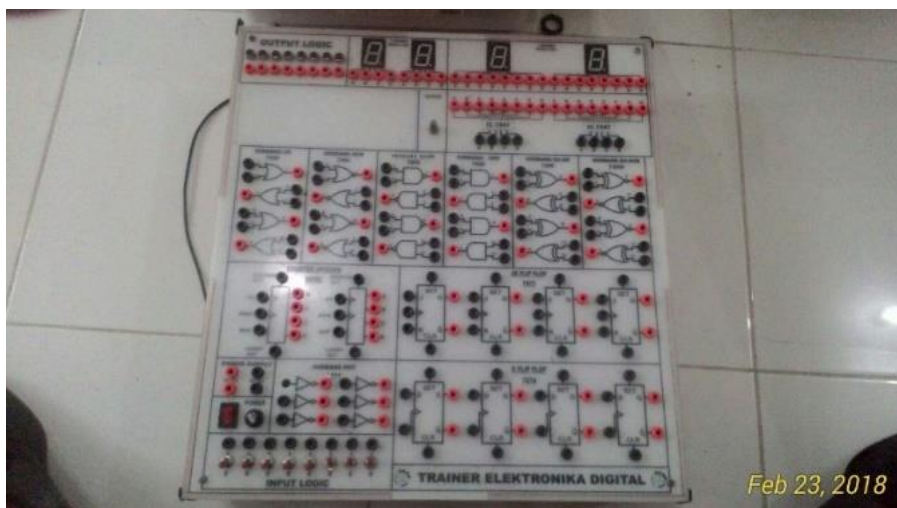**Figure 2.** Situation of laboratory in school

Figure 3. Media trainer that used for practice in laboratory

From the interview can choose the best design of virtual laboratory that can be similar to real laboratory. The media trainer can be put on the virtual laboratory so it can use by student to improve the skill on digital electronics just like in real media. Interview with teacher result if many of the student have the smartphone and can be use when in school and student never use the smartphone for the education.

3.2 Planning
On the planning stage this study conduct the preparation for develop the virtual laboratory. First set up the equipment to program the virtual laboratory and prepare the utilities to use the virtual reality, which is VR box, and VR controller. The program to develop virtual laboratory is using unity, design 3D using blender and Program script is using C# language. The VR box and VR controller that be used for virtual reality can be seen on Fig. 4.

Figure 4. VR box and VR controller

3.2.1 Modeling. This stage conduct a design for every material for virtual laboratory, the design is make by blender application. The model of blender is convert to unity to give a color place to virtual laboratory. The model created as similar as posible to real object. The model of object can be seen on Fig. 5.
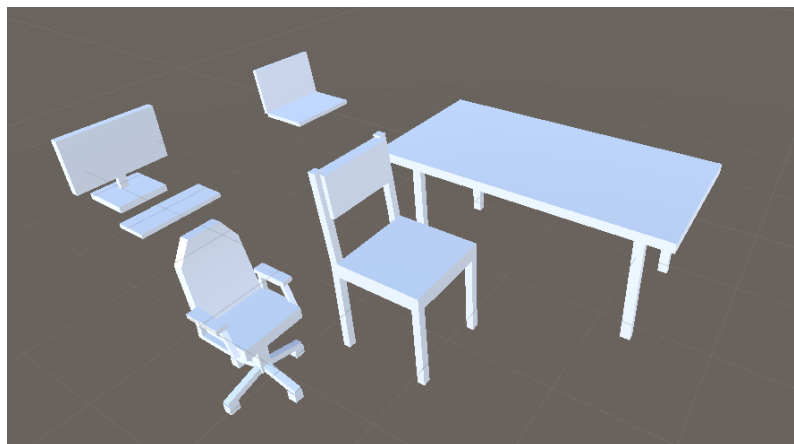

Figure 5. Model of object for virtual reality

3.2.2 Construction. On construction stage, this study conduct the design to make as real as possible in some aspect. Characteristic of virtual object created same like real object. Construction object include coding and testing the application. Coding is using visual studio with C# and for testing is using unity. For construction of the virtual laboratory first to do is compile the model to a virtual laboratory. The result of virtual laboratory can be seen on Fig. 6.
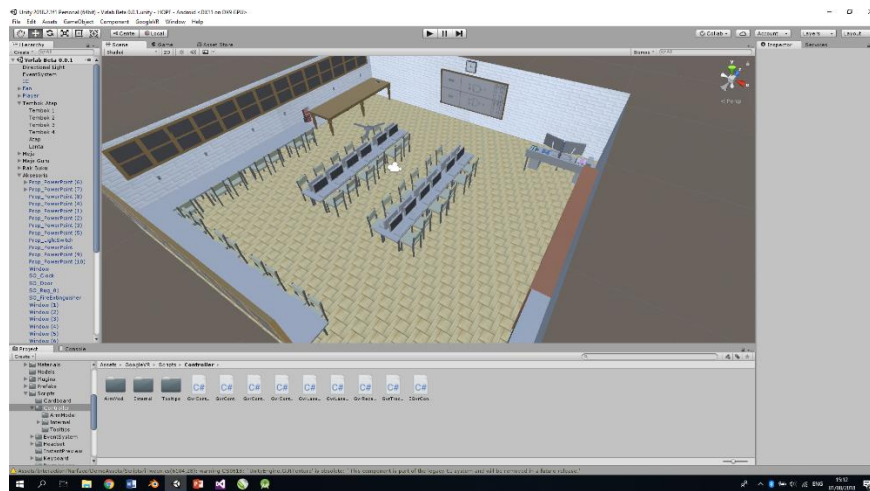
Figure 6. Combiling model to be a virtual laboratory

The second stage is making a program to make main character can move around the virtual laboratory. The program is make with visual studio. After coding, the main character can move around the virtual laboratory using VR controller. On this stage, program that make main character move around and do anythink as posible without broken the object on the virtual laboratory. The coding can be seen on Fig. 7.
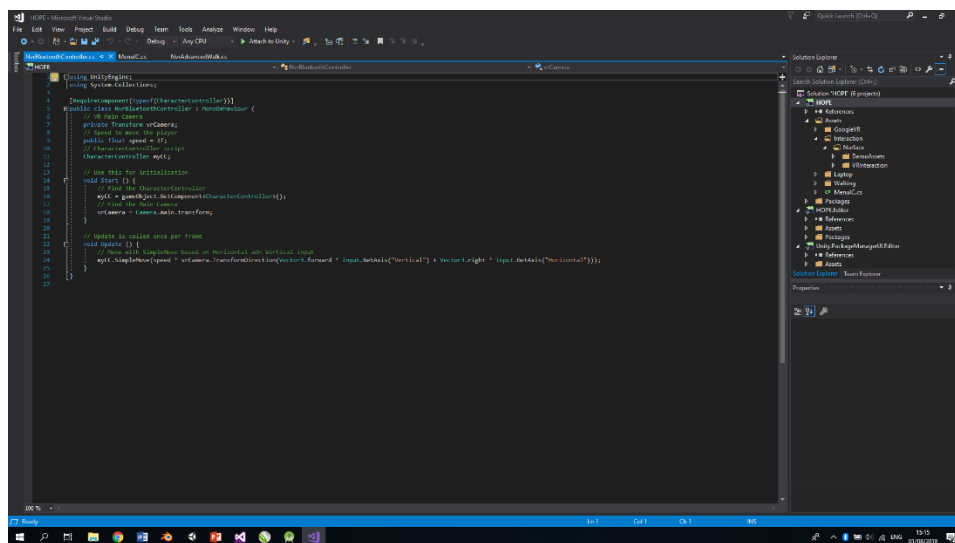

Figure 7. Coding program visual studio

The last after coding and compile the program and coding the virtual laboratory test on unity to ensure the program work corerctly. The test to know the problem of the program and check the situation on virtual laboratory. The test program that show the main character can move around the virtual laboratory can be seen on Fig. 8, Fig. 9, and Fig. 10.

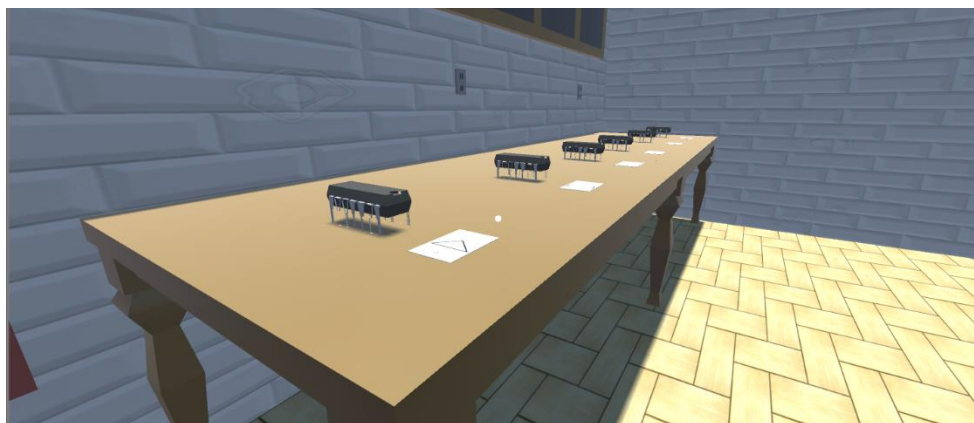**Figure 8.** View of Virtual Laboratory from behind of class

Figure 9. View of Virtual Laboratory on the practice table

Figure 10. View of Virtual Laboratory from front of class

3.2.3 Deployment. The last deploy on the student that have digital electronics course and measure the skill improvement of the student with virtual laboratory. The application must be installed on student phone and student can use the virtual laboratory. The smartphone require at least android OS 5.0. The smartphone also must be support on VR like sensor gyroscopes and accelerometers. The installed virtual reality on android can be seen on Fig. 11.

Figure 11. Virtual laboratory installed oh android smartphone

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4. Conclusion

The design virtual laboratory of digital electronics using a virtual reality technology that can make user to feel the virtual like the real laboratory. Virtual laboratory can used by the student every time everywhere and it can improve skill of student for digital electronics competence. Virtual laboratory digital electronics have a media that can used by student to practice like in real laboratory. The design of virtual laboratory created as similar as possible to real laboratory. It is because the virtual reality technology that used on virtual laboratory so the object on virtual laboratory can be similar to real object.

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