Development of Interactive Virtual Laboratory Media with Tinkercad Platform on Analog Electronics Material

Anik Nur Handayani 1*, Salsabila Sonia Nafista 1, Arya Kusumawardana 1, Hakkun Elmunsyah1, Kohei Ara1, Rosa Andrie Asmara3
1Department of Electrical Engineering and Informatics, Universitas Negeri Malang, Malang, Indonesia
2Information Science Saga University Saga, Japan
3Information Technology Politeknik Negeri Malang, Malang, Indonesia

Abstract. The development of science and technology has experienced rapid progress which has a significant impact on people's lives. One of the affected fields is education, where the utilization of science and technology can strengthen the learning process. In this context, the development of the right strategy and the use of supporting components are very effective. This research aims to analyze and develop the needs of teaching materials in the subject of Fundamentals of Electronic Engineering, focusing on Analog Electronics material. The method used is the development of teaching materials in the form of V-Lab-based jobsheets using the tinkercad website platform, as well as the preparation of guidebooks for teachers and students of Mechatronics Engineering in the subject of Basics of Electronics Engineering, especially on Analog Electronics material. Furthermore, the feasibility of V-Lab-based teaching materials using the Tinkercad website platform was tested. The results show that the use of the Tinkercad platform makes it easy to simulate electronic circuits without the need to install additional software. This platform helps students in better understanding the analog electronics material, as it can be accessed flexibly. Based on these findings, it can be concluded that the development of V-Lab-based teaching materials through the Tinkercad platform has great potential in improving the quality of analog electronics learning.

1 Introduction

Vocational High Schools focus on specific vocational fields with the aim of producing a technical workforce that suits the needs of industry. Learning in SMK involves theory and practice as an implementation of the theoretical material that has been studied previously. Teaching materials are an integral part of the learning process in SMK. If teaching materials are developed as needed and used properly, it can improve the quality of learning and education, one of which is the practicum process.

* Corresponding author: aniknur.ft@um.ac.id
Practicum conducted by students is generally limited to space and time at school to limit student understanding. This limited practicum learning can utilize technology, one of which is Virtual Lab (V-Lab). V-Lab is a computer program that allows students to interact with experiments using computers through a computer network [1]. Learning with V-Lab can significantly affect students' ability in learning outcomes with better improvement and can increase confidence and knowledge [2][3]. V-Lab helps students to do online practicum anytime and anywhere [4].

V-Lab is available in several applications, such as Proteus and Multism, which require software to be installed on the computer. However, the use of this software has the disadvantage that the teacher cannot verify whether the work collected is the student's own work or not, therefore a platform is needed that can guarantee the authenticity of student work. One platform that supports online circuit simulation is the Tinkercad website. The advantage of Tinkercad is that users can access it without the need to install it, and the work done on the site will be automatically saved. Students can also collaborate and discuss in making simulations and can be involved in classes created by teachers in Tinkercad [5]. The Tinkercad platform has enough components to provide adequate functionality in electronics subject activities [6].

This study aims to analyze and develop the needs of teaching materials in the subject of Fundamentals of Electronic Engineering, focusing on Analog Electronics material. The development of teaching materials in the form of guidebooks and V-Lab-based practicum jobsheets using the Tinkercad website platform. Guidebooks are a complete source of information and instructions, for readers [7]. Meanwhile, jobsheet is one of the teaching materials that can be used in practicum learning, so that it can help improve student memory and understanding [8]. Jobsheets are used in practicum activities to facilitate students in doing certain practicum activities [9]. The use of jobsheets can affect students' independence, which can be seen from their behavior during practice. Student independence includes being confident, responsible, highly motivated, and not dependent on others [10].

2. Research methodology

The media design and development stage in this study consists of five main stages, namely (1) identification of learning activities, (2) determination of important tasks, (3) development of learning media (4) implement teaching materials and (5) evaluation of learning media. These stages are illustrated in Figure 1.

![Fig. 1. Stage of Development.](image-url)
2.1 Identification of Learning Activities

This stage is carried out by interviewing the material teacher and students. Identification is carried out in the Mechatronics Engineering department of SMK Negeri 4 Malang, especially classes X A and B. Learning in analog electronics material is mostly done by practicum. The need for tools and components in practicum is the main thing for the continuity of these activities. The condition that occurs is that tools and components are limited, so students are often required to buy components first. The limited number of tools makes students have to take turns to use the tool. So far, practicum activities have not utilized virtual laboratories to support practicum learning. The majority of students know some virtual laboratories, constrained by information on how to work or the menu presented in the virtual laboratory. Identification of the learning process is also carried out including the material taught in the form of current and voltage gain on transistors, in addition to identifying learning facilities including whiteboards, projectors, and wifi available in the class or laboratory used. Based on the analysis conducted on learning activities, this development has the potential to develop media that will function as teaching materials, namely analog electronics material jobsheets and virtual laboratory guidebooks as supporting platforms.

2.2 Determination of Important Tasks

Important tasks carried out in this development include determining learning outcomes, designing the framework of teaching materials and determining design needs in teaching materials. Important tasks that have been determined will be implemented to produce development products. The learning outcomes used are adjusted to the learning outcomes that have been determined at school. The Analog Electronics material jobsheet will contain three practicums.

2.3 Develop of Learning Media

At this stage, the important task produced is the learning outcome used in the Analog Electronics material jobsheet is to calculate and measure the current and voltage gain on the transistor. The Analog Electronics material jobsheet contains three practicums, namely (1) Jobsheet 1 Transistor as Common Base Amplifier, (2) Jobsheet 2 Transistor as Common Collector Amplifier, and (3) Jobsheet 3 Transistor as Common Emitter Amplifier. The structure of the jobsheet consists of an outer cover, inner cover, preface, table of contents, introduction and contents of the jobsheet with the three practicums. Each practicum has a section consisting of media development objectives, theoretical basis, tools and materials, experimental steps, simulation results, analysis, conclusions and a list of references. In addition, a virtual laboratory guidebook was also developed which consisted of an outer cover, inner cover, preface, table of contents, list of images, and Tinkercad website guide. This development also includes design including guidebook cover design, jobsheet cover design, page background which can be seen in Figure 2, Figure 3 and Figure 4 respectively. The V-Lab Tinkercad website was chosen as a supporting platform for the teaching materials to be developed. Autodesk Tinkercad is a free web application that can be used for 3D design, electronics, and coding. Tinkercad is suitable for use in electronic learning. Simulation on the website is easier because users only need an internet connection without installing the application first before using and can be used on devices with low specifications. The feature in Tinkercad also offers classes that can be monitored and directed by teachers, but in this feature teachers can only see simulation results from students without providing material. Teachers can connect Tinkercad with a learning platform such as Google Classroom to provide material to students. Tinkercad has the advantage that there are two ways to access...
the website, namely access using an email account and an invitation that has been distributed by the teacher to students.

**Fig. 2.** Guidebook Cover Design.

**Fig. 3.** Jobsheet Cover Design.

**Fig. 4.** Page Background Design.
2.4 Implement Teaching Material

Implementation of teaching materials on 66 Mechatronics Engineering students of SMK Negeri 4 Malang Batch 2022. Teaching materials have been validated by material experts and media experts, as well as small group tests and large group trials. The trial was conducted on all students of class X/A and X/B of Mechatronics Engineering of SMK Negeri 4 Malang Batch 2022 with a number less than 100 [11]. Coordination with teachers and students is carried out before implementation smoothly and does not interfere with learning time.

2.5 Evaluation of Learning Media

The evaluation stage has been carried out at each stage before moving on to the next stage. This evaluation is carried out with the aim of assessing the quality of the product being developed. The evaluation stage here is in the form of internal and external evaluation [12]. The first thing to do is determine the criteria for evaluation. This stage is limited to the second level of evaluation, to determine perceptions of the product that has been developed and test its feasibility among experts and students. The second thing to do at this stage is selecting the tools used during the evaluation. This research and development uses a tool in the form of a closed questionnaire by providing answers to make data processing easier and easier for respondents to answer questions in the questionnaire. The questionnaire also provides a blank column that respondents can fill in with criticism and suggestions. The questionnaire was given to material experts, media experts, and students. The determined evaluation criteria and tools are continued with the third thing, namely the implementation of the evaluation. Internal evaluation (another term for formative evaluation) is carried out to determine the quality of the product before it is implemented, while external evaluation (another term for summative evaluation) is carried out so that the resulting product has high validity so that no improvements are needed and is suitable for use.

3. Equations and Mathematics

3.1 Material Expert Validation

Material expert validation is carried out by two experts by filling out a validation sheet until the product is declared valid [15]. Material expert one is a lecturer in Electrical Engineering and Informatics, Faculty of Engineering, State University of Malang. Material expert two is a teacher of Analog Electronics material at SMK Negeri 4 Malang. Material expert validation is carried out on the tinkercad website guidebook, teacher jobsheets and student jobshee. The guidebook validation received a percentage of 96.88% by material expert one and 94.79% by material expert two, based on this percentage, it is included in the very valid criteria. The teacher's jobsheet received a percentage of 100.00% by material expert one and 99.31% by material expert two with very valid criteria. The last validation was carried out on the student's jobsheet getting a percentage of 96.53% by material expert one and 97.22% by material expert two.

3.2 Media Expert Validation

Media expert validation was carried out by two experts. Media expert one is a lecturer in Electrical Engineering and Informatics, Faculty of Engineering, State University of Malang. Media expert two is one at SMK Negeri 4 Malang. Media expert validation is carried out on the tinkercad website guidebook, Analog Electronics material jobsheet, and tinkercad website to determine the suitability of the platform for use in practicum. Guidebook
validation received a percentage of 87.50% by media expert one, while media expert two received a percentage of 100.00% with very valid criteria. Jobsheet received a percentage of 94.05% by media expert one and 96.81% by media expert two. The last validation on the tinkercad website is to determine the level of suitability if used for practicum of Analog electronics material. On media experts one get a percentage of 96.88% and 100.00% by media experts two so that from these percentages the tinkercad website is suitable for practicum.

3.3 Small Group Test

The small group test was conducted on class X A and B students of Mechatronics Engineering of SMK Negeri 4 Malang as many as 10 students who were determined by random sampling technique. The simple random sampling technique was chosen so that the subjects or respondents in this study had the same opportunity [13]. The results of the small group test on the guidebook received a feasibility value of 89.64% with very valid criteria, while the results of the small group test on the jobsheet received a feasibility value of 90.11% with a very valid description. The small group test also measures the level of the supporting platform used in analog electronics practicum whether the product is suitable for analog electronics practicum. The tinkercad website as a supporting platform in analog electronics practicum has a percentage of 90.00% with a very valid statement or appropriate if used in these teaching materials for practicum Analog Electronics material.

3.4 Large Group Test

The large group test was conducted on 56 students of class X A and B of Mechatronics Engineering of SMK Negeri 4 Malang. The large group test conducted at the implementation stage is to measure the feasibility of the teaching materials developed to see the response of students regarding the teaching materials [14]. The results of the large group test on the guidebook obtained a feasibility value of 90.45% with very valid criteria presented in Table 3.21, while the feasibility value on the jobsheet obtained a feasibility value of 90.74% with very valid criteria. The large group test at the implementation stage also measures the level of the supporting platform used in analog electronics practicum whether the product is suitable for analog electronics practicum. The tinkercad website as a supporting platform in analog electronics practicum has a percentage of 91.18% with a very valid description.

4. Conclusion

Based on the results of the research conducted, the teaching materials can be used in online and offline learning. The tinkercad website can be used to support offline practicum as a simulation platform before doing practicum with real tools and components. Students can use the platform without having to download or install the platform. The tinkercad website makes it easier for teachers and students to interact, and teachers can find out the authenticity of the practicum carried out by students. Overall, the development of this teaching material has great potential to improve the quality of analog electronics practicum learning. For future research, teaching materials for analog electronics practicum can be integrated with the Learning Management System (LMS) used by schools. Research can be conducted to identify the impact of this integration on learning efficiency, student participation and interaction between students and student and teacher interaction.
Acknowledgements

The author would like to express his deepest appreciation to the State University of Malang, Indonesia, which has supported this research.

References


