Utilizing Virtual Laboratory to Improve CNC Distance Learning of Vocational Students at Higher Education

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Abstract – **This research develops learning materials for Computer Numerical Control (CNC) programming courses based on virtual reality technology. The impact of the Covid-19 pandemic on social activities, one of which is the educational aspect, has changed the learning pattern to a massive one where the learning process that should be carried out face-to-face, but now must carry out distance learning. Therefore, alternative learning media is needed to support the practicum process from a distance by utilizing virtual reality technology that is simulated using digital devices. The Software engineering models, namely: requirements, design, implementation, verification, and maintenance phases are the five primary stages used in this study, which uses the waterfall development model research method. The feasible of the virtual laboratory obtained the results of material validation, learning media, and small group trials of 12 diploma students of Mechanical Engineering at Universitas Negeri Padang. The findings of the study found that small group trials in CNC virtual laboratory can be successfully utilized in CNC programming courses. This research is expected to have implications for improving learning outcomes in CNC programming courses by using virtual laboratory technology in creating a conducive and quality learning atmosphere, so that the learning material provided can be accepted by students.**

1. Introduction

The past few decade have seen a rapid increase in the development of computers, laptops, cellphones and internet networks. The development in the communication sector changes the way people interact with each other and impacts various aspects of societies all around the world, including Indonesia. The digital devices have made communication and information sharing in a borderless society, which has an impact on people's psychological well-being in terms of their needs for survival and their attachment to technology [1], [2] [3]. The corona virus that emerged at the end of 2019 in Wuhan, China came as a shock to many nations, including Indonesia. Due to the risk and high contagiousness of the Covid-19 virus, people's lifestyles were altered. Social interaction that had previously taken place during work from office hours is now prohibited by the implementation of work-from-home [4], [5]. To assist and aid the community in carrying out social activities, many digital gadgets that are connected to a worldwide network via the use of internet technology are required in the work-from-home situation.

The Covid-19 pandemic has had a profound impact on social activities, including those in the field of education, changing learning patterns in such a way that distance learning using online learning resources is now required to carry out the learning process, which was previously carried out face-to-face [6], [7]. When conducting lectures, educators must use a synchronous learning technique in which both students and lecturers are online at the same time and location. This is done with the aid of digital devices [8],[9]. When teachers and students interact in a learning environment at the same time through video conferences or chat, this is called synchronous learning [10].

This is also closely tied to how quickly science and technology are developing (Science and Technology). Higher education in the vocational field contributes significantly to the production of qualified graduates who satisfy the requirements to take on the issues the Indonesian country faces. This is because vocational programs tend to emphasize practical rather than theoretical courses [11], [12]. Practical learning during a pandemic that cannot be done offline is implemented through vocational education [13], [14]. Only technology and engineering study programs have an essential competency requirement that cannot be met: using and operating tools or machines that are highly intricate and difficult to manage. Because many students found it difficult to fully comprehend the material if they could not directly see the form of the equipment or machines owned by the laboratory, laboratories and workshops that were converted into student lecture facilities during the Covid-19 pandemic were almost never implemented.

Ways for forecasting workpiece cutting in a virtual environment to increase accuracy while using a 5 Axis CNC machine [15] reviews prior research on the development of CNC. The use of sophisticated CAM technology in CNC-based collaborative virtual reality as an alternative to traditional methods of optimization is explored in study [16]. A research report claims that the corrective measures taken on CNC parameters throughout the planning process utilizing virtual technology lead to accurate planning machine tools with accurately improved parameter convergence [17]. The deployment of a virtual laboratory-based teaching and learning procedure for learning CNC programming in Indonesia was not discovered through study in the literature [18], [19]. The researcher plans to conduct a survey of the growth of CNC programming learning in many parts of the manufacturing business based on several similar research references. The researchers also recognize an opportunity to develop CNC programming in distance learning as it is an area that has not been researched much yet.By providing students with infrastructure facilities, it is anticipated that the indirect benefits of creative, innovative, and interactive learning processes will increase students' competence. For example, using virtual laboratories to teach CNC programming instead of remotely is expected to build a sustainable learning environment, foster students' professional competence, and improve education [20], [21]. In light of this, the study concentrates on the introduction of tools, machine tool components, and systems in CNC programming until the cognitive level of students is achieved in learning with user-friendly virtual reality technology simulations that can initially simulate the automatic operation of CNC machines. Users can engage indirectly in moving virtual spaces in both

theoretical and actual cyberspace. Alternative learning media are thus necessary to support practicum classes remotely via virtual reality technology, specifically tools or media that allow users to engage with the environment in a virtual world reproduced by digital equipment to create the sense that they are in that area [22], [23]. The study's purpose is to discover a way for virtual student practicum activities that can improve an individual's internal cognitive, emotional, and psychomotor capacities. The most crucial element in research activities, experiments, and scientific test observations is the virtual laboratory as a location for scientific application, theory testing, and research trials that require suitable equipment and complete infrastructure.

2. Thinking Framework

This study aims to boost the originality and efficiency of these materials. Based on previous research, the development of this learning medium uses virtual reality technology to produce the features and operations of the virtual laboratory, which has improved the standard of learning CNC programming.The roadmap and mechanism of this research are:
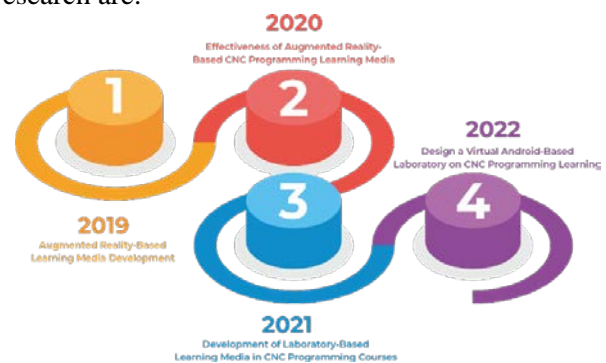

Figure 1. Committee Roadmap

2.1. Computer Numerical Control

Manufacturing-related technological advancements are expanding quickly and making substantial progress. It is impossible to separate the growth of product planning from the requirement for technology, which ranges from increasingly complex automation systems to using supercomputer technology to operate machines that include lathes, milling machines, drilling machines, and other machine tools. A CNC (Computer Numerically Controlled) machine is a machine that combines computer technology and mechanical technology. CNC machines have operating systems and software that are directly controlled by computers [24]. In general, there is better synchronization between the mechanics and the laptop during the construction of CNC machine tools and their work systems [25].

In this way, CNC machines are superior to traditional machine tools of the same or similar type in terms of precision, flexibility, and suitability for mass production. A machine that is controlled by a computer utilizing a numerical language (movement commands using coded numbers and letters) is known as Computer Numerically-Controlled [26].

Enhancing hands-on learning and helping students understand, CNC machine learning leverages the computer numerical control language used in computerized control manufacturing processes and machine tools [27]. A big and powerful mill-turn machine that has been created for use in virtual reality simulations of 3D programs and object processing has been used in a variety of industrial settings [28]. It is anticipated that the developed interactive CNC machine media will be able to present an environment that displays virtual machines and can display simulations of CNC machine movement head-mounted tools virtual reality CNC machines developed for real-time display. The designed interactive CNC machine media will be tested in universities in advance [29]. These findings demonstrate that users may view a colossal milling machine in 3D.

2.2. Virtual Laboratory

The software allows users to conduct experiments on a variety of electronic devices, integrating text, sound, images, video, and animation to simulate in-person interactions and other activities. It runs on personal computers and is used to conduct experiments on a variety of electronic devices. The VSM (Visual Simulation Model) program, which handles the critical variables of merging simulations of an experimental process that may be used in learning, is the cutting-edge virtual laboratory component [30], [31]. The use of a virtual laboratory as a practical teaching tool for comprehending experiments can enhance student learning opportunities promoting literacy, increase competence, and enrich the curriculum as well as make activities [32], [33]. Virtual laboratories may reach a large number of individuals in many different locations and are generally more straightforward and more uncomplicated to use than conventional laboratories, where the process is carried out offline [34]. Using a virtual laboratory to learn can connect theory and practice, turn passive learning into active learning, and inspire higher-order thinking in pupils.

Virtual reality works by enabling the user to see various objects in the virtual world, which are visual images produced by computer simulations [35]. Users can then interact with the virtual world and receive feedback as if it were real, both physically and verbally, using this tool in the form of VR

glasses fiction and physics [36]. One of the benefits of VR is that it can connect users to the virtual world by speeding up complex tasks that take a long time and making them easy to use various technological features. This VR box, which is where a smartphone works to show virtual visuals in real-time, is generally shaped like diving goggles but has closed lenses instead of open lenses of diving goggles [37]. Advanced VR headsets, like the Oculus Rift, don't require cellphones inside; instead, they contain a screen that shows virtual reality films and images and can be connected to a computer via Bluetooth.

The purpose of learning to use a virtual laboratory is to increase scientific literacy using interactive multimedia that teaches the working principles of CNC machines in general and to share resources owned by students via the internet. In one of the studies on virtual laboratories in the field of chemical engineering studies, as many as 93% of respondents considered virtual laboratories to have many uses [38]. Its use gives users the freedom to use media as an effort to develop knowledge for students, lecturers, and other people with a virtual laboratory [39]. The use of virtual laboratories is also conveyed by Achmad Buchori [40], that is, (a) it can be used at any time and anywhere, (b) it encourages students to conduct more experiments despite time constraints, complexity, and the possibility of injury, (c) it boosts students' interest in learning through interaction, (d) it improves their proficiency with IT, (e) it helps them better apply what they have learned in class, and (f) it saves money.

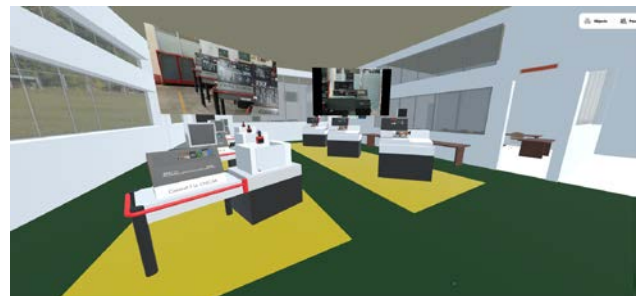*Figure 2. Virtual Laboratory*

3. Methods

The research method used is the Software Development Life Cycle (SDLC) model. The Waterfall method is the oldest software development method because of its natural nature.

3.1. Research Design

According to [41], the primary stages of the waterfall development technique include requirements analysis, design, implementation, verification, and maintenance.

Figure 3. Waterfall Model

3.2. Research Procedure

To construct a virtual laboratory, the Waterfall model was chosen as a method and a guide. The development process consists of 5 steps, as shown in Figure 3. With the appropriate, methodical software engineering preparation stages, namely:

Need analysis is a stage in problem identification, one of which is the analysis of the infrastructure for learning, the motivation of students to learn, and the competencies and abilities that need to be acquired. To later use it as an evaluation for the next stage of development, the needs analysis process focuses on designing a system that will be developed and implemented for students using virtual laboratory of CNC technology. The aim of this system is to encourage users to interact virtually with the requirements checking system required by them.

After conducting a needs analysis, the design stage is used to create the learning materials that will be used. It describes the User Interface design flow from start to finish, its structure, theoretical underpinnings, applications utilized, and the focused material, as well as the kind of technology that will be used for those who will be directly involved in the learning process. The various design processes are as follows: 1) creating a storyboard utilizing the Exploratory Tutorial method that incorporates content from the relevant syllabus organized to create a good application flow/scheme that is simple to use, 2) creating 3D things such as CNC machines, machine tools, platforms, etc. using the Spoke by Mozilla application. These assets are designed once storyboards are constructed.

The implementation stage involves instructional media and programming system that are used to create a faster and more efficient learning. So that the virtual laboratory development stage can be completed by the functions that have been made based on needs, the design that has been successfully designed from a computer can then build a CNC virtual laboratory application based on the blueprint design that has been successfully developed.

When sending virtual laboratory CNC programs to users, it is vital to evaluate every feature to prevent system failures. The anticipated outcomes are in line with the needs of the people who were targeted at the outset of the design. After the CNC virtual laboratory design phase is complete, tests using the black box methodology must be carried out by researchers to ascertain the success rate of system development. Additionally, each CNC Programming lesson at Mechanical Engineering Department, Faculty of Engineering, Universitas Negeri Padang involves testing actual students.

The virtual laboratory CNC application's maintenance phase serves as a regular check to ensure that the program can genuinely run as intended. Periodic maintenance is required to fix any defective application functions that are discovered throughout the maintenance process, as well as to add any missing functionality to the virtual laboratory CNC program.

Validation testing is carried out in obtaining validity data from the virtual learning media CNC laboratory with the initial step of preparation of the material validation test seeing aspects of learning design, material coverage, usefulness, and media validation testing looking at the media display aspects, ease of navigation, overall function, as well as the revision of virtual learning media CNC laboratory based on comments and advice given by the validator. Both media and material specialists will examine the product to ensure it meets the required standard in the validation process. The instrument utilized in the validation test was a validation sheet that was filled out by three different experts. Small group trial is carried out using virtual learning media CNC laboratory that has been revised based on comments and suggestions of validators with research subjects of 12 students of the Mechanical Engineering Diploma at Universitas Negeri Padang who follow CNC programming classes. Effectiveness tests are not discussed in this paper.

3.3. Research Instruments Data

The following data-gathering methods were employed by the study's instruments: 1) questionnaires for material assessment that include responses or material assessment components following the CNC Programming syllabus, 2) product validation questionnaires derived from expert replies on the usefulness of linguistic rules, the composition of colors, and the appropriateness of learning objectives, as well interesting learning based on virtual laboratory, 3) Finally, a small group trial assessment questionnaire was created by consulting with knowledgeable professors in the subject of study to gauge how easy or challenging it was for them to use the CNC virtual laboratory.

3.4. Data Analysis Technique

Recognize examples of descriptions that have been used as references in research on the usefulness of CNC virtual laboratory learning tools. The following methods are taken to obtain the validation and small group trial results from a virtual laboratory learning media questionnaire with descriptive statistics: giving a score for each of five Likert-scaled responses, calculating each validator's total score by adding together all the scores from the specified indications, and calculating the eligibility value using the formula:

$$P = \frac{f}{N} \; x \; 100\%$$

Keterangan:
NA = Value Percentage
S = Frequency
M = Value Percentage

To determine the level of eligibility criteria based on the average percentage in the CNC virtual laboratory application measured according to Table 1. refers to data analysis [42].3

Table 1. Percentage of Feasibility Criteria

No	Percentage	Criteria
1	81% - 100%	Very Feasible
2	61% - 80%	Feasible
3	41% - 60%	Feasible Enough
4	21% - 40%	Not Feasible
5	0% - 20%	Very not Feasible

The revision step is carried out based on feedback and suggestions from validators, lecturers, and students after the last stage of maintenance review, the development of learning media is based on the findings of individual product trials, small group trials, and limited trials.

4. Result and Discussion

4.1. Result

This research will help the Universitas Negeri Padang Department of Mechanical Engineering develop instructional materials by utilizing digital virtual laboratory technology. The learning materials in the CNC (Computer Numerical Control) programming course are employed on a VR box, which is a place where a smartphone works to project virtual visuals in real time and is shaped like a pair of diving goggles with closed lenses. The virtual laboratory is created as software that can be accessed online and downloaded as files for Windows computers and virtual reality headsets.

The procedures in developing a virtual laboratory for CNC Programming courses, namely:

4.1.1. Requirement Phase

According to observations made by students at the Department of Mechanical Engineering Universitas Negeri Padang, learning in the CNC programming subject, in particular, is ineffective and less varied due to the distance learning model. As a result, the majority of students encounter challenges when trying to understand information both theoretically and practically during lectures. There is a need for learning media as a support for students in building a critical learning environment that is creative, innovative, and interactive that has an impact on graduate competencies, according to an interview survey conducted with lecturers supporting the CNC programming course. It was discovered that lectures using a remote implementation model made student competencies in classes not achieved according to graduate learning achievements which were set late.

The literature review on the achievement study of the Semester Learning Plan curriculum for the CNC programming course, the Department of Mechanical Engineering, Universitas Negeri Padang, with the subject matter of CNC TU-2A and CNC TU-3A study material with the leading achievement indicators is as follows: a) examines the fundamental application of CNC programming in operation numerically controlled machine tools with a computer (CNC machine), b) applying command codes in the manufacturing (milling). An overview of the CNC programming course, which teaches the fundamentals of operating CNC machines, including tool offsets, axis systems, reference points, linear interpolation using M and G codes, turning cycles, and milling cycles using sub-program input.

Based on system analysis at the CNC virtual laboratory created for the Spoke by Mozilla Hubs application, a web-based 3D editor application integrated with Sketchfab and Google Poly that enables simple import of 3D assets that have previously been designed using Javascript code layout arrangement. Spoke is a Virtual Reality support platform for Mozilla Mixed Reality. To create a CNC virtual laboratory simulation that enables users to engage in distance learning by interacting in the virtual CNC laboratory environment, starting from theoretical study rooms and interactive practical learning rooms, Mozilla will import assets created using the Blender application to build 3D layouts into Spoke real-time.

4.1.2. Design Phase

The design stage serves to build a system for developing the virtual laboratory for CNC programming courses with the concept of use case diagrams, functionality diagrams, system block diagrams, and techniques that have been designed as a way to test users to see the reality of the functions in the developed media.**Use Case Diagram.** The study below demonstrates how the system is presented to users to interpret interactions between users, lecturer, and students based on a needs analysis, as seen in the diagram:
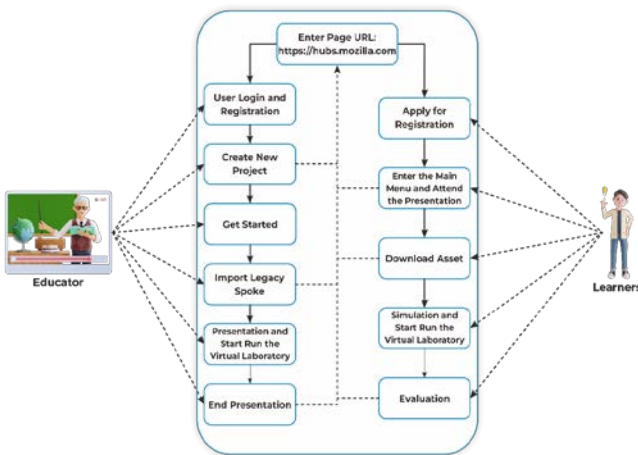

Figure 4. Use Case Diagram

System Block Diagram. The system block is designed to show the workflow of the virtual laboratory CNC systematically, the use of which is a group user that can be accessed using the VR Box and controller as the leading hardware in its operation in several steps, namely: 1) prepare the VR box and controller to make sure they function correctly. 2) the virtual reality box with a cellphone built-in is used to access the app. 3) use the device and enter the main menu section of the Spoke by Mozilla virtual laboratory CNC application to register a user account. 4) start the project and adjust the avatar used in room settings, and 5) users can enter the spawn point to be able to interact directly with the CNC Virtual Laboratory environment.

Based on the design that has been made on the virtual laboratory CNC media, it is divided into five functional modules [43], shown in Figure 5 below. 1) basic learning tools to provide an initial understanding to students with basic knowledge through teaching material modules in the form of images, text, and e-video, 2) system Main Menu simulation of the use of virtual laboratory CNC using 3D avatars which provide instructions for starting via the new menu project so that users can feel the existence of a virtual environment in virtual class theory and practice of CNC machines in the learning process in real-time, 3) virtual Platform allows students to enter the CNC virtual laboratory room while observing the learning environment through practicum videos and simulations of using tools and machines CNC in the laboratory and learning about K3 education through virtual posters when carrying out practicums, 4) use Guide when carrying out the learning process which can be downloaded on the Spoke by Mozilla virtual laboratory CNC plug-in connection as a relevant teaching and learning resource on the platform provided , 5) the uses of the platform may vary; users can enter the CNC virtual laboratory in groups using the VR Box and controller platform, allowing them to discuss and exchange ideas even during distance learning.
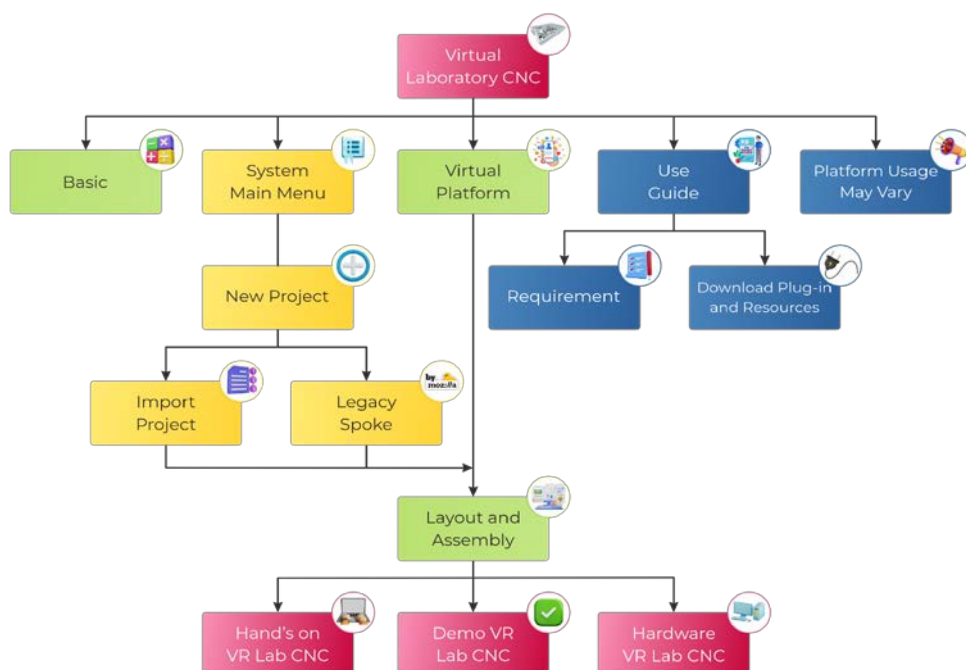

Figure 5. System Block Diagram

Functionality Diagram. In achieving the learning objectives, the functionality diagram shows the virtual laboratory function in the form of a simulation for supporting data in development, namely: a) design and structure of the CNC e-lab as a multifunctional online environment for theoretical and practical training, b) when the user entering the spawn point, there will be a 3D avatar that can be used by lecturers and students in real-time, c) simulation and start running which contains 3D asset attributes such as lathes, milling machines, TU-2A CNC machines, etc., d) features communicate in real-time which can be done in the main room virtual laboratory.
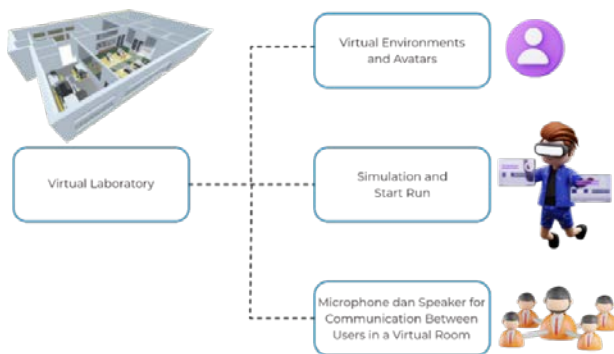

Figure 6. Functionality Diagram

4.1.3. Implementation Phase

This is the implementation phase of creating virtual laboratory learning media for CNC programming courses.: The virtual laboratory is created in the form of an application that runs on Android devices running at least Android 6.0 (Marshmallow) and is based on the VR Box and controller. The 3D environment is initially set up in the form of lathes, milling machines, TU-3A CNC machines, long tables, short tables, seats, blackboards, and virtual laboratory rooms that are adjusted to the coordinates of the positions of other virtual items when building the system. Classrooms for CNC programming courses which have a variety of components and machines available, are designed using the Blended application, which is designed with similarity based on the CNC Laboratory of the Department of Mechanical Engineering, Universitas Negeri Padang, which aims to facilitate interaction and user access with the objects provided.
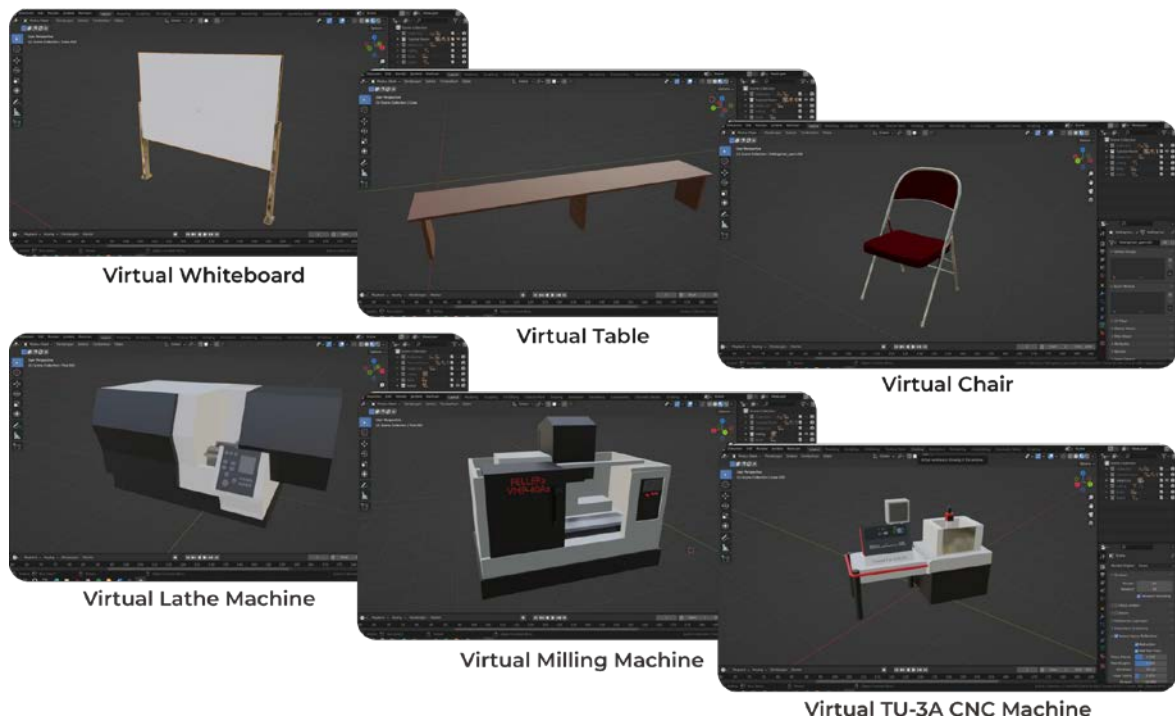

Figure 7. Assets 3D Tools Object and Virtual Machines

Steps to Import the Metaverse Project to Spoke: 1) at this stage, the user will be directed to open the URL page: https://hubs.mozilla.com/, which can be searched using the search menu on Google, which later the user will enter on the Spoke page for registration and login account, 2) after entering the spoke page, log in using email to be able to enter the main menu on the Spoke page to be able to create a new project, 3) enter your email address and then press the "Send Magic Link" button. Open a Gmail account to determine if the verification email has been issued. If it has, click on the link.

After clicking the link, the user will be directed to the verification page. 4) after successfully logging in, creating a room can be started. To initiate a new project tailored to your requirements, click on the "Get Started" button.5) Add a new project by clicking "New Project" Button. Spoke has provided several rooms that can be used. Because we already have a room that has been created, click new empty project. 6) here's what the default project looks like. Import the created project by clicking "File" → "Import legacy spoke". 7) select the Spoke file. After successfully importing, do not forget to click "Publish to Hubs" so the room can be used.

The previous action leads to the Virtual Lab Layout Interface display. The subsequent steps are as follows: a) After the assets are imported from blender and uploaded, they are arranged in the layout that was created in the Spoke by Mozilla application, arranged according to the actual layout in the CNC Laboratory. b) Before testing, the Spoke application

by Mozilla must be published or granted public access so that the virtual laboratory can be used on the user's accessing server. The trick is to press the "Publish to Hubs" button in the image below. You will receive a request to change the screen name and add your attribution, and finally, press the "Allowremixing" button. c) After the assets and virtual laboratory layouts are published, the user can do a test by pressing the "Open" button in the hubs. The user will be directed to a new window. d) To start the simulation, the user can press the "Create a room with this scene" button, then the display will change to enter the main menu. e) Click on "Join Room" button by clicking the "Enter room" button. f) Here is the presentation of the spawn point that has been set to be used by the user to try to start the application with black box testing to see the functionality of the application that has been designed.
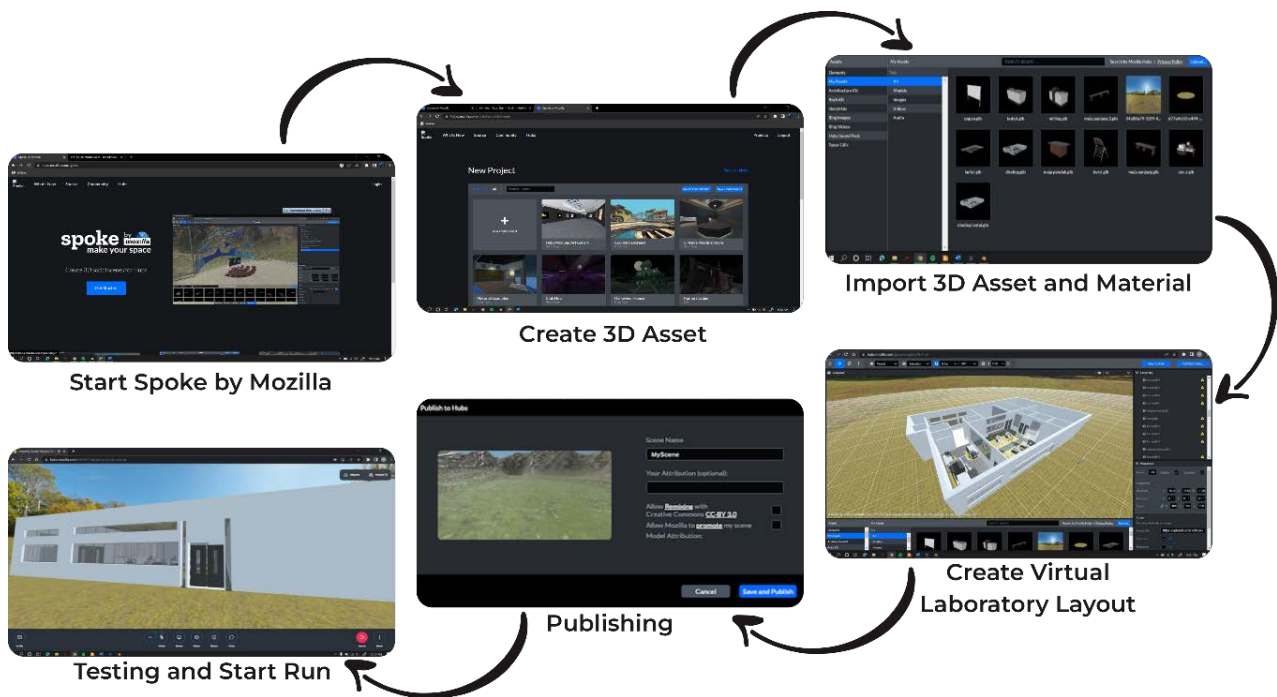

Figure 8. Virtual Laboratory CNC Work Steps

4.1.4. Verification Phase

Testing is performed to determine whether the program will function smoothly and according to the previous design. The test consists of the following steps: a) displaying an application that begins with a splash screen and the main menu on my Mozilla speaking hubs; and b) testing user character control, at the spawn point, especially on the Virtual Reality

Box controller, and the character may run under user control, indicating that the test was successful c) testing the touch between the character's fingers and the description panel; the closer the touch between the character's fingers and the panel, the better the touch; d) testing the capture of each virtual object, signified by the virtual object being taken attached to the character's hand.
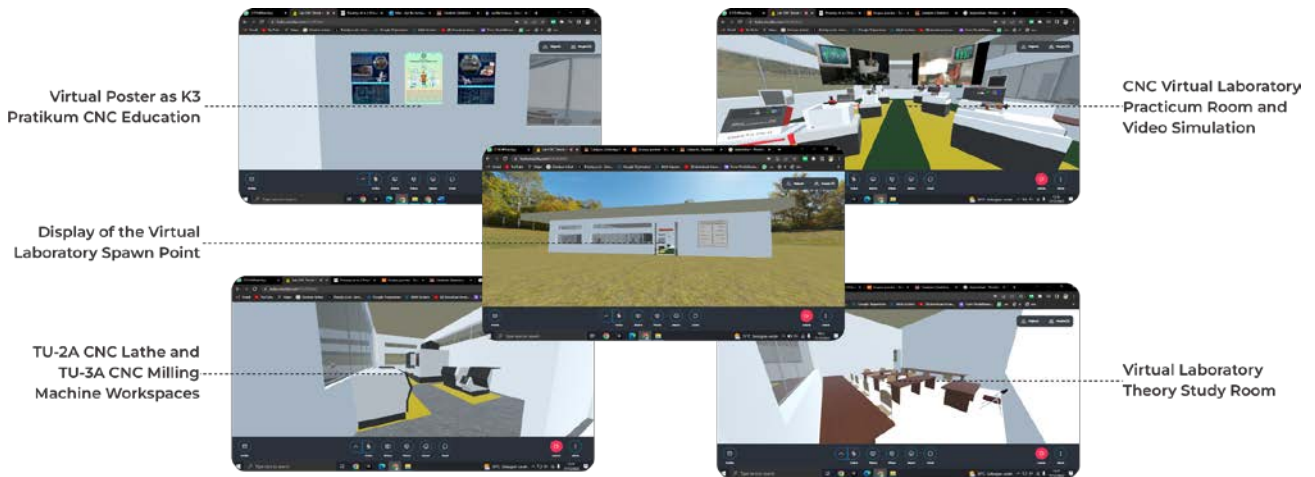
Figure 9. Virtual Laboratory CNC Testing

4.1.5. Maintenance Phase

After completing the verification phase, the final stage is the maintenance phase which updates and fixes several deficiencies, such as errors and bugs in the CNC virtual laboratory on the main menu display in CNC programming learning. Maintenance is also carried out to update the development version of the color user interface on 3D objects in learning media, which is carried out at a particular time.

4.1.6. Validation

Validity testing was conducted to ensure the validity of the data. This was the Virtual Laboratory CNC validity test stage carried out to measure the validity of learning media.

The data were obtained through questionnaires and based on validator data input. This test was carried out by validators, which consisted of expert validators in the CNC programming course and in the development of digital learning media of CNC virtual laboratory.

Validation was carried out using the focus group discussion (FGD) method with expert validators in the field of CNC programming course material and expert validators in the development of digital learning media CNC virtual laboratory. The results of the validity were assessed using a validated questionnaire which functioned to see the validity of the research data that had been presented. The results of the validity test of the virtual laboratory CNC are obtained in the following validation:

Table 2. The results of the validation of the CNC virtual laboratory on material aspects

No.	Aspect Assessment	V1	V2	V3	Percentage	Description
1	Learning Design	87,8%	91,2%	88,9%	89,3%	Very Feasible
2	Material Coverage	89,9%	93,8%	89,6%	91,1%	Very Feasible
3	Usefulness	90,5%	92,3%	92,3%	91,7%	Very Feasible
Overall Average Percentage					90,7%	Very Feasible

The results of the validation of the material aspects are given in Table 2, validated by three experts with data interplay aspects of learning design of 89.3% categorized as "very feasible", material coverage aspects of 91.1% categorized as "very feasible", aspects of usefulness of 91.7% categorized as "very feasible" with an overall average percentage of 90.7% very feasible are used to increase student motivation and understanding of learning in CNC programming courses with comments and suggestions given on learning questions virtually it is even more varied, which is equipped with an automatic question discussion feature so that it has an impact on the cognitive level of the students who take the class.

Table 3. The results of the validation of the CNC virtual laboratory on media aspects

No.	Aspect Assessment	V1	V2	V3	Percentage	Description
1	Media Display	91.7%	91.5%	88.9%	90.7%	Very Feasible
2	Ease of Navigation	95.6%	93.4%	93.6%	94.2%	Very Feasible
3	Overall Function	95.4%	93.9%	94.8%	94.7%	Very Feasible
Overall Average Percentage					93.2%	Very Feasible

As mentioned in the Method section, the validation of media aspects was conducted by three experts. The results obtained are shown in Table 3. The results reveal that 1) media display aspects has a feasibility rate of 90.7%, which is categorized as "very feasible"; 2) ease of of navigation had a feasibility rate of 94.7%, which is also categorized as "very feasible"; and 3) overall function aspects had a feasibility of 93.2%, also putting it in the "very feasible" category. The overall average percentage was 93.2%, indicating that the alternative means of learning through virtual learning independently on CNC programming courses is highly valid. The validators also provided suggestions and comments on the user interface, which led to regular updates and an increase in the accuracy percentage of avatar movements used by users. These improvements helped to prevent bugs in the virtual laboratory, resulting in an easy user experience and more precise real-time reading tools.

Table 4. Results of small group trial with CNC virtual laboratory

No.	Aspect Assessment	Percentage	Description
1	Media Presentation	90.4%	Very Feasible
2	Use of Learning Media	93.7%	Very Feasible
3	Authenticity Material	92.4%	Very Feasible
4	Cognitive and Interactive Levels	93.7%	Very Feasible
5	Benefit	94.2%	Very Feasible
	Overall Average Percentage	92.9%	Very Feasible

The small group trial phase was carried out to see the ease of use of virtual laboratory-based learning media in CNC programming courses. The small group trial used revised media based on validators' suggestions and comments with the research subjects of 12 diploma students of Mechanical Engineering at Universitas Negeri Padang who took CNC programming classes according to the research procedure above. Data obtained from small group trials on the media presentation aspect 90.4% categorized as very feasible, the use of learning media aspect 93.7% categorized as "very feasible", the authenticity material aspect 92.4% categorized as "very feasible", the cognitive and interactive levels aspect 93.7% categorized as "very feasible", and the benefit aspect 94.2% categorized as "very feasible" with an overall average percentage of 92.2%, which is categorized as very valid. Therefore, the student responses show that developed media is categorized as "very feasible". However, there are some suggestions and inputs given by students to improve the specifications of the CNC virtual laboratory, which saves more on the use of using internet data in real time.

4.2. Discussion

The media generated in this study is based on virtual reality technology, which allows users to interactand experience the virtual world environment in real-time, directly replicated using the VR Box controller device, allowing users to enter the virtual CNC laboratory. A virtual laboratory is built according to user needs and designed using blender software, Spoke by Mozilla Hubs application, a web-based 3D editor application integrated with Sketchfab, which provides a visually real view ranging from a) CNC virtual laboratory layout on spawn points and introduction to the practice room, b) 3D asset display of virtual CNC tools and machines accompanied by video tutorials on the use of CNC-TU 2A and CNC TU-3A, 3) simulation of the use of a virtual live CNC machine using a VR Box controller that provides vibration sensations during program input and running machines, 4) distance learning is carried out online which can communicate directly between fellow students in the CNC programming class so that the atmosphere of simulation running CNC machines can run conducive and interactive.

This study results as the form of learning media for the CNC programming course that makes use of virtual laboratory (VR Lab) technology which is used on a Virtual Reality headset in the form of diving goggles with a closed lens which is a place for placing cellphones that project virtual images in real-time. In its development, initial observations were made on students from the Department of Mechanical Engineering UNP who were oriented towards lectures in achieving CNC programming competitions and basic level understanding of CNC TU-2A to CNC TU-3A. Synchronous learning strategies also have a synchronous learning strategies by utilizing technology, primarily information technology used in education.

The CNC virtual laboratory learning media goes through several stages, starting from the validity and small group trial. The validation trial was carried out using the focus group discussion (FGD) method by providing a validated assessment questionnaire validator to see the validity of the research data. The validation aspect consists of CNC programming course material validation and validation of digital learning media CNC virtual laboratory.

Based on the validation test, the results of all aspects of the material and learning media were declared "very feasible ".

The small group trial was conducted on 12 students for more than 5 minutes utilizing a CNC virtual laboratory in the classroom. The students instantly filled out the questionnaire supplied, given the ease of use of media based on the following link: https://hubs.mozilla.com/GAJBQk4. A virtual laboratory is considered "very feasible" in supporting education in distance learning.

5. Conclusion

This research produces virtual laboratory-based learning media in CNC programming courses as an innovation to support the learning process in conveying information, thereby fostering student learning motivation towards the cognitive level of independent learning ability. The research team succeeded in developing CNC laboratory virtual media that supports distance learning in training students' critical, creative, and innovative ways of thinking so that when users cannot enter the laboratory class directly, they have alternative means by utilizing a well-developed and tested virtual laboratory. After validation tests and small group trials through a series of tests, it can be concluded that the CNC virtual laboratory learning media is declared very feasible to use. The development of virtual laboratory-based media as a result of this research is a solution to direct and distance learning. However, CNC laboratory virtual media has not been tested for effectiveness in learning. Therefore, further research can examine the influence on students' cognitive levels and the effectiveness of learning using virtual laboratory media in seeing improvements in learning outcomes and student motivation for CNC programming courses.

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