

Feasibility Test of Raspberry Pi Based Spectrum Analyzer and Transfer Level Register-Software Defined Radio as Learning Media for Frequency Measurement

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ABSTRACT

The purpose of the study was to test the feasibility of a raspberry python-based prototype spectrum analyzer and a software-defined radio-level transfer register designed to meet the practical needs of the Telecommunications Engineering laboratory. For the initial stage, the feasibility test was carried out at SMK Negeri 1 Pangkep, South Sulawesi. The method of data collection was carried out using a test and questionnaire method to determine the effectiveness and feasibility of the developed teaching aids. The subjects for assessing the wireless turn signal system teaching aid were media experts and material experts as many as 2 teaching staff from SMK Negeri 1 Pangkep, Department of Communication and Networking Engineering in the field of wireless Engineering. The results showed that the feasibility of the spectrum analyzer trainer as a learning medium for wireless technology practice based on the results of expert and user tests, it was found that the percentage level of feasibility of wireless learning media as a learning medium was 80.19% which could be categorized as very feasible.

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1. INTRODUCTION

Technological developments have entered the industrial revolution 4.0, one of the impacts is on the world of education. Education 4.0 includes a meeting of neuroscience, cognitive psychology, and educational technology, using web-based digital and mobile, including applications, hardware and software (Nilasari, 2019). In the 4.0 era, those tasked with facilitating and encouraging students to be able to learn independently, responsibly, creatively and innovatively are education providers. Education is strived to produce people who have high learning abilities, so that students will be able to

adapt and respond well to new challenges (Arie Wibowo Khurniawan, S.Si., 2015). When viewed in terms of the concept of digital literacy, it does not only rely on "reading" but also increases the ability to analyze and use digital information obtained (Nastiti & Abdu, 2020).

Printing students to have independent skills and expertise is the task of educational institutions, namely vocational education (Alimudin et al., 2019). Vocational education is an effort to provide learning experiences to help develop their potential; therefore, each individual has special characteristics in interacting with the world of work through learning experiences. This process is a process of optimal self-development of students. This condition can be the basis of vocational education, namely "learning by doing, with a curriculum oriented to the world of work" (Supriyanto, 2018). The purpose of vocational education is to produce working people, in the sense that humans are independent and independent, not a burden to their families, communities, nations and countries (Zahrok, 2020).

Vocational High Schools (SMK), according to the Law of the Republic of Indonesia Number 20 of 2003 concerning the National Education System, it is defined that vocational education is education that prepares students to be able to work in certain fields (Haricahyo et al., 2020). The purpose of implementing education in vocational schools is to prioritize the preparation of students to enter the workforce by developing a professional attitude. One of the efforts that can be done so that these goals can be achieved is by improving the quality of learning in schools (Rizaldi et al., 2021). Vocational secondary education is aimed at preparing human resource needs in accordance with the needs of the community, this is part of the efforts made to not cause new unemployment problems (Roseno & Wibowo, 2019). The subjects presented in SMK are grouped into subjects: normative, adaptive, and productive (Fitriyadi, 2013).

The SMK curriculum is designed to prioritize competence. One of the obstacles in fulfilling these competencies is the implementation of laboratory practicum's related to the availability of frequency measuring tools/spectrum analyzers. Spectrum Analyzer is a powerful real-time audio (RTA) tool for visualizing and analyzing signals from Smartphone device microphones in the frequency domain (Rosdianto et al., 2021). Spectrum analyzer is one of the most fundamental signal processing operations required in engineering and forms the basis of various systems in application areas such as measurement of signal distortion from audio equipment, spectrum monitoring for government frequency allocation of various radio services, and testing of electromagnetic emissions from equipment (King et al., 2021). In the field of education, audio spectrum analyzer devices are needed for physics and electronics laboratories. In addition, it is also used as a tool to determine the frequency response of a loudspeaker (Raharjo & Zakaria, 2019). One tool that functions as a spectrum analyzer is a demultiplexer (Mehaney et al., 2021).

Compared to Spectrum Analyzers in general, this Prototype Spectrum Analyzer has a relatively cheaper price, but the features it has are not as complete as the Spectrum Analyzer. In addition, with the Prototype Spectrum Analyzer, it is hoped that it can function as a learning aid that can be used by educators in the wireless learning process to support and improve the quality of learning (Rahman & Islam, 2016). RTL-SDR based spectrum can be used proficiently as an alternative to existing hardware spectrum analyzers as RTL-SDR devices are quite inexpensive (About \$20) and small in size, this system also offers cost effectiveness by providing portability.

Raspberry is the hardware selected as the application server (Fernández-Pacheco et al., 2019). The popular Raspberry Pi platform offers a complete Linux server on a small platform with IoT at a very low price (Arunpradeep et al., 2020). The Raspberry Pi has all the functions of a standard computer (Jolles, 2021). Raspberry Pi is used to design low-cost monitoring networks in agricultural applications for wider adoption (Gonzalez-Huitron et al., 2021). Raspberry Pi is also great for software and hardware applications making Arduino projects simple (Mudaliar & Sivakumar, 2020).

The Software Defined Radio (SDR) concept was first proposed in 1991 (Perotoni & dos Santos, 2021). SDR is defined as a device that implements radio functions such as sending and receiving signals, via software, not hardware. The target of this technology is to reduce physical components and make

most of the changes by software (Santos-Luna et al., 2019). This makes SDR a very versatile tool for performing analysis on the frequency spectrum and also allows programmers to use software to create cracking tools (Pozniak et al., 2019). For programmability and reconfiguration purposes, field programmable gate arrays (FPGAs) are the platform of choice for implementing most SDR concepts (Balakrishnan et al., 2019). SDR processors are challenging to design because multiple-input multiple-output (MIMO) orthogonal frequency division multiplexing (OFDM) links require tremendous processing power (Kultala et al., 2019).

The feasibility of a project is measured by four types of feasibility, namely technical feasibility, economic and financial feasibility, political feasibility, and administrative feasibility. Two principle criteria included in the technical category are effectiveness and adequacy. Effective means the project can achieve the expected goals. Economic and financial viability relates to costs and benefits, while political viability relates to estimates of the project's influence on the various political roles or forces in society and government associated with the project. To measure the feasibility of a project, an instrument is needed. The instrument must be valid so that it can measure what it wants to measure (Hendryadi, 2014). Validity is the extent to which the measuring instrument (test) truly describes what is intended to be measured. There are three types of validity, namely content validity (content validity), criterion validity (criteria validity), and construct validity (concept validity) (Pažur, 2020). Content validity is carried out to ensure whether the contents of the questionnaire are appropriate and relevant to the study objectives (Ihsan, 2015). Content validity is the validity that is estimated through testing the feasibility or relevance of the test content through rational analysis by a competent panel or through expert judgment (Hendryadi, 2017). An estimate of the content validity of the tests was obtained by thoroughly and systematically examining the test items to determine the extent to which they reflect and do not reflect the content domain. Lawshe (1975) in Bashooir & Supahar (2018) proposed a content validity ratio (CVR) to measure the degree of expert agreement on a single item and which can express the level of content validity through single indicators ranging from -1 to 1.

Testing the spectrum analyzer prototype was carried out at the Makassar Airport Authority office area V by testing the performance of frequency measurements between spectrum analyzers Rohde & Schwarz brand with a prototype. From the test results, it shows that the performance of the prototype is stable and is the same as the results of measurements using a Rohde & Schwarz brand spectrum analyzer at a frequency measurement of 433 MHz. The second phase of the feasibility test for the use of this prototype was carried out to students and vocational school educators, so that it could be used as a reference for improving the prototype as a learning medium for measuring frequency.

Based on the description above, the researchers will conduct research with the objectives of: 1) Obtaining the results of tests carried out using RTL-SDR on the Single Board Computer (SBC) Raspberry pi; 2) Obtaining test results in terms of the performance of the spectrum analyzer trainer using the raspberry pi as a device to process radio/ wireless signals; 3) Knowing the feasibility of the spectrum analyzer trainer as a learning medium for wireless technology practice based on the results of expert and user tests.

2. METHODS

The population in this feasibility test is all students of SMK Negeri 1 Pangkep majoring in Communication and Networking Engineering as many as 270 people divided into 9 classes. The sample in this test is students of SMK Negeri 1 Pangkep, majoring in Communication and Network Engineering (TKJ) class 2A and class 2B totalling a total of 40 students. The data collection method in the feasibility test of this prototype engineering is using the test and questionnaire method with the aim of knowing the effectiveness and feasibility of the developed teaching aids. The test questions are multiple choice questions. The questionnaire method aims to determine the feasibility of the developed teaching aids. The subjects for assessing the wireless turn signal system teaching aid were media experts and material experts as many as 2 teaching staff from SMK Negeri 1 Pangkep, Department of Communication and Networking Engineering. The data analysis method in this engineering, using a

check list testing model that focuses on the functional requirements of the software. Checklist testing attempts to find errors in the following categories: (1) incorrect or missing functions, (2) interface errors, (3) errors in data structure or external database access, (4) performance errors and (5) initialization and termination errors. To test the feasibility of the spectrum analyzer design, a trial was carried out for its use in the wireless engineering communication material practicum majoring in Communication and Network Engineering (TKJ). The population in this feasibility test is all students of SMK Negeri 1 Pangkep majoring in Communication and Networking Engineering as many as 270 people divided into 9 classes. The sample in this test is students of SMK Negeri 1 Pangkep, majoring in Communication and Network Engineering (TKJ) class 2A and class 2B totalling a total of 40 students. To test the feasibility of the spectrum analyzer design, a trial was carried out for its use in the wireless engineering communication material practicum majoring in Communication and Network Engineering (TKJ). The population in this feasibility test is all students of SMK Negeri 1 Pangkep majoring in Communication and Networking Engineering as many as 270 people divided into 9 classes. The sample in this test is students of SMK Negeri 1 Pangkep, majoring in Communication and Network Engineering (TKJ) class 2A and class 2B totalling a total of 40 students. To test the feasibility of the spectrum analyzer design, a trial of its use was carried out in the wireless engineering communication material practicum majoring in Communication and Network Engineering (TKJ).

3. FINDINGS AND DISCUSSION

3.1. Analysis of the Use of Design Tools

Instruments for learning media experts

Rating indicators

This instrument contains points about aspects related to learning media including: 1) information clarity, 2) Design. The following is a grid for instructional media expert instruments.

Table 1. Grid for Learning Media Experts

No	Aspect	Indicator	No. Item
1	Information	The overall interactivity of the learning media	1
		Clarity	Ease of recognizing parts of the prototype design
	Ease of connecting parts of the prototype design		3
	The time required for operation is not long		4
	Setting in frequency tracking is easy		5
	The reading of the frequency tracking results is very clear		6
	The use of navigation/settings contained in the learning media menu is very clear		7
	Overall navigation difficulties in the use of learning media		8
	Use of communicative language	9	
2	Design	Display clarity	10
		Size, color and shape	11
		Image illustration	12
		Color Match	13
		Font compatibility	14
		Appropriate placement of the button layout	15
		The suitability of the placement of the text layout	16
		Overall interest in the media	17
		Overall interactivity	18
		Design tool view design	19
		Security from damage to design tools	20

Learning media expert validation test results

Assessment questionnaire for learning media experts from aspects (1) clarity of information (2) design aspects. The percentage of assessments of learning media experts in this case are teachers of SMK Negeri 1 Pangkep who are competent in the field of learning media in communication and network techniques. The percentages and assessments of media experts are presented in the following table.

Table 2. Validation Results of Learning Media Experts

No.	Aspect	Observed score	Expected score	Presentation (%)
1	Information Clarity	150	180	83.33
2	Design	220	260	84.62
	Total	370	440	84.09

Instruments for Users

Rating Indicator

Instruments for users are reviewed from the aspects of: 1) material delivery strategy, 2) usability, 3) screen design and 4) program operation. The instrument grid for users can be seen in the following table:

Table 3. Grid for Learning Media Users

Number	Aspect	Indicator	Number of Item
1	Design	Size, color and shape	1
		Image illustration	2
		Color Match	3
		Font compatibility	4
		Appropriate placement of the button layout	5
		The suitability of the placement of the text layout	6
		Overall interest in the media	7
		Overall interactivity	8
		Design tool view design	9
		Security from damage to design tools	10
		Ease of understanding design blocks	11
		The time it takes to display the measurement results is not long	12
2	Ease of Operation	Standard size tool, not heavy and can be mobile	13
		Display/image clarity	14
		Ease of connecting/assembling designs	15
		The use of language in the application is easy to understand	16
		easy to use navigation menu	17
		Ease of observing the display of measurement results	18
		Design tool sensitivity	19
		Ease of reading measurement results	20

User Test Results

The assessment of the user test results in terms of aspects and indicators can be seen in table 3.

Assessment questionnaire for students of SMK Negeri 1 Pangkep, covering aspects of (1) design, and (2) ease of operation. Students who are assessors of learning media prototype Spectrum Analyzer are students majoring in TKJ class 2A and 2B. overall students who assess as many as 40 people.

The percentage of student assessment data in terms of aspects is presented in the following table:

Table 4. User Test Results In Terms of Indicators and Aspects

Aspect	Indicator	India's total score office	Max score	Indicator percentage	Total aspect score	Aspect percentage (%)	Total (%)
Design	1	130	160	81.25	1578	75.87	76.41
	2	119	160	74.38			
	3	135	160	84.38			
	4	120	160	75			
	5	113	160	70.63			
	6	129	160	80.64			
	7	142	160	88.75			
	8	110	160	68.75			
	9	105	160	65.63			
	10	131	160	81.88			
	11	109	160	68.13			
	12	106	160	66.25			
	Ease of operation	13	129	160			
14		116	160	72.5			
15		115	160	71.88			
16		127	160	79.38			
17		138	160	86.25			
18		122	160	76.25			
19		119	160	74.38			
20		125	160	78.13			

The following is a summary of data from each assessment carried out by each respondent.

Table 5. Summary of result data

Evaluation				Average
Media expert		User		
Information Clarity	Design	Design	Ease of Operation	
83.33	84.62	75.87	76.94	80,19

Discussion of Media Expert Test Results and User Test

Testing the feasibility level of wireless learning media using an instrument filled by 2 learning media expert teachers, and 40 students from SMK Negeri 1 Pangkep. Before being used, the instrument was piloted by a team from the Makassar Region V Airport Authority and validated by 2 teachers at SMK Negeri 1 Pangkep to test the feasibility level of the spectrum analyzer design as a learning medium for wireless techniques by using an assessment or score of 1 to 4.

The results of the assessment of learning media experts and usage tests in the learning process were changed in the form of percentages. In accordance with the established categories, namely 0-25% means less worthy, 26-50% means quite feasible, 51-75% means feasible and 76-100% means very feasible (Arikunto, 1996: 244). The test results of each validator are as follows:

Learning Media Expert

In conducting this expert validity test, it consists of assessing aspects of information clarity and design aspects. In the aspect of clarity of information in it there are indicators to see how much the level of clarity of information in wireless engineering learning media for students of SMK Negeri 1 Pangkep. The indicators are listed in tables 1 and 3. In each of the indicators measured, it turns out that on average they have a very decent value. In each indicator the value obtained is not below 75%. When viewed from the validation data in table 2, the results obtained in the aspect of information clarity on wireless engineering learning media for vocational students are 83.33%.

The value of the validation results for the clarity of this information is included in the very feasible criteria. In the design aspect, the indicators measured include the level of compatibility in the use of colors, the compatibility of the use of fonts, and the level of user interest in learning media. Likewise in the design aspect, for each indicator the value obtained is not below 75%. When viewed from the design aspect, the material expert validation obtained a value of 84.62%. The value obtained can be classified in the very feasible category. The overall validation level of wireless learning media according to the assessment of learning media experts obtained a total percentage of 83.98%. This percentage includes aspects of design and clarity of information. Based on this total percentage,

Based on this, according to media experts, wireless technical learning media for Vocational High School students is very suitable to be used to support the process of learning and teaching activities in Vocational Schools.

For the results of content validation using the content validity ratio, where The number of appraisers is 22 people and there are 18 appraisers who state that our item is essential, then the CVR value is as follows:

$$\begin{aligned} \text{CVR} &= (2ne/n) - 1 \\ &= (2 \times 18 / 22) - 1 \\ &= 0.6. \end{aligned}$$

By looking at the table, the minimum CVR value with 20 raters is 0.42, while the CVR value obtained is 0.6 so it can be said that the item is valid.

In accordance with the results of the content validation, the wireless technique learning media for SMK is relevant or feasible to be used in teaching and learning activities in SMK. Information Clarity Aspects; 83.33% Ease of Operation aspects; 76.94% Overall Validation; 80.14%

User (student)

Assessment for users (students) includes design aspects that describe students' enthusiasm or interest in the learning media used and convenience aspects that describe the level of ease of use of navigation and simulation on wireless engineering learning media. In the assessment of students there are 20 indicators which are described as 13 items to measure design aspects and 7 items to measure ease of use aspects. The highest average value of the indicator is 88.75% which is found in the design aspect of item no.7, an indicator that measures the overall interest of the media, and the ease of operation of item no.17, an indicator of the ease of use of navigation, and the lowest indicator value of 71.88% is found in the design aspect of item no.15, the indicator of ease of connecting the design. The lowest value is still classified in the decent category, so that in general the items that have this value are understandable. According to the student's assessment of the design aspect, the average value obtained was 75.87% or rounded to 76%. This value can be categorized as a very feasible result. This value can be interpreted that the level of interest and enthusiasm of students towards wireless engineering learning

media for vocational students is very high. Assessment on the aspect of ease of use of learning media an average of 76.94%.

The value obtained can be categorized as a very feasible result. It can be interpreted that the use of wireless learning media for vocational students is relatively easy to use. In table 4.8, it can be seen that the overall validation level of wireless technique learning media according to user (student) assessments obtains a total percentage of 76.41%. The percentage includes aspects of design, and ease of use. Based on the total percentage, the level of validation of wireless learning media when converted to a feasibility table is in the very feasible category.

Based on this, the wireless technique learning media is feasible to be used as a means of supporting the process of learning and teaching activities in SMK.

Overall Validation Results

From the data that has been obtained at the engineering stage which can be seen from the summary of the data table 4, the feasibility level of wireless engineering learning media as a learning medium for SMK with a percentage of 80.19% which can be categorized as very feasible. So the learning media in this engineering is very suitable to be used as a medium for learning wireless techniques for Vocational High School students.



Figure 1. Result of Design Feasibility Test

Based on the feasibility test of the design carried out with a sample of 20 users and 2 media experts/teachers in the field of wireless engineering, the overall results obtained were 26% of the feasibility of information clarity, 26% of media experts' designs, 24% of user-friendly designs. and ease of operation by 24%.

The results of tests carried out using RTL-SDR on a Single Board Computer (SBC) the Raspberry pi can display the frequency spectrum, whether it is carried out singly or applied to a network so that it can be used as a medium for learning wireless technology practices or other materials that measure frequency. In terms of performance, the performance of the spectrum analyzer trainer using the raspberry pi as a device to process radio/wireless signals is quite good in CLI (command line interface) mode, but is relatively slow when used on a desktop as a portable spectrum analyzer that can be used as a learning medium. The feasibility of the spectrum analyzer trainer as a learning medium for wireless technology practice based on the results of expert and user tests, obtained a percentage of the feasibility level of wireless engineering learning media as a learning medium of 80.19% which can be categorized as very feasible. Even though it is feasible to use, to maximize the results, learning media users must also be proficient in using it. Because whatever media is chosen, educators must be able to use the media. The value and benefits of learning media are largely determined by how the skills of educators use these learning media. The skills of using this media can also later be passed down to students so that students are also able to skillfully use the selected learning media.

The importance of involving users in conducting feasibility tests on prototypes is because the main purpose of the prototype is to develop a model or product design into a final product that can meet user demands. So that in the product development process, users must take part by evaluating and providing feedback. The feedback provided can be used as a reference in product development. In addition, the use of prototypes can bring up new ideas that can be developed into a feature to complement the product. This is in line with the main benefit of using a prototyping system, namely being able to know the user's needs in advance so that they can find out what the priorities and needs of users are, so the product development process will take place faster.

The prototype itself is not the final product that will be circulated later. The prototype is made for the initial needs of software development and to find out whether the features and functions in the program run according to the planned needs. So that product developers can spot flaws and errors early before implementing other features into the product and releasing the product.

4. CONCLUSION

From the results of tests carried out using RTL-SDR on a Single Board Computer (SBC) the Raspberry pi can display the frequency spectrum, whether it is carried out singly or applied to a network so that it can be used as a medium for learning wireless technology practices or other materials that measure frequency. In terms of performance, the performance of the spectrum analyzer trainer using the raspberry pi as a device to process radio/wireless signals is quite good in CLI (command line interface) mode, but is relatively slow when used on a desktop as a portable spectrum analyzer that can be used as a learning medium. The feasibility of the spectrum analyzer trainer as a learning medium for wireless technology practice based on the results of expert and user tests, obtained a percentage of the feasibility level of wireless engineering learning media as a learning medium of 80.19% which can be categorized as very feasible.

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