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Development of “PRO Rakyat” Application for Cost Reduction and Effectiveness of Examination

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Abstract: Government Regulation No. 19 of 2005 concerning National Education Standards, explains that the government and education units need to assess student learning outcomes. Technological advances coupled with the call of the Ministry of Education and Culture of the Republic of Indonesia to carry out the Computer-Based National Examination made paper-based exam began to be abandoned. This research uses the research and development method with the analytic, design, development, implementation and evaluation (ADDIE) model. However, in practice, there are still many educational units that have not been able to carry out due to various reasons including not having adequate infrastructure. Therefore a computer-based test model and or smartphone that is designed can be used without the need for high-specification devices. This model was designed with open source software namely Debian, NGINX, PHP-FPM, Moodle, PostgreSQL, and PFSense. The concept of the server is optimized so that only one server can accommodate hundreds of students in one session without requiring high specifications. Finding of the research are; testing using a computer and/or smartphone does not require high specifications on either the client or server-side, the interface that is designed neatly and simply makes it easy for test-takers to operate the application, test takers become more free and calm in carrying out exams using computers and or smartphones, exams using computers and/or smartphones have more flexibility in terms of question variations, exams using computers and / or smartphones are more cost-effective, exams using computers and/or smartphones are more desirable than paper exams.

Keywords: paper-based exam, computer-based test, examination.

1. Introduction

National Standard School Examination (NSSE) is an activity to measure the competency achievement of students by the Education Unit by referring to the Competency Standards for Graduates to gain recognition for learning achievement. National Examination (NE) is an activity to measure the achievement of graduates' competencies in certain subjects nationally by referring to the graduate competency standards. (Government Regulation Number 19 of 2005 concerning National Education Standards). In 2020, there are 7,153 schools carrying out paper-based exams in several junior high school, senior high and vocational high schools. (Indonesia, 2019a) (Indonesia, 2019b) (Indonesia, 2019c). Even though the use of paper media for the final assessment of students is less effective and efficient than using computer media. Computer-based exams are an attractive option for many reasons, including the logistics distribution of testing and the reduction in time and job requirements, especially when evaluating large groups of students. (Ita, Keckskemety, Ashley, & Morin, 2015).

Examination using paper media is also likely to cause fraud. The Minister of Education, Muhadjir Efendi stated that the, most important thing, in my opinion, is that almost 99 percent of fraudulent practices can be eliminated, the practice of dishonesty, which used to be very systemic, structured. Now we can eliminate it with this new system and platform. Besides, the paper media used for exams is very limited in terms of making questions. The form of questions that can be written on these sheets of paper is less varied. Compared to the use of computers in a learning process it can provide more and more varied learning experiences for students so that this can increase learning motivation and develop information technology and computer skills for students (Nurchali, 2010).

So far, the percentage of computer-based examination has been increasing, in 2016 there were 4382 schools and in 2019 there were 85,960 schools. (K. P. d. K. R. Indonesia, 2019) Deputy Chairperson of Commission X DPR RI, Sutan Adil Hendra stated that a sufficiently measurable benefit is the budget savings spent, especially for the procurement of examination papers, which can save 20 percent from regular exams and 30 percent in distribution costs. Chairperson of Persatuan Guru Republik Indonesia, Urwah Rosyidi said that with the computer-based exam program being further enhanced, it is hoped that it can improve the quality of education in Indonesia.

The benefits that have been raised by various parties related to the implementation of computer-based exams, however, there is one thing that is still a matter of debate in the implementation of computer-based exams, namely the issue of funds. Head of research and development agency of the ministry of education and culture, Totok Suprayitno said that if you are committed to implementing NSSE, you are welcome to share with other schools, fellow high school and vocational high school or primary school that have computers. In terms of NSSE implementation, there are still many shortcomings that must be addressed immediately. The main challenges mentioned in the research conducted by (Wang & Tahir, 2020) include technical problems such as unreliable internet connection. The Indonesian government must work together at various levels to overcome the problem of lack of facilities and quality of teachers, especially in several educational institutions such as Islamic boarding schools. (Carolina, 2017) Data from the Ministry of Education and Culture in April 2018 obtained information that 34.6 percent of schools (at all levels) chose to continue implementing NSSE, 16.5 percent NSSE by staying at other schools. Nationally, 48.9 percent of schools have participated in NSSE fully independently. A news item in Jawa Pos: 2018 informs that given the high cost of UNBK needs, there are schools that charge students with varying amounts of fees, starting from IDR. 600,000, IDR. 800,000, IDR. 1,100,000, up to IDR 1,500,000.

Research that has been conducted by Aisah (2019) concluded that the test model using a smartphone makes it easier for students to work on questions and for teachers to facilitate administration and reduce costs. However, there are shortcomings in this study, namely applications with hundreds of users have not been tested at once and users must have an internet connection when using the application. Another study by (Abdillah, 2016) concluded that smartphone and computer-based exams facilitate preparation and completion of activities ranging from administration to exam results. However, in this study there are several shortcomings, namely security issues. Users can access other applications while using the exam application, this allows users to cheat during the exam. In addition, the empirical research analysis conducted by (Sung, Chang, & Liu, 2016) concluded that the overall effect of using mobile devices in education is better than when using a desktop computer. The use of information technology like this has been applied to the integrated synchronous learning design researched by (Bower, Dalgarno, Kennedy, Lee, & Kenney, 2015) with the conclusion that this design results in more active learning.

The various statements above can be concluded that the implementation of computer-based examinations has many benefits, but in the technical field, there are still many schools that experience difficulties and are not able to carry out computer-based examinations due to inadequate infrastructure problems and according to the standards of the Ministry of Education and Culture. The infrastructure mentioned above is quite expensive, apart from that there are almost no other applications that can be used for computer-based exams or smartphones with high performance and for free. Therefore the author tries to formulate how the paperless-based exam can still be implemented even though it uses simple infrastructure and does not need to buy the application by making a computer-based exam design or smartphone using the Prakyat CBT application. This application uses a low resource composition on the server-side, uses the network topology in general, and restrictions on multiple access to other activities when using the application, that's can minimize cheating during exams.

2. Research Method

The development design that will be used in this research is ADDIE. The research was conducted at Vocational High School of Muhammadiyah 1 Temanggung, Central Java. The ADDIE development design steps consisting of five steps, namely (1) analysis, needs analysis to determine the right problem and solution, (2) design, determine the system model, compile the system framework, map resource requirements, (3) development, developing applications with the system model that has been chosen, (4) implementation, testing the system, carrying out tests, and distributing response questionnaires, and (5) evaluation, analyzing and correcting errors that occur during testing and implementation (Branch, 2009).

3. Result And Discussion

3.1 Analysis

The analysis step is a needs assessment process, identifying problems (needs), and performing a task analysis (Sutabri, 2012) The researcher analyzes the need for application development and analyzes the feasibility and terms of development at this step. The steps of the analysis carried out include two steps that are analysis needs and analysis of field conditions. Broadly speaking, the stages of the analysis carried out by the author are as follows:

• **Analysis of field conditions**

Analysis of field conditions is one of the data collection techniques in field research. Field research is a data collection method in qualitative research that does not require in-depth knowledge of the literature used and the specific abilities of the researcher (Neuman, 2006). This analysis was carried out to see the conditions in which the research was carried out. The researcher will conduct a survey directly to collect data at this step. The data collected is only basic data including (1) the number of all entities involved in the application implementation process, (2) the number of rooms used for the exam, (3) room plans. Some of these basic data serve as initial considerations and calculations in building applications. This data is also used for designing a network topology or model that will be applied during the implementation process. Besides, it will facilitate analysis at the time of implementation if certain obstacles occur.

Needs analysis

In systems engineering and software engineering, needs analysis includes the work of determining the needs or conditions that must be met in a new product or product change, which takes into account the various needs that intersect among various stakeholders (McConnell, 1996). The needs of the results of this analysis must be able to be implemented, measured, tested, related to identified business needs, and defined to a level of detail sufficient for system design (Stellman & Greene, 2005); (Wiegiers & Beatty, 2013). The next process after knowing the conditions of the research place is needs analysis. Requirements analysis is carried out through an inventory of the hardware and software that will be used to build the system. The composition of the software and hardware used is as follows:

Table 1: Software & hardware needs

No	Software	Version
1	NGINX webserver	1.16 or other versions
2	PHP language program (Lerdorf, Tatroe, Kaehms, & McGredy, 2002)	7.2 or other versions
3	Postgresql database (PostgreSQL, 1996)	10.12 or other versions
4	Debian operating system (Hertzog & Mas, 2013)	9 or other versions
5	Virtual box	6 or other versions
6	pfSense	2.3 or other versions
	Hardware	Quantity
1	PC 8 Core	1
2	Internet access	1
3	Network cable	1
4	Ethernet card	1

3.2 Design

The second step of the ADDIE model is the design stage. This stage begins to design the application to be developed. Furthermore, the design stage is carried out by determining the elements needed in the system such as compiling the requirements map and system framework. Researchers also collect references that will be used in developing applications, such as setting the core parts of the application and displaying the user interface (Luther, 1994).

The first part is the core of the application. This section discusses in detail the components that are the core of the application. The components included in this section have been described in the previous section. All these core parts are packaged in a single data package called a server. This server will be the center of all activity during the test, serving and managing data entry and exit for each active client.

Five main components form the core of the application, namely the NGINX web server, the PHP-FPM module (Skvorc, 2015), Moodle (Rice & William, 2006), and the database which are packaged in one data package or server. On the outside of the server, there is one component: the pfSense route. The flow in more detail can be explained as follows:

Table 2: Process of the server

Process	
1	The client requests data to the server
2	Pf Sense accepts the request and defines the client route and then passes it to the server
3	The server component that receives the request first is the NGINX web server and passes it to the PHP-FPM module
4	The PHP-FPM module receives the request and translates the request (Skvorc, Punt, Rafie, Pitt, & Lavaryan, 2017) in question whether the request is to the database or to MOODLE and then passes on the request.
5	MOODLE accepts the request and processes the request, then returns it to the PHP-FPM module at the same time notifying the request in question requires a database or not. If you need a database, it will be forwarded by the PHP-FPM module.
6	The database will receive the request and return it to the PHP-FPM module
7	The PHP-FPM module will return the request to the NGINX web server and so on until it returns to the client

The second part is the system interface. The interface of a system is determined at this stage system planning. Therefore find out in advance the parts of the interface represent the interface design better system (Elfida & Nasution, 2005). The system interface is divided into two, namely the administrator interface and the client interface. In the administrator interface, the author tries to design a special interface that is more interactive. This interface is specially designed for supervisory and other administrative purposes such as printing participant cards and so on.

The client interface is already available from one of the core components of the application, namely Moodle. (Dougiamas & Taylor, 2003) In this study, the Moodle interface will be set with a standard theme or Boost. The use of this theme is not only simple but also to lighten the server load because this theme does not display a lot of theme program code.

3.3 Development

The development stage is the product realization stage. At this step, application development is carried out by the design. The initial process is carried out by building the system installation the same as in general. Furthermore, the development process is carried out by adjusting several parts that become the core of the system, namely setting the process per second on the webserver and customizing the main application system. The installation sequence at this stage is first the operating system installation, second the NGINX server web installation (Nedelcu, 2010), the third PHP-FPM module installation, the fourth the Postgresql database installation, the fifth Moodle installation, and finally the pfSense routing installation.

3.4 Implementation

The fourth stage is implementation. Implementation is limited to schools designated as research sites. Besides, it is also limited to the implementation time because it follows the school schedule. Implementation is carried out by all students and teachers. Students as test-takers, teachers as supervisors, and technicians, and proctors. The examination is carried out in classrooms, each room consisting of one wireless network, one supervisor, and a maximum of thirty-five students with a duration of each subject ninety minutes.

The server composition at the implementation stage consists of one main server with a virtual operating system already installed, namely Debian and contains several core application components. The server functions as a service that manages all exam activities starting from randomizing questions for each participant, sending questions to each participant, and storing participant answers and accumulating the number of correct or wrong answers to produce a final score. Then there is one more computer that functions as a network manager or provides a data path to each device connected to the main server. This computer contains the FreeBSD virtual operating system in which there is pfSense software as a route or network manager.

The network scheme or topology used at this stage of implementation is a Star topology. This topology makes the hub/switch as a terminal or data traffic center. For security reasons, the servers are on the local network. (Kumar & Goyal, 2019). Computers that are on the local network can minimize attacks such as DDOS. (Singh & Behal, 2020). The topology used is as follows:

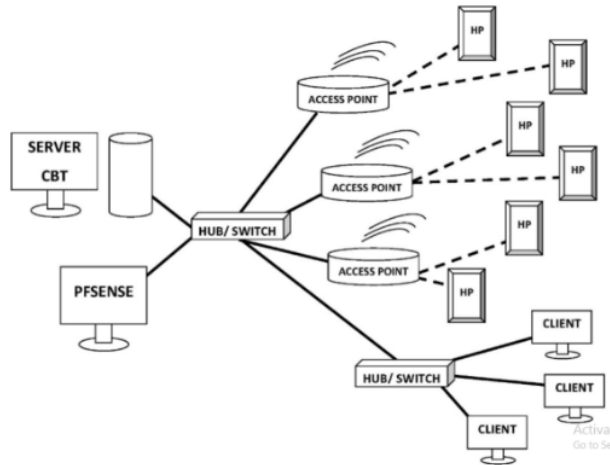


Figure 1. Computer and smartphone-based exam topology

Figure 1 above shows the flow used in the implementation of computer-based and smartphone-based examinations. If explained, the flow of the image above is as follows:

Table 3: implementation of computer-based examinations

Process	
1	Clients or test-takers can use a smartphone or computer to administer the exam.
2	Smart phones are connected via Access Points or Wifi, this method is often referred to as wireless networks. While the computer is connected via a cable connected to the Hub / Switch.
3	All Hub / Switches are connected to a central Hub / Switch, which is the central Hub / Switch which is directly connected to the server and routing computer or pfSense.
4	Pf Sense manages all network traffic and assigns clients an identity within that network. Only with this network identity clients can access the server.
5	The server manages all incoming requests and returns data to the client on demand.

The flow and cycle formed are as shown in the table above. Please note that this computer-based and smartphone-based exam process does not use internet access at all. So that test takers and schools do not need to think about internet access or fees for it. This is following the principle discussed in the previous chapter that the implementation of computer-based or smartphone-based exams must be carried out at the lowest possible cost.

3.5 Evaluation

At this stage the researcher made the final revision of the application developed based on the input obtained from field notes. This is intended so that the application developed is truly appropriate, realistic, and tested and can be used by other schools so that the benefits can be obtained widely. To obtain data about the use of this application, researchers distributed questionnaires and carried out accumulated exam cost comparisons.

The questionnaire that was distributed was used to gather data about the effectiveness of the computer-based and smartphone-based examination method. This questionnaire was aimed at students and teachers. While the accumulated exam fees serve to test or compare costs between paper-based exams with computers and smartphones. The sample used was 457 students and 45 employee teachers.

The results obtained from the implementation process (ADDIE) were obtained by distributing questionnaires so that several important points were obtained which were sufficient for the analysis process of the developed application. Some of the important points are as follows:

Table 4: Distributing questionnaires

No	Point	Information
1	Smartphone specifications	Relates to testing application capabilities
2	Ease of operation and application display	deals with interface ease testing
3	Impressions during exams	related to troubleshooting application testing
4	Problems that arise during the exam	related to testing troubleshooting applications for evaluation
5	Conclusion of the selection of the test method	deals with testing the application as a whole

3.5.1 Smartphone specifications

There are several questionnaire questions related to this, the following is a list of questions and the results of the responses:

Table 5: Questionnaire and result of smartphone specification

	Information	Form	Result	Result
1	How much RAM did you use for this test?	Questions	132 : 1Gb or lower	370 : 2Gb ++

3.5.2 Ease of operation and application display

There are several questionnaire questions related to this, the following is a list of questions and the results of the responses:

Table 6: Questions and the results of the responses of ease

	Information	Form	Result (Agree)	Result (Not Agree)
1	This application is easy to use and feels light / does not eat up HP memory	Agree/ Not agree	455	47
2	The display of this exam application is easy to use/understand	Agree/ Not agree	460	42
3	I find it easy and not confused when logging in	Agree/ Not agree	457	45
4	I feel easy and not confused when I end the exam (submit All and finish)	Agree/ Not agree	477	25
5	I find it easy and not confused when logging out	Agree/ Not agree	483	19

3.5.3 Impressions during the exam

There are several questionnaire questions related to this, the following is a list of questions and the results of the responses:

Table 7: Questions and the results of the responses of impression

	Information	Form	Result (Agree)	Result (Not Agree)
1	I feel calmer and less worried when I do exams because my next-door friend can't copy my work	Agree/ Not agree	453	49
2	I feel calmer and have more time when I do the exam because filling out the answers is just one touch/click	Agree/ Not agree	461	41
3	I find it easier to do questions with an android model exam like this	Agree/ Not agree	446	56
4	I find it difficult to understand the problem because the appearance of the cellphone is smaller, different from the paper	Agree/ Not agree	264	238

3.5.4 Problems during the exam

There are several questionnaire questions related to this, the following is a list of questions and the results of the responses:

Table 8: Questions and the results of problem during the exam

	Information	Form	Result (Agree)	Result (Not Agree)
1	During the implementation of this exam, I felt very well	Agree/ Not agree	343	159
2	I would prefer a model test using a smartphone like this instead of using paper	Agree/ Not agree	426	76
3	Did you change your cellphone during the test due to an error	Yes/ No	Yes: 150	No: 352
4	During this exam, how many times did you experience errors?	Agree/ Not agree	304 : under 5x	198 : above 5x

3.5.5 Result of the selection of the test method

There are several questionnaire questions related to this, the following is a list of questions and the results of the responses:

Table 9: Questions and the results of conclusion

No	Information	Form	Result (Smartphone-based)	Result (Paper-based)
1	If you were given the freedom to take the exam, what kind of exam model would you prefer? With paper or with a Smartphone?		414	88

The total number of statements and questions is fifteen with a score of one each. Meanwhile, cost testing with a comparison of the accumulated exam costs is done by simple summation of paper-based exams with computers and smartphones. This accumulation was not only carried out once but several times for examinations. The calculation is equipped with the number of exam participants as a comparison of the percentage so that it is objective. The calculation plan is as follows:

Table 10: Accumulated cost paper & computer-based exams

Paper-based exams				
	Activity	Cost (Rp)	Number of examinees	Accumulated costs for each participant
1	Exam 1	34.672.000	502	69.000
	Exam 2	23.778.000	422	56.000
	Exam 3	35.850.000	523	68.500
Computer-based and smartphone-based exams				
	Activity	Cost (Rp)	Number of examinees	Accumulated costs for each participant
1	Exam 1	25.568.000	623	41.000
	Exam 2	15.961.000	591	27.000
	Exam 3	15.881.000	583	27.000

A comparison of the accumulated costs of paper-based and computer-based and smartphone-based exams is done by comparing the two tables.

4. Conclusion

Based on the data from the questionnaire responses, several things can be concluded :

The test using a computer or smartphone does not require high specifications. This conclusion is obtained from table 5 which contains a questionnaire about the specifications of smart phones. Of the 502 respondents, 132 respondents used smart phones for exams with 1 GB RAM specifications and or lower, the remaining 2 GB and or higher. It can be said that 26% of the respondents use a smartphone with below average specifications or an older model smartphone. Furthermore, this data is linked to table 8 which contains a questionnaire about problems that occur during the exam. The majority of respondents only experienced problems during exams under 5 x, namely 304 respondents. From the empirical analysis, namely the field survey, the majority of the problems that occur are errors in entering the exam code. Meanwhile, the majority of the process during the examination process went smoothly. It can be concluded that there are no significant problems on the server and network sides. Problems that arise are caused by human errors. In this study, the researcher had anticipated the bottleneck (Jaffe, 1981) during the exam by controlling the network and servers.

The neat and simple design of the interface makes it easier for test takers to operate the application (Kaligis & Fatri, 2020). This conclusion can be seen from table 6 which contains the ease of operation and application display. Of the five questionnaire questions which are averaged, it shows that 92% of respondents agree that the application is easy to use or respondents do not find it difficult to operate the application. Researchers have conducted research that the appearance of a client server type application designed with the latest programming language will have a responsive display because it is accessed using a browser. (Strandberg et al., 2004).

Exam participants become more relaxed and calm in carrying out exams using computers and or smart phones because the questions that appear on each participant are different. This can minimize cheating during exams. (Nasution, 2013). In addition, exams using computers and or smart phones have greater flexibility in question variations. (Dougiamas & Taylor, 2003).

Exams using computers and or smart phones are more cost effective. This conclusion can be seen from table 10 which contains the comparison of exam costs using paper and computers or smart phones. Cost efficiency or reduction is calculated by comparing costs before and after (Rahmawati, 2016) the exam using a computer or smartphone. The fee for each examinee on the first paper exam was 69,000, while the first test with a computer or smartphone was only 41,000. There is a fee reduction of 28,000 or 40% for each test taker. On the second exam there was a decrease in fees by 29,000, or 52% for each examinee. On the third test there was a reduction in costs by 41,500 or 60%. It can be seen that exams using a computer or smartphone have a significant cost reduction effect.

Exams using computers and / or smartphones are more desirable than paper exams. This conclusion can be seen from table 9 which contains a questionnaire about the selection of the test method. There were 414 respondents or 82% stated that exams using computers or smart phones were more desirable.

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