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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 must 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 exams begin 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 been unable to carry out due to various reasons including inadequate infrastructure. Therefore, a computer-based test model and designed smartphone can be used without high-specification devices. This model was designed with open-source software: 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. The findings of the research are testing using a computer, and a smartphone does not require high specifications on either the client or server side; the interface is designed neatly and makes it easy for test-takers to operate the application, test-takers become free and calm in carrying out exams using computers and or smartphones, exams using computers and smartphones have more flexibility in terms of question variations, exams using computers and smartphones are more cost-effective, exams using computers and smartphones are more desirable than paper exams.

**Keywords:** Paper-based exam, computer-based test, examination, ADDIE, student

## 1. Introduction

The 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). There are still a lot of paper-based examinations in several schools; it was recorded that until 2019, in one of the high school level areas and the equivalent, they still used paper (Handoko et al., 2019) even though the use of paper media for the final assessment of students is less effective and efficient than using computer media (Nurchaili, 2011). "Since we implemented NSSE in 2015 until now, it has been proven that this Computer-Based National Examination (UNBK) is very effective in increasing the integrity or honesty index in the implementation of the National Examination," said Bambang at the Taklimat Media on National Examination at the Ministry of Education and Culture (Murtiana, 2011).

Examination using paper media is also likely to cause fraud. The Minister of Education stated that the most important thing is that almost 99% of fraudulent practices can be eliminated, the practice of dishonesty, which used to be very systemic and structured. Now, we can eliminate it with this new system and platform. Besides, the paper media used for exams could be more extensive regarding making questions. The form of questions that can be written on these sheets of paper is less varied. Compared to using computers in a learning process, it can provide more and more varied

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learning experiences for students, increasing learning motivation and developing information technology and computer skills for students (Nurchaili, 2011).

So far, the percentage of paper-based examinations has decreased; on the other hand, computer-based exams have increased, and the high school and vocational high school levels have reached 80% (Greenlaw & Brown-Welty, 2009). Deputy Chairperson of Commission X Parliament of the Republic of Indonesia stated that a sufficiently measurable benefit is the budget savings spent, especially for the procurement of examination papers, which can save 20% from regular exams and 30% in distribution costs. The Chairperson of the Teachers Association of the Republic of Indonesia 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 (Jeong, 2014). Head of the 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 schools and, vocational high schools or primary schools that have computers. Regarding NSSE implementation, many things still need to be addressed immediately. Instead of wanting to digitize student exams and use of ICT, what happens is that schools that have yet to be able to provide computers/laptops and other NSSE technical prerequisites in schools feel discriminated against (Iqbal, 2019). Data from the Ministry of Education and Culture in April 2018 revealed that 34.6% of schools (at all levels) chose to continue implementing NSSE, and 16.5% NSSE by staying at other schools. Nationally, 48.9% of schools have participated in NSSE fully independently. A news item in Jawa Pos: 2018 informs that, given the high cost of Computer-Based National Examination (UNBK) needs, there are schools that charge students varying amounts of fees, starting from IDR 600.000 (USD38.44), IDR 800.000 (USD51.25) IDR 1.100.000 (USD70.47), up to IDR 1.500.000 (USD96.09).

Research conducted by Aisah (2019) concluded that the smartphone test model makes it easier for students to work on questions and for teachers to facilitate administration and reduce costs. However, there are areas for improvement in this study. Namely, the application with hundreds of users has yet to be tested at once, and the user must have an internet connection when using the application from start to finish. Another study by Mas Bakar et al. (2018) concluded that smartphone and computer-based exams facilitate the preparation and completion of activities ranging from administration to exam results. However, this study has several areas for improvement, namely the need for more security when using the application. Users can access other applications when using the exam application, of course, this allows users to cheat during the exam.

The various statements above show that implementing computer-based examinations has many benefits. However, in the technical field, many schools still experience difficulties. According to the Ministry of Education and Culture standards, they cannot carry out computer-based examinations due to inadequate infrastructure problems. The infrastructure mentioned above is quite expensive; apart from that, almost no other applications can be used for computer-based exams or smartphones with high performance and for free (Fluck et al., 2009). 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 Prorakyat CBT application. This application uses a low resource composition on the server side, the network topology in general, and restrictions on multiple access to other activities when using the application, which can minimize cheating during exams.

## 2. Methodology

The development design that will be used in this research is ADDIE. The research was conducted at the Vocational High School of Muhammadiyah 1 Temanggung, Central Java. The ADDIE development design steps consist 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. Results

### 3.1 Analysis

The analysis step is a needs assessment process, identifying problems (needs) and performing a task analysis (Claver et al., 2000). The researcher analyzes the need for application development and 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. The stages of the analysis carried out by the author are as follows:

### 3.1.1 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 conducted. 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; and 3) room plans. 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 during implementation if certain obstacles occur.

### 3.1.2 Needs Analysis

In systems engineering and software engineering, needs analysis includes determining the needs or conditions that must be met in a new product or product change, which considers the various needs that intersect among various stakeholders (Nielsen et al., 2015; 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 (Wiegers & Beatty, 2013; Stellman & Greene, 2005). 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 used to build the system. The composition of the software and hardware used is described in Table 1.

**Table 1: Software and hardware needs**

| No. | Software | Version |
|---|---|---|
| 1 | NGINX webserver | 1.16 or other versions |
| 2 | PHP language program | 7.2 or other versions |
| 3 | Postgresql database | 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 (Davis, 2013; Sul et al., 1998).

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

Five main components form the application's core, namely the NGINX web server, the PHP-FPM module, Moodle, and the database packaged in one data package or server (Skvorc, 2015; Rice, 2006). On the outside of the server, there is one component: the pfSense route.

The second part is the system interface. The interface of a system is determined at this stage of system planning. Therefore, find out in advance the parts of the interface that 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 designed for supervisory and administrative purposes, such as printing participant cards.

The client interface is already available from one of the application's core components, namely Moodle. This study will set the Moodle interface with a standard theme or Boost (Dougiamas, 2004). The use of this theme is not only simple but also to lighten the server load because this theme only displays a little theme program code. The flow is described in more detail in Table 2.

**Table 2: Process of the server**

| No. | Description |
|---|---|
| 1 | The client requests data from 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 et al., 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 |

## 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 system's core, namely setting the process per second on the web server 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, 2015), the third PHP-FPM module installation, the fourth the Postgresql database installation, the fifth Moodle installation, and finally the pfSense routing installation (Douglas & Douglas, 2003).

## 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 limited to schools designated as research sites. Besides, it is also limited to the implementation time because it follows the school schedule. All students and teachers carry out implementation. 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 (35) students with a duration of each subject of 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 (Abate & Di Cosmo, 2017; Murdock, 1993). The server functions as a service that manages all exam activities, starting from randomizing questions for each participant, sending questions to each participant, storing participant answers and accumulating the number of correct or wrong answers to produce a final score. Then, one more computer 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 with pfSense software as a route or network manager. The network scheme or topology used at this implementation stage is Star. This topology makes the hub/switch a terminal or data traffic centre. The topology used is illustrated in Fig. 1.

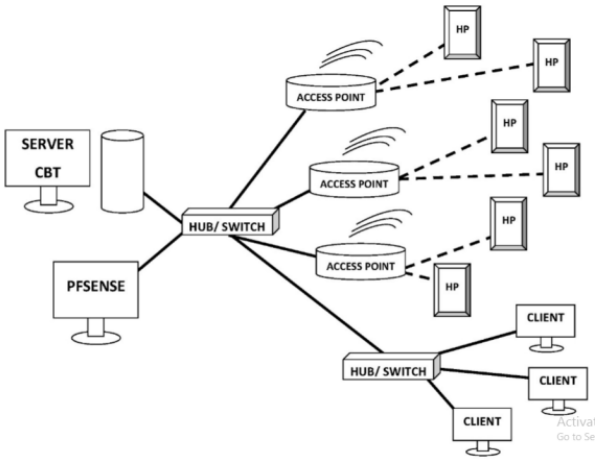


**Fig. 1: Computer and smartphone-based exam topology**

Fig. 1 shows the flow used in implementing computer-based and smartphone-based examinations. If explained, the image flow above is as follows in Table 3.

**Table 3: Implementation of computer-based examinations**

| No. | Process |
|---|---|
| 1 | Clients or test-takers can use a smartphone or computer to administer the exam |
| 2 | Smartphones are connected via Access Points or Wifi; this method is often called 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. Only with this network identity can clients access the server |
| 5 | The server manages all incoming requests and returns data to the client on demand |

The flow and cycle formed are shown in the table above. Please note that this computer-based and smartphone-based exam process does not use Internet access. So that test takers and schools can think about something other than internet access or fees for it. This follows the principle discussed in the previous chapter: implementing 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 distributed questionnaire was used to gather data about the effectiveness of the computer-based and smartphone-based examination methods. This questionnaire was aimed at students and teachers. At the same time, 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 sufficient for the developed application's analysis process. Some of the important points are as follows in Table 4.

**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 and 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 shows the questionnaire and the results of smartphone specifications.

**Table 5: Questionnaire and result of smartphone specification**

| No. | Information | Form | Result | Result |
|---|---|---|---|---|
| 1 | How much RAM did you use for this test? | Questions | 132 : 1Gb | 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, as shown in Table 6.

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

| No. | Information | Form | Agree | 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 as shown in Table 7.

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

| No. | Information | Form | Agree | 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 |

### 3.5.3 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 shows the questions and the results of the problem during the exam.

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

| No. | Information | Form | Agree | 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 |

### 3.5.4 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, as described in Table 9.

**Table 9: Questions and the results of conclusion**

| No | Information | Form | Smartphone-based | Paper-based |
|---|---|---|---|---|
| 1 | If you were free 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, scoring one each. Meanwhile, cost testing by comparing the accumulated exam costs is done by simply summating 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 to compare the percentage so that it is objective. The calculation plan is as follows in Table 10.

**Table 10: Accumulated cost paper and computer-based exams**

| Paper-based exams | | | | | | |
|---|---|---|---|---|---|---|
| Activity | | Cost (Rp) | | Number of examinees | Accumulated costs for each participant | |
| | | IDR | USD | | IDR | USD |
| 1 | Exam 1 | 34.672.000 | 2.209.82 | 502 | 69.000 | 4.40 |
| | Exam 2 | 23.778.000 | 1.515.49 | 422 | 56.000 | 3.57 |
| | Exam 3 | 35.850.000 | 2.284.90 | 523 | 68.500 | 4.37 |
| Computer-based and smartphone-based exams | | | | | | |
| Activity | | Cost | | Number of examinees | Accumulated costs for each participant | |
| | | IDR | USD | | IDR | USD |
| 1 | Exam 1 | 25.568.000 | 1.629.57 | 623 | 41.000 | 2.61 |
| | Exam 2 | 15.961.000 | 1.017.27 | 591 | 27.000 | 1.72 |
| | Exam 3 | 15.881.000 | 1.012.17 | 583 | 27.000 | 1.72 |

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

## 4. Discussion

Based on the data, the computer or smartphone test does not require high specifications. This conclusion is obtained from Table 5, which contains a questionnaire about the specifications of smartphones of the 502 respondents; 132 respondents used smartphones for exams with 1 GB RAM specifications and or lower, and the remaining 2 GB and or higher. 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 during the exam. Most respondents only experienced problems during exams under 5x, namely 304 respondents. From the empirical analysis, namely the field survey, most problems 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. Human errors cause problems that arise. 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 averaged, 92% of respondents agree that the application is easy to use or needs help to operate the application. Researchers have researched 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 on each participant are different. It can minimize cheating during exams (Nasution, 2013). In addition, exams using computers or smartphones have greater flexibility in question variations (Dougiamas & Taylor, 2003).

Exams using computers and or smartphones are more cost-effective. This conclusion can be seen from Table 10, which compares exam costs using paper and computers or smartphones. 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, fees decreased by 29.000 or 52% for

each examinee. On the third test, there was a reduction in costs by 41.500 or 60%. Exams using a computer or smartphone have a significant cost-reduction effect.

Exams using computers and smartphones are more desirable than paper exams. This conclusion can be seen from Table 9, which contains a questionnaire about the test method selection. Four hundred fourteen respondents, 82%, stated that exams using computers or smartphones were more desirable.

## 5. Conclusion

Based on the data from the questionnaire responses, several things can be concluded: 1) testing using a computer and smartphone does not require high specifications on either the client or server-side; 2) the interface is designed neatly and makes it easy for test-takers to operate the application; 3) test takers become more free and calm in carrying out exams using computers and or smartphones; 4) exams using computers and smartphones have more flexibility in terms of question variations; 5) exams using computers and smartphones are more cost-effective; and 6) exams using computers and smartphones are more desirable than paper exams.

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