INTERNATIONAL JOURNAL ON INFORMATICS VISUALIZATION

Web and Android-based Test Application Development and its Implementation on Final Semester Examination

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Abstract—**This research aims to revolutionize the examination process in vocational schools by developing the FlyExam application, an Android-based test platform derived from improvements to the TCExam interface. The core goal was to create a powerful, easy-to-use, and effective tool for semester assessment. Following a Research and Development (R&D) approach, this research uses a 4D model: Define, Design, Develop, and Disseminate. Validation procedures require expert evaluation of the technical aspects and usability of the application. At the same time, practicality is assessed through engagement with students and teachers, and effectiveness is measured by student performance. Expert reviews and user feedback confirm the validity and practicality of the application. During implementation, the LAN network topology proved to be a conducive environment for conducting semester exams, increasing the efficiency and reliability of the testing process. The integration of TCExam and FlyExam on mobile devices shows the potential of transitioning from traditional paper-based exams to digital platforms, offering greater flexibility and accessibility. Future research efforts could explore FlyExam's scalability and adaptability in various educational contexts and its long-term impact on assessment practices and academic outcomes. Additionally, ongoing improvements based on user feedback can lead to further improvements and the incorporation of new features, ensuring FlyExam remains relevant and effective in meeting evolving vocational education needs. In summary, the development of FlyExam represents significant progress in the modernization of assessment methodology, with the potential to simplify the process and improve the learning experience in vocational schools.**

Keywords—**Computer Based Testing (CBT); computer-based assessment; test using phones; Android.**

I. INTRODUCTION

The Final Semester Examination in Vocational High Schools requires a long enough time for the vocational competency tests/practical tests to assess students' skills. Doing tests for 3 to 5 subjects in each level and each skill competency takes about one week. It is followed by an exam to measure students' knowledge in their school subjects, which ranges from 8 to 11 subjects, and usually takes another week. On average, the full implementation of semester examinations for Vocational High Schools is two weeks [1], [2]. The amount of time needed for the Final Semester Examination at Vocational High Schools will undoubtedly require many costs and has some weaknesses, including 1) Providing the exam questions, specifically: papers, copying of the question script, and Honorarium for teachers who made the questions. 2) Honorarium for the exam supervisor and committee. 3) Consumption fee for the test supervisors and

organizers during the examination. 4) Paper and other stationery. 5) Checking the test results requires much time. 6) the possibility of subjectivity from the examiner. 7) allows students to cheat on their friends. 8) Use a lot of space/ rooms. 9) Many people are involved in conducting the exam [3], [4].

Several deficiencies mentioned earlier will influence the expenses of conducting semester examinations at Vocational High Schools. Consequently, these shortcomings will decrease the available funds for other school endeavors, including enhancing human resources quality, procurement, and supplementary learning facilities. The school must manage its finances efficiently to allocate more resources for various activities. One strategy to achieve efficiency is by leveraging computers and students' devices or phones for administering semester examinations [5]–[7].

Computer-based testing commenced in the early 1970s when computer capabilities were relatively limited, and the substantial funding required restricted their widespread adoption [8]. However, technological advancements have

facilitated the development and integration of computerized exams into extensive testing initiatives, including licensing, certification, admission, and psychological assessments [9]–[11]. Numerous studies have highlighted the myriad advantages of computer-based testing across various dimensions when juxtaposed with traditional paper-based tests [12]–[17]. Utilizing computers in assessments has been shown to enhance learning outcomes. Additional research suggests that students exhibit a more positive attitude and increased motivation for learning when engaging in computer-based tests compared to traditional paper-based tests. Moreover, studies involving graduate students revealed that a significant majority, 61.8%, preferred computer-based tests over their paper-based counterparts [18]–[21].

The rapid advancement of cell phone technology has endowed these devices with capabilities akin to those of traditional computers. Modern smartphones boast ample internal and external storage capacity, high-speed processors (CPUs), wireless connectivity options such as Wi-Fi and Bluetooth, integrated sensors, GPS functionality, cameras, and sophisticated operating systems. With these features, a mobile phone possesses all the essential elements to function as a computer [22], [23]. Furthermore, smartphones support the execution of various small computer programs, known as mobile applications or apps, which offer diverse functionalities [24], [25]. These include viewing and editing text files in formats like Word and PDF, instant graphic rendering, web browsing, access to dictionaries, scientific calculators, and numerous other utilities. When harnessed positively, the cell phone emerges as a valuable tool for learning and education [26].

Using smartphones to conduct final semester examinations is a viable alternative to paper-based and computer-based exams. Some factors underpinning this assertion include the number of students who have Android phones. According to a preliminary survey of Vocational High Schools No.1 Lahat South Sumatera students conducted in May 2018, 680 out of 972 students (70%) have an Android Mobile Phone. Also, Android mobile devices can utilize a web browser to access applications hosted on a server. However, Mobile phones can be configured to restrict user access to the device, a crucial feature for ensuring the security of exam implementation. In addition, Android-based mobile phones are extensively employed in educational settings, particularly to supplant the role of computers in accessing learning materials and to leverage the device's capabilities for independent learning assessments.

Drawing from the descriptions provided for paper-based, computer-based, and phone-based tests earlier, we can formulate the following comparative table (Table 1) to illustrate their differences.

TABLE I
THE COMPARISON OF USING PAPER, COMPUTER, AND PHONE-BASED TESTS AT VOCATIONAL HIGH SCHOOL

No	Examination Activities	Tests		
		Paper	Computer	Phone
1	Provision of the Examination room	√	√	√
2	Examination Supervisor	√	√	√
3	Questions	√	-	-
4	Packing Committee Copying the Questions	√	-	-
5	Answer Sheet	√	-	-
6	Checking the Answer Sheet	√	-	-
7	Provision of Special Room	-	√	-
8	Randomize Questions	-	√	√
9	Quickly Obtain the Test Result	-	√	√
10	The Need for LAN Network Infrastructure	-	√	√

Based on the information presented in Table 1, it can be inferred that employing phones in school examinations, particularly in Vocational High Schools, offers superior efficiency compared to paper-based and computer-based tests. Upon examining the comparison between computer-based exams and paper-based exams, it was observed that the two testing systems had minimal discernible impact on the validity and overall reliability of the tests [27], [28].

Organizing phone-based and computer-based exams requires an application that can be used on both devices [29], [30]. One of the applications for conducting computer-based exams is TCExam. The TCExam application has open-source code created for electronic examinations (CBA-CBT). This application allows educators to write, schedule, deliver, and report quizzes, tests, and exams. One of the benefits of TCExam is that it is powerful enough to handle exams with more than 100 clients. From several preliminary tests conducted before this study, TCExam can test up to 380 clients with one server. The program also helped in designing questions and tests efficiently.

Besides, it used quite a small amount of memory. Development research on the TCExam application is conducted to produce a FlyExam interface test and an Android-based client application to obtain those benefits. Also, this research aims to determine the validity of the applications developed using the FlyExam application for Final Semester Examination for students of class X and class XI at Vocational High Schools No.1 Lahat South Sumatera. Finally, this research aims to find out the practicality of the FlyExam application that has been developed.

The research conducted will produce two applications: (1) a test interface on the server and (2) Client-side applications specifically for Android-based phones and tablets. The application that is built will not change everything related to TCExam. The built-in application is an additional application to make the TCExam usable for Android-based tests on the test interface. The application developed for the client side will be named FlyExam.

Prior research has predominantly concentrated on students' reactions to computer-based examinations. However, this study investigated student perceptions regarding computer-based CBT (Computer-Based Testing) tests at Ilorin University, Nigeria. Analysis of the tests both before and after the motivational intervention reveals a notably favorable shift

in student attitudes towards computers and mobile devices as platforms for administering assessments. Their study aimed to assess the impact of computer-based learning versus traditional approaches on student attitudes and academic outcomes in analytical chemistry. Examination of test scores affirms the absence of consistent performance disparities between paper-based and computer-based formats [27].

This study aims to produce a valid and practical Android-based test application. Besides obtaining a valid and practical application, the researcher will also reveal the application's effectiveness by comparing the exam results using a computer with the paper-based test results.

II. MATERIAL AND METHOD

This research is development research using the Four-D development model. This model consists of four steps of development, namely Define, Design, Develop, and Disseminate [31]The dissemination stage is the main reason for choosing the four-D development model. Its purpose is to promote the products produced as acceptable to users. The final stage of product development is the most important, although it is most often overlooked [31]. The development resulted in creating two products: a web-based examination interface and a client application designed for Android phones. The process involved the following steps:

A. Define

During this phase, a comprehensive understanding of all TCExam application functions is acquired, and meticulous documentation of all system-related files is conducted. This task aims to evaluate the utility of each source code segment employed in the application development process. The application folders are categorized into three main sections: admin, public, and shared.

B. Design

This stage is for designing:

1) The test interface: It is a web page displaying questions that examinees will access. This page is created using a bootstrap with a responsive display; the display can be adjusted to the size of the screen accessing the page.

2) FlyExam design: FlyExam is a browser created to access the test page. This stage is for designing the homepage display and security features to ensure safety and comfort during the exam. Restrictions on accessing the files when performing tests and recording question scripts on the screen are significant concerns in designing the applications.

C. Develop

The test interface and the client application program codes are written at this stage. The application is tested for its functions and application security. The Android client side must meet the following security requirements:

1) Students cannot leave the application during the examination. Therefore, limiting students' access to other files or mobile phone applications is necessary while conducting the exam. Students can leave the application if the examiner gives them a token.

2) During the exam, the home button and activity button

on the Mobile is not accessible. The goal is to prevent students from accessing other files or applications on their mobile phones while conducting the exam.

3) Access to screenshots and screen recorders is impossible during the exam process. The goal is that the displayed questions cannot be recorded to avoid leakage of exam questions.

D. Disseminate

At this stage, the application is disseminated; the aim is to ensure that the application built is entirely free of errors and to obtain input from the users. This free application is promoted through YouTube channels and WhatsApp groups. User entries are recorded as material to make improvements to the application.

This research produces two applications: 1) a Server application for the test interface and 2) a client application (FlyExam) for Android phones/gadgets. The applications designed have been tested for validity and practicality. In testing the validity, the applications are checked by three experts in web-based and Android applications. The practicality of the test is analyzed through questionnaires prepared for users (students and teachers).

In assessing the validity of the application, Aiken's V formula for validity testing is employed [32].

$$V = \sum s / [n(c\text{-}1)] \qquad (1)$$

In this evaluation framework, the validity rating is calculated using Aiken's V formula, represented as follows: S = R – Lo, where Lo denotes the lowest validity rating (e.g., 1) and R represents the rating given by the evaluator. Additionally, the highest validity rating, denoted as C (e.g., 5), is factored in.

The assessment of practicality involves analyzing students' feedback regarding the application's utilization during examinations. The optimal scoring criteria for this analysis can be outlined as follows:

$$Prs = \frac{A}{B} x\ 100\% \qquad (2)$$

where A represents the total scores of students' answers, and B signifies the maximum achievable score.

TABLE II
PRACTICALITY CRITERIA

Achievement %	Category
90 – 100	Very Practical
80 – 89	Practical
65 – 79	Quite Practical
55- 64	Less Practical
0 – 54	Not Practical

The sampling was taken using the Simple Random Sampling technique, which was taken from 2 groups of tests, the phone-based and computer-based examinations. Both the phone-based exam and the computer-based exam groups are considered homogeneous.

The trial of the use of applications for examinations was conducted once. The trial was conducted for small groups in class XI of Computer Network Engineering, XI Software Engineering, and XI Electricity of students of Vocational High School 1 Lahat with 90 students. This trial is used to

determine whether all the application functions ran well. The results of the trial were used to improve the application. The second trial was carried out on all students of Vocational High School No.1 Lahat, and there were 1019 students of class X and class XI conducted in the semester examination.

III. RESULTS AND DISCUSSION

A. Test Interface for Computer-Based Exams

The development has produced an interface for Android-based tests and computers. The test interface is a web page accessed by examinees who use phones or computers. This page used the PHP Version 7 programming language, and the application display was made using Bootstrap 4.1.3. The access to the data and the course flow of the program are adopted from the TCExam application by utilizing the functions provided by TCExam developers. The results of the development are shown in Figure 1 below.
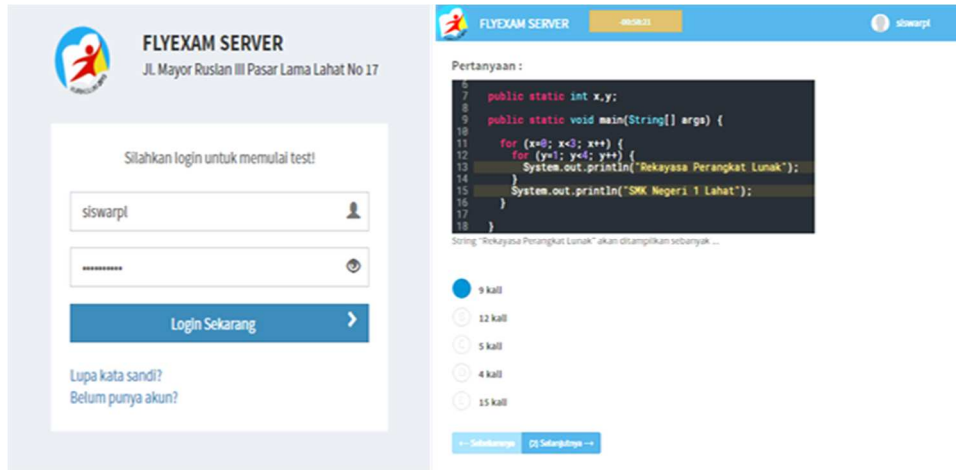

Fig. 1 Test Page Interface

B. Fly Exam Mobile Application

The FlyExambro Application is designed for Android phones or tablets to access web pages hosted on a server. This application restricts users from accessing content outside the test application by established security standards. The following Figure 2 illustrates the outcomes of the application development.
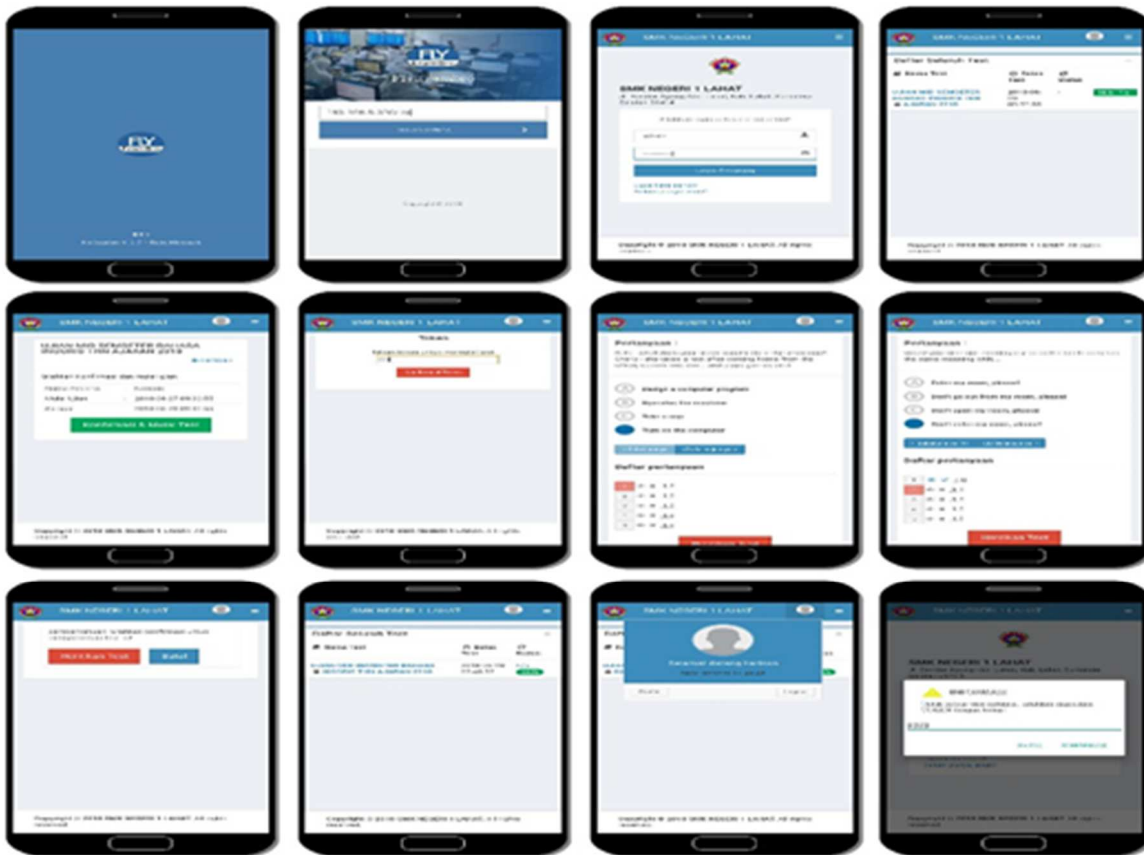

Fig. 2 FlyExam Browser Display

C. Validity of the Application

Before conducting trials with students, the application undergoes validation by three experts specializing in web-based applications and computer-based learning media. These experts provide insights into the concept of validity, which encompasses assessments of sufficiency and practicality tailored to specific purposes [33]. Validity serves as an evaluative guideline determining the degree to which empirical evidence and theoretical rationales substantiate the appropriateness and effectiveness of inferences and actions derived from test scores [34]. Based on these perspectives, it can be inferred that the validity of something necessitates backing from empirical evidence and theoretical justifications for interpreting test scores, thereby correlating with the precision of the assessment. The average data presented in Table 3 is obtained from the questionnaire given to the validators.

TABLE III
EXPERTS VALIDITY

Test Variables	Aikens'V
Display Design Quality	0,85
Easiness of Application Usage	0,87
Application Quality	0,86
Application Output Quality	0,96
Test Security Quality	0,85

From the data presented, all the application quality variables created are categorized as valid.

D. Application Trials

Before the application was implemented on the semester exam, limited trials were conducted on class X, namely class XI Computer Network Engineering, XI Software Engineering, and XI Electrical, taking randomly 90 students, 45 computer-based exam students, and 45 students again paper-based examinations. Tests were carried out for two lessons: Indonesian Language and Mathematics.

It was assumed that there were no differences in the results of the test using a computer and the results of the test using paper. T-test is used as a comparative test between 2 independent samples. The study design used True Experiment Design.

TABLE IV
RESEARCH DESIGN

Computer-based exams	Treatment	Paper Based Exam
R1	X	R2

E. Implementation of Applications in Final Semester Examination

In implementing phone/gadget and computer-based exams using the developed applications, the applications are installed on servers with the Ubuntu 16.04 operating system. Supporting server applications that must be installed on the server are 1) Apache Webserver; 2) PHP 7; 3) MySQL database; 4) DHCP server; 5) FTP server; 6) SSH server. The server specifications used during the trial are the Xeon X5670 double Processor, 16GB RAM, and SAS 300GB Hard Drive.

Due to the limited access to Wi-Fi and computer network devices, the implementation of the application testing on the semester exam for all students of class X and XI of Vocational High School No. 1 Lahat was done by dividing students into 4 test sessions. The test was split into two test groups. The exam group used phones, and the exam groups used computers. These two test groups accessed the same application and the same server. The division of exam groups is explained in Table 5 and Table 6.

TABLE V
LIST OF ROOMS & PHONE-BASED TEST SESSION

Class	Room	Session 1	Session 2	Session 3	Session 4	Total
X	13	30	30			
	14	30	30			
	15	30	30			336
	16	30	30			
	17	30	30			
	18	30	6			
XI	13			30	30	
	14			30	30	
	15			30	30	280
	16			30	10	
	17			30		
	18			30		
Total		180	156	180	100	616

TABLE VI
LIST OF ROOMS AND COMPUTER-BASED TEST SESSION

Class	Room	Session 1	Session 2	Session 3	Session 4	Total
Class X	LAB-1	40	40			
	LAB-2	32	32			
	LAB-3	28	28			
	LAB-4	8	11			403
Class XI	LAB-1			40	40	
	LAB-2			32	32	
	LAB-3			28		
	LAB-4			8	4	

Test time allocated for one subject is 1 hour for 30 to 40 items. The questions are tested in the form of multiple-choice and short answers. A network topology is designed to use an Android and computer-based exam application on the semester exam of the 2017/2018 academic year at SMK Lahat. The network topology used to implement Android-based mobile phones and computer exams is shown in Figure 3.
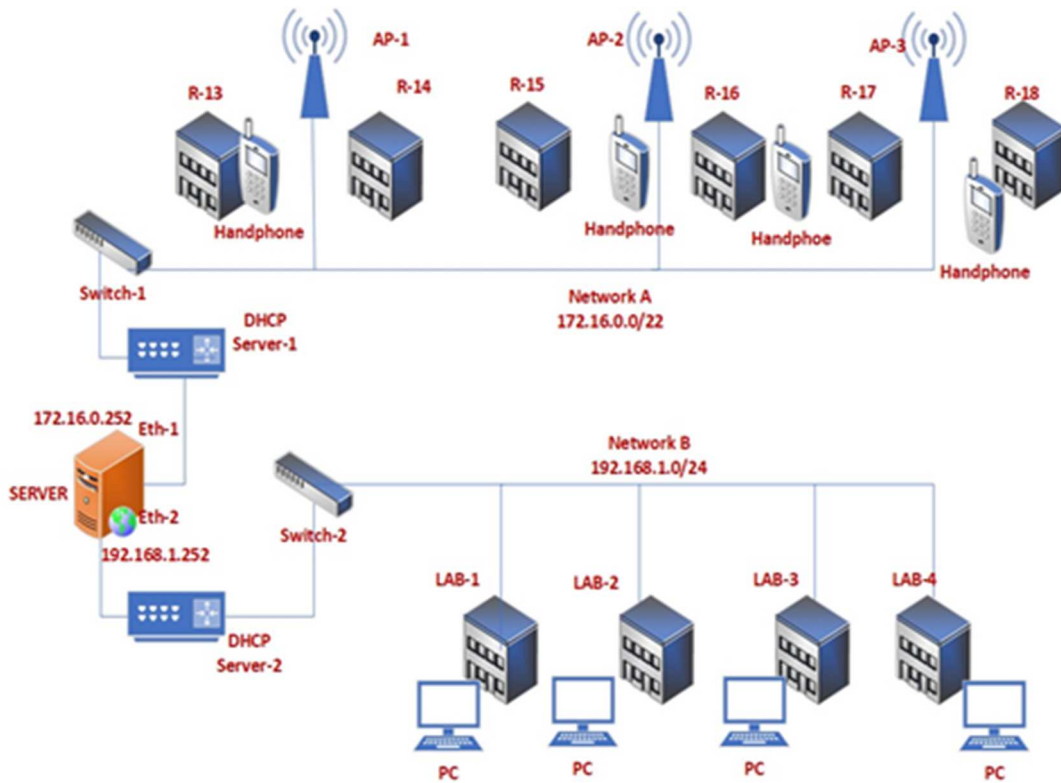
Fig. 3 Network topology for phone and computer-based tests

LAN networks are divided into two, namely network A and network B. Network A is used for Phone-based tests, while network B is used for computer-based tests. Each network is connected to the server by installing two NICs (Network Interface Cards). R-13 to R-18 are classrooms used for Android phone-based exams. Every 2 (two) rooms use 1 (one) access point (AP). Sixty users use one access point. The total number of users of access points in 1 exam session is 180; for the exam using a computer, one session can be accessed by a maximum of 111 users. The total maximum number of examinees for one session is 291 participants.

Network A's IP address was used using the subnetting IP Address of class B, 172.16.0.0, subnet mask 255.255.252.0. The usable host addresses are started from 172.16.0.1 to 172.16.3.254. The total number of hosts that can be used is 1022. This IP address is given by a DHCP server installed on the server. Thus, all mobile devices connected through each access point will automatically get an IP address.

Utilizing Wi-Fi networks through access points AP-1, AP-2, and AP-3 is safeguarded by the WPA2 security protocol, widely regarded as the most secure configuration for Wi-Fi networks. WPA2 security is extensively adopted to ensure the safety of both private and enterprise networks. In comparison to its predecessors, WEP, which employs the RC4 algorithm without crucial management, and WPA, which utilizes the Temporal Key Integrity Protocol (TKIP) with a hash algorithm for essential randomization, WPA2 employs the Advanced Encryption Standard (AES) algorithm for data encryption [35].

Network B is the type of network that uses cable. It is done in 4 (four) computer laboratories with a total number of 111 units of computers. Each computer gets an IP address from a DHCP server. The IP address used uses class C with a maximum number of 254 hosts. The address used is 192.168.1.0 / 24.

The NIC server connected to Network A uses an IP address of 172.16.0.252/22, while the NIC connected to Network B uses an IP address of 192.168.1.252/24. Access the test application from Network A using the URL http://172.16.0.252, using the FlyExam application specifically for Android phones, while accessing the test application from Network B using the URL http://192.168.1.252.

F. The Practicality of the Application

The type of data obtained is quantitative data. It is written in the percentage of students and teacher responses and converted into practical categories in Table 7. The results of the questionnaire responses of students and teachers to the application development were then analyzed by percentage analysis. The number of student samples used to test the practicality of applications is presented in Table 7.

TABLE VII
SAMPLES OF THE RESEARCH

Number of participants in phone-based examinations	Number of samples	Number of participants in computer-based tests	Number of samples	Research Samples
616	315	403	250	565

For the teacher, surveys were distributed to three instructors specializing in Computer and Network Engineering Competencies and two instructors focusing on Software Engineering Competencies. After data processing, the findings obtained from both students and teachers are summarized in Table 8.

TABLE VIII
AVERAGE SCORES OF ANSWERS GIVEN BY STUDENTS AND TEACHERS

Variable	% Students Score	Category	%Teachers Score	Category
Design Display Quality	76,77	Quite Practical	81,14	Practical
Easiness of Application Usage	83,02	Practical	82,50	Practical
Application Quality	85,57	Practical	76,00	Quite Practical
Application Output Quality	93,45	Very Practical	81,00	Practical
Security of The Application Quality	86,80	Practical	84,66	Practical

The two tables show that the application is classified as practical. The lower number is seen in Display Quality. This variable, according to students, is quite practical. According to the teacher, however, the application quality is still practical. The rest is relatively practical. According to students, even the Quality of the Output Application is classified as Very Practical.

Promotions are made through the web, YouTube, WhatsApp, and Telegram groups for more extensive use. The FlyExam application for Android has been used by hundreds of vocational and high school schools spread throughout Indonesia for the National Standard Final Examination in March 2019. These schools are in South Sumatra Province, West Sumatra Province, Jambi Province, Bengkulu Province, Riau Province, Jakarta, Java West, Central Java, East Java, and others. The WhatsApp group has 550 recorded users, and the Telegram group has 865.

G. Discussion

This research is classified into development research. This development research is researching and testing to develop existing products. The first stage of this research is reviewing existing products, designing products, and conducting internal testing. After passing internal testing, made products, product revisions, and field tests. This research focused on developing the TCExam application interface and client application for Android mobile phones. TCExam is distributed by the author for free and with an open-source code (http://tcexam.org). In developing the test interface, the application developed does not change the appearance and performance of the existing TCExam application. It follows the applicable license given by the TCexam maker https://tcexam.org/licensing/.

The TCExam is distributed with a dual license scheme, so it is available either as Open-Source Software or with a Commercial License by usage case. The commercial license allows you to use your logo on the public interface (the client logo), make changes that will not be publicly released, and integrate TCExam with a commercial service. The existing copyright notices and links to TCExam and Tecnick.com Websites must be kept intact and visible (at the bottom of the pages). TCExam application cannot be rebranded.

Applications built separately from TCExam utilize the database, tables, and TCExam functions placed in special folders and separated from the TCExam folder. The main goal is that the tests made with TCExam can be accessed using Android phones and accessible from a computer. In summary, it can be explained that if the user wants to take the test using the original TCExam application interface, they can access the original URL from TCExam. On the other hand, if the user wants to access it from an Android phone, or the IOS, they can access the URL such as http://ipserver/cbt. The application test interface is placed in the cbt folder.

The interface application of the TCExam and the FlyExam application has been tested on 1019 students for the semester exam conducted from May 21 to May 26, 2018. No application defects were found during the testing, and the application went as expected. The results of this field test follow the results of the application validity test by the expert. All validated variables have shown valid categories, as shown in Table 3. Likewise, the practicality of applying all testing variables is already included in the practical category.

During the test implementation phase of this study, observations regarding the Local Area Network (LAN) design revealed several significant aspects. Initially, the configuration of IP Addresses on the DHCP (Dynamic Host Configuration Protocol) Server for Network A (as depicted in Figure 3) utilized class C addresses, specifically 192.168.0.0/24, accommodating a maximum of 254 hosts. The initial exam session proceeded smoothly. However, challenges arose during the second session, as many students encountered difficulties accessing the exam.

To validate the assumption, the configuration of the DHCP server was examined. It was discovered that the Leased DHCP settings were set to 120 minutes, equivalent to 2 hours, indicating the duration for which an IP address is rented. Khadilkar elaborates that to analyze basic usage patterns assess the impact of altering DHCP lease times on traffic patterns and address space utilization, understanding client activity dynamics is crucial. Since clients regularly release DHCP messages, their activity can be inferred from them. Clients typically send an "update" message approximately halfway through the lease time, as expected by the DHCP protocol. During implementation, it was observed that the DHCP server refrains from assigning an IP address previously used by another client, even if that IP address is no longer in use by the original client [36][37].

The temporary solution for the first day of the test was to restart the DHCP server. Restarting the DHCP server was done every time you started the test on the second exam session, the third exam session, and the fourth exam session. A permanent solution to overcome the problem of a client who cannot get an IP address is to merge a DHCP server with the TCExam server. It can be done by installing a DHCP server on an Ubuntu 16.04 Linux server (ISC-DHCP-SERVER), then creating the main configuration by making a subnet from IP Class B, with the address: 172.16.0.0/22. From the subnet address, IP Address is obtained with the range 172.16.0.1 to 172.16.3.254. The total number of hosts is 1022 hosts. Based on calculations with the client, 180 X 4 sessions = 720 addresses prepared is sufficient. Furthermore, from the second day of the exam until the last day of the test, the problem of the client not getting the IP address is no longer found. The semester exam can take place well until the last

day of implementation.

From the dissemination of applications that hundreds of users have used, inputs for the improvement of applications have been obtained, including:

- FlyExam Browser security on Android mobile phones restricts access from browser Chrome to Desktop mode.
- Use a browser specifically for PCs to limit access to local hard drives and turn off shortcut buttons such as CTRL + ESC, CTRL + P, etc.
- Add applications to import questions using Microsoft Word.
- Add applications for import users and groups
- Add application for item analysis

User input has been improved in the application and distributed to users. Furthermore, no more clients got the IP address from the second day until the last day of the exam. The semester exam ran well until the last day of implementation.

IV. CONCLUSION

This research yielded two outcomes: the Exam Interface Application tailored for TCExam, and the test application for Android phone users, named FlyExam. The Test Interface is installed on the server side, while FlyExam is installed on each student's handphone. The applications were tested for validity and practicality and implemented in the Final Semester Examination at Vocational High School 1 Lahat South Sumatera in 2018. The validity is tested with experts, a web-based application expert, and two media experts. Practical tests are carried out for application users, students, and teachers. The application is declared valid by the expert and practical by the users.

In the implementation phase, selecting access point devices must be the primary consideration. The quality of access points determines the smoothness of the test using a mobile phone. The access points used in the testing can handle up to 60 users. DHCP servers integrated with application servers in this study were better than DHCP servers using routers. The DHCP server uses the routers, which were only capable of class C, for 254 clients. The minimum number of IP Addresses must be allocated equally to the number of Android phone clients, even though the client is divided into several test sessions. Based on these conclusions, the semester exam using phones with the TCExam application and FlyExam are appropriate for replacing the paper-based exam.

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