Adopting the DFORS-quiz app on Mobile Systems for Learning in Education with a focus on Digital Forensics

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Abstract

Technological devices such as smartphones have dramatically impacted how education is approached in the 21st century. With easy access to the internet and applications, including Microsoft, Apple stores, and Google Play stores, students and educators can access several tools to alleviate the burden of learning. We developed an Android-based application to encourage Digital Forensics self-guided learning. The outcome will demonstrate how Digital Forensics help to facilitate efficient learning in society. While many students or individuals do not like being quizzed, it may be a surprise to many that quizzing encourages the retention of information and fosters excellent comprehension. One may argue that a few benefits of quizzing are that it promotes active learning and critical thinking. A strong focus of this paper is to merge mobile technology with Digital Forensics as a tool for self-learning using the Digital Forensics (DFORS)-Quiz application. DFORS is an application that will aid in building the Digital Forensics curriculum courtesy of the features it bears. Furthermore, the limitation of this study is that iPhone users will be excluded considering the platform solely runs on Android. The college students who are non-Android users would be left out from using the DFORS. Another limitation imposed is the relatively smaller sample size affects the reliability of the outcomes.

Keywords: Computing Education, Digital Forensics, DFORS, Mobile Application, Smartphones.

1. INTRODUCTION

A vast majority of college students in America have either come across a mobile device or own one. Mobile devices such as mobile phones and other personal device assistants (PDA), such as tablets, etc., have provided ease of use to enable individuals in the educational system to gain access to worldwide information. This paper primarily aims to use DFORS (Digital Forensics) as a learning tool and study guide for the mobile use of Digital Forensics.

Digital Forensics curricula in various universities are not standardized and are often hidden under sub-computer/cybersecurity courses as there are few aspects of this field being taught to their fullest extent (Dafoulas & Neilson, 2019). The need to find solutions to provide a broadly adopted Digital Forensics curriculum to aid in

creating more highly trained professionals in the field (Stigall & Choo, 2022). Just like Digital Forensics, Mobile learning requires adherence to set standards and regulations to ensure that there is integrity in incorporating the aspects of cybersecurity (Sobel, Parrish, & Raj 2019). Over the years, the educational system has transitioned from the traditional Abacus system of counting to a more modernized augmented and virtual reality environment. This evolution has brought about numerous learning models to gain deep understanding about Digital Forensics.

For this paper, we will be addressing these research questions:

1. Will the DFORS mobile quiz application be helpful for the Digital Forensics curriculum?
2. How can we assess the effectiveness of our DFORS application on Digital Forensics Students?

2. LITERATURE REVIEW

Background Information

There is a need to set standards that provide both technical and educative learning approaches in the Digital Forensics field of study. The problem statement of this research is that there is a lack of good learning platforms tailored primarily toward Digital Forensics. The demand for Digital Forensics specific study materials which provide an in-depth degree of foundational knowledge is slowly on the rise as Digital Forensics should no longer be just a subset of cybersecurity or computer science.

Computing Education

Computing education is a necessary area of knowledge for modern-day students to provide insight on how to implement the experiences and lessons for purposes of developing and enacting them in real life. According to Limanto et al., (2020), it should be within everyone's purview that data is the next big thing in the future, and as such, so is the process of reading and analyzing data. The more available up-to-date course context is in a digital environment, the better-increased retention rates it fosters in active learning (Park et al., 2020).

Braguglia and Jackson (2012), reaffirmed the teacher's primary concern is to foster the knowledge retention potential of the students through engagement and effective teaching and learning methods. Digital Forensics students ought to be taught effectively to establish a link between theoretical concepts and the implementation aspect. One sure way to look at it is through digital games, which are described as "an effective and efficient instructional strategy for computing education" (Petri, Wangenheim, Borgatto, Calderón, & Ruiz, 2022).

One essential key for computing education is programming languages. Drawing from McGill and Decker (2020), the lack of tools, languages, and environments (TLEs) in curriculums limits our knowledge of the best approach to computing education. Thus, it is evident that programming languages are essential for the computing education of Digital Forensics students.

Digital Forensics

Educating students on the numerous aspects of Digital Forensics will contribute immensely by bridging the gap in the curriculum (Scanlon et al., 2017). Studies show there are not enough mobile applications which provide digital forensics students with study materials or testing environments to ensure they evaluate themselves through a series of questions designed for this field (Dafoluas 2019, Sitgall 2022). Specific processes, concepts, and procedures have been used to teach Digital Forensics. Over time, Digital Forensics has been taught using a scenario-based approach which entails the emulation of a given analysis of a laptop (Batten & Pan, 2008).

The basic forensic techniques resulted in finding deleted files and backing up memory and network packets, among other skills. This teaching activity proved effective in teaching students with little to no prior background knowledge. Digital Forensics education encounters diverse challenges, which are grounded on the lack of a curriculum to establish its foundation. Scanlon (2017) discusses the challenges that digital forensics education and training tend to bring on students. Curriculums are time-consuming and require the use of big amounts of data which should be further analyzed.

For this reason, Scanlon (2017) recommended creating the EviPlant system. Eviplant is designed to serve the aspects of efficient invention, manipulation storage, and even distribution challenges that crop up where education and training in Digital Forensics are concerned. It works on the principle that the system relies on the initial distribution of base disk images. These happen to be images that tend to have only base operating systems, according to Scanlon (2017). Through the creation of the EviPlant system, other challenges facing Digital Forensics education and training, such as proficiency testing and malware analysis, can be discussed. Plans are in the works to

resolve these issues.

Learning environments are ideal for exposing the students to an atmosphere where they can acquire one-on-one experience on what is needed in the field. At this juncture, it is crucial to note that even though learning environments are considered practical, they have been perceived as failing to engage users and tend to be relatively under-used (Lavoué et al., 2019). The researchers emphasized that many institutions do not have a good, conceptualized approach to teaching Digital Forensics, and as such, a framework was designed (Gupta et al., 2022). The framework provided a platform where the concepts can be implemented. Some institutions too, like Sam Houston State University, have their Digital Forensics curriculum integrated in the current cybersecurity program (SHSU, 2022).

Mobile Application

Currently, education has gained an edge with the array of mobile learning applications introduced to the digital market space. These applications have been tweaked to provide a practical and fun learning experience (Limanto et al., 2020). They are designed to assist with learning areas of interest to the individual student. Also, mobile applications are usually deployed to engage users in an independent, intuitive learning, attractive platform which makes it independent from textbooks (Limanto et al., 2020).

With the need for incorporating mobile systems into learning environments being the realistic way to engage students and teachers, education processes have moved to the development of mobile applications. One such educational approach is the "Algos" developed by (Oliveira et al., 2020), which aims to support the teaching and learning process management in Operating Systems (2020). Similarly, a study relating to a mobile system for educational purposes was conducted to investigate the use of a Mobile e-Learning application termed the "Mel app" (Neffati et al., 2021).

The finding from this paper by Neffati et al. (2021) suggests that other non-conventional yet technical approaches to electronic learning via smart devices should be explored and in the authors' case, their approach saw an increase in learning activities from smartphones than any other smart devices. The "Mel" application eased the learning practice by encouraging instructor and e-learner relationships to maintain communicative development-based e-learning for Technical Higher Education (THE). The study also involved:

- Testing the device in extreme situations.
- Extending the application space.
- Evaluating instructive perspectives and capabilities of the device under increasingly various understudy and beginner inhabitants.

Smartphones

Most educational mobile applications that provide educative resources also provide a testing environment to ensure learning outcomes. Upon completion of the tests, the students receive a score which helps them evaluate their comprehension skills. In addition to testing the students' comprehension, it is vital for instructors to facilitate the proper use of mobile devices during learning. This includes using the devices to carry out appropriate activities like group work and discussion (Sophonhiranrak, 2021).

Accordingly, both the lecturers and the students can receive feedback from any location at any time. Lecturers are provided with the opportunity to customize the application such that it becomes their own personalized program. This customization ensures teachers can transfer their visions and experiences for the use of technology. Additionally, podcasts may also be introduced in the classroom setting. Podcasts aid in reinforcing the depth of understanding among the students owing to the increased memorization of content and deeper learning. Unlike the previously reviewed papers, this paper advocates for the recall of learning modules using a mobile quizzing application. When applied in a learning environment, this quiz application efficiently gauges and assesses a student's progress within the confines of a learning objective. Thus, having learners recall content from a quiz in a mobile application is an effective way to help reinforce learning content. This technique is also used in a corporate environment as it enables and fosters learning retention and it is designed not to overwhelm users with numerous learning objectives. We strive to address the widening gap between acquiring theoretical knowledge and practical skills, especially in forensic studies (Gupta 2022, Nasharuddin & Umar 2021).

3. METHODOLOGY

In this segment, we will cover the implementation steps with two main modules for this application and a flowchart of the project procedure.

Learning Objectives

For the DFORS application, the learning objective would be limited to Digital Forensics I (DF1) as it

primarily contains contents suited for Digital Forensics beginners including the fundamentals of Digital Forensics (DF) and Information Assurance (IA) technologies. These areas of focus according to the curriculum of SHSU include Hardware forensics, Open System Interconnection (OSI) Model, knowledge of network packets, and some level of basic programming (2022). The DFORS essentially contains questions from all the content summaries of the course DF1.

Identify appropriate data collection strategies

To ensure that we adopted the right and appropriate data collection strategy we traced our steps back to understand the aim of this paper (Borromeo et al., 2022). The research aimed to test a theory using a tool designed to improve the learning process of demographics. We adopted a Qualitative and Quantitative data collection approach. This approach entailed utilizing both a questionnaire and a survey method when gathering data relevant to the hypothesis related to an educational tool (Nasharuddin & Umar, 2021). This approach helped us to analyze the change in the pre- and post- testing phases. The feedback was gathered as well as satisfactory remarks on using the study tool.

Quantitative Analysis

The quantitative tests would be an experiment to see if the addition of a mobile learning platform provides a more practical learning experience and increases the retention of foundational concepts within a field of study, such as Digital Forensics, (Twining et al., 2017). Sophonhiranrak (2021) pointed out that in research conducted between 2006-2018 quantitative methodologies were used more than any other kind of methodology relating to mobile learning. We conducted a frequency analysis using IBM SPSS statistics software.

We applied the Likert scale to provide frequency analysis in areas including the program of study, the number of participants, mean value, and standard deviation of the survey questions. The scale of 1 is being the least value and 5 is being the most value. The findings revealed a total of DF1 undergraduate students (n=17), the number of students who participated in the survey (n=8), and the percentage of participants (47.1%). This number is coincidental with the number of Android users (n=8) who participated in the survey. Perhaps, if DFORS was available on the iPhone platform, the (52.9%) of non-participants would have been lower.

Based on our survey data collection method we were able to carefully analyze the results to obtain a mean value of 3.60. These values we inferred by looking at the response value per question in our survey found in Appendix Table 1.

Qualitative Analysis

The qualitative test is a method which creates a platform for test-users to provide feedback on areas of improvement within the mobile learning platform. The aim of the test would be to use feedback from participants to address areas of concern (Farghaly, 2018). To respond to the research questions, the methodology and results were analyzed accordingly. (Littell et al., 2008).

For our qualitative approach, we decided to conduct a closed-ended survey analysis to gather precise and accurately classified answers. But first, we ensured our survey questions had correlation to the research questions, see Table 2. This step was to provide us with valid reasons that benefit from the research and contribute to the field of Digital Forensics.

Survey Question	Research Question
Overall, how would you rate the mobile application?	Research Question 2
How convenient was the use of the mobile application?	Research Question 2
How useful was the content of the learning materials?	Research Question1
How did the questions relate to your curriculum?	Research Question 1
Were there difficulties in the functionalities of the mobile application?	Research Question 2
How well did you understand the questions from the mobile application?	Research Question 2
How comfortable was the experience of using this mobile application to study?	Research Question 2
How helpful would this mobile application be to your assimilation of the course curriculum?	Research Question 1

Table 2: Correlation of survey questions by our research question.

We analyzed our feedback using a content analysis approach to organize and tabulate data relating to the research. For this experiment, we used a third-party software called Survey Monkey

to collect our data from the survey. The feedback we got had both negative and positive remarks.

The negative remarks were regarding DFORS functionalities and course content in the DFORS environment. The positive remarks suggested that the learning environment was useful and has course curriculum user benefits. Our general findings applied to only the number of participants (n =8) and not the pilot participants (n=3) who tested DFORS first.

Sampling Procedures
Cluster sampling is the most convenient and conducive for two main reasons; the size of the group/cluster is manageable, the sampling equally represented individuals within the small group. However, Rataj & Wojcik (2020) and Marshall (1996) suggested checking that the sample is represented well within the context of the experiment, such as the attributes of gender and course of study. The reasons are to foster equal opportunity for participation amongst genders as well as to ensure that participants have a pre-existing ample knowledge of the course of study.

Though the cluster size is the best attainable sample size for this experiment, we recognize that this study showed a vast gap between genders. The findings revealed there are more males than females in the STEM field of which Digital Forensics is a part. This disparity could potentially result in biased samples, thus having an underrepresented subcategory for this research (Makarova, 2019).

Overview
Once the application is started, a user can decide to access the assessment module to do some quizzes related to their course of choice. Subsequently, they could go to the learning module that would guide them to their institution's learning portal to do quick study (lessons) before accessing the assessment module. Afterward, they conduct a survey which informs the DFORS creators of the user's feedback.

In the diagram, Figure 1, the application starts with the user running the mobile application. They would be prompted to create an account. Afterward, the user would have accessed any one of the two most important modules (Assessment and Learning Module) selected to advance to their choice of task within DFORS.

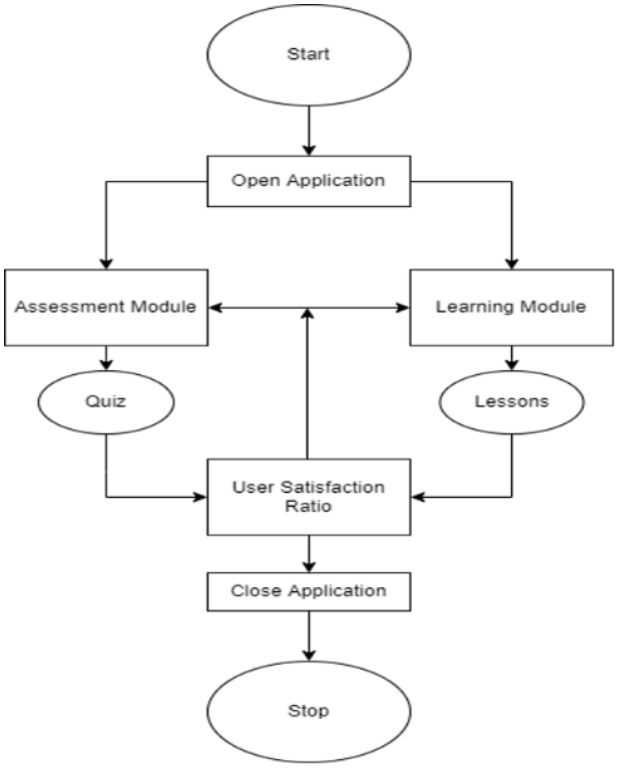

Figure 1: a general framework of DFORS application.

Learning Module
The learning module is a very important part of the application content as it contains all necessary and relevant information in line with the curriculum and the degree of knowledge experience centered on DF1. By clicking on the learning module, the user is directed to an interactive screen which provides the necessary information. Among the components of the Assessment and Learning modules are: terminologies, the fundamental knowledge of Digital Forensics, operating systems, hardware and software, and file types amongst other interesting foundational topics (Oliveira et al., 2020).

Assessment Module
This module contains all forms of quizzes, exercises, and practice questions necessary and relevant to the curriculum of the program. This area of the application is necessary to ascertain the degree of understanding as well as the level of retention of information relating to the content of the material. The assessment module plays a huge role in ensuring that the results of each exercise serve as a motivational entity to boost the morale of each user. In turn the motivational aspect could yield long-term positive progress reports.

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User Satisfaction Ratio
The ration is the degree to which each student is either satisfied or not regarding the outcome of each module's objective. Students who want to first take a quiz before moving to the learning modules may have a different satisfaction ratio as compared to students who want to take the lessons first. Regardless of the preferred choice each student ought to have the flexibility in their approach to self-learning within their mobile environment and the tool was designed to meet users' perceived needs, as well as required knowledge content (Borromeo et al., 2022).

4. IMPLEMENTATION

Pre-Implementation Phase (Design)
For the implementation of this project, we designed the quiz using content from DF1 which was provided by the faculty member in charge of the course. We ensured the content of the quiz was aligned with the course objectives which included topics ranging from hardware forensics to programming languages as well as memory management, Transmission Control Protocol/Internet Protocol (TCP/IP), and network packets as sourced from SHSU cybersecurity program for a bachelor's degree (2022). For the testing content, we ensured it was verified and approved by the instructor of DF1 to validate all the testing content is included in the learning objective of the DF1 class.

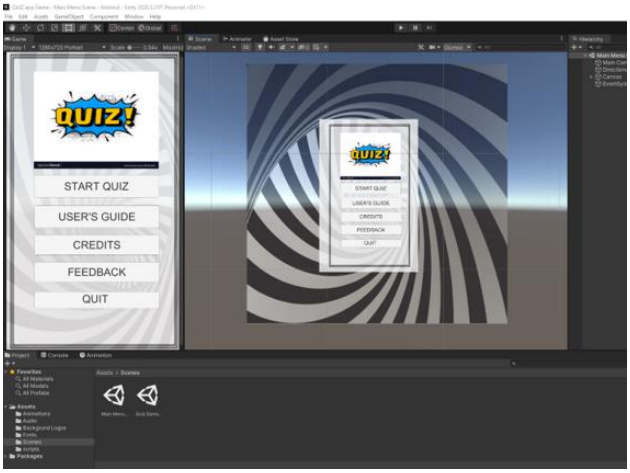

Figure 2: Creating DFORS using the Unity gaming engine

For the building of the DFORS application, we employed the use of Unity open-source software shown in Figure 2. We used it because according to Comber, Motsching, Mayer & Haselberger (2019), it has fascinating and engaging tools that were used in training young professionals. The Programming language used in building this application is C-sharp (C#) housed within Microsoft Visual Studio.

The DFORS application took approximately two months from initiation to successful deployment. The DFORS application took approximately one (1) hour to complete the assessment module. During the pre-tool testing phase, we performed an initial test on the application with 3 students to ascertain areas that could be heavily worked on within the mobile environment. We fixed certain bugs, made updates, and provided images which corresponded to the output. Changes in functionalities were adjusted to fit the general public's use.

Figure 3, shows the final look of the mobile application. This new look was based on the updates and numerous debugging we performed in the application ahead of the final implementation phase. Afterward, we distributed the DFORS application to a class of 17 students.

Smartphones have the potential to be a good learning medium. The benefits of games to engage learning are the use of games to focus on the activeness and experience of the user (Hastawan et al., 2019). Also, we decided to include a scoreboard to ensure the intended users are goal-oriented to score higher after each failed question.

Post-implementation Phase
We implemented and tested the newly updated application on a few willing participants who majored in cybersecurity and Digital Forensics. We used Survey Monkey to collate the results of the survey. Our respondents were mixed gender and race undergraduate students. We embedded a link within the application environment to connect the application users to a survey environment to ensure all the activities from the start of the quiz to the feedback response were conducted within the same environment. Researchers concluded actively acquiring data and user interaction analytics helps foster better improvement and interaction during learning activities (Vidakis et al., 2019). This makes the whole experience worthwhile.

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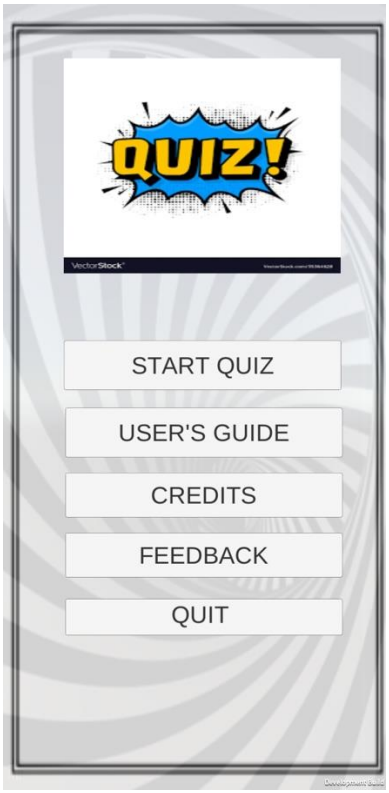

Figure 3: Full functionality.

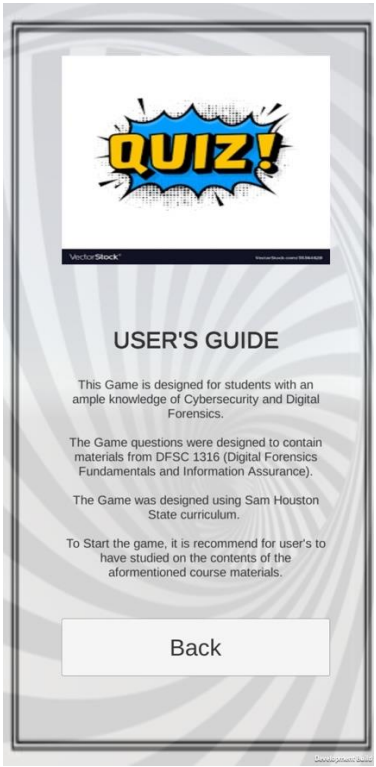

Figure 4: user guide with basic instructions.

Figure 5 shows the image of a Survey Monkey, and the survey services we used in conducting our experimental survey. Embedding the link within the application environment proved useful in collating feedback. It also aided us in properly documenting our methodological approach. Figure 6 and figure 7 both show the interface of the application and a scoreboard to show players how well they are doing.

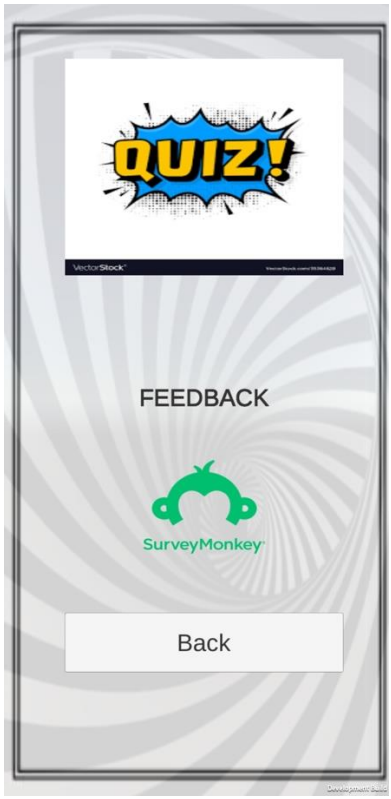

Figure 5: an embedded link to an online survey portal.

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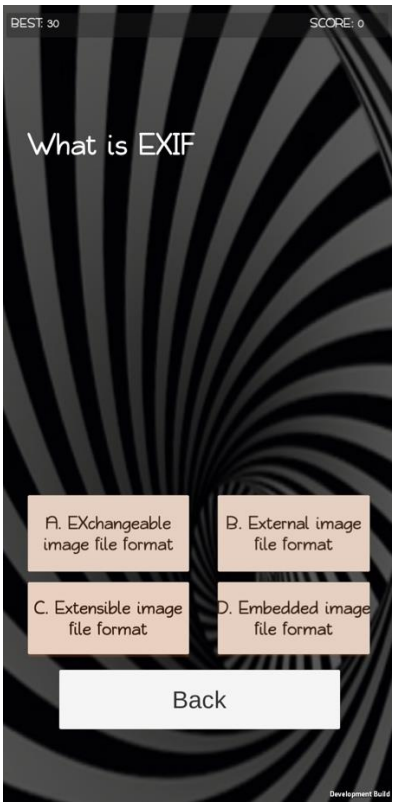

Figure 6: sample question in DFORS.

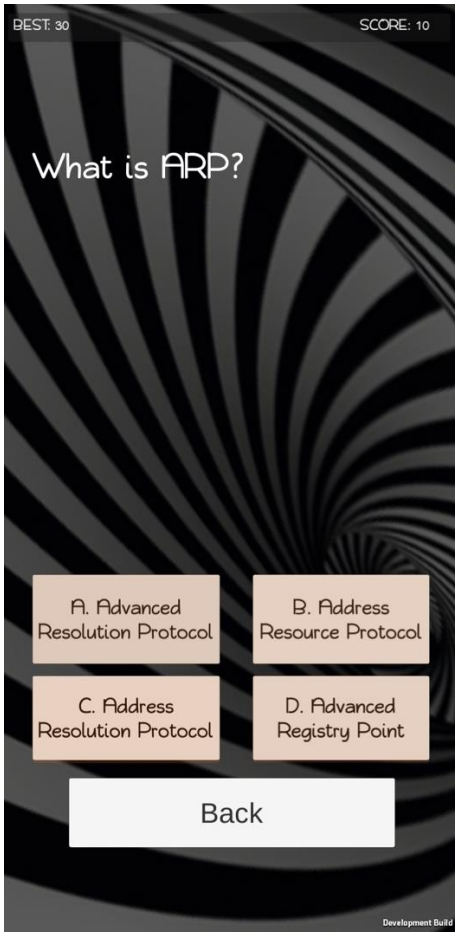

Figure 7: score sheet to track player's progress.

5. RESULTS

After the completion of the quizzing application, we reached out to a particular class of students who were in their second semester first year. We invited the whole class, which was 17 students in total. However, a total of 8 students participated in the survey and rated an overall 75% of feedback as excellent and about 12.5% recorded it as fair (Figure 8). The prerequisites needed for the students is listed below. The students were:

- In possession of cell phones,
- Digital Forensics or cybersecurity majors,
- Possessing sufficient knowledge of cybersecurity and Digital Forensics,
- Enrolled in the course whose current scheme

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is used in designing the quiz application,
- Yet to be enrolled for their final exam.

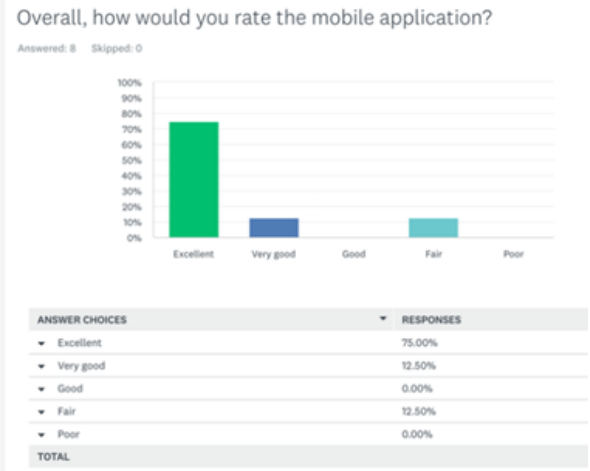

Figure 8: Students' survey on DFORS.

The duration of the testing windows was two weeks before the final week. There was ample time utilize the app as their exams were oncoming and they were closing in on the semester revision week. Students could use DFORS to refresh their memory on all that was covered in the weeks leading up to their finals. The students were not offered any special incentives for participating or contributing to the testing of the application.

They voluntarily agreed to participate as DFORS could help them study better. The students took their time to review the quizzing application and had approximately two and a half hours to complete each session. They first needed to go through and answer all the questions on the application before proceeding to attempt the post-survey questions, which were embedded in the mobile application for seamless ease of use. This testing phase benefited their recollection and retention of coursework covered throughout the semester.

The faculty instructor and Teaching Assistant also aided in reminding the students during class hours to participate in the testing of the application. Due to the low turnout of the class participants, we can only assume that if the students had sufficient time, the participation numbers would have been higher. The following figures show the feedback from an experimental group participating in this survey.

We certified that DFORS was convenient and easy to navigate. The perceived usefulness of the Technology Acceptance Model (TAM) was tailored in Figure 9, as 62.50% of users finding the application very convenient. (Ma et al., 2021). According to Figure 11, the DFORS received about 50% positive feedback from users who confirmed through the answer to research question 1 -- The DFORS mobile quiz application is useful for the Digital Forensics curriculum.

37.5% of users from Figure 10 found the questions obvious and apparent. This was indeed a key moment as it brought about the possibility of collaborating with tutors and lecturers across numerous fields and disciplines. The DFORS is fair as it offers reasonable grounds to ensure that the testing questions are from a somewhat relatable and familiar environment. Hence, we employed the aid of exceptional expert tutors with knowledge of the topics covered to supply us with relevant and industry-inspired questions.

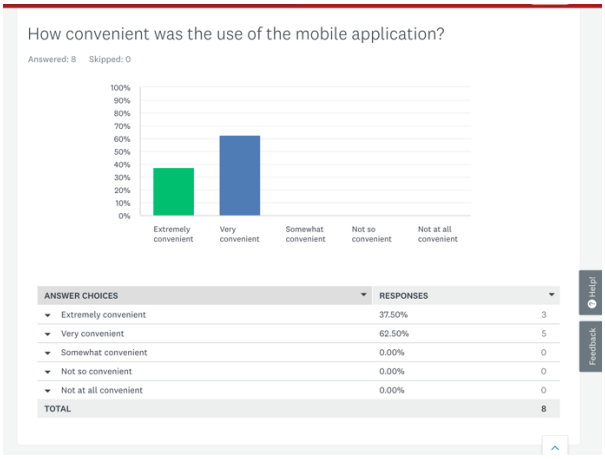

Figure 9: Survey on DFORS convenience.

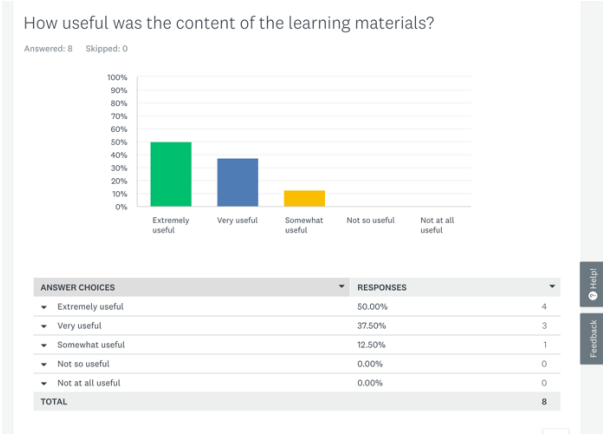

Figure 10: a survey on DFORS content usefulness.

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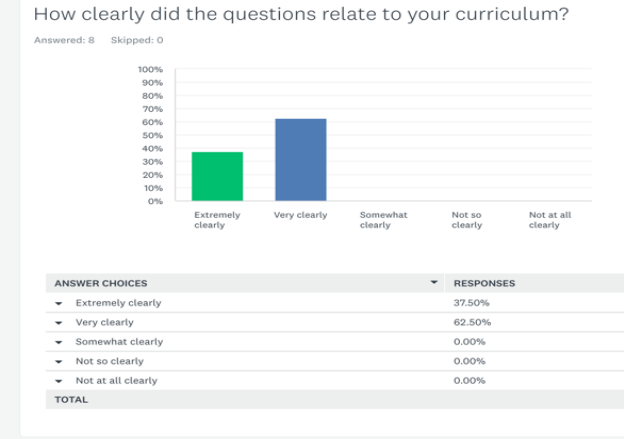

Figure 11: Survey on how DFORS relates to their curriculum.

The more significant challenge is going back to the implementation phase to conduct more user-friendly tests that could bring a change to combat the difficulty some users experienced (See Figure 12). 25% of users found it extremely difficult, while 37.5% found it not so difficult, and only about 12.5% of saw the application's functionalities as not difficult. The difference might be caused by whether the students completed the Learning Module before they accessed the Assessment Module.

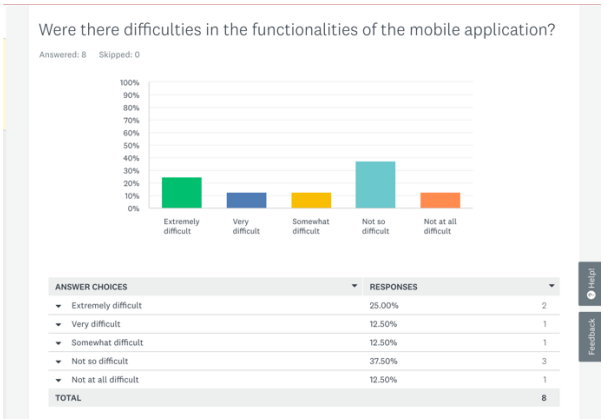

Figure 12: Survey on DFORS functionalities.

While we recorded 50% of students claiming they understood the questions in Figure 13, we also recorded 37.50% of students who also suggest they understood the questions very well. But 12.50% of students claim they do not understand the question well. This disparity is something that should be brought to the attention of the assigned teacher as an avenue to explore varied teaching practices.

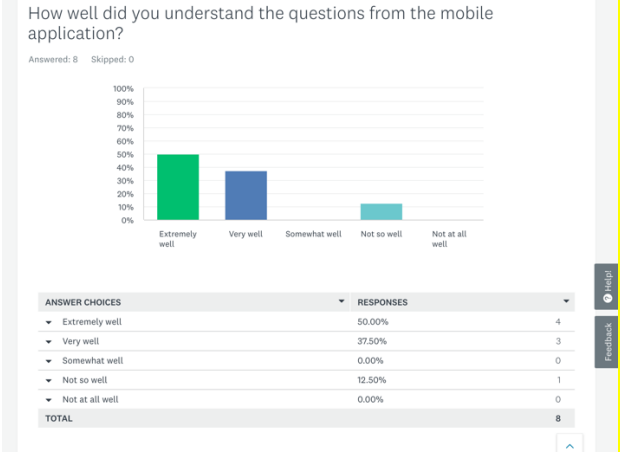

Figure 13: Survey on question comprehension in DFORS.

Figure 14 shows positive feedback from users. The users reportedly were extremely, very, and somewhat comfortable with using DFORS. The record high was 62.5% with an average of 12.5% low. The difference might be linked to the difference in users' perception of what they define as comfortable.

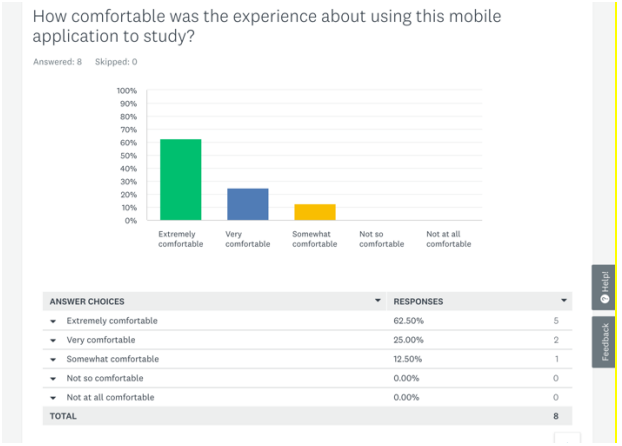

Figure 14: Survey on users' DFORS experience.

75% of users in Figure 15 found DFORS to be extremely helpful. Their assimilation of course contents was enhanced through use of the App. The high response suggests that using

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DFORS could be integrated as a study guide.

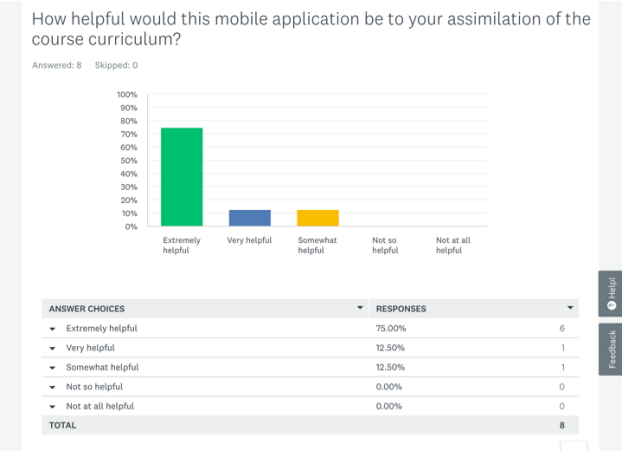

Figure 15: Survey on the relationship between DFORS and DF1.

6. CONCLUSION

In our work so far, the mobile application has had reviews that meet the purpose of its creation. The participants greatly accepted the design model of the application. Of the numerous mobile applications for quizzing, this one is tailor-specific to students of SHSU. The use of current curriculum is relatable and easily assimilated due to constant active engagement of the content with the tutor of the course. We also had our challenges which include a small experimental group, a lack of robust quizzing materials, and users experiencing difficulties in the functionalities of the application. Unfortunately, DFORS was only available on android platforms for this project. We ought to make it available across multiple platforms such as IOS and Microsoft Windows phones.

Research question 1: Will the DFORS mobile quiz application be helpful for the Digital Forensics curriculum? Yes, it will be helpful as it has been proven to be both practical and needed for the general knowledge and understanding of the foundational concepts of Digital Forensics. It is also helpful for non-Digital Forensics students who wish to have a glimpse at what Digital Forensics entails. DFORS could be re-purposed to fit any institutional-related course content, which makes it highly beneficial.

Research question 2: How can we assess the effectiveness of our DFORS application on Digital Forensics Students? Using our survey approach, we tested the effectiveness of our DFORS application on Digital Forensics students. Based on the survey responses from Figure 15, the DFORS mobile learning approach proved to be effective. It also suggests how useful the learning content was from the responses in Figure 10 and Figure 14. The users responded being comfortable using DFORS to study. We conclude that DFORS could potentially be a tool used in promoting self-learning amongst students. In turn it could yield academic excellence for the users.

7. FUTURE WORKS

As computing information educators, we are always on the verge of consistently discovering revolutionary new areas. Thus, in the future, we intend to include more modules/courses and In-app videos for visual learning. Providing links to the system learning management services could be established. Moreover, real-time quiz testing could be featured for a more immersive learning experience. To make learning more fun and technologically inspiring, a virtual reality quizzing platform could be adapted to include a space that is unique to each user yet offers a self-learning pace for any user.

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Appendix

Table 1. Statistical inference

Frequency Analysis							
		Likert Scale	Overall, how would you rate the mobile application?	How convenient was the use of the mobile application?	How useful was the content of the learning materials?	How did the questions relate to your curriculum ?	Were there difficulties in the functionalities of the mobile application?
N	Valid	5	5	5	5	5	5
	Missing	0	0	0	0	0	0
Mean			3.60	3.60	3.60	3.60	3.60
Std. Error of Mean			1.122	1.030	.812	1.030	.400
Std. Deviation			2.510	2.302	1.817	2.302	.894
Variance			6.300	5.300	3.300	5.300	.800
Range			6	5	4	5	2
Sum			8	8	8	8	8