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Papers

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An Interactive Mixed Reality Ray Tracing Rendering Mobile Application of Medical Data in Minimally Invasive Surgeries

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Short Paper

Smart Home: Power Electric Monitoring and Control in Indonesia

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NFC Based Electronic Medical Record

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Abstract—NFC technology allows off-line data transfer between mobile phones. In addition NFC also has a secure element section that allows to store data securely. Through special applications the data can be modified by the authorized party using an authentication system. In this study an electronic medical record was developed using NFC. The results of alpha and beta testing show that the application has good performance.

Keywords—NFC, Near Field Communication, Electronic Medical Record

1 Introduction

The development of medical record in the information age is electronic medical record (EMR). EMR is medical record that utilizes server as storage place, web as media for reading and updating data, and internet as communication media between server and web based application. The completeness and accuracy of medical record data on EMR can be better than conventional medical records. A well-built EMR meets at least some of the most important electronic data storage elements - privacy or confidentiality, integrity, authentication, access control and non-repudiation, but it is very difficult to meet availability. Medical record data that has been entered in EMR should be accessible whenever and wherever as needed. This availability requirement is difficult to meet due to its reliance on internet connection and the availability of server services where EMR is stored. Internet connections are often problematic so that medical record access can be disrupted especially in Indonesia internet connection is not evenly distributed. The availability of server services is also sometimes disrupted due to several reasons such as repair, maintenance, operating failure of server computers, and disrupted power supplies.

The retrieval and processing of data stored on the server can only be done online through the internet or intranet network. It is therefore necessary that technology allows the capture and processing of data off-line and under conditions that allow data stored on mobile devices to be sent to the server for wider purposes. Technology that can answer those needs is NFC. Through NFC data can be retrieved and processed off-line, but at the moment allowing such data can be sent to the server for wider purposes. In

addition, NFC-based medical records also allow medical record data to be used by health care wherever independent of where the first medical record is made.

Electronic medical records research, among others, performed by [1], [2] and [3]. In [1] we investigated the benefits of EMR that facilitated administrative personnel in patient information retrieval, whereas at [2] and [3] it was suggested that EMR was beneficial for patients because it increased efiesiensi in the process of health care.

The development of smart card-based medical records was developed by [4], [5] and [6]. These three studies use RFID cards to store medical record data. The development of electronic medical records further exploits the NFC as performed by [3] and [7]. In addition to medical records the researchers also developed an NFC-based health care system such as [8] and [10].

2 Literature Review

2.1 Medical record

Medical Record is a file containing records and documents about the patient containing identity, examination, medication, other medical treatment on health care facilities for outpatient, hospitalized by both government and private [9]. The benefits of medical records include medicinal purposes, improvement of service quality, education and research, financing, health statistics, as well as legal, discipline, and ethical proofs.

The need for a practical, complete, and accurate medical record becomes an urgent need in today's healthcare services. The practicality of medical records, among others, can be seen from the media used in storing medical record data, the process of updating medical record data, and the process of reading medical records. Medical records are also required to contain complete information about the patient's medical history. Data on medical records is used as a reference of medical personnel in dealing with patients therefore this data must be accurate. Three properties of medical records are difficult to meet by conventional medical records by using paper as the medium. [10]

2.2 Near Field Communication

Smartphone technology continues to grow with the addition of various features that make this communication tool into multi-use. One feature that is currently embedded in the smart phone is Near Field Communication (NFC). This device allows the smart phone to communicate with other mobile devices without going over the cellular network at a distance of about 4 cm. In addition via NFC smart phones can also read data stored in smart cards (NFC tags). Currently many smart phone devices are equipped with NFC. By 2018 about 1,907 million smart phones have been equipped with NFC [11].

Products with NFC capability will dramatically simplify how to interact with other NFC-enabled products because NFC offers fast connections in terms of secure exchange of information or payments. Standard communication between two devices

that support NFC occurs when they are at a distance of 0 to 10 cm [12]. Simple or tactile movements can initiate NFC connections. Another advantage of NFC is compatible with bluetooth or Wi-Fi technology.

NFC and bluetooth are communication technology with short communication range that has been integrated with cellular phone. The main advantage of NFC over bluetooth is its very fast set-up time. If a bluetooth device needs to perform a manual process to identify another bluetooth device, the connection between two NFC devices can be done instantly (<0.1 seconds) [12]. Maximum NFC data transfer of 424 Kbps, lower than the bluetooth of 721 Kbps. NFC has a radius of communication that is closer than bluetooth that is less than 10 cm. This provides a better level of security and makes NFC very suitable for crowded areas. Unlike bluetooth, NFC is compatible with existing RFID technology. Another difference with bluetooth is on the type of network used. NFC network type is point-to-point while bluetooth is point-to-multipoint.

NFC advantages over RFID include NFC can be used for two-way communication and installed on smart phones [13]. In addition, NFC is also equipped with a device capable of setting the secure element [14]. These advantages make NFC suitable for applications that require secure storage and exchange of data via smart phones such as e-payment applications [15] & [16] or e-wallet [17], medical records [3], health services [18] & [19], and airport services [20].

3 Research Methodology

Medical record activities based on Guidelines for Medical Record & Procedure of Hospital 2006 include [9]:

- Acceptance of patient (recording of patient's social data)
- Recording of service data
- Data management
- Reporting
- Storage / Retrieval of data

Such activities shall be eligible for the implementation of privacy or confidentiality, integrity, authentication, access control, non-repudiation, and availability.

The development of NFC-based medical record that will be conducted covers all media recording activities as well as qualified in the implementation of such activities. The preferred approach in solving this problem is a system approach with high levels of security [21], accuracy, and reliability. Through this approach can be realized eligible system in the implementation of medical records.

This research begins with literature studies on medical records, electronic medical records, NFC, communication protocols, encryption, and applications in the android operating system environment. This literature study produces some information about aspects of medical record and NFC based system that can be used as base in determining the requirement and system specification. Based on the specifications and then designed the system with the beginning of the development of NFC-based medical record system

architecture. Applications developed based on the architecture that has been developed with attention to the level of data security whether stored, read, or modified.

4 Results and Analysis

4.1 Architecture

The NFC-based EMR architecture can be seen in Fig [22]. The EMR application on the doctor's phone can be used to read and change the EMR content, while the EMR application on the patient can only be used for reading. When the patient first comes to the doctor and the doctor does not have the patient's EMR then the doctor needs to copy the EMR from the patient's phone by tap between the patient's phone and the doctor's phone. Upon medical examination of the patient then the doctor will renew the EMR and keep it. Patients will get the latest EMR from a doctor using NFC.

This architecture also allows one phone to be used to store multiple EMR from different people. Confidentiality is maintained with the use of autotentication in developed application.

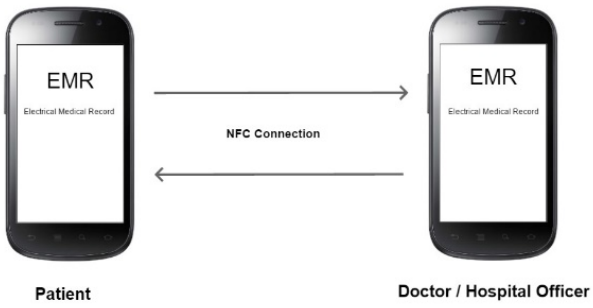

Fig. 1. NFC-Based EMR Architecture

4.2 Use case

The developed application consists of two parts: the first part is used by the doctor and the second part is used by the patient. Fig 2 shows the use case of the developed application. Patients are not entitled to add or change EMR, whereas doctors may add or change EMR.

Users of EMR application both a doctor and a patient must register on the application before using the EMR facility. After enrolling a doctor or patient can use the application after performing the autontication. Doctor use the application to create a new EMR or update an existing EMR. The latest EMR that has been made by the doctor is then sent to the patient via NFC by tap. If the patient visits another doctor, then the EMR stored in the patient's phone can be copied to the doctor's phone using NFC. The delivery process of EMR uses NFC so it does not depend on internet network.

4.3 Class diagram

Class diagram of EMR application is presented in the form of model view control. Every strereotype in the class diagram represents a class in the application. The boundary/UI were created using XML, and the class control was created using Java. The database utilised to apply class entity was SqLite. Each boundary has a control to deal with processes. The control in the boundaries will attract another control to do a more specific process.

The login control is for examining whether an account exists. The account consists of two types, that is, patient's account and doctor's or hospital staff's account. Class UserLocal is utilised to store user's information that has logged in. Class account is used to save account's information, and class user is used to store information regarding users. Fig 3 shows the class diagram of application.

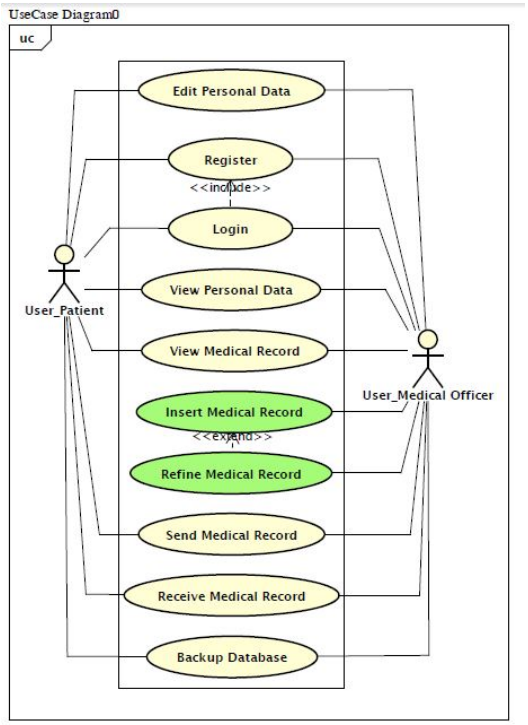

Fig. 2. Use case

4.4 Alpha test

Alpha test is used to test whether the entire application function can work properly or not. The test is done by using dummy data and the results can be seen in Table 1 The alpha test results show that the application can work in accordance with the requirements that has been set.

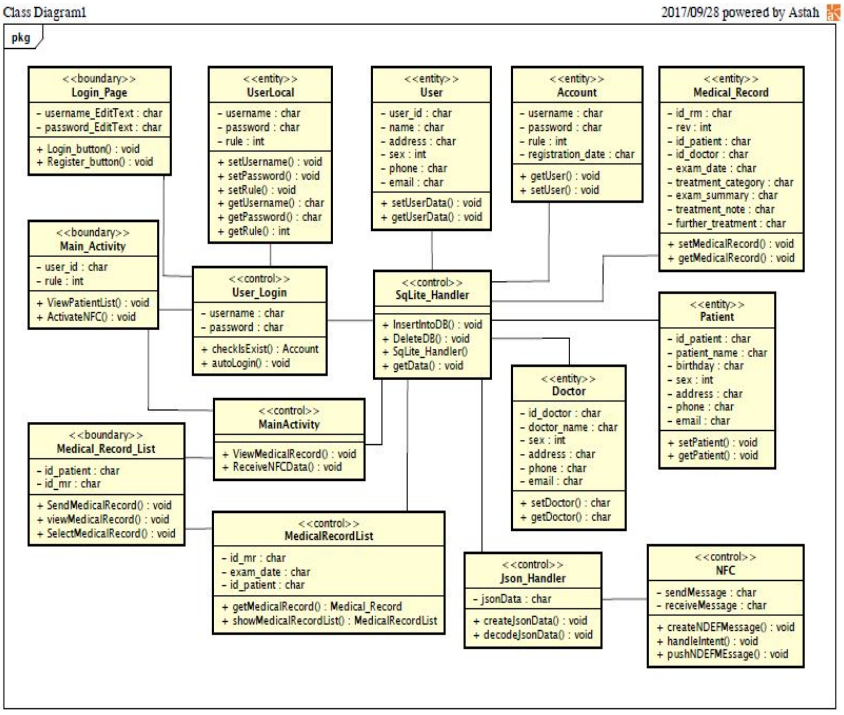

Fig. 3. Class diagram

4.5 Beta test

The next test to be performed is a beta test. In this test some doctors and patients will be involved. The beta test results will be a material improvement in application development. Through the beta test is expected to know how far the usability level of application by doctors and patients. The results of beta test in a hospital in Indonesia can be seen in Table 2.

The MOS score calculation results show the average MOS score is 4.28. This shows that the developed application has good performance. The smallest MOS score is in question number 3. This indicates that the developed application still has a slight error. One example of an error that still occurs in the application is when sending of EMR data from the doctor to the patient or vice versa. If data sending is not successful the sender often presses the send button continuously so that the buffer becomes full. If the cellphone memory is small, it can cause freeze. In addition to errors, one of the weaknesses in NFC-based is that data is not stored on the server so online EMR usage cannot be done and this reduces the level of EMR data availability.

This research will be continued with the design and implementation of web-based EMR that will cover the shortage of NFC-based EMR. NFC and web based EMR will increase the availability of EMR data because it can be accessed on-line and off-line. The interesting thing about future research is the process of synchronizing content that is updated via NFC and the web.

Table 1. Alpha test result

Function	Scenario	Actual Result	Status (pass/fail)
Patient Registration	The researcher tried to enter a new patient data into the patient application	The new patient data added	pass
Doctor Registration	The researcher tried to enter a new doctor data into the doctor application	The new doctor data added	pass
Sending patient's data to doctor's phone	The researcher tried to sent a patient data from patient's phone to doctor's phone using NFC	Patient data sent to doctor's phone	pass
Insert New EMR	An EMR insert to doctor's phone	An EMR added in doctor's phone	pass
Update EMR	An EMR in doctor's phone is updated	An EMR in doctor's phone is updated	pass
Sending an EMR data from patient's phone to doctor's phone	Using two phones, the researcher tried send a EMR from patient's phone to doctor's phone	An EMR sent to doctor's phone	pass
Sending an EMR data from doctor's phone to patient's phone	Using two phones, the researcher tried send a EMR from doctor's phone to patient's phone	An EMR sent to doctor's phone	pass

Table 2. Mean Opinion Score

No	Question	SA	A	LA	DA	SDA	MOS
1	This EMR application is easy to install?	8	7	0	0	0	4,53
2	Fast login access	8	7	0	0	0	4,53
3	There has never been an error in the EMR application	3	8	3	1	0	3,87
4	Access time for each feature is fast and stable	4	10	1	0	0	4,20
5	The EMR application menus are easy to understand / familiar	5	9	0	1	0	4,20
6	Overall, EMR applications are easy to operate	6	9	0	0	0	4,40
7	The filling of personal data and medical record is easy	5	10	0	0	0	4,33
8	The data transfer process from HP doctors / medical personnel to HP patients is easy to do	5	8	2	0	0	4,20
9	EMR application is useful for the process of medical services for the community	6	7	2	0	0	4,27
Average MOS score							4,28

*) SA= Strongly Agree, A=Agree, LA = Less Agree, DA=Disagree, SDA = Strongly Disagree

5 Conclusion

The NFC's ability to transfer data at close range safely without the need for an internet network allows it to be applied to various applications such as electronic medical records. Design and Implementation of NFC-based electronic medical records have been conducted in this study. From alpha testing can be concluded that the application can work in accordance with the requirements that have been set. The beta

testing results show the average MOS score is 4.28. This score shows that the developed application has good performance.

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Cloud Mobile Storage for Mobile Applications

The Dynamic Storage Injection Pattern

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Abstract—The data storage in mobile cloud computing domain is an important topic because of the large amount of data devices can provide. Different kinds of sensors retrieve information and send them to data storages. But the storage location can move even dynamically during their uses. So, these changes must be managed at runtime. In the other part, Android devices are good computers to acquire information and send them to a storage area. These devices are well-known, ergonomic and useful machines sorely used. In this paper, we present a software architecture from Android devices to Cloud storage areas to put down data when the data stores are dynamically moving. The different parts of these distributed applications are built around Android with JSON messages for REST services and moving NoSQL databases in the Google app engine. The exchanges between the cloud and the Android devices use the Google Cloud Messaging (GCM) protocol. Furthermore, even without network access, the saving is made locally in the smartphone. The synchronization with distant databases is automatically made when the network becomes again available.

Keywords—Mobile Cloud Computing; moving data storage; REST; Cloud computing service model; NoSQL cloud databases; Sync API for Android.

1 Introduction

Cloud infrastructure give hardware, data storages, APIs to manage them and so we can develop software for customers to put in it. We can use it as virtual supply and these parts are well known as IaaS (infrastructure as a service), PaaS (platform as a service), SaaS (software as a service) [1]. On the other hand, the top daily activities on smartphones and tablets are about email access, shopping on the Internet and health coaching [2]. The mobile users are now spending many times consuming digital media within mobile applications. Therefore, these applications need to save their states even if there are network disruptions. Furthermore, the mobile applications must include a software strategy to track whether a network connection is available. In case of the lack of network, a local backup can be done to keep trace of the useful business

data. Finally, the remote database can dynamically change at runtime and the mobile application must know dynamically these changes. If a database is available, applications, customers, and business users, can access it. However, any condition that involves the remote database inaccessible causes the failure of the remote persistence tier and the storage must be momentarily made locally. The required availability of an application will vary from system to system, but it must be predicted.

Our work is about the dynamically changing of data storage accessible and supplied by smartphones. For example, Leon and al. [3] change the servers and so the data storage to address the underutilization of these resources and so reducing costs. Zhangbing Zhoua et al. also treat the subject of replaceability assessment of resources in [4] and Espadas et al. propose an elastic model to use underutilized resources [5].

A network problem can involve unreachable remote databases. So, the location of the storage must be known. Another reason to change the location is the poor performance of the current database to another instance. The extreme limit occurs when no remote database is available, so a local persistence should be achieved. Therefore, the dynamically change of a database is a crucial problem.

In the context of mobile applications, the Cloud access is a crucial feature. For example, it ensures the business data access when the network is available. However, it also introduces two aspects of the communication. A Cloud point of view occurs for the selection of the database access point, and then this feature is send back to the mobile application. In addition, a mobile point of view appears about the existence of this database access or not. In the first case, it means that the work session can be saved in a remote manner. In the second case, the work session should be saved locally. Depending on the activation of the connection access, the local state will be updated to the remote database access and the local state will be erased.

So data storages are one of the main part of an application and it can be used for instance to contain the isolated applications from the OS and the low level VM when installing the whole virtual machines [6]. Our architecture is useful for example, when a user or a device need to obtain many data and store them in data storages. Such a solution helps to continue mobile users to keep a shopping session and more generally to manage a working context. It is the case when a person wants to make an inventory of a shop or a hangar. He uses his smartphone or his adapted device to read information linked to the material (QR code, barcode), and send them to a storage area. This data procurement must be made quickly. The same model must be done to obtain the knowledge of a boat shipment just arriving in a port harbor by using RFID technology, RFID tags being attached to articles. We have something similar for managing a crowd of person passing in given places by using NFC tag loaned to them in a museum for example.

A set of sensors, which spot a lot of data about cars on a highway and require to send information to a storage place need to use our kind of architecture. If the network link is damaged, these sensors must be coupled with an intern storage area. Therefore, these sensors are linked with micro programs inside micro-controllers put for example on Arduino card or microcomputers as Raspberry card. In these all cases, the local database is a kind of cache we use temporally to be flushed when the network is already available.

The treatment of the data is made on server side but, generally the problems to access or even use a remote database are not approached. In this paper, we propose an architecture were these problems (network availability, dynamic databases changes) are solved. Moreover, our architecture describes and implements a dynamically change were data are stored and describe what it must be made when the network is not available. So, we define protocols for moving databases. The specifications of data storage are made but different implementations can be dynamically chosen or injected. It is a dynamic storage injection design pattern closed to the injection dependence design pattern. Therefore, in this paper we also define an injected storage architecture.

In this paper, we use the whole stack of the services model of the cloud computing: Software as a Service (SaaS) with GCM, Platform as a service (PaaS) with our applications service appengine [7] and Infrastructure as a Service (IaaS) for the data bases in the Google cloud. In addition, of course, we developed cloud clients.

In the following of this paper, we present related works on this subject in the second section. In the third section, we introduce our general software architecture. It has two parts, a cloud part presented in the fourth section and a mobile part in the fifth section. We indicate some futures works and ideas on the subject in the sixth section and draw a conclusion.

2 Related Work

This section introduces references to existing works, which are useful to understand our approach and our contribution to the mobile software engineering.

2.1 Mobile Cloud application: service access everywhere

Cloud computing is defined as the ability to provide a set of servers and services to the large set of users. As a software point of view, mobile cloud computing allows to use services for mobile clients anywhere the mobile end users are. They use information technology as a service over the network and can consider that a data model is managed in a cloud and a view can be obtained remotely for a mobile device. Today, this kind of architecture is become popular. Several well-known applications such that Snapchat and Facebook [8], Instagram [9] and so on are a reference of such kind of applications. A user has access anywhere to any application of the suite using a mobile device.

At the design step, this choice has consequences on the software architecture. The back-end software is deployed into a cloud and visible anywhere through the network. Many mobile applications have such a structure and when a user downloads such application, it installs a client part on its mobile device. This one will be used as an ideal network client for the building of all the exchanges. As an example, the Gmail application can be download from a market [10] and then the users read their mails anywhere they are. Waze application [11] is also an example of a graphical applica-

tion whose code is downloaded from a market place and it only displays the responses of the requests.

2.2 MVC architecture evolution (Model View Cloud)

Based on a distributed architecture, the mobile device plays the role of graphical client where the data model is on a remote server. The updates come through network stimuli, which update the display. Because of the important role of the user interface thread activity, the network behavior is managed in other threads and a global asynchronous behavior is considered between the mobile client and the cloud server. For instance, during a travelling by car, a Waze's user receives data about his geographical context, which are displayed on his screen. If the traffic network is stopped, then the display is frozen until a new reception.

2.3 Remote access from mobile device

Often a mobile device plays the role of a client in a distributed application. For instance, users want a remote access to the sensors of a device or an application needs to filter the data from a set of mobile devices. However, the question is how to create a remote access to a server. In that, we consider the device as a resource set where each of them is behind a Web service. However, the Web service technology has evolved, and the REST approach is well accepted in the domain if the embedded systems.

On the server side, the management of the requests is a key feature for such a client connection. When the number of requests becomes high, the mobile service must use threads. The service launches at least on thread per requestor. By the end of a request, the memory is reused by the virtual machine to the next requests.

Several frameworks already exist for programming REST services on mobile device but the Google's framework called Restlet was the first one to provide a portable way of programming. It manages also a set of object mappings over XML, JSON and raw strings

2.4 Synchronization with the cloud

When we are looking for a cloud service provider where we can keep our files and folders, there are confusions on three terms: cloud storage, cloud backup, and cloud synchronization. While all of three serve as a remote place to stow data, the use case for each differs.

The first cloud usage stays the data storage. It is like having an external hard drive online that is accessible anywhere.

Cloud backup differs in that it is usually automated. Depending on the service, it can happen continuously or on a set schedule. When a file is created or modified, the newest version is uploaded and stored on the cloud.

Synchronization means keeping the most up-to-date version of a file or files on two or more devices. It is ideal for collaboration or people who frequently use multiple

devices. Many cloud backup and cloud storage providers have incorporated synchronization into their services. In our context, this occurs when a remote database and a local database of a mobile device need to merge their data or compute their difference.

2.5 Gap covered by our proposed architecture

Some technologies address on data treatment in the cloud and in the mobile cloud computing domains. For example, Dropbox and Google Drive offer convenient file syncing and sharing. Some papers are interested by the security (availability, reliability, fault-tolerance) of the data as in [12] or data integrity, data confidentiality, and availability in [13]. Some systems as HDFS [14] and ceph [15] are built to treat very well these particularities by using redundancy and tools to manage it. They are good systems for big data technologies. In [16], Lieyun Ding et al. consider the problem of large data management without the aspect on the access from a mobile device. In [17], B. Jiang et al. treats the synchronization data coming from mobile devices with the cloud and we address in this paper. But we didn't find papers which discuss about the dynamic moveable data bases in the cloud so the moveable data in the cloud which the main contribution of this paper. Moreover, we study, in this paper, moveable data bases coming from mobile devices so two kinds of dynamic moveable domains.

A new software architecture is proposed by Yen-Hung Kuo et al. in [18] based on the use of services. Also, the data source is exposed through a local or remote service and the client selects one of them depending on local criteria. In that case the authors consider the availability of the client and not the availability of the services. Often the data source is not reliable enough and over a long period of time, a service can reboot. The reliability must be considered in the context of mobile access where the network is a key resource. We propose in the next sections a new architecture which answers to these drawbacks.

3 Software Architecture

It is essential to identify mobile applications over a network. For instance, International Mobile Equipment Identity (IMEI) [19] is an identifier for a smartphone. An Android smartphone can also be a Wi-Fi hotspot and propose an SSID. However, these two ids cannot be used for our architecture. First IMEI is not confidential and must be avoided in most use-cases without limiting required functionalities. Second, we want to use internet network, not only Wi-Fis one. Because the identifier of a mobile device is not enough, it is necessary to build a compound identifier based on the material identifier and the software identifier. So, our choice is to use the GCM architecture.

The different entities we use in our architecture are:

- The Google Cloud Messaging API (GCM),

The regId obtained by GCM, which identifies a smartphone. Furthermore, we builta regId database which stores the regIds of the different smartphones called the regId registry

- The different remote moving databases and the Google application, which manages them and inform the smartphones every time the database is changing.

There are two parts in our architecture: a cloud part and the mobile part. In the cloud part, there are the different moving databases and an application which manages them: this application knows the current database which is used and sends this information when the database is changing and when a new smartphone wants to be connected to our architecture. This Google app is called the database manager. Furthermore, as we use regIds to contact the mobile smartphones, we built another Google application which main part is to store these regIds. This second Google cloud application is called the regIds registry.

In the mobile part, there is an Android application with receives the location of databases to put down the data or put them locally when the network shuts down for instance.

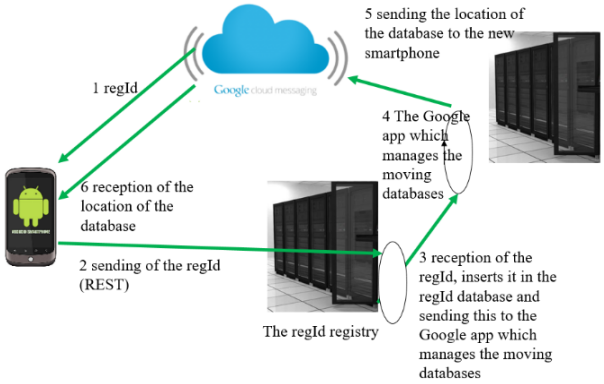

Fig. 1. The initialization step

We use the Google Cloud Messaging API (GCM) to send information from the Google cloud to Android platforms. So, a GCM project has been built in the Google cloud. When a smartphone wants to participate to our architecture, it asks for this GCM project an identifier and receives a regId. With this identifier and the GCM project, information can be sent to it.

There are two main steps in our architecture. First when a smartphone wants to participate to this distributed application: it is the initialization step. Second when the database is changing and the Google app, which manages these changing databases, must inform all the smartphones: it is the changing databases step.

The main applications, which wants to send information and data to the smartphones, are Google Cloud applications. So, the regIds of the smartphones must be known by a Google cloud application of our architecture.

We first study the initialization step. We use the fig.1 above.

- **First,** the Android app, as it participates to the GCM architecture, asks and receives a regId from the cloud (arrow labeled 1). Then it sends it to the centralized Google application called the regId registry (2). Then the Google application, which receives this new regId, informs the Google application, which manages the changing databases (3), the database manager. Therefore, the database manager can send to this smartphone the location of the database (arrows labeled 5 and 6) where the smartphone must deposit its data.
- **Next,** we study the changing databases step. We use the figure 2 below. Every time, the database changes, the database manager asks the regId registry (arrow 2), obtain all the regIds (3) and broadcast the information of the new database to every smartphone using these regIds and GCM (4). Therefore, every smartphone knows the new database (5) where it must send its data.

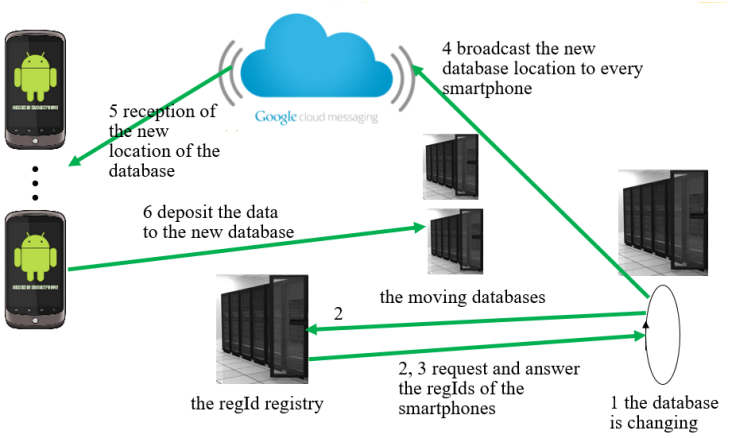

Fig. 2. The changing database step

So, we define two protocols the first one is the initialization process and the second one depicts the exchanges in a stationary mode.

4 Cloud Part

In the cloud part, our software architecture follows a layer pattern. It means that the mobile user can consider our mobile application as a layer stack where the closer layer is its graphical user interface and the farther is assigned to the network management. As shown in figure 2 a mobile phone can receive data from a service deployed in a cloud or it can send data to a web application.

Our need for mobile cloud computing is increasing because it is a way to become nomad users. In addition, anywhere we are, an Internet access provides not only the data from the cloud but also it allows the access of new HTTP services. In our soft-

ware architecture, the figure 1 highlights two main services. One is a regId receiver, which means a REST service, which collects and persists all the regIds. The second one is the database url provider. It gives a valid location of another service, which is able to persist the user data.

These two cases follow a usual architecture as multi-tier layer. Figure 3 displays the software architecture that implements the relationship of the arrow labelled 6 in Figure 2. This layer structure manages every technical role into its own layer. In our example, the rightmost layer is where the data are saved, which means a database. Because we have developed a Cloud application, the database is a NoSQL database called DataStore in the Google implementation.

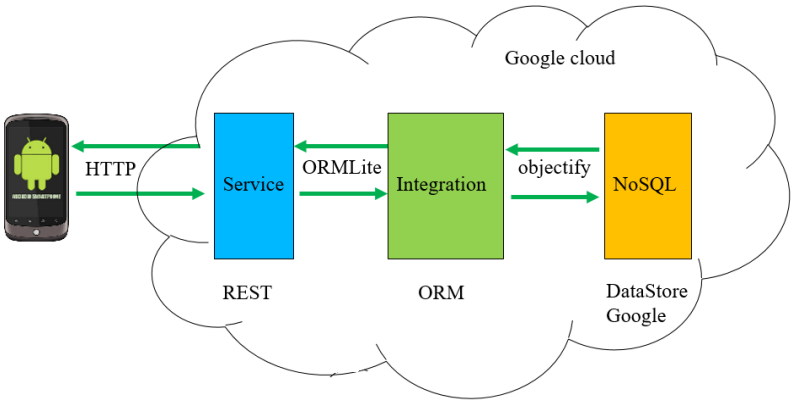

Fig. 3. The persistence layer

The next layer in the middle part plays the role of a mapping between an object world and a relational world. It provides a data access object per table of the data source. Because, some statement need the use of several data access objects, this layer called ORM layer exposes useful persistence services, which need to manage transactions over the data source.

These persistence services fill a role locally to the data manager, but they have to be called from another remote endpoint where the data are first recorded. A mobile device is such device and needs to call remotely a persistence service. We have built a REST layer with the objective is to map persistence operation on HTTP methods. These three layers equip all data manager on our network.

4.1 RegId receiver service

A registering identity is a way to identify mobile device in a mobile cloud. However, a mobile device cannot choice its identity. This depends on the network, the chosen architecture, which is used by the devices. For this reason, we have built a GCM project, which is a service to provide the identification of mobile devices. It provides a unique regId per device.

As soon as a mobile phone receives a regId, this one is saved into a remote registry where a service called regId registry records these regIds. This registry keeps all the device identifiers in case of resource location changes in our software architecture.

4.2 Database url provider

All the active devices will receive a notification about the change of the location of the databases. In our case study, the changes are given by the new uniform resource location (url) of the persistence layer and it is obtained by the database url provider. So dynamically, we can inject a right persistence layer in our software. It is a similar thing as the well-known design pattern dynamic dependency injection but in the domain of persistent layer in the mobile cloud computing. Therefore, it is a kind of new design pattern we call a dynamic storage injection design pattern.

On the server side, the database url provider service has also an update alert. It checks the availability of a persistence layer. When the connection test provides a timeout or when there is no database available, the mobile clients cannot persist their data. In the first case (no network available), the mobile is notified by an intern event. In the second case (no remote database available), the mobile clients are informed by the database url provider service. In both cases, the mobile devices save the data locally.

When several remote persistence layers are recorded into the application, the database provider can provide one of this persistence layer.

4.3 Persistence service

A first persistence application is built and deployed in the Google Cloud Platform for saving the data. For the reception, a web service exposes this application on HTTP protocol. The url database provider provides this location to any mobile client which sends a request about. However, behind this address the software architecture is defined as a classical Java EE application. This means that a mapping object relational requires first the declaration of one entity class per business table. Even if our database is not relational, a mapping is essential because, it applies a reuse approach of the persistence management, as design patterns dissociate the specification of a work and its implementation.

Next, the definition of data access object hides the use of request over objects in memory cache. Each class contains five methods, which covers all the needs over a table. CRUDS is the name attached to such a set of methods, create, read, update, delete and searchAll. Because a statement can touch more than one table, also we have created persistence services for the management of several entities in a consistent manner inside a transaction. Finally, we have created a REST service per persistence service for the usages in a SAAS of the Google cloud.

The goal of all this work is to create an access to a NoSQL Database called Google Cloud Datastore, which is built for automatic scaling, high performance, and ease of application development. It uses redundancy to minimize impact from points of failure. It uses also a distributed architecture to automatically manage scaling. Moreover,

Cloud Datastore is exposed to applications through multiple clients. It also provides a SQL-like query language. All our services have access to a precise schema that is available anywhere in the cloud.

5 Mobile Part

The mobile project management needs the use of dedicated tools not only for the built application but also for the tests and their automation. Even if the framework role stays similar from Java EE application to mobile application, we need to adapt each of them to the embedded system domain.

5.1 Network exchange

The mobile application is often a web client of a web application server. In addition, the data stream often comes from a mobile source to a service in a cloud. Our software architecture needs to take into account the data stream in the opposite sense. This means that data are imported from the cloud into a mobile application. Today, Representational State Transfer (REST) is a style of architecture based on a set of principles that describe how networked resources are defined and addressed. Roy Fielding [20] first described these principles in 2000. REST is an alternative to SOAP and JavaScript Object Notation (JSON). It is important to note that REST is a style of software architecture as opposed to a set of standards and it is particularly suitable for embedded applications. A framework called Restlet allows developers to create new REST services, which expose resource from a mobile phone. This framework is also portable, and the same structure is proposed from the development over a cloud. This allows a uniform approach for all the network exchanges.

5.2 Business mobile application

When the data exchanges occur at runtime, they play a role of business data injection into a remote workflow. Our use case is about the management of contacts with the use of a remote database. Therefore, the body of the requests contains a data structure useful for the remote service. On the service side, these data structures are considered as resources. This is a reason why REST services are more suitable than other remote access types.

Our concrete implementation of a REST Web service follows four basic design principles, use HTTP methods explicitly, be stateless, expose directory data structure-like URIs and transfer JavaScript Object Notation (JSON) objects.

HTTP GET is defined as a data-producing method that has intended to be used by a client application to retrieve a contact, to fetch contacts from a Web server or to execute a query with the expectation that the Web server will look for and respond with a set of matching contacts. The basic REST design principle establishes a one-to-one mapping between create, read, update, and delete (CRUD) operations and HTTP methods. According to this mapping.

- To create a contact on the server, use POST,
- To retrieve a contact, use GET,
- To change the state of a contact or to update it, use PUT,
- To remove a contact, use DELETE

We adopt the same naming convention for all the Web services of our distributed mobile application. Moreover, the mobile device exposes web services for the injection of a registration identifier. We apply the same mapping between the operations of the various REST services.

5.3 Local persistence layer

Our mobile client application needs to store data somewhere. We may store our data and it sometimes do it in the local embedded SQLite database. We had to decide between writing SQL queries, using a Content Provider (useful if you want to share your data with other apps), or using an ORM as explained before. We have selected an embedded ORM. However, when the data are locally saved, it becomes essential to synchronize databases when a connection is possible. This is done, using a SyncAdapter Android API that is able to update the data from the mobile device to the data store in the cloud. This requires the creation of a content provider in the mobile client. The SyncAdapter pilots the update until its termination.

A key feature of our case study is the evolution of the remote databases. Because the backup of the contacts can be done on distinct databases including the local database in the smartphone, we have adopted the same REST service interface to all data stores. This allows the mobile client to become stable even a new data store is considered. The same Web service is also useful when databases are synchronized. This happened when several contacts are saved locally to the mobile device in the case of the network is unreachable and when an access point becomes available.

6 Results and Benchmarks

Our distributed software is deployed over a network, which is the crucial resource. It is possible to track the network activity when a mobile application is making network requests. Usually data are sent to servers. These servers are virtual machine in the cloud and we have developed and deposit software to manage these data in these servers. Therefore, we use a SaaS cloud architecture.

We use the Google cloud infrastructure for that. The figures we are going to present under come from the Google console and the Google user interface to manipulate the Google cloud. The software put in the Google cloud are called Google apps.

6.1 Software architecture

In the initialization step described in the figure 1, we use two Google Cloud data stores. The first one records the different regIds. This database is unique in our archi-

tecture. The second indicates the URI of the current databases where data are stored. This second database is also unique in our architecture.

Therefore, we have a data store where regIds are recorded with their values (beginning by APA) and the date when it was recorded. We wrote a Google cloud app to manage this data store and this Google app is traced by the figure 4.

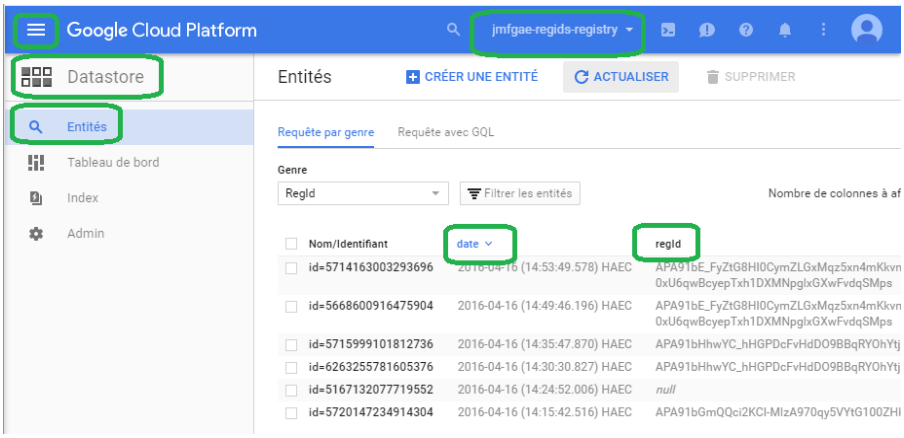

Fig. 4. The Cloud Dashboard for RegId DataStore

In our architecture, the databases where data are stored can vary. So, we must manage these moves. For that, a database for the records is located by an URI. These URIs are recorded in a data store in Google Cloud.

The second data store shown in the figure 5 records the URI of the database where the mobile phone will push their data. We put too the date when an URI is available. We wrote a Google cloud app to manage this data store.

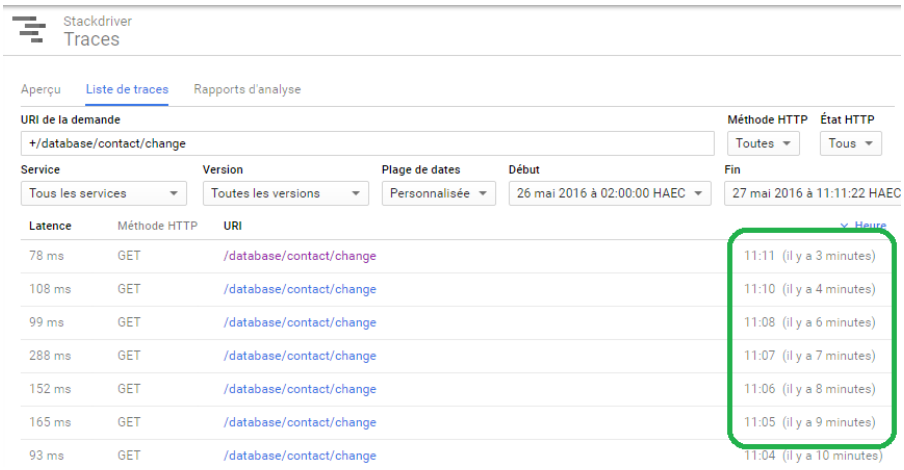

Fig. 5. The Cloud database manager

In the figure 6, we have a third database where the data coming from mobile smartphone are recorded. This database is shown in the figure 2. Even this database can change; they have all the same structure i.e. a Google Cloud data store with the kind of records as shown in the figure 6.

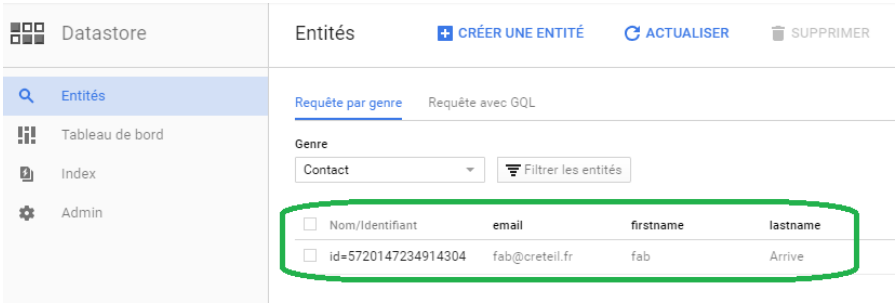

Fig. 6. A Cloud Contact Database

6.2 Benchmarks

We have used Dalvik Debug Monitor Server (DDMS) and Systrace to break down what our application is doing and for how long. On Android, every application runs in its own process, each of which runs in its own virtual machine (VM) called Android Runtime (ART). Each VM exposes a unique port that a debugger client can attach to it.

The DDMS includes a Detailed Network Analyzer (DNA) that makes it possible to track when our application is making network requests. Using this tool, we can monitor how and when our application transfers data and optimize the underlying code appropriately. We can also distinguish between different traffic types by applying a filter to network sockets before use. When we look at the behavior of the mobile application (mobile-client), it receives periodically registration identifiers and data source url from the cloud. On the other side, the mobile application sends REST requests to remote servers.

By monitoring the frequency of our data transfers, and the amount of data transferred during each connection, we identify areas of our application that are made more battery-efficient. This corresponds to the packages called contact network and regid network. We have identified the cause of transfer spikes.

6.3 Management of the transfer spikes

The main energy consumption is due to network traffic regardless the algorithm of selecting the protocol. From the Bluetooth to the WiFi, the use of communication sensors involves an energy cost. Mohammad Tawalbeh notes in [21] that the network transfers cost often more than the screen even if the luminosity is high. Also, he proposes to disable some network services such as Bluetooth service, IrDA (Infrared

Data Association) service and so on until a need appears. This allows to suppress the lookup of network base or the test of the signal range.

Good battery technology simply hasn't arrived yet in 2018, which means it's down to software and settings to configure the limited power. In the domain of hostile environment, all the resources are limited: not only the energy but also, the network capabilities, the memory, etc. Kaushik Dutta et al. [22] propose to cache a set of results concerning the most useful application. They define in a strategy of cache management which reduces the energy consumption.

There are multiple cases of moving data into and out of the cloud which can generate spikes. The first scenario is called a bursting case where the databases, applications and middle-tier servers are all based in the same location. When the cloud provides a large volume of data, it involves an overcome of activities with spikes of requests and a burst of resources. The second use case is about the replication of data and applications in the public cloud. If something goes wrong, then the whole workspace is saved and after resumption, the transfer spike occurs.

7 Conclusion and Future Works

In our paper, we present the opportunity to change dynamically storage areas. However, of course, as we use Android smartphones, the client part can move too. Therefore, our paper presents an architecture where the two parts, client and server can move.

We prove in this paper that we can save data coming from mobile devices to moving databases. The databases can change dynamically and the mobile devices know the new database to store their data. Even there is no network; data can be save by the mobile in their own local SQLite databases. In fact, as the well-known dependency injection used in object-oriented software architecture, we built a storage area injection to dynamically change the places where data can be saved. This dynamically storage area injection can be proposed as a new design pattern for software architecture using databases. May be this kind of software need to be quite generic to be easily translated from a machine to another. So, our storage area injection design pattern can be use in software built on dependence inversion.

The mobile devices are good machines to retrieve information. But a lot of other machines can make the job for example in the Internet of things domain. Raspberry PI, Arduino cards, different sensors and other technologies are good candidates to collect information. Therefore, we can suggest developing software for these connected objects. In addition, we must inform these Internet connected objects where to send their collected data to changing storage in the cloud.

Our work could be extended with the use of mobile service. This will transform our software architecture into a more elastic architecture where mobile components will income into the mobile client. These new components will play an invoker role. So, depending where the end user is, he will receive on his mobile phone a piece of code which is a service invoker of a service which is hosted in the cloud. This approach suppresses the need of an API gateway, which helps the discovery of the useful ser-

vices but introduces a new dependency on a technical API. Also, it provides the client part a more evolving behavior; when exchange format changes then the mobile component brings a request builder which take care of the new packet format. This means that the mobile part becomes easier maintainable than before.

Our architecture used Google Cloud Messaging (GCM) to inform the different smartphones. In fact, the part Firebase Cloud Messaging (FCM) [23] of the Android Firebase technology is the new version to send messages to and receive from the cloud.

Our work was implemented and tested using the local SQLite databases of Android smartphones, MySQL databases on servers and NoSQL databases in Google cloud using appengine technologies [24]. We can propose to store and share data in a peer-to-peer infrastructure between smartphones using Wi-Fi direct. Our work is accessible in a git format at https://github.com/mourlin/fmjmf.

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An Interactive Mixed Reality Ray Tracing Rendering Mobile Application of Medical Data in Minimally Invasive Surgeries

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Abstract—Visualization of patient's anatomy is the most important pre-operation process in surgeries; minimally invasive surgeries are among these types of medical operations that counts totally on medical visualization before operating on a patient. However, medicine has a problem in visualizing patients' through looking through multiple slices of scans, trying to understand the three-dimensional (3D) anatomical structure of patients. With Mixed Reality (MR) the developments in medicine visualization will become much easier and creates a better environment for surgeries. This will help reduce the excessive effort and time spent by surgeons to locate where the problem lies with patients without looking through multiple of two-dimensional (2D) slices, but to see patients' bodies in 3D in front of them augmented in their reality, and to interact with it whatever pleases them. Moreover, this will reduce the number of scans that doctors will ask their patient's for, which will result in less harmful x-ray dosages for both the patient and the radiologist. Biomedical development in medical visualization is an active research topic as it provides the physicians with required devices for clinically feasible way for diagnosis, follow-up and take decisions in different disease lifeline. Current clinical imaging facility can provide a 3D imaging that can be used to guide different interventional procedures. The main challenge is how to map the information presented in the digital image with the real object. This is commonly implemented by mental processing that requires skills from the medical doctor. This paper contributes to this problem by providing a mixed reality system to merge the digital image of the patient anatomy with the patient visual image. Anatomical image obtained from Computed Tomography (CT) or Magnetic Resonance Imaging (MRI) is mapped over the patient body using virtual reality (VR) head-mounted device (HMD).

Keywords—Mixed reality, volume rendering, medical imaging, ray-casting, ray-tracing.

1 Introduction

The current growth in medicine and technology should proceed at the same level. Furthermore, medicine should take advantage in the speedily development in

technology. One of these significantly important subjects of medical applications using new technologies are the visualization of human anatomy [1,2]. Interventional radiology procedures using imaging guidance such as CT/MRI does not meet complete surgeon's satisfaction. In current procedures, radiologists must scan the patient from different positions. Thereafter, surgeons and radiologists must investigate the scanned images to better locate the problem. Consequently, doctors and patients are exposed to heavy radiation. However, some types of medical imaging systems provide a series of scans that can be viewed as a 3D model using appropriate software that can guide interventional clinical procedures.

Augmented reality (AR) was used to provide a solution to this medical problem for a long time [3]. The core challenge in these applications is to offer real-time accurate representation of human organs that is enough for surgeon to proceed with clinical procedure [4]. The developed system should consider the data acquisition device (e.g. video camera, human eye, etc.), the data registration that maps the digital data to be mapped with the real visualized object, and finally, the motion handling and calibration. In this research, we consider the following scenario. A patient is undergoing a minimally invasive surgery where the surgeon needs to process some procedure like injunction of medication or biopsy. We also assume that a CT or MRI image of the patient is available. However, it is difficult for the surgeon to map the 3D anatomical image to the real patient. This happens frequently when the surgeon lack experience in similar procedures. It requires mental process to imaging how the 2D slices presented on the screen are represented on the patient in surgery room. The target of the developed system is to map the anatomical image over the patient real body for easy to comfortable process. Our developed system should be a one step forward to solve the problem of visualizing human bodies.

Volume rendering of 3D image data of patient is multiple slices is the revolution in imaging human body [5]. A voxel is the 3D equivalent to a pixel and are the smallest element in a 3D object [6]. Voxels are used to build 3D objects, mostly used in computer graphical applications like computer games, but also used to render a volume. Applications on volume rendering have taken a large part in interventional and minimally invasive surgeries over the past couple of years. Before the volume-rendering concept is used, there were other techniques that concentrate on visualization via surface shading. It transforms the volumetric data into geometric primitives then screen the pixels. It is good in representing the object but not the best for visualization.

When it comes to volume rendering, the technique displays the information inside the object volume, it is a direct display, the technique transforms volumetric data to screen pixels directly, and it uses transparency to see through volumes. The presented study aims at the development of MR software that will be used in minimally invasive surgeries and interval procedures. Several Groups and associations formed of researchers and scientists have also work in this same field of technology, but none of which went on developing such software in MR, neglecting its vast importance in medicine, some of these works are mentioned in Section 3.3. Our goal is to reduce the heavy load of scans visualization, as well as saving time and effort. This procedure will be much cheaper than the previous methods. Our system requires only

a smartphone and a MR ready headset. Mixed Reality is the combination of Virtual Reality (VR) and AR [7]. This combination brings together the real world and the digital one in one reality [8, 9]. It allows the users to interact with both physical and virtual items, making it more practical than previous methods.

2 Materials and Methods

2.1 System overview

The introduced system visualizes medical images (CT, MRI) as a 3D object. First, we use the developed software to visualize the medical images by using volume rendering ray-casting technique. The term volume rendering is used to describe techniques, which allow the visualization of 3D data. Volume rendering is a technique for visualizing sampled functions of three spatial dimensions by computing 2D projections of a colored semitransparent volume. The technique works as follows:

Step 1:

- Trace from each pixel a ray into object space.
- Compute and accumulate color/opacity value along the ray in the process of pixel compositing.
- Assign the obtained value to the pixel.

Figures 1 and 2 illustrates the process of Ray-marching and compositing of pixels.

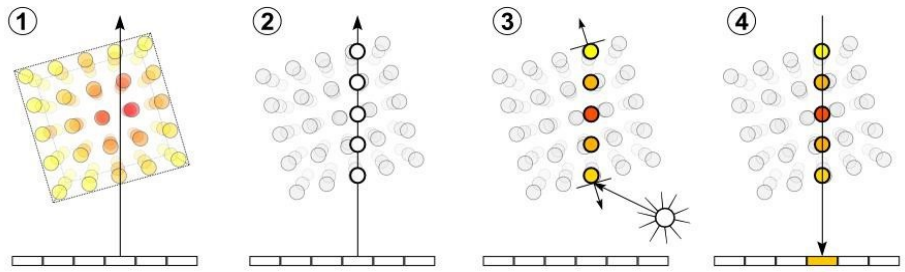

Fig. 1. Ray-marching process [10, 11].

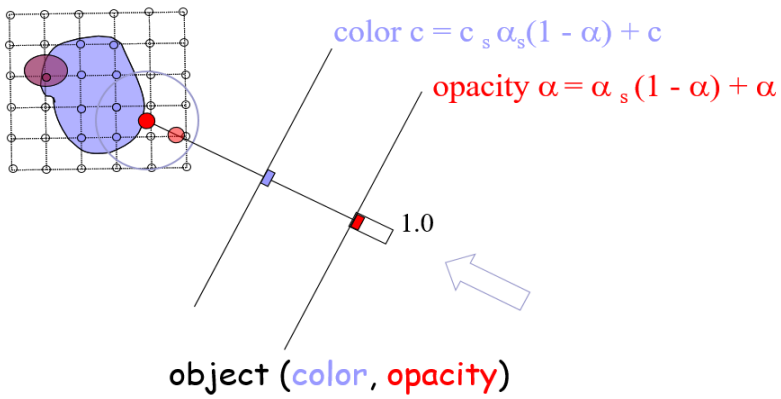

Fig. 2. Compositing of pixels' color/opacity along the ray [11, 12], where c is the color of pixel, and ∝ (alpha) refers to the opacity.

Step 2

In this step, we use compositing technique named alpha blending, i.e. the iterative computation of discretized volume integral. Figure 2 illustrates how alpha blending works while each ray goes through the object on its direction.

The developed software runs on Samsung Gear VR headsets and using its pass-through camera feature. It will enable the software to augment the 3D object of the medical scans in real world space. Interaction with the augmented object will be performed using the Gear VR controller. Users could manipulate the viewed 3D object generated from the medical images sliced by hiding parts of the object or view it in different ways with some GUI features to help the user to interact with it more easily, such as:

- Increasing visibility
- Increasing and Decreasing Opacity
- Clipping (removing parts of the object) on the X, Y and Z axes.
- Rotation and Translation

Briefly, the considered scenario may be summarized as follows:

- First obtain volumetric medical data Digital Imaging and Communications in Medicine (DICOM) [13], or RAW file format.
- Preprocess the data to the best possible lossless form of useable data.
- The data are stored afterwards on a smartphone then mount it on a VR headset that has a pass-through camera feature.
- The software will render the preprocessed data as a 3D object into reality using AR technology through the virtual reality headset.
- User will interact with the 3D object via Gear VR controller.

Using this scenario, surgeons and radiologists will be able to see the scanned slices of the patient as a real 3D object in front of them and will be able to interact with it through a controller. They have the capability to zoom in or out or even to make parts of the object transparent as well as clipping parts of it.

2.2 Image acquisition

CT or MRI scanners first scan the patient. Afterwards, measured data is sent to an online archive to be stored and registered. Thereafter, the data has to be sent to the smartphone via wireless communication for processing and visualization. In this study, we have used CT data provided from Suez Canal University Hospital with blind patient information. An example of the image slices is shown in Fig. 3. Moreover, we have used some online free available CT data to confirm the validity of the proposed method using different resources.

3 Results and Discussion

3.1 Samples and results

In this section, we demonstrate results obtained from experimental study using the developed system. In Fig. 3, a sample of abdominal CT slices obtained from single image from the CT data used in this experiment. These images demonstrate the anatomical structural of human internal organs.

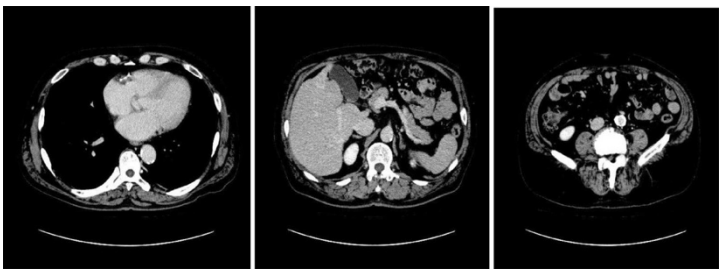

Fig. 3. Sample slices from the first CT dataset.

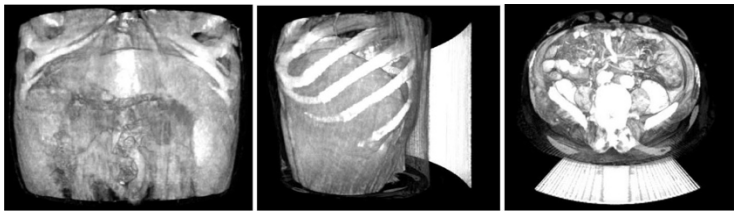

Fig. 4. (left) A 3D object rendered with ray marching by using the first dataset, full opacity, no clipping, front facing, (center) rotated 90 degrees on the Y-axis and (right) rotated 90 degrees on X-axis.

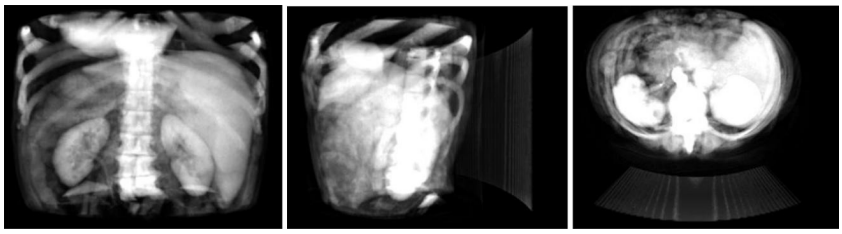

Fig. 5. (left) Same 3D object, 0.03 opacity, no clipping, front facing, (center) rotated 90 degrees on the Y-axis and (right) rotated 90 degrees on X-axis.

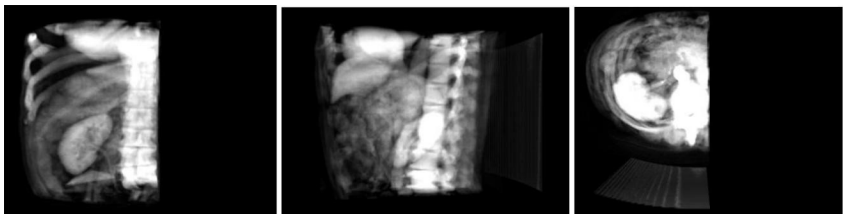

Fig. 6. left) Same 3D object, 0.03 opacity, clipped 50% of it on X-axis, front facing, (center) rotated 90 degrees.

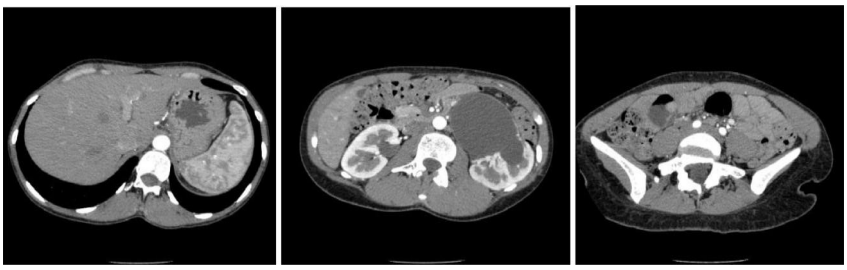

Fig. 7. Sample slices from the second CT dataset.

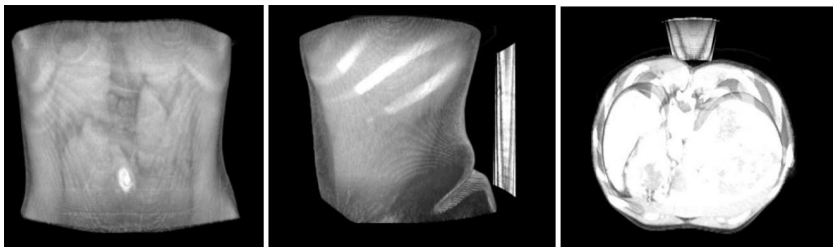

Fig. 8. (left) A 3D object rendered with raymarching using the second dataset, full opacity, no clipping, front facing, (center) rotated 90 degrees on the Y-axis and (right) rotated 90 degrees on X-axis.

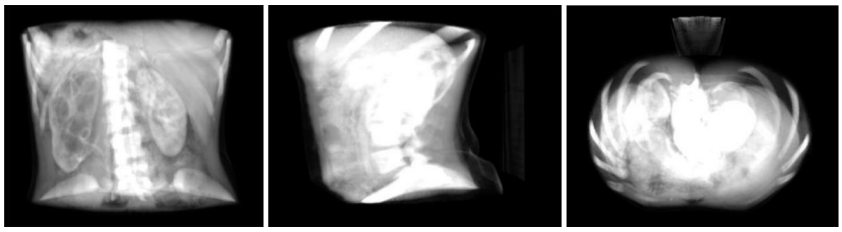

Fig. 9. Same 3D object, 0.03 opacity, no clipping, front facing, (center) rotated 90 degrees on the Y-axis and (right) rotated 90 degrees on X-axis.

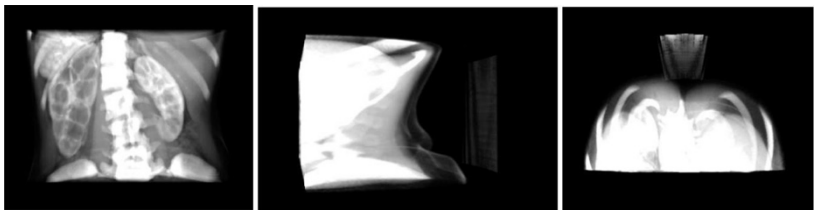

Fig. 10.(left) Same 3D object, 0.05 opacity, clipped 50% of it on Y-axis, front facing, (center) rotated 90 degrees on the Y-axis and (right) rotated 90 degrees on X-axis.

The proposed method is implemented using volume image shown in Fig. 3 and the surface of the patient's body as a 3D object viewed from three different angles is shown in Fig. 4. The volume rendering displays the 3D object with focus on the surface only. It is not possible to view internal structures with this visualization setup. The internal structures can be viewed with three different angles after decreasing the opacity value as shown in Fig. 5. Several organs can be viewed with higher quality. Spinal cord, liver and kidneys can be viewed accurately in 3D structures. Figure 6 is showing only half of the rendered object viewed from three different angles using the first dataset. The same experiment is repeated for the second dataset and results are shown in Figs. 7-10.

3.2 Discussion

The proposed software will help in minimizing the visualization of medical images, saving time and effort for surgeons and radiologist, with relevantly fast run time. It requires few minutes to render a data set of 300 images. This method has a potential to be adapted in several minimally invasive surgeries where the surgeon is required to view internal structures mapped with the patient body in real-time. Results indicate that using the proposed method can help in the rendering and 3D visualization of CT volumes in very short time that lead to exact recognition of different large size objects. However, it is still challenging to observe small size objects such as blood vessels and veins. Further development is required to improve the accuracy towards a better visualization of objects with size less than 10 mm.

3.3 Related work

In 2010, a group of researchers from university of München, Germany, started a project that maps the CT scans obtained with patient body. Their AR system of optical tracking and video see-through head HMD for visualization was developed to keep track of the objects in the scene. This process is carried out by two separate optical tracking systems. Four infrared ARTtrack2 cameras have been mounted to the room's ceiling to obtain an outside-in optical tracking system, while an infrared (IR) camera mounted directly on the HMD is used as an inside-out optical tracking system. They have used video image as context layer, while is rendering focus layer with volume rendering. Occlusion handling is shown for instruments and hands" [14]. Images of their work are shown in figure 11.

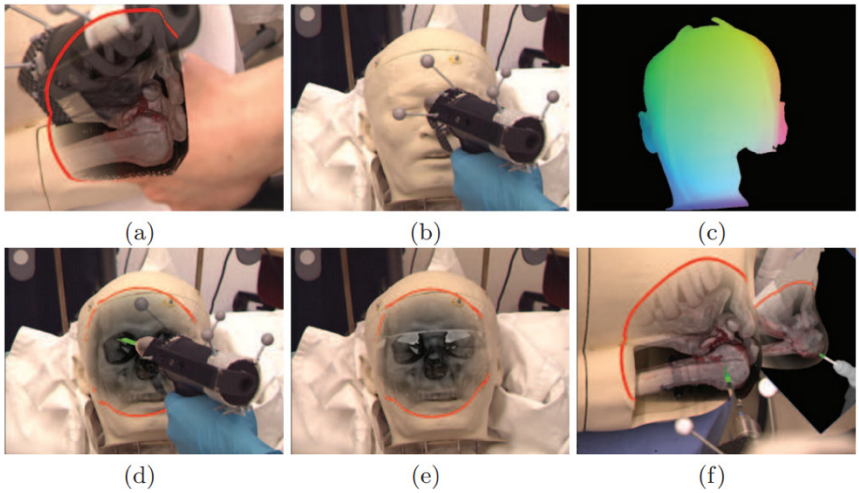

Fig. 11."(a) Illustration of the occlusion problem. (b, c, d) Render pipeline for correct occlusion handling, (b) video texture, (c) hit texture for the skin, (d) final composition of (b) and (c). (e) like (d) with in-body MPR. (f) Focus and Context rendering with shaded volume rendering for the focus layer (bone), virtual mirror and instrument." [14]

Similarly, in 2018, a recent research carried out by group of researchers and scientists [15], they have developed a VR imaging technique that displays and interacts with optical coherence tomography (OCT) data. Their application was installed on a high-end notebook (Windows 10 home, 64bit, NVIDIA GeForce GTX 980 8192MB GDDR5, 32 RAM, CPU Intel Core i7-6700K CPU @ 4.00 GHZ, 4 cores). As in most VR applications, they used in their development phase headsets that connects to a powerful personal computer (PC). As a result, the used hardware delivers very high frame rates, when rendering high quality OCT data. They have reported that their application reaches a normal of 180 frames per seconds (fps) while rendering high quality volumetric data. They have used HTC Vive (VR headset) to render the data in a virtual reality environment [15]. Pictures of their work are shown in figures 12 and 13.

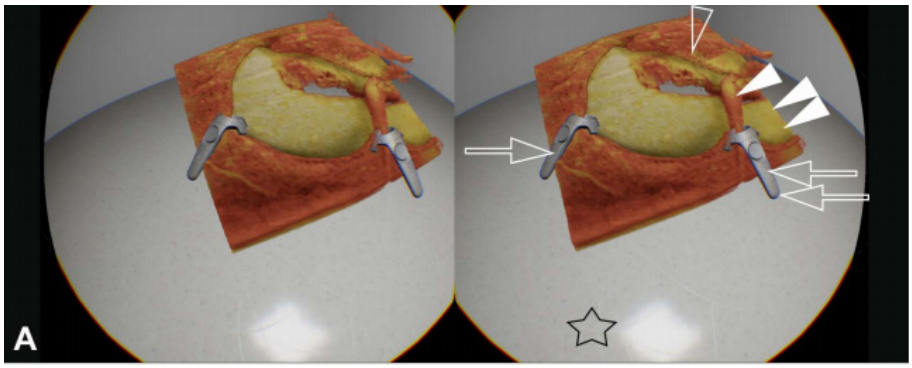

Fig. 12."Stereoscopic illustration of the VR environment displaying volume OCT data of a peripheral retinal tear" [15]

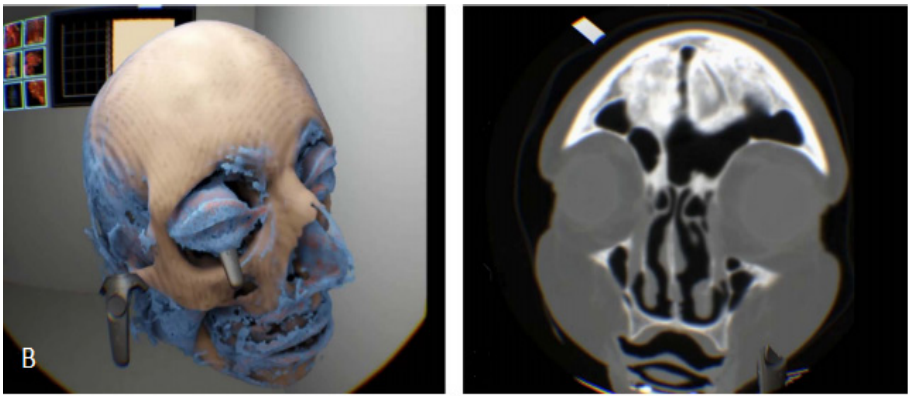

Fig. 13."VR CT of a skull with soft tissue rendering and corresponding original CT data with intensity display" [15]

Their development approach is to render original point-cloud data rather than polygons or meshes, which enhance the detail level and preserves complexity rather than reducing it.

The relation between their work and our work maybe be summarized as followed: is both works tend to image medical data in virtual environments. However, there is no point of comparison between both research works, since both projects use different types of hardware. Our work was tested on a smartphone and the research of [15] was tested on a high-end PC.

Nevertheless, our work has more potential in future medical applications, with more interaction with the real world since we have implemented the volume rendering technology in MR rather than VR.

4 Conclusion and Future Work

4.1 Conclusion

In this study, we discussed the developed system and software that will be used as a new method in visualization of medical images. The software can deliver better visualizations to surgeons and radiologists, helping to create a better environment for surgeries.

4.2 Future work

The research presented in this study also provide a strong basis for future work in awareness and in volume rendering technologies. One area of future work is in uniting the knowledge gained about mixed reality with knowledge about medicine. Another extent is in applying the results studied here to the many real-world situations in which reconstruction of 3D medical data is an important problem.

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Intention to Use Smartphones among Peruvian University Students

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Abstract—This document is a report on the findings of a study aims to investigate human motivations affecting an adoption decision for smartphone among Peruvian university students. This research investigates smartphone users' perception using technology acceptance model (TAM). It is analyzed perceived ease of use, perceived usefulness and attitude toward to keep using a smartphone as determinants for behavioral intention to keep using a smartphone between Peruvian university students, evaluating them with reliability and validity and confirming the hypotheses elaborated for the study. Findings indicate that the behavioral intention to keep using a smartphone (BIU) was significantly influenced by perceived ease of use (PEOU), perceived usefulness (PU) and attitude toward to keep using a smartphone (AKUS) and also, PEOU influenced significantly to PU. This study not only provides valuable information about students´ the intention to keep using a smartphone, but also enriches the current literature, focusing on Peru, which has a different commercial characteristics and cultural background as compared to North America, Europe and Asia. According to the current literature review, this is the first study on this subject that specifically focuses on the use of smartphones by Peruvian university students.

Keywords—Intention to use, Peruvian students, Technology Acceptance Model, TAM, Smartphone

1 Introduction

The way in which people is in contact with other have been changing due to different tools and smartphones have an important place in this changing process because increased the Internet traffic for finding information, enjoy music and videos, and even manage the personal agenda for job and studies. Additionally, with the arrival of more sophisticated equipment, new operating systems, very useful applications to use them daily and even with the reduction of costs due to the arrival of new competitors has generated an increase in users. Some previous research focused in the evaluation of the implementation of mobile apps in daily learning activities [1], observation of implementing a mobile application news tool for disseminating messages in a university [2] and observation of the relationship between mobile phone usage in classroom in a university [3].

Specifically, Poushter [4] reported that in 2016 the percentage of smartphones penetration was being leaded by South Korea (88%), Australia (77%), and United States (72%). Peru reported only 25% (29% men, 21% women), 41% in people between 18 and 34 years old and 15% in older than 35 years old. Other report made it by Newzoo [5] show the list of countries by smartphone penetration in April 2017 is leaded by United Arab Emirates (80.6%), Sweden (72.2%), Switzerland (71.7%), South Korea (71.5%) and Taiwan (70.4%). Peru is in 37 ranks with (36.0%). The statistics show a unique growth, which is getting faster and for that reason is attractive for research activities as smartphones bring many functions that make life easier for people, through the rapid management of their information and many forms of communication. Despite what may have been investigated, it should be considered that smart phones are a new technology therefore there is a need to investigate its components linked to interpersonal and mass communication. This knowledge is expected to collaborate with the construction of theory for current communication technologies. To achieve this, it is necessary to evaluate both the factors that affect the use of smartphones by users, taking into account that there is little evidence of the profile. Specifically in the case of Peruvian university students, there is no previous evidence.

The main objective of the present investigation is to analyze the psychological factors of the users that generate an influence in the use of the smart phones. To this goal, the study use the framework of the technology acceptance model (TAM) developed by Davis, Bagozzi & Warshaw [6] so the present study measure the influence of the perception of ease of use the smartphone (PEOU), perceived usefulness (PU) and, attitude toward to keep using the smartphone (AKUS) over the intention to keep using smartphones (IKU). It is valuable to evaluate the use of smartphones in the population of university students because according to the age they usually have a high usage is expected but is also evaluating how much of that use is related to their academic activities and is measured further how important it is for them to use the smartphone to solve their day to day life in college; there have no studies on this topic specifically in Peru, which has a low level of smartphone penetration (in comparison to other countries even in South America) and also have different habits as compared to other regions. In this situation, the current exploratory study focuses on Peruvian university students' smartphone preferences and practices. The literature review reveals that very few studies investigated the smartphone adoption and fewer studies have empirically tested university student's perceptions to explain the adoption of smartphone for their daily academic activities.

We aimed to supply answers these questions in this research:

1. What is the most frequently used app for Peruvian university students when performing their usual academic activities, and are female and male differences in relation to their preferences?
2. For how many years have, you used a smartphone and which operator currently provides you with the mobile phone service Between Peruvian university students?
3. What is the influence of perceived of ease of use the smartphone (PEOU) over perceived usefulness (PU)?

4. What is the influence of perceived of ease of use the smartphone (PEOU) attitude toward to keep using smartphone (AKUS)?
5. What is the influence of perceived usefulness (PU) over attitude toward to keep using smartphone (A)?
6. What is the influence of attitude toward to keep using the smartphone (AKUS) over behavioral intention to use smartphone (IKU)?
7. What is the influence of perceived usefulness (PU) over behavioral intention to use smartphone (IKU)?

1.1 Theoretical background

Between the models most successfully employed in many field researches, the technological acceptance model (TAM) stands out. Davis, Bagozzi & Warshaw [6] developed this model based on the theory of reason action (TRA) by Ajzen and Fishbein [7]. One important issue is that the TAM was especially developed to predict the acceptance of information systems by users in organizations, it means in a work facilities. According the authors of the model, the main aim of TAM is to explain the factors that determine the utilization of ICT by a number of users of technology. The TAM suggests that perceived usefullness and ease of use are determinants in an individual's intention to use a system. The TAM helps to know if a technology is going to be used in an optimal way but it is necessary to identify external variables that influence the usefulness and ease of use perceived by ICT users. Nowadays, the different organizations need their employees must use optimally the ICT. Also, universities are implementing more technology for supply education in undergraduate and postgraduate students and in this case these students face the same situation against ICT. The model seeks to predict the relative importance of perceived usefulness (PU) and perceived ease of use (PEOU), together with other variables relevant to specific research contexts, on either intention to use or actual use [6]. TAM is based on two main characteristics:

1. **Perceived usefulness (PU).** It refers to the degree to which a person believes that using a specific system will improve their performance on the usual activities (job for workers, classes for students).
2. **Perceived ease of use (PEOU).** It refers to the degree to which a person believes that using a particular system will make less effort to perform their usual tasks (job for workers, classes for students). The most important prediction during the use of the TAM is that PEOU affects PU, and both PEOU and PU jointly influence behavioral intention to use or intention to keep using a specific technology system. Also, the TAM suggests that it is necessary to add more relevant variables that may influence the two key variables of the model (PU and PEOU). When the model would be completed it will be more simple and general and finally useful to understand the relation and can improve behavior in any specific population. Research model is described in figure 1.

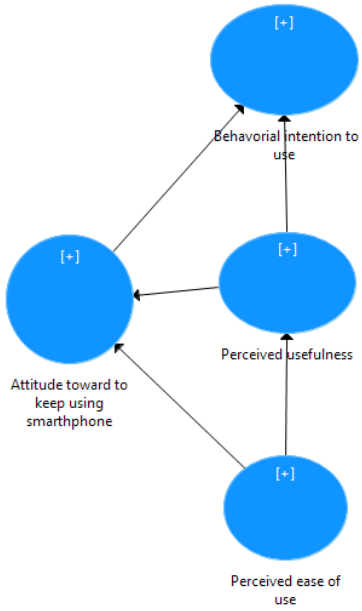

Fig. 1. Research model

2 Literature Review

In the literature, TAM has been studied for over 20 years. Reviewing the current literature, existing studies in the field can be grouped into some categories according to the kind of technology analyzed in the study. TAM has been tested as a theoretical framework showing its robustness in specific areas. First, in health area, some studies focused in acceptance of telemedicine like Hu study [8], which evaluated acceptance of telemedicine by physician in a tertiary hospital in Hong Kong. The perceived usefulness was found to be a significant determinant of attitude and intention but perceived ease of use was not. Holden & Karsh [9] analyzed 20 studies developed in clinicians using health IT for patient care. Outcomes show that TAM predicts a substantial part of the use or acceptance of health IT. Secondly, in commercial services, Ha & Stoel [10], analyzed acceptance of e-shopping and using a structural equation model revealed that consumer perceptions of usefulness and attitude toward e-shopping influence intention to shop online, while perceived ease of use does not influence attitude toward e-shopping. Aboelmaged & Gebba [11] tested the model in acceptance of mobile banking services and the outcomes indicated a significant positive impact of attitude toward mobile banking and subjective norm on mobile banking adoption, and effects of behavioral control and usefulness on mobile banking adoption were insignificant. Also, Diatmika, Irianto & Baridwan [12] focused on acceptance of accounting information system; they found that perceived usefulness, subjective norm, task technology fit and self-efficacy showed influence on behavior intention. Perceived ease of use, perceived behavior control and personal innovativeness in IT has no effect on behavior intention.

Thirdly, in mobile use and services, Joo & Sang [13] evaluated acceptance of use of smartphone in Korean consumers, using a structural equation model and demonstrated that Koreans' smartphone use is influenced more by motivations based on instrumental and goal-oriented use than by ritualized and less-goal oriented use. Park & Kim [14] tested acceptance of mobile cloud services using a structural equation modeling analysis and found that user acceptance of mobile cloud services is largely affected by perceived mobility, connectedness, security, quality of service system, and satisfaction. About previous studies, literature show studies were developed in different regions:

- North America. United States: Landry, Griffeth & Hartman [15]. Canada: Ifnedo [16].
- Asia. South Korea: Park [17]. Hong Kong: Cheung & Vogel [18]. Jordan (Al-Adwan, Al-Adwan & Smedley [19]. Saudi Arabia: Alharbi & Drew [20]. Indonesia: Beldad & Kusumadewi [21]. Thailand: Teo [22]. Kuwait: Al-Daihani [23].
- Europe. Italy: Persico, Manca & Pozzi [24].
- Africa. South Africa: Chipps [25].
- Oceania. Australia: Atif, Richards, Busch & Bilgin [26].

Previous studies show that the TAM is a well-suited model that allows explaining the adoption and use of different information and communication technology (ICT) systems. However, there is a gap of research for Latin American countries in this issue which is the focus of the current study: Peruvian students. In spite of low level of smartphone penetration in Peru, 64.1% of population in Lima city, capital of Peru, has access to Internet and only 11.9% in rural areas accord INEI [27]. Having a smartphone gives many opportunities for the search of information but at the same time is a source of distraction for students, including during the dictation of classes by the teacher in the classroom. So are smartphones really being used correctly? Is it a misperception that the students waste time when they use the smart phone for a long time?

3 Methodology

For current study were employed both open-ended and closed-ended. Students from the business school of one private university in Lima, Peru were sampled. Data was collected between 25 August 2017 and 12 September 2017. A total of 404 students participated and completed the survey. Only 366 students completed the survey properly. In the research design, university students' sex, age, e-mail preference, app preference, smartphone usage time, amount of smartphone in the past, mobile phone company. In this context, students were asked:

1. What e-mail do you use most when doing your university tasks?
2. What is the most frequently used app when doing your college homework?
3. What cycle are you currently in?
4. For how many years have, you used Smartphone.
5. How many Smartphones have you had before the current one?
6. What operator currently provides you with the mobile phone service?

Obtained data was evaluated by frequency ratios in developing a general understanding about commonly preferred digital sources of Peruvian university students. Next, it was explored what were perceived usefulness, perceived ease of use, attitude and behavioral intention in Peruvian university students. It was used as reference the instrument of Park and Chen [28]. Seventeen statements with each constructed described before in a *Likert 5-points questionnaire were asked.*

- **Perceived usefulness**
  1. Using the smartphone in my job would enable me to accomplish tasks more quickly
  2. Using the smartphone would improve my job performance
  3. Using the smartphone would enhance my effectiveness on the job
  4. Using the smartphone would make it easier to do my job
  5. I would find the smartphone useful in my job
- **Perceived ease of use**
  1. Learning to operate the smartphone would be easy for me
  2. I would find it easy to get the smartphone to do what I want it to do
  3. I would find the smartphone to be flexible to interact with
  4. It would be easy for me to become skillful at using the smartphone
  5. I would find the smartphone easy to use
- **Behavioral intention**
  1. Whenever possible, I intend to use the smartphone in my job
  2. To the extent possible, I would use the smartphone to do different things
  3. I intend to increase my use of the smartphone in the future
- **Attitude toward to keep using smartphone**
  1. Using the smartphone for my tasks is a good idea
  2. Using the smartphone while do my tasks is terrific
  3. Using the smartphone is beneficial to my tasks
  4. I like using the smartphone for my tasks

3.1 Validation with SEM-PLS

Using Partial Least Squares Structural Equation Modeling (PLS-SEM) was analyzed the validity of construct and discriminant and, internal consistency by the composite reliability. SmartPLS statistical package accord Ringle, Wende & Becker [29] is used to calculate the factorial structure of the indicators, using Partial Least Squares. SEM-PLS aims to predict the latent variables by estimating Partial Least Squares (PLS) and Principal Component Analysis (PCA). The main advantage of PLS is the greatest strength calculations to smaller samples and breach of statistical assumptions of the variables (non-normal distribution, different levels of measurement, multi collinearity, among others). With PLS structural equation modeling technique can be evaluated simultaneously two methods: the measurement model and the structural model. In the case of validity, the measurement model is used which involves the analysis of the reliability of each indicator, the internal consistency of each dimension, analysis of average variance extracted and discriminant validity. In a PLS model, the individual reliability of

the indicators is assessed by examining the load between each indicator and dimension, accepting as reliable those above 0.706 loads, although some authors suggest not be so rigid in early stages of development instruments. Another measure used to evaluate the fit of the model is the average variance extracted that provides the amount of variance that a construct (dimension) obtains from its indicators about the error variance. A good fit requires values above 50%.

3.2 Validation of construct of behavioral intention to use with SEM-PLS

Table 1 shows that all the factor weights of the dimensions of the behavioral intention to use are greater than the expected minimum (.706), with average variance extracted by scale between 67.1 and 76.6%, and high levels of composite reliability (between .881 and .929). These values confirm the internal consistency and construct validity of each of the subscales of behavioral intention to use.

Table 1. Construct validity of the items of the scales of behavioral intention using Structural Equations of Variance using Partial Least Squares

	Items	Loading	Composite reliability	Extracted variance
Perceived ease of use	Learning to operate the smartphone would be easy for me	.796	.919	.693
	I would find it easy to get the smartphone to do what I want it to do	.792		
	I would find the smartphone to be flexible to interact with	.843		
	It would be easy for me to become skillful at using the smartphone	.825		
	I would find the smartphone easy to use	.902		
Perceived usefulness	Using the smartphone in my job would enable me to accomplish tasks more quickly	.834	.911	.671
	Using the smartphone would improve my job performance	.762		
	Using the smartphone would enhance my effectiveness on the job	.781		
	Using the smartphone would make it easier to do my job	.857		
	I would find the smartphone useful in my job	.859		
Attitude toward using smartphone	Using the smartphone for my tasks is a good idea	.896	.929	.766
	Using the smartphone while do my tasks is terrific	.838		
	Using the smartphone is beneficial to my tasks	.881		
	I like using the smartphone for my tasks	.885		
Behavioral intention	Whenever possible, I intend to use the smartphone in my job	.852	.881	.712
	To the extent possible, I would use the smartphone to do different things	.844		
	I intend to increase my use of the smartphone in the future	.835		

*Source: 366 school business students. Self-prepared

4 Findings

A total of 366 students completed the survey properly. Distribution of sample among two genders with 192 females (mean age = 21.53; SD: 2.90) and 174 males (mean age = 22.10; SD: 2.95) indicated no conspicuous biases. 117 students were between 2 to 5 academic cycles and 249 were between 6 to 10 academic cycles. About smartphone usage time, mean was 7.4 years (SD: 4.237) and about number of smartphones used in the past, mean was 3.64 (SD: 2.492).

Data of e-mail preference, app preference smartphone and Mobile Phone Company was evaluated. Gmail (51.9%) and Hotmail (44.8%) were the two emails preferred by the students for were the two emails preferred by the student´s purposes. WhatsApp (61.5%) and Facebook (37.4%) were the two apps preferred by the students for were the two emails preferred by the student's purposes. Distribution of Mobile Phone Company were Claro (48.2%), Movistar (25.7%), Entel (22.2%) and Bitel (3.9%)

Also, figure 2 shows the research model tested.

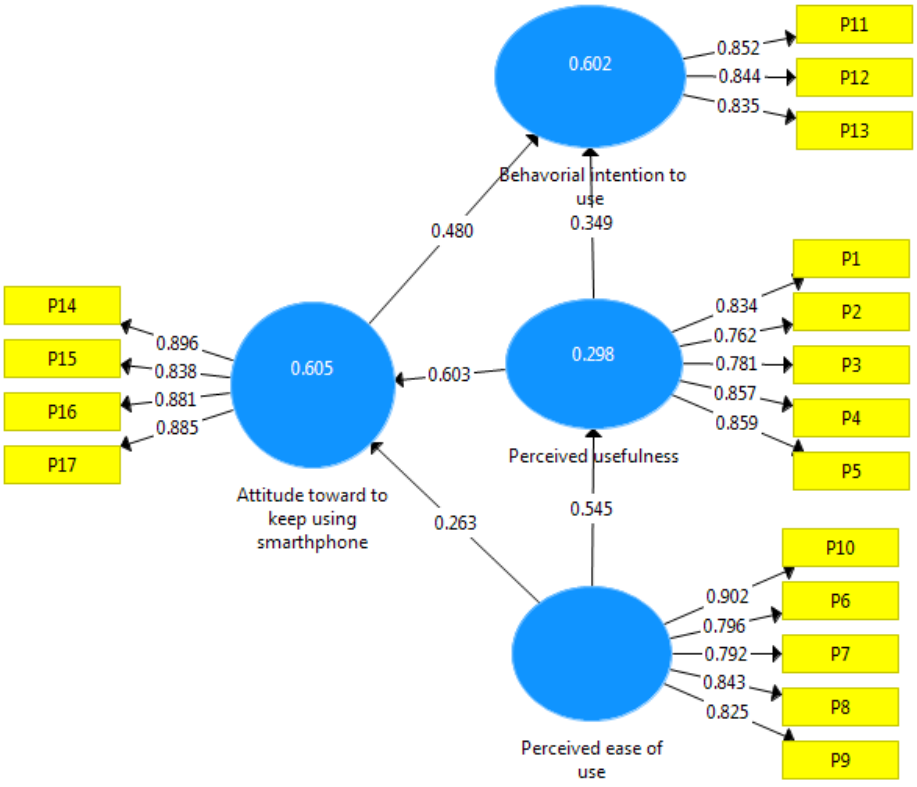

Fig. 2. Research model tested

Considering the relation shown in fig. 2, we evaluated the objectives 3, 4, 5 and 6:

- **The influence of perceived of ease of use smartphone over perceived usefulness:** The influence of perceived ease of use smartphone has a positive effect of 0.545 over perceived usefulness. The influence of perceived of ease of use smartphone explains 29.8% of the attitude toward to keep using smartphone.
- **The influence of perceived of ease of use smartphone over attitude toward to keep using smartphone:** The influence of perceived of ease of use smartphone has a positive effect of 0.263 over attitude toward to keep using smartphone.
- **The influence of perceived usefullness over attitude toward to keep using smartphone:** The influence of perceived usefulness has a positive effect of 0.603 over attitude toward to keep using smartphone. The influence of perceived usefullness together with perceived of use smartphone explains 60.5% of the attitude toward to keep using smartphone.
- **The influence of attitude toward to keep using smartphone over intention to keep using smartphone:** The influence of attitude toward to keep using smartphone has a positive effect of 0.480 over intention to keep using smartphone.
- **The influence of perceived usefullness over intention to keep using smartphone:** The influence of perceived usefullness has a positive effect of 0.349 over intention to keep using smartphone. The influence of perceived usefullness together with attitude toward to keep using smartphone explains 60.25% of the behavioral intention to use.

Table 2 shows significance of the path coefficients between the variables. It is included outcomes of bootstrapping with 5000 resample. It is verified that all values are significant.

Table 2. Significance of the path coefficients between the variables

Relations between variables (Beta values)	Original sample	Sample mean	Standard error	T statistical
AKUS → BIU	0.480	0.480	0.118	4.049
PEOU → AKUS	0.263	0.259	0.105	2.502
PEOU → PU	0.545	0.542	0.100	5.443
PU → BIU	0.349	0.350	0.119	2.934
PU→ AKUS	0.603	0.606	0.085	7.061

*Source: Simulation through Bootstrapping. Resample (5000 times), $p<0.01$
*Note: Attitude toward to keeping using smartphone (AKUS), Perceived usefulness (PU), Perceived ease of use (PEOU), Behavioral intention to use (BIU).

5 Discussion

The current study aims to investigate human motivations affecting an adoption decision for smartphone among Peruvian university students. Taking a different cultural background, when compared to North America, Europe and Asia, outcomes are noteworthy in order of enriching existing literature in the field. The outcomes strongly

support the influences of variables to explain the behavioral intention to keep using smartphone.

About smartphone usage time the mean was 7.30 and looking mean age of sample, many have been initiating the use of smartphone since 15 years old; this information together with amount of smartphone in the past (3.64) shows that in approximately seven years , since 15 years old, students changed 3-4 times their smartphone, it means change device each two years. Other interesting information is about email preference because according to report of September 2017 of Email Client Market Share [30] the percentage of users using Gmail was about three times more than those using Hotmail but in current study the percentage is very similar. About usage of app, according to comscore.com, users using WhatsApp was about three times more than those using Facebook but in current outcomes, it was only double. Also, it is surprising that the former monopoly supplier in Peru for more than 20 years, Movistar, has only 25.7%. This figure is almost half of the market leader, Claro, in this student sector with a value of 48.2%.

The findings indicated that Behavior Intention of Use (BIU) was widely influenced by Perceived Usefulness (PU) and Attitude toward to Keep Using Smartphone (AKUS). Also, PEOU and PU had a positive influence to AKUS. During the study it was found that the impact of PU on AKUS was stronger than that of PEOU. These outcomes are consistent with previous studies as Rauniar, Rawski, Yang, and Johnson [31] in which PU influence positively over AKUS in 0.69 and PEOU influence positively in AKUS in 0.60. This outcome implies that Peruvian student´s feelings about smartphone usefulness will play a more important factor that student´s perception of easiness in determining physician's attitude toward to keep using smartphone. Also, PU was positively affected by PEOU. The relationship between PU and PEOU has been documented and the results confirmed the importance of the link between them as Wallace and Sheetz [32] for evaluate the adoption of software measures, Cheung & Vogel [18] for acceptance of e learning, Joo & Sang [10] for smartphone usage and Ooi & Tan [33] for acceptance of smartphone credit card.

6 Conclusion and Future Work

This effort of adapting TAM into the investigation of business student's intention of smartphone use was successfully demonstrated in this research. One important component was the AKUS in predicting BIU in business students confirms the validity of TAM model as other previous reported like Kin & Shin [34] for acceptance of smart watches and Ma, Chan & Chen [35] for acceptance of smartphone in older adults. Developing studies that allow evaluating the acceptance of technology is a crucial aspect, for which the type of product or consumption that is thought to use must be taken into account. Certainly it is not the same to accept the use of a basic type of smartphone, perhaps more similar to the old phones than to accept a smartphone of last generation and likewise, it is not similar the acceptance of the use of smartphone depending on the type of contract of navigation; thus, while those who have unlimited services will be able to rely heavily on the use of the smartphone, those who have a prepaid service will

have a restricted use in the university, being more similar to returning home and using the Internet via Wi-Fi as part of the Internet system at home.

The previous mentioned aspects are characteristics that must be taken into account for future studies so that the sample can be characterized, which has inside the conditioning factors for the results to be different. An additional aspect knows who pays for the mobile phone service because it will be different when the student pays directly with the money of his parents or his work and another one when his parents pay. It is also recommended to take into account these differential aspects for future studies. We should also mention that this is an initial study using a convenience sample. Future studies can also to use a high number of sample and more qualitative information after the main study. Also, cross-cultural studies can reveal deeper information for future studies. The use of TAM approach allows an easy and reliable methodology to measure acceptance to technology.

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An Examination of the Determinants of the Adoption of Mobile Applications as Learning Tools for Higher Education Students

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Abstract—The main purpose of the present study was to examine whether mobile applications could be adopted as feasible tools for learning purposes at higher education institutions. Furthermore the study's intention was to conduct an empirical investigation into students' perceptions towards mobile applications being introduced as learning aids. The researcher developed a conceptual model derived from the technology acceptance model in order to measure the constructs used in the study. Adopting a quantitative approach, the field study was conducted in South Africa at a selected higher education institution. Research data was collected from 380 registered students at the selected higher education institution who were older than 18 years. Using SPSS 23 and AMOS 23 software programs, Structural Equation Modeling (SEM) was performed to analyse the data set. The results revealed that perceived usefulness, perceived ease of use, attitudes towards a mobile application, intention to use a mobile application were all significant predictors for the actual use of mobile applications for learning. The findings of the study illuminate the importance of the determinants of the adoption of mobile applications for learning in higher education.

Keywords—Technology, mobile application, students, higher education

1 Introduction

The advent of mobile education technologies into teaching and learning has given rise to both new opportunities and challenges to educators (Handal, El-Khoury, Campbell & Cavanagh, 2013) [21].The rapid advance in broadband and wireless internet technologies has promoted the utilisation of wireless applications in our daily lives (Hwang, Yang, Tsai &Yang, 2009). Application software, also referred to as an application or an app, relates to a software designed to assist users in performing specific or various related tasks (Handal, El-Khoury, Campbell and Cavanagh, 2013) [21]. Advancement in mobile technology and learning applications have broadened the scope of learning areas outside of formal education by allowing flexible and instant access to rich digital learning sources (Cheon, Lee, Crooks & Song, 2012) [13]. Access to mobile online lectures can provide an opportunity for learning by students while commuting (Massey, Ramesh & Khatri, 2006) [37]. For example eSchoolBag, is a platform that

allows students to download/upload homework, access class announcements and complete exercises, anywhere, anytime (Massey et al., 2006) [37].

Education in particular has benefitted from technologies such as computers and the internet (Abdullah, Ward & Ahmed, 2016) [1]. Being economical, flexible and accessible without constraints of time and distance, technologies such as electronic learning (e-learning) systems are becoming increasingly relevant in the Higher Education context (Abdullah et al., 2016 [1]; Lin, Lu & Liu, 2013) [35]. An e-learning system is defined by Lee, Hsieh and Ma (2011) [32] as an information system that can integrate a wide variety of instructional elements through audio, video, and text delivered through live chat sessions, online discussions, forums, tests and assignments. The present study will primarily focus on the adoption of mobile applications as educational tools. The study used the Technology Acceptance Model (Davis, Bagozzi & Warshaw, 1989) [18] to examine the determinants of the adoption of educational mobile applications in higher education.

In numerous empirical studies (Ong & Lai, 2006 [42]; Pituch & Lee, 2006 [45]; Sánchez & Hueros, 2010) the utility and applicability of the Technology Acceptance Model (TAM) has been supported in a wide range of educational settings. Wang, Wiesemes and Gibbons (2012) [56] define mobile applications for educational purposes as learning tools used to gain knowledge through mobile devices. Mobile devices include mobile devices such as tablets and smartphones. Nonetheless, mobile devices facilitate mobile learning (m-learning) which involves a form of learning that makes use of mobile communication technologies that give students the capacity to continuously learn anywhere and anytime (Moreira, Santos & Durao, 2017) [41]. According to Rainie (2012) [46] over 60% of young adults aged between 18-29 years, own smartphones and use them for a variety of purposes such as, surfing the internet for information, texting , social networking and reading emails. This therefore reveals how significant a role smartphones play in young adult's lives. Smartphones and mobile apps have developed into an everyday staple in the lives of young people including Higher education students (Green, Cantu & Wardle, 2014 [20]; Moreira et al., 2017) [46].

1.1 Problem investigated

The South African higher education landscape is faced by a plethora of challenges which include transformation, student unrests and poor student graduation rates (Barkhuizen, Rothmann & Van de Vijver, 2013 [6]; Barkhuizen & Rothmann, 2006 [5]; Letseka & Maile, 2008 [34]). Mobile applications have the potential to positively support teaching and learning in higher education institutions by providing universal communication, study aids and flexible location-based services for learners (Cheon et al., 2012) [12]. Moreover, the higher education landscape is particularly suitable for the integration of student centred mobile educational applications to be adopted because mobile devices have become ubiquitous on university campuses among both students and staff members in both developed and developing countries (Cheon et al., 2012 [12]; Rogers, Palmer & Miller, 2017). According to the International Telecommunication Union (ITU) (2015), seven billion people in the world have access to mobile devices

coverage. Africa has the second largest and fastest growing mobile phone market in the world (ITU, 2015). According to Phuangthong and Malisawan (2005) [44], most researchers have focused on mobile applications, users' acceptance and the application of mobile learning in developed countries (Brown, Ryu & Parsons, 2006 [7]; Liu, 2008 [36] and Chao and Chen (2009) [10]. However, limited research has explored the adoption of mobile devices to facilitate learning in higher education institutions within the African context (Kaliisa & Picard, 2017) [26].

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2 Literature Review

Baker (2000) [4] considers reviewing current literature relevant to a research interest to be an essential initial step and basis for undertaking the research study. In an educational environment, students can utilise mobile devices to support their learning. Mobile devices , such as personal digital assistants (PDAs), mobile phones, or portable computers are increasingly being incorporated in learning activities by educators (Wu, Hwang, Tsai, Chen & Huang, 2011) [57]. This research focuses on problem solving in education utilizing technology, which echoes past research from Sediyono, Kristinawati and Paseleng (2018) [49]. In this respect, mobile technology, allows learning activities to be carried out inside and outside of the classroom (Wu et al., 2011) [57]. Researchers have established that what really matters is students being able to access the right educational resources at the right time in the right place (Shih, Chu & Hwang, 2011[51] and Wu et al., 2011) [57].

As a form of learning, mobile learning involves learning, which is facilitated by mobile devices. Mobile learning provides continuous opportunities to extend spaces and times for learning by learners (McCaffrey, 2011) [38].

There are four types of learning approaches that can be supported by mobile devices, namely:

- Individualized learning
- Situated learning
- Collaborative learning
- Informal learning

Through individualized learning, mobile learning allows students to pace themselves as they learn and acquire knowledge. On the other hand, situated learning occurs when students utilize mobile devices to learn within a real life context. Collaborative learning occurs when students utilize mobile devices to interact and share knowledge with other students. Finally, informal learning occurs when students are able to utilize their mobile devices out of the classroom setting at their convenience (Wu et al., 2011) [57]. Several

studies focusing on the use of mobile devices to facilitate learning have provided empirical evidence supporting the effectiveness of mobile devices in the learning process. For example, in a study conducted by Hwang, Yang, Tsai and Yang (2009) [24] mobile and wireless communication technologies were used in a Chemistry course to train students on the operating procedure of the single-crystal X-ray diffraction experiment. In this vein, mobile applications have been reported to facilitate learning activities, which include, sharing of information, robust debates and the discussions of important topics.

The potential benefits of mobile applications as learning tools has received extensive support in terms of being cost saving, ubiquitous, and convenient (Cheon et al., 2012) [12]. According to Young (2011), mobile applications on mobile devices can be used as study aids that can be easily accessed by learners when they are at home during any time of the day.

The characteristics of mobile devices are three fold:

- **Portability** - mobile device can be taken to any location because of their size
- **Instant connectivity** - because of the wide spread accessibility of the internet mobile devices can be used to access any information instantly
- **Context sensitivity** - with regard to the availability of the internet, any use of mobile devices can be tracked and measured to gather necessary data and information (Churchill & Churchill, 2008 [14]; Klopfer, Squire & Jenkins, 2002 [28]; Sharples, 2000 [50]).

Recent research showed that 67% of students' smartphones and tablets are reportedly being used for academic purposes (Chen & Denoyelles, 2013) [11]. Research also indicates that most students use mobile devices for academic applications including university applications (such as, UCF mobile, Tegrity, Mobile learn), educational application (such as, Flash cards, Khan Academy and iTunes U), e-books (such as, Course Smart and Inkling), Google and Safari for accessing information (Chen et al, 2012) [11].

The following sections in the paper will comprise of the theoretical grounding underpinning the study, research objectives, hypotheses, research methodology, findings/results, managerial and academic implications, conclusions and lastly suggestions for future research.

2.1 Theoretical grounding

For the purpose of this study the theoretical grounding will be guided by, the Technology Acceptance Model (Davis et al., 1989) [18], Theory of Planned Behaviour (Ajzen, 1991) and the Theory of Reasoned Action (Ajzen & Fishbein, 1975). These theories were be used to explain students' behaviour towards the adoption of mobile applications as learning tools. Moreover, this study will add to our understanding of theory through the application of the aforementioned theories within the African higher education context to comprehend the adoption of mobile applications as learning tools.

Technology Acceptance Model: The technology acceptance model (TAM) proposed by Davis (1989) [17] is the most widely used and recognized theory for explaining an individual's acceptance and adoption of information technology (Lee, Hsieh &

Hsu, 2011) [32]. TAM determines user's attitudes and recognises the role of perceived ease of use (PEOU) and perceived usefulness (PU) in the comprehension of user's acceptance of information systems (Min, So & Jeong, 2018 [39]; Taylor & Todd, 1995 [53]; Venkatesh & Davis, 2000) [55]. Increasingly, TAM has been used as an explanatory tool in investigating m learning amongst students. In a study conducted by Park, Nam and Cha (2012) [43] it was found that the TAM is an acceptable model to explain student's acceptance of m learning. TAM highlights the importance of two key dimensions, namely, Perceived Usefulness (PU) and Perceived Ease of Use (PE). In this vein, PU represents the extent to which individuals believe that technology will aid them in achieving their intended outcomes. On the other hand, PE denotes the extent to which an individual believes that adopting technology will ease and support their cognitive efforts (Park et al., 2012) [43].

Theory of Reasoned Action: According to Tsai, Chen and Chien (2012) [53] the theory of reasoned action is widely used to explain human behaviour. According to theory of reasoned action (Ajzen & Fishbein 1975) [3], intentions are the sole determinant of the behaviour (Sommer, 2011) [52]. According to the theory of reasoned action (Ajzen & Fishbein, 1975) [3] in order for an individual to fully engage in a certain behaviour, their behaviour is driven by their intentions.

Theory of Planned Behaviour: The theory of planned behaviour (TPB) is a theory intended to predict and explain human behaviour in specific settings (Ajzen, 1991) [2]. The theory of planned behaviour is an extension of the theory of reasoned action, which addresses the limitation of the theory of reasoned action in not accounting for behaviours in which individuals do not have complete voluntary control. Hence, the theory of planned behaviour has the additional component of perceived behaviour control has a determinant for behaviour intention (Ajzen, 1991) [2].

3 Research Objectives

The main objective of the literature was to investigate the determinants of the adoption of mobile applications as learning tools by students in higher education.

4 Research Conceptual Model

In the conceptual model adapted from the TAM (Davis, Bagozzi & Warshaw, 1989) [18], Theory of Planned Behaviour (Ajzen, 1991) [2] and the Theory of Reasoned Action (Ajzen & Fishbein, 1975) [3], perceived usefulness, perceived ease of use, attitudes on mobile applications, intentions to use mobile applications and the actual use of mobile applications will be presented. Based on the conceptual model, hypotheses are developed for the present study.

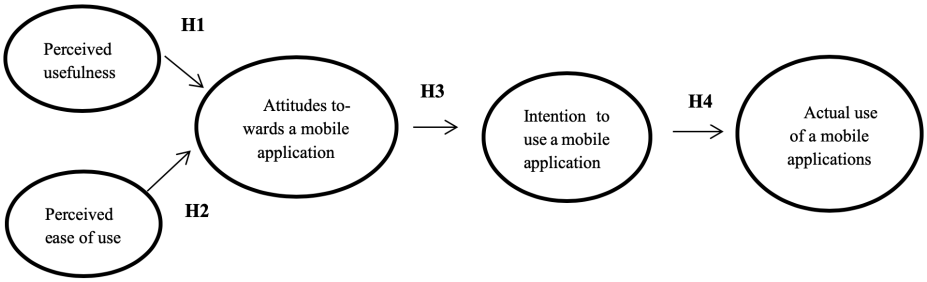

Fig. 1. The proposed conceptual model

4.1 Hypotheses development

Perceived usefulness and Attitudes towards a mobile application: According to literature, perceived usefulness is a construct used to measure user's satisfaction with information systems (Calisir & Calisir, 2004) [15]. In empirical research, perceived usefulness has been identified as an important predictor for the adoption technology systems such as mobile payments, mobile commerce and mobile learning (Brown *et al.,* 2006 [7]; Chao & Chen, 2009) [10]. Furthermore, it is believed that if a particular technology system is useful in one's daily life and activities it will automatically change their attitudes towards it. Perceived usefulness is an important determinant for an individual's acceptance and usage of information technology, the features of the technology, and the targeted users acceptance of the technology. Within the educational context, perceived usefulness is noted to positively influence users' attitudes towards mobile application tools as learning and educational tools (Chen *et al.,* 2012 [57]; Moon & Kim, 2001) [40]. Kim and Woo (2016) [27] suggest that ease of use positively influences attitudes towards technology. Therefore, inferring from the literature and the abovementioned empirical evidence, the study hypothesises that

H1: There is a positive relationship between perceived usefulness and attitudes towards mobile applications among higher education students.

Perceived ease of use and attitudes towards mobile applications: Perceived ease of use refers to the degree to which a particular user of a technology system views it as easy and with less effort to use (Chang, Kim and Oh, 2002; Koo, 2003; Chang, Yan and Tseng, 2012). Lee, Cheung and Chen (2005) [31] suggest that perceived ease of use can be seen as a moderate predictor of the intention to use technological devices as educational tools. However, Kim and Woo (2016) [27] argue that ease of use positively and strongly influences attitudes towards technology. Within the educational context, perceived ease of is noted as an important determinant for an individual to accept and adopt on information technology to aid in their learning (Moon et al, 2001) [40]. Therefore, inferring from the literature and the empirical evidence abovementioned, the study hypothesizes that:

H2: There is a positive relationship between perceived ease of use and attitudes toward mobile applications among higher education students.

Attitudes towards a mobile application and intention to use mobile applications: An attitude towards a behaviour relates to an individual's positive or negative

feelings towards performing the behaviour (Cheon et al., 2012) [12]. Attitudes towards using technology positively and directly influences the behavioural intention to use that technology (Kim & Woo, 2016) [27]. Attitudes towards using and accepting technology are included as a key construct in TAM (Chang *et al.,* 2012). Therefore, deducing from the literature and the abovementioned empirical evidence, the study hypothesizes that:

H3: There is a positive relationship between attitudes towards a mobile application and the intention to use that mobile application among higher education students.

Intentions to use a mobile application and actual use of the mobile application

Intention refers to an individual's motivation in his or her's conscious plan to exert effort to carry out behaviour (Eagly & Chaiken, 1993) [19]. According to Venkatesh and Davis (2000) [55] intentions to use a certain type of technology system have a direct influence on the actual use of that technology system. Research by several scholars (such as, Hong, Thong Moon & Tam, 2008 [22]; Moon & Kim, 2001 [40]; Hong, Thong & Tam, 2006) [23] on students and mobile applications has shown that students' behaviour towards adopting mobile learning tools is guided by reasoned conscious intentions towards the use of these mobile applications as learning tools. Drawing from TAM, Lee et al., (2013) [30] purport that a user's intention to adopt mobile applications is the most immediate predictor of the actual usage of the mobile applications. Therefore, inferring from the literature and the abovementioned empirical evidence, the study hypothesizes that:

H4: There is a positive relationship between the intention to use a mobile application and the actual use of that mobile application among higher education students.

5 Research Methodology

5.1 Research design

The study utilised the positivist paradigm, a philosophy that is of the view that knowledge stems from human experience (Collins, 2010) [16]. A quantitative research approach was adopted for this study whereby a 28-item survey questionnaire was self-administered to 380 research participants at a selected South African university. Convenience sampling was adopted to select the research participants (students), which involves selecting suitable participants who are willing to participate in the study (Collins, 2010) [16]. In the present study, due to the difficulty in obtaining suitable and willing research participants within the research setting, convenience sampling was deemed suitable as recommended by (Collins, 2010) [16]. Furthermore, drawing from the methodological precepts adopted by Cheon et al., (2012) [12], data analysis through Structural Equation Modeling (SEM) was deemed suitable for the sample obtained through the convenience sampling process in the study. The data for the research in question was normally distributed therefore qualifying it for a SEM analysis as indicated in table 4 with standard deviation values ranging from 0,896 to 1,045 falling within the recommended threshold of -2 and +2.

5.2 Measurement instrument

The research constructs in the research instrument were developed and adapted from previous studies investigating similar phenomenon. The research instrument consisted of two sections namely; Demographic section and 5 point Likert scale type questions based on the research conceptual model. The Likert scale was measured from 1 = Strongly disagree; 3= Neutral; 5= Strong agree. In terms of data analysis SPSS 23 and AMOS 23, software programs were used to perform SEM.

6 Results / Findings

Table 1. Sample Demographic Profile

Gender	Frequency	Percentage	Age	Frequency	Percentage
Female	166	43.7	18-19	232	61.1
Male	214	56.3	20-25	133	35
Total	380	100	26+	15	3.93
			Total	380	100
Marital Status	**Frequency**	**Percentage**	**Academic level**	**Frequency**	**Percentage**
Single	13	96.6	High School	317	83.4
Married	367	3.4	Diploma	6	1.6
Total	380	100	Degree	43	1.3
			Post-graduate	13	3.4
			Other	1	0.3
			Total	380	100

As indicated in table 1 above, female participants represented 43.7% of the total sample whereas male participants accounted for 56.3% of the total sample. In terms of the participants educational levels most of the participants had a high school qualification as indicated by 317 out of a total of 380 participants. Participants with a post-graduate qualification had the least representation as indicated by only 13 out of the total 380. The following section illustrates the inter-construct correction matrix of the study's constructs.

Table 2. Correlations between Constructs

Inter-construct Correlations Matrix					
	PU	***PEU***	***ATT***	***I***	***AU***
Perceive Usefulness (PU)	1				
Perceived Ease of Use (PEU)	0.521**	1			
Attitudes Toward Mobile Applications (ATT)	0.676**	.527**	1		
Intentions To Use Mobile Applications (I)	0.599**	.420**	.721**	1	
Actual Use of Mobile Applications (AU)	0.464**	0.389**	0.554**	.515**	1
**Correlation is significant at the 0.01 level (2-tailed).					

The inter-construct correlation matrix was used to test for discriminant validity of the research constructs. Correlations among latent constructs were evaluated in order

to observe if they were, lower than 1.0. As indicated in table 2 below, the inter-correlation values for all paired latent variables are below 1, therefore, implying that there is the presence of discriminant validity (Chinomona, Lin, Wang & Cheng, 2010) [13]. Below is table 3, which depicts the model, fit for the study's research data. It can be observed that all the model fit indices met the required thresholds.

Table 3. Model Fit

Model fit criteria	(χ2/DF)	GFI	CFI	IFI	NFI	RFI	TLI	RMSEA
Indicator value	1,713	0,926	0,970	0,970	0,932	0,918	0,964	0,043

(χ2/DF): Chi-square, GFI: Goodness of fit index, CFI: Confirmatory fit index, IFI: Incremental fit index, NFI: Normed fit index, RFI: Relative fit index, TLI: Tucker Lewis index, RMSEA: Root mean standard error approximation

6.1 Scale accuracy analysis

Results of scale reliability are presented in table 4 whereby Cronbach's alpha coefficients were above 0.8 while the composite reliability values ranged from 0.824 to 0.882. Furthermore, it was observed that most of the AVE values ranged from 0.644 to 0.750. The measurement model produced a ratio of chi-squared value over degree-of-freedom of 1.713, which is acceptable as it falls below the recommended 3 recommended (Ullman, 2001). Other model fit indices that included the GFI, CFI, IFI, NFI, RFI and TLI were 0.926, 0.970, 0.970, 0.932, 0.918 and 0.964 respectively. All these model fit measures were above the recommended threshold of 0.8 (Chinomona, Lin, Wang, & Cheng 2010) [13]. The RMSEA was 0.043, which fell below the recommended threshold of 0.08.

Table 4. Accuracy Analysis Statistics

Research Construct		Descriptive Statistics				Cronbach's Test		C.R. Value	AVE Value	Highest Shared Variance	Factor Loading
		Mean Value		Standard Deviation		Item-total	α value				
PU	PU1	1,961	2,238	1,02	0,978	0,717	0,888	0,882	0,697	0,457	0,743
	PU2	2,282		0,989		0,733					0,766
	PU3	2,324		1,006		0,682					0,743
	PU4	2,229		0,94		0,709					0,771
	PU5	2,382		0,98		0,681					0,702
	PU6	2,253		0,936		0,696					0,742
PEU	PEU1	2,011	2,078	0,942	0,896	0,743	0,859	0,861	0,734	0,278	0,817
	PEU2	2,018		0,909		0,708					0,789
	PEU3	2,174		0,832		0,713					0,779
	PEU4	2,111		0,903		0,659					0,732
ATT	ATT1	2,132	2,105	0,946	0,957	0,624	0,849	0,841	0,644	0,52	0,739
	ATT2	2,311		1		0,617					0,699
	ATT3	2,024		0,934		0,733					0,745
	ATT4	2,021		0,941		0,681					0,662
	ATT5	2,037		0,963		0,643					0,735
BI	BI1	2,071	2,159	0,918	0,908	0,726	0,869	0,87	0,75	0,52	0,807
	BI2	2,061		0,871		0,703					0,769
	BI3	2,35		0,896		0,77					0,839
	BI4	2,155		0,947		0,687					0,75
AU	AU1	2,521	2,505	1,056	1,045	0,65	0,849	0,824	0,669	0,307	0,7
	AU2	2,653		1,065		0,712					0,774
	AU3	2,463		1,02		0,737					0,785
	AU4	2,382		1,037		0,653					0,673

χ^2/df = 1.713, GFI= 0.926, CFI = 0.970 , NFI=0.932 , RMSEA= 0.043; [a] significance level significance level significance level p<0.001

* Scores: 1 – Strongly Agree; 3 – Neutral; 5 –Strongly Disagree.

6.2 Path modeling and hypotheses testing

Table 5 presents the results of the structural equation modeling followed by a discussion

Table 5. Results of sructural equation model analysis

Proposed Hypothesis Relationship	Hypothesis	Factor Loading	P Value	Outcome
Perceived usefulness (PU) Attitudes (ATT) ⟶	H1	0.64	***	Supported and significant
Perceived ease of use (PEU) Attitudes (ATT) ⟶	H2	0.23	***	Supported and significant
Attitudes on mobile applications (ATT) Intention to use (I) ⟶	H3	0.88	***	Supported and significant
Intention to use (I) Actual use (AU) ⟶	H4	0.68	***	Supported and significant

6.3 Discussion of hypotheses results

It can be observed in table 5 that all four hypotheses are supported.

- From the **first hypothesis** (H1) it can be noted that perceived usefulness positively and significantly affects attitudes as indicated by a factor loading of 0.64. This implies that the more participants perceive mobile applications as useful products the more positive their attitudes become towards them.
- In terms of the **second hypotheses** (H2) which is supported by the findings, it can be observed that the perceived ease of use of mobile applications for educational purposes leads to the development of positive attitudes towards those applications.
- It can be seen that for the **third hypothesis** (H3), attitudes on mobile applications positively and significantly second hypotheses influence the intention to use those applications for educational purposes as indicated by a factor loading of 0.88.
- Lastly for the **forth hypothesis** (H4) it can be noted that there is a positive relationship between the intention to use mobile applications and their actual use. This finding implies that the more the users' are motivated and intend to use mobile applications for educational purposes the more they will use and adopt the mobile applications.

7 Managerial and Academic Implications

The present study has both implications for academicians and managers in various ways. First, academicians would benefit significantly in understanding the acceptance and adoption of technology by students in their learning process. The study allows academics to gain insight of the interrelationships of the factors that influence the adoption of technology to facilitate learning by students. The study allows academics to ascertain the perceived usefulness of technology for learning by students within the South African context. The study can be used by Higher Education institutions within

the South African context to facilitate learning through the use of technology platforms. From a marketing perspective, organizations that design online educational appliances can understand the factors that influence the adoption of online learning resources with Higher education institutions. Moreover, the findings of the study can aid organizations that develop online educational appliances to ascertain if their products would be viable in the market and the potential challenges they would face in launching those products.

8 Conclusion

The present study sort to investigate the determinants of the adoption of mobile applications by students at a selected Higher education institution. For purposes of the study, the Technology Adoption Model (TAM) adopted and adapted by the researchers. From the findings of the study it was found that student's attitudes towards the use of a mobile application was positively influenced by their perceived usefulness and perceived ease of use of the mobile applications. Attitudes positively influenced the student's intention to use the mobile applications. This research revealed that the use of a leaning application was well received by students reflecting the findings of (Zidoun, Talea, & Dehbi, 2016) [58]. Additionally, Yunita, Nursechafia, Setiawan, Nugroho and Ramadhan (2018) established that mobile phone usage in classrooms was significantly beneficial to students, further supporting findings of the present study in question. Finally, student's actual adoption of mobile applications for learning purposes were directly influenced by their intention to use the mobile applications.

9 Suggestions for Future Research

Future research could be comparison in nature and include using students from more higher education institutions in South Africa to ascertain if there is a difference in the adoption of mobile applications by students from different Higher education institutions. Moreover, future research can involve the adoption of a qualitative research design in which participant's would be interviewed to gain a deep understanding of their technology adoption behaviour. A longitudinal study could be adopted to ascertain the changes in the adoption behaviour of students of technology. More research participants including academic staff members can be included in future research.

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An Application of Flipped Classroom in Mathematics Teacher Education Programme

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Abstract—A body of literature has suggested the benefits of flipped classrooms in mathematics learning at university. However, there is still a lack of evidence regarding the benefits in the context of mathematics teacher education programme. This study aimed to examine the effectiveness of a flipped classroom application in a mathematics teacher education programme at a private university in Indonesia. A total of thirty-one pre-service teachers participated in the study. Multiple data collection methods were employed including observation, written journals and tests. The data were then analysed both quantitatively and qualitatively. The findings showed that flipped classroom promotes independent learning, with the type of classroom encouraging students to work together with other peers and improved learning awareness. However, some challenges were highlighted in flipped classroom application such as technical issues, editing recording skills, and it was time consuming. Recommendations are offered in reference with the findings.

Keywords—Flipped classroom, mathematical modelling, teacher education, pre-service teacher

1 Introduction

Recently, flipped classroom has become increasingly popular in teaching and learning classrooms. In Journal of Interactive Mobile Technologies particularly, we have identified at least three studies examining the application of flipped classroom learning in educational classroom settings, such as Martínez and Garaizar [1] and Ng and Baharom [2]. A body of literature has been suggested that flipped classroom instruction offered benefits as well as an alternative method to the traditional learning environment, where learning started mainly from the classroom [3]. For example, White, McCollum, Bradley Roy, Yoon, Martindale, and Worden [2], state that the

flipped classroom-learning model provides students with opportunities to take control of their own learning process, constructing knowledge before the classroom activity. Such a control, according to White at al., may help the students to focus and sharpen their learning activities through high-order learning exercises [4]. In addition, flipped classroom learning promotes both students' individual and collaborative learning with their peers as teachers have prepared and organised all learning materials, including podcasts of the class sessions, as well as other cases or problems with set answers that students can access online apart from their classroom sessions.

In particular, the application of flipped classroom within the field of mathematics learning at school as well as university classrooms has also attracted attention from practitioners as well as researchers, among others, Muir and Greiger [3] and Wasserman, Quint, Norris and Carr [5]. Muir and Geiger conducted a study to examine the application of the flipped classroom in a grade 10 mathematics learning classroom. They revealed that the flipped classroom offered the flexibility to cater to the wide range of students' needs in learning mathematics, potentially optimising the available time to improve students' understanding of mathematical concepts. The flexibility assistance as offered by the application of flipped classroom included video resources, explanation of particular concepts, exercises, and other types of tutorial materials. This kind of assistance in turn enabled the students to take more responsibility for their own learning, thus improve their autonomy in mathematics learning.

Wasserman et al. [5] examined the use of flipped classroom in teaching Calculus III within the context of higher education and found that it increased students' communication skills during the class session and more importantly, such an application improved their mathematical performance. The central argument for the improvement relied upon students' active discussion with their peers during the classroom activities, through which students were encouraged to exchange and share their understanding with their peers regarding the material they had already learned. In other words, flipped classroom learning benefits the students in that it provides personalised learning experiences. Moreover, it may facilitate the students to not only improve their understanding but also motivate them to achieve their learning competences [6].

In the current study, we adopted a flipped classroom design to facilitate pre-service teachers' learning of mathematical modelling. Specifically, the application of flipped classroom aimed to facilitate two main activities:

- To provide opportunities for pre-service teachers to learn and practice mathematics modelling within a flipped environment via video lectures material
- To promote independent and collaborative learning among the pre-service teachers.

The use of flipped classroom teaching model in learning mathematics is relatively new. Nonetheless, reflection of the flipped classroom activity has a very important role in supporting the development and improvement of the quality of learning mathematical modelling [7], [8]. Reflective teaching provides meaningful opportunities to collect information about what is happening in the classroom [9], so that we can identify

successful activities. To understand the effectiveness of the flipped classroom, researchers used two main instruments, namely a teaching journal and students' responses. The teaching journal was examined with our collaborators during the entire class, while students' responses were gathered using a survey with questions regarding learning material, video lectures, and classroom activities scored on a Likert scale. This reflective teaching activity has the potential to influence and promote future success in improving class practice [10].

2 Theoretical Framework

2.1 Flipped classroom instruction in the mathematics classroom

Flipped classroom (henceforth, FC) instruction offers an alternative to traditional learning, where learning started from the class [1] [9] [10]. FC provides students an opportunity to be more proficient in the fundamental knowledge before class [13], [14], so that class activities can be concentrated to refine their understanding [2] [13] [14]. More importantly, as students obtained materials before the classroom session, they have more opportunity to study and discuss the materials with peers.

Beside benefiting the students, the FC mode provides teachers with an opportunity to incorporate the learning material and video lecture as learning assistance to support individual student's learning in their homes [12]. A body of literature has suggested that the model facilitated students' independent learning as they have more opportunities to manage their learning time. Many teachers also believe that the FC enables personalised learning that may positively impact on the students' cognitive development [6], [13], [17].

2.2 Video lecture

The application of video lectures in the FC has been widely recognised to support the student learning experience [6], [17], [18], providing students with the opportunity, not only to learn independently, but also revisit lectures out of the class [15]. For example, if students do not understand the core content of material, then they can play a video to clarify the missed concept. Furthermore, students who understand the core-material can also play the video to boost their competence. Indeed, the video lecture offers more opportunities for students to watch and review the lecture in a more convenient way of learning [19], [20].

In the current study, we recorded teachers' instructions during the FC to serve three main purposes:

- To support the students centred learning experiences in the FC
- To allow students to comprehend the core content of the subjects by reviewing them at home
- To provide the podcast explanation about the necessary exercises. Figure 1 details the steps of the video lecture development process:

Fig. 1. Video lecture development process

In setting learning goals, the team determined the minimum competences that students were required to be achieve, then selected the learning material to be given to students. The learning material was assessed throughout the process by preparing entire aspects, such as teaching delivery, and media required, for excellent video lecture. After the preparation, a script was developed for the video lecture to guide the recording process, minimising potential errors during the recording. Two scripts were developed: an explanation lecture and student exercise video instruction. The explanation video lecture was concerned with the main-content of the subject, while the student exercises aimed to assist students to understand the necessary problems. The duration of the video explanations was approximately 45 minutes, with an average duration of 15 minutes per mathematics problem for the exercises video.

2.3 Instructional delivery methods

Instructional delivery method in this paper adapted the procedure of Solihat and Mulyono [21]. Flipped classroom provides an opportunity for teachers to implement and combine two learning models: learning in video lecture and face to face learning models. Face to face, sessions (F2F) aimed to:

- Allow teachers to explain material that cannot be understood
- Facilitate learning in groups of students
- Class discussion: F2F lasted 120 minutes and were conducted once a week.

In total, thirteen topics were discussed during thirteen F2F sessions, in which students were assigned into small groups of five to enable collaborative learning. Many studies have suggested that collaborative learning with peers helps students to be more active, enable them to exchange their understanding related to materials, as each student has a different level of understanding [22]. During the students' collaborative work, teachers acted as facilitators to control the group activities and to help clarify particular complex problems [20]. The entire F2F instructional class procedure followed the lesson plan as follows:

Objective:

- To help pre-service teachers understand concepts, and the basics of mathematical modelling.
- To enable pre-service teachers to complete modelling and mathematics materials.
- To help pre-service teachers develop and design mathematical problems related to modelling.

Textbook: Varberg, D., Purcell, E. J., & Steven, S. E. 2007. Calculus, 9th. New York: Pearson/Prentice Hall.

Time: Thirteen sessions, 120 minutes per procedure:

- Pre-presentation stage (25 minutes). Students discuss in groups FC that have been studied before the lecture, including preparing the results of group discussions related to materials, laptops, markers, presentation files and preparing the projector.
- Presentation stage (20 minutes). Students present the results of their discussions related to topics that have been studied before the lecture. The presentations were carried out in groups, which were randomly assigned by the teacher.
- Discussion phase (10 minutes). Students participate in question and answer sessions related to the presentation.
- Teacher feedback (25 minutes). The teacher provides feedback and clarification related to the presentation material and discussion.
- Exercise tasks (40 minutes). The teacher provides exercises related to the material to the whole group. Students are asked to discuss, perform the exercises given, and present the results of their work in front of the class.
- Teacher feedback (15 minutes). The teacher provides feedback on the presentation of the exercises that have been done and presented by the students.

In addition to F2F, virtual activities in FC were also conducted to facilitate student learning outside the classroom. According to Harrington [5], the percentage of virtual activities in F2F-C class sessions ranged between 20% and 80%. In the context of this study, the goal was to use virtual classrooms to replace F2F sessions in the delivery of lecture material. Specifically, the virtual class aims to

- Provide students with independent learning through FC prepared by the teacher
- Help students to improve their understanding of modelling mathematics
- Provide learning assistance by providing explanations related to solving problems that are integrated with the reference book.

In practising the flipped classroom, video lectures were prepared to help teachers explain and re-explain materials from the textbook. Roux and Nagel (2018) stated that students were usually too lazy to read the book; videos provided the main material explanation so that students can learn the material before the class [4], with both subject material and exercise explanations generated in video lecture format. The subject material explanation was provided step by step, explaining the subject from the beginning until the end to support students to learn individually in their home [17], [19].

3 Methodology

3.1 Reflective teaching

Reflective teaching is considered an alternative to help promote teacher's professional development [24]–[26]. It provides teachers with a wonderful

opportunity to see the fundamental principles and beliefs which highly affect their practice in the classroom. Reflection activity can be an effective tool [27], not only to describe the teacher profile, but also to improve the students' learning environment. The main purpose of reflective teaching is to investigate teacher practice more deeply in an attempt to understand comprehensively how to increase student learning [9]. Investigating teaching practice in the classroom, provides information regarding activities that need to be improved, as well as those aspects that can be kept, which can help to achieve more effective classroom practice in the future.

In conducting our reflective teaching practice, we employed several instruments such as self-observation, student journals and questionnaires. Similar instruments were apparent in previous reflective practice studies [28]–[30]. Self-observation can help to examine teaching practice through simple actions like taking notes when teachers are aware of a mistake. The reflection also needs to be supported by the results of student questionnaires [31], as a response to past experience and involves conscious withdrawal and experience examination as a basis for evaluation and decision making, as well as a source for planning and action [10]. Students' responses can be the greatest source for teaching evaluation to help improve teaching practice quality. It was anticipated that these various instruments of reflective teaching would support and motivate us to provide more effective teaching in future classroom practice.

3.2 The participants

Thirty-one pre-service teachers enrolled in modelling mathematics courses were involved in our flipped classroom practice, of which there were eight males and twenty-four females. Our observation before this study showed that they could operate basic computer applications, including the ability to operate videos on a computer, open files stored in a flash disc, make presentations with power point and operate multimedia applications. Also, they could operate internet search engines, correspond by email, upload and download applications and files from websites and do offline and online printing. In addition to these computer skills, they could make connections between smartphones and computers (also laptops), particularly transferring data from smartphones to computers or laptops.

3.3 Data collection methods and the analysis

Three data collection methods were employed to help reflect on the experience of teaching the flipped classroom, namely self-observation, student journals, and student questionnaires. According to Solihati and Mulyono [21], self-observation allows teachers to examine and observe their teaching practice so that they can continue to improve their learning activities. To implement self-observation, the teachers collected the information gathered from class discussions and student feedback during their learning out of the class in addition to student journals. Students were also asked to get involve in the survey related to teaching with flipped classroom.

As suggested by Solihati and Mulyono [21], the data collected from self-observation and student journals were analysed using content analysis adopting Rayford's (2010) procedure. First, the observations and student journals were colour coded according to emerging themes, which were then collated to establish the pattern and to calculate the frequency. Finally, the frequency and code pattern led to the reflections and outline discussion sessions. The results of the student questionnaires were statistically analysed, calculating the mean (M) and standard deviation (SD).

4 Findings and Discussion

This section will present the findings obtained from critical reflection on FC teaching in mathematical modelling for pre-service teacher. The following themes is appeared from the reflection.

4.1 Advantages of flipped classroom

Flipped classroom helped students to comprehend the mathematic modelling lesson: The FC practice used video lectures purposely designed to support students' understanding of mathematical modelling. Student usually spent more than an hour to learn new material, however learning through video lecture allowed students to manage their own time. Some students watched the entire video explanation without stopping, while others stopped and started the video when they understood the explanation. In addition, some students repeated the video explanation according to their understanding. Data have shown us that students can easily hone their understanding through exercising problems, when students face difficulties, they can refer to the video explanation and exercises [5]. Before starting the face to face session, most students were familiar with the material that they were going to learn. The FC model not only allowed students to learn earlier in their home, but also facilitated students to improve their understanding about the subject.

This information indicated that the flipped classroom not only facilitated students to attain mathematical knowledge independently but also allowed students to improve their competence gradually through learning out of the class. The flipped classroom was also useful for teachers and students, as teachers could prepare and explain the video lecture in their home, while students can easily learn the material in their home. Although face to face contact can be diminished [32], some mathematical problems need direct communication between teachers and students. Nonetheless, this learning model has proven that the flipped classroom can support students' mathematical competence as well as students' learning outcomes.

The flipped classroom increased students' learning awareness: The flipped classroom encouraged students to have learning awareness, mainly because the student needed to determine when they started to learn the material or when they stopped learning. Although learning before class is challenging for students [26], some students reported that this learning model had gradually improved their learning motivation, although they were required to put in more effort before the class. In FC practice,

students were encouraged to use the pause button when watching the video explanation and if they encountered any difficulties, they should take notes and record any problems corresponding to content lectures [23]. Bergmann and Sams (2012) stated that students who implement note taking typically come to class with some reasonable problems that teachers can assist them to overcome. Consequently, the FC model gave students an opportunity to realise their weaknesses, so that in the class meetings, they could ask questions. During interviews, students reported that "this learning model enforced me to set the particular time when to start learning", even though Xiu et al. (2018) stated that some students may resist adopting the FC model because it requires more effort on the students' part.

Flipped classroom supports a collaborative learning environment: The FC encouraged students to learn in a collaborative learning environment, with some students initiating small group discussions. The groups were designed to facilitate peer teaching activities among students. Indeed, most students watched the videos in small groups of three or four students, not alone but they encouraged their peers to learn together in a particular place. By learning together, they shared their understanding, as once a student understood the concept, they could help their friends to achieve the learning objective. This indicated that the FC supported students to learn collaboratively with their peers, so that when they encountered any difficulties, they posed questions to their peers without hesitation. This suggested that collaborative learning strengthened student communication skills, continuously helping students to grow into a productive group discussion. Although not all problems can be solved in a group discussion, students can record all difficulties and ask questions in class meetings [6]. Tague and Czocher (2016) reported that flipped classroom promoted students to work together, in class and out-of-class instruction, thereby continuously having a positive impact on students' learning [34]–[36].

4.2 The challenges in applying flipped classroom

There are several challenging aspects in the implementation of flipped classroom such as technical issues and it is time consuming as follows:

Technical Issues

Recording skills for flipped classroom: Recording skills are an issue when making video lecture. Although an appropriate camera was provided for recording the video explanations, making a good video requires recording skills. For example, during recording, the teacher did not remain in the same place, sometimes they needed to move to write on the whiteboard or she/he demonstrate a particular concept, but as the camera only recorded in one angle, it had to move according to the teacher's position, which disturbed the video explanation so that the video lecture did not produce good video images.

Video editing skills for the flipped classroom: Once the learning video is available, it is necessary to have the editing process skills and the video transfer process so that it is worth sharing. In this first case, we found it difficult to video edit and were required to familiarise ourselves with the video editing software. We required help to edit the videos so that each video took more than three hours to edit, which was time consuming

and impacted on the FC preparation. On reflection, video editing was a vital process for FC preparation, so additional help was required so that we could focus on the teaching process.

Flipped classroom was time consuming during the preparation process: FC learning requires a lot of preparation, such as:

- The material to be delivered,
- Recording readiness for FC assistance,
- Exercises used to evaluate students' understanding, and
- Preparing assessment instruments during face-to-face meetings.

To prevent long recording times, teachers should prepare the recording readiness for FC assistance to help make effective video lectures. Teachers should also prepare the instruments to evaluate students' understanding as FC practice eliminates some face-to-face meetings. The instruments should ensure that students comprehend the given material, analyzing both students' strengthens and weaknesses regarding the material. The instruments to evaluate face-to-face meetings should facilitate students' activities both in and out of the classroom, evaluating students' learning activities to help identify any problems encountered by students. Students can reveal their problems privately or in front of the class. The complete preparation is required before the class begins, requiring commitment from the entire team for the success of FC activities.

4.3 The impact of flipped classroom on students

Student responses: Table 1 provides a summary of the student questionnaires. In general, the students agreed that the learning course content was easy to understand (M = 4.56, SD = 0.70), that the course intellectually stimulating their interest in this subject (M = 4.41, SD = 0.96) and the flipped classroom stimulated their interest in this subject (M = 4.03, SD = 1.03).

Most students were very satisfied with the quality of the flipped classroom (M = 4.15, SD = 0.89). Furthermore, the questionnaire results showed that most students greatly appreciated this flipped classroom activity (M = 1.66, SD = 0.69) and they intend to use the system for learning in familiar authentic environments in the future (M = 4.21, SD = 1.04). For example, when students encountered some difficulties, they recorded the problem on paper.

At the end of every session, the learning activity was evaluated in three different aspects: learning material, video lecture, and classroom activity. First, regarding learning materials, 40% of student reported that they were very good, 25% good, 20% excellent, and 15% of students thought they needed improvement. Secondly, most students considered the video lecture as very good and excellent for supporting flipped classroom, although the video quality needed to improve. Lastly, most students thought that the classroom activities were good.

In formatting this reflection, we also asked some group representatives to comment on our teaching performance. One student commented "I am very happy in this learning model because I can learn the material prior to meeting in the class", suggesting that

the FC model motivated him to learn at home and that it has continuously had a positive impact on students' learning [34]–[36].

Table 1. Students responses regarding learning experiences using flipped classroom

#	Item	Mean	SD
Students response in Learning Material			
1	I benefited a great deal from the course content and understood the subject material of this course	4.56	0.70
2	I have found the course intellectually challenging and stimulating	4.41	0.96
3	My interest in the subject has increased as a consequence of this flipped classroom	4.03	1.03
4	I believe I have achieved the learning outcomes of the course	4.18	1.00
5	The assignments helped me attain the learning outcomes of the course	4.06	0.89
6	The course video lecture helped me attain the learning outcomes	4.41	0.99
7	Using the system improves my learning performance	4.26	0.83
Overage of video lecture in flipped classroom			
8	Using the flipped classroom improves the quality of my learning	4.15	0.89
9	Using the system helps me to accomplish learning tasks more quickly	4.62	0.70
10	Using the flipped classroom increases my productivity	4.24	0.99
11	Using the flipped classroom enhances my effectiveness on the learning	4.00	1.04
12	Using the flipped classroom improves my learning performance	4.26	0.90
13	Using the flipped classroom improves my modelling performances	4.03	0.97
Overage of perceived classroom activity			
14	I think using the system for learning is more interesting than using a textbook	4.00	0.89
15	I like to practice my skills with the system in real-life situations	4.32	0.91
16	I feel more free and relaxed during my learning with the flipped classroom activity	4.12	1.07
17	I think I learned more by using the flipped classroom than by using a traditional learning model	4.03	0.90
18	Using the flipped classroom activity can increase my learning motivation	4.09	0.93
19	If I had to give a grade to my learning experience with the system, I would give it high score	4.41	0.82
20	I feel happy to use this flipped classroom learning modelling in the future	4.21	1.04

Note: Mathematical Modelling.

5 Conclusion and Implications

The main purpose of this research was to understand the effectiveness of the flipped classroom via teaching reflection. The reflection on the implementation of the flipped classroom indicated that the major problems were technical problems that required expert assistance in the successful implementation of the flipped classroom. The flipped classroom was a very different experience for students as they had to study first at home. Nonetheless, it encouraged collaborative learning and the creation of a peer teaching environment. Self-study before learning in class is challenging and requires effort on the part of the students. Diligent students were highly motivated and students experiencing difficulties requiring peer assistance in understanding encouraged the creation of peer teaching among students.

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Critical Success Factors to Improve the Adoption of Social Media in Teaching and Learning: A Case Study at a Traditional University

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Abstract—Mobile devices and social media tools are two emerging technologies that have positively influenced teaching and learning practices at traditional universities. Regardless of the popularity of social media, few lecturers make use of these tools for educational purposes. The objective of this paper was to identify critical success factors to improve the adoption of social media among lecturers at a traditional university in South Africa. The unified theory of acceptance and use of technology (UTAUT) was chosen as the theoretical foundation for this study. A quantitative, survey data collection method was used to collect data. A questionnaire was distributed to all academics at the university, with a response rate of 39 %. From these, descriptive statistics were used to analyse data and the Pearson chi-square test was used to establish the association amongst different variables. The following CSFs were identified to enhance emerging technologies at traditional universities: management support; provide adequate ICT infrastructure and resources; provide sufficient training for lecturers, and introduce a champion to promote social media. The study, therefore, recommends that these four critical success factors must be considered by universities to adopt social media in teaching and learning.

Keywords—Barriers to social media adoption; teaching and learning; higher education.

1 Introduction

Mobile devices and social networking sites are two emerging technologies that can positively influence teaching and learning practices at traditional universities. Initially, social media was employed by both lecturers and students for personal use only; however, the technology has now advanced to include other domains as well [1]. Universities are using social media platforms to maintain alumni relations, increase institutional reputation and pride, as well as to increase student – lecturer interaction. However, the slow pace of social media adoption at universities may be attributed to

the barriers that avert the incorporation of emerging technologies in the academic environment [2-3]. Stephanie and Vladlena [4] state that lecturers need to know the barriers that prevent social media adoption in higher education to be in a better position to find effective strategies to overcome these barriers.

The objective of this paper is to provide critical success factors (CSF) to increase social media adoption and continued use among lecturers for teaching and learning activities at universities. For this reason, the study of barriers to social media adoption is important to enhance social media adoption and continued use at universities. The paper is outlined as follows: The first section discusses the literature followed by the methodology used in this study. The following section introduces the UTAUT which is followed by a discussion of the results and after that the contribution of the study and conclusion.

2 Benefits of Social Media in Teaching and Learning

Social media, for instance, Facebook, Twitter and wikis, along with open social practices, for example, blogging, are useful in teaching and learning environments in diverse ways [3]. These tools provide convenient communication, collaboration and sharing of information with peers in the classroom, subject experts and peers outside the class [2, 5]. Additionally, the use of numerous social media tools is attractive at universities to improve student – lecturer interaction. Social media enables discussion and information diffusion amongst students and lecturers, thereby building a common understanding of the course material [6]. The following section discusses barriers to social media adoption in academia.

3 Barriers to Social Media Adoption in Teaching and Learning

Several barriers prevent lecturers from adopting social media in the classroom. The seven barriers that were identified by the researcher in literature will be discussed below.

3.1 Inadequate ICT resource and data costs

Almeshal [3] reveals that some lecturers find it challenging to utilise social media in teaching activities because there is a shortage of ICT infrastructure at universities, e.g. not all classrooms have computers. This result is supported by Schlenkrich and Sewry [7] who found that most students enrolled at universities access social networking sites in the university computer laboratories and libraries. Some students do make use of their mobile phones, but prohibitive data cost is always a concern. South Africa is one of the most expensive countries on the African continent when the cost of data is compared [3, 6]. Therefore, mobile data is a luxury for many students in the country, and it is not reasonable or sustainable to expect students to pay for their data.

3.2 Availability of social media at universities

Social media and other recreational sites are often blocked in computer laboratories at universities as a precaution to improve network speed and the productivity of students [2, 8]. This constraint does not allow lecturers to experiment with different types of teaching and learning tools in class as students must have continuous access to social media if they intend to use it in the classroom.

3.3 Computer and technology literacy skills

Literature indicates that the technology literacy of both lecturers and students are important to adopt social media in the academic setting [9-10]. Technology literacy refers to an individual capacity to "design, develop and control use and assess technological systems and processes" [11, p. 7]. Gualtieri et al. [5], Stephanie, and Vladlena [4] found that the most important barrier to social media adoption and continued use is the lecturer's computer and technology literacy skills.

Oye, Iahad and Rahim [9] describe computer literacy skills as the "ability to use computers and related technology efficiently, with a range of skills covering levels of applying ICT effectively as a tool to research, organise, evaluate and communicate information" (p. 98). Researchers postulate that the expertise to adopt social media in the academic environment at universities is enhanced by effective technology training which must be hands-on, systematic and continuous [5]. Thus, computer literacy skills are a requirement for the implementation of social media tools in the academic environment.

3.4 Background of the learners

Murire and Cilliers [2] state that some students are not exposed to emerging technologies because they had previously resided in rural areas with no access to technological devices or the Internet. For this reason, students may not be familiar with specific social media applications that could be used for academic courses. Lecturers must provide training, support and encouragement to the students to make use of the technology.

3.5 Attitude and beliefs towards social media use at universities

The adoption of social media in academic settings is primarily determined by lecturers' attitudes and beliefs [3]. Thus, lecturers influence the choice of and determine how social media could be used in the classroom. Bexheti et al. [1] found that a lecturer's attitude is a major enabling or disabling factor in the adoption of social media in teaching and learning. Lecturers who have positive attitudes towards social media are comfortable incorporating it into their teaching and learning.

Successful transformation of social media in academic environment environments needs lecturers to develop a positive attitude towards emerging technologies [3]. The development of lecturers' positive attitudes toward ICT is a key factor for enhancing

social media integration as well as reducing educators' resistance to emerging technologies used in teaching and learning.

3.6 Lack of management support

One of the institutional barriers is a lack of managerial support for social media integration in the academic setting. Managerial support may be the most critical factor as it provides the needed financial resources, develops a vision and plan for social media integration, and provides incentives and encouragement [5]. Furthermore, university management needs to prioritise, create awareness and set an expectation that emerging technologies, such as social media, must be used in the academic environment. Management must prioritise social media integration cost to support the training of lecturers on how to integrate social media into their teaching pedagogy. If university management places a strong emphasis on social media adoption, the result will be increased student – lecturer interaction, student centred learning, and improvement in throughput rates [3, 12]. Additionally, when universities do not take time to develop a policy on social media in the classroom, lecturers and students will be confused regarding when it is appropriate to use these emerging technologies [13].

3.7 Online security and privacy

Some students perceive social networking sites as their personal space and do not want their studies to intrude in this space. The students' often cite privacy concerns as a reason why they do not want to participate in social media activities in the classroom. While there are security measures available online to protect the individual's privacy, there is no guarantee that students are aware of these measures or will make use of them [14]. Consequences that could result from the use of social media in the academic setting include identity theft, online and physical stalking, cyberbullying, as well as defamation [6, 14]. Regardless of these concerns, lecturers believe that social media sites are valuable in the teaching and learning environments. The next section discusses the theory employed in the study.

Unified Theory of Acceptance and Use of Technology: The unified theory of acceptance and use of technology (UTAUT) was chosen as the theoretical background for this study. UTAUT was developed initially by Venkatesh, Morris, Davids, and Davis in 2003 and is one of the most cited theories in information systems [15, 6].

UTAUT is based on four primary constructs:

- Performance expectancy is the degree to which lecturers will perceive that using the social media will help them improve work performance in the academic environment.
- Effort expectancy the degree of effort that lecturers perceive they need to adopt and use social media in the academic environment.

- Social influence is described as the degree to which lecturers perceive that important external parties, such as peers or management, believe they should use social media in the classroom.
- Facilitating conditions refers to the degree to which organisational and technical infrastructure at universities exist to support the use of social media in the classroom. Additionally, these constructs are moderated by four facilitating conditions: experience, age, gender, and voluntariness of use. The following section discusses results from the study [16].

4 Research Methodology

The study applied a mixed method approach to data collection. Both qualitative and quantitative data gathering methods were used to complement each method. Inductive reasoning was applied to the study. A quantitative survey tool was used to collect the data from lecturers at one university in the Eastern Cape. The questionnaire was adapted from the original questionnaire that Venkatesh et al. [16] published to test for the acceptance and continued use of new technologies. The questions were adapted to reflect the social media context of the study.

The study population comprised of 200 full-time staff in all the faculties of the university. A convenience sampling method was used to identify and distribute the questionnaire online to all lecturers. Before this, the questionnaire was piloted to 10 lecturers, who were not included in the primary study, for suitability, user-friendliness and unambiguousness. Ethical approval was obtained from the University Research Ethics Committee.

The Statistical Package for the Social Science (SPSS 24) was used to analyse the primary data. Descriptive and inferential statistics, including the Pearson chi-square test, was applied to analyse the data collected using questionnaire from the research participants.

After the critical success factors were formulated, an open-ended questionnaire was sent to five experts in the field of technology integration in the academic environment in higher education to elicit their opinions about the factors. The feedback received was used to refine the critical success factors. The following section discusses results of the study.

5 Results and Discussion

5.1 Demographics

The response rate of the study was 39%. The study participants consisted of 54.2% female and 45.8% male lecturers. Lecturers were requested to rate their knowledge of teaching and learning. The majority of the lecturers indicated that they are moderate to very knowledgeable (79.5%), while 20.5% stated that they are incredibly

knowledgeable about teaching and learning. No lecturers felt that they were not knowledgeable at all about teaching and learning.

5.2 Age of lecturers

The age groups were divided into four categories: under 30 years of age, between 30 - 40, 41-50, and over 50 years of age. The distribution shows that the 41-50 years age population consisted of the majority of the lecturers (39.8%), followed by the 30 - 40 year age group with 34.9%. The lecturers that were younger than 30 years of age and older than 50 years of age each were less than 15.0% of all the lecturers combined. The findings of the study are not congruent to statistics of age ratio of the academic population in South Africa. Bezuidenhout and Cilliers [17] state that more than 50% of the academic staff at South African higher education institutions is above 50 years of age and approaching their retirement time. Therefore, this means that younger lecturers responded as they are more receptive to using new technologies in the academic environment. The age groups of lecturers are presented in Table 1.

Table 1. Lecturers' age groups

Age Group	Frequency (N=83)	Percentage (%)
< 30	9	10.8
30 – 40 years	29	34.9
41– 50	33	39.8
> 50	12	14.5
Total	**83**	**100.0**

More than half of the lecturers were older than 41 years of age. In general, the older generations find it more challenging to adopt new technology which will affect the use of social media in the academic setting [18]. Venkatesh et al. [16] confirm that age influences the integration of emerging technologies. It is believed that younger adults are more computer literate because they are familiar with technology in their everyday lives [14].

Lecturers were asked how frequently they used social media in the academic environment. The majority of the lecturers (33.7%) reported that they use social media occasionally, while 22.9 % indicated that they have never used social media tools in academia. Only 15 lecturers, or 18.1 %, reported that they use social media tools on a daily basis.

Table 2. Frequency of social media tools in teaching and learning

Use of social media	Frequency (N=83)	Percentage (%)
Daily	15	18.1
Once a week	6	7.2
Once a month	15	18.1
Occasionally (when I cannot avoid it)	28	33.7
Never	19	22.9
Total	83	100.0

The results indicated that most lecturers are not utilising social media in teaching and learning for academic purposes although they know social networking sites. This could be a personal preference of the lecturer or because of the nature of the specific courses where social media is not considered to be useful. Different teaching styles in the various faculties may not be compatible with social media, e.g. Mathematics or Accounting that is practical.

5.3 Performance expectancy

In this study, 92.7% of the lecturers were positive that social media supports teaching and learning as well, as improves their productivity in the classroom. Performance expectancy also tested significantly for both the age and gender. The questions that proved significant were:

- "I feel that social media will support teaching and learning" was statistically significant ($\alpha = 25.818$; $p<0.05$)
- "Using social media for teaching and learning enables me to be more productive" was statistically significant ($\alpha = 29.973$; $p<0.05$)
- "Using social media for teaching and learning enables me to be more productive" was statistically significant ($\alpha = 25.355$; $p<0.05$)

Performance expectancy on intention to use social media was moderated by gender and age such that it is more significant for female and older employees, but these influences decrease as the older female participants gain more experience with the technology. Furthermore, the majority of the study population consisted of lecturers who are older than 41 years of age. As pointed out previously, the older generation finds it challenging to adopt the technology, and this influences the use of social media in the academic setting [16].

Furthermore, these findings are similar to the results obtained from a study conducted by Mbodila, Ndebele, and Muhandji [19] at the University of Venda. The researchers reported that performance expectancy is the most influential factor of social media use in the academic setting, as social media will assist the lecturer to improve their job performance. This could allow an increase in the lecturer's integration of emerging tools in the academic environment in teaching and learning since general information technologies are included. The findings from the study are comparable to the results in research [1, 9] where effort expectancy was found to be among the factors influencing lecturers to incorporate emerging technologies in academia.

5.4 Effort expectancy

The majority of the lecturers (71.1 %) indicated that social media is easy to use for teaching and learning purposes. The results indicated that all the lecturers are knowledgeable about teaching and learning. Additionally, the lecturers (60.3%) were positive that their interaction with social media in academia is clear and understandable. Interestingly, 39.7% of the lecturers felt that it would be difficult to learn how to make

use of social networking sites in the classroom. However, once the initial learning curve is overcome, most lecturers agree that social media is easy to use for teaching and learning activities. No question tested statistically significant in this category.

Effort expectancy was found to be among the factors influencing lecturers to adopt social media in the academic setting. The results indicated that some of the lecturers are adopting social media because it is comfortable to use and familiar to them [20]. This is one of the reasons for using emerging technologies like Facebook, Twitter and Whatsapp as lecturers are familiar with the application.

5.5 Social influence

More than half of the lecturers (54.2%) felt that they are influenced by others (colleagues) to employ social media. In contrast, just more than half of the lecturers (54.3%) indicated that the senior management did not support the use of emerging technologies in the academic environment. Social expectancy tested significantly for both the age of lecturers and their reported knowledge about using social media. The three questions that tested significantly were:

- "People who influence my behaviour think I should use social media for teaching and learning activities" was statistically significant for social influence ($\alpha = 26.582$; $p<0.05$)
- "People who influence my behaviour think I should use social media for teaching and learning activities was statistically significant for social influence ($\alpha = 12.754$; $p<0.05$)"
- "In general the Department of Higher Education supports the use of social media in teaching and learning" was statistically significant ($\alpha = 19.\ 435$; $p<0.05$)

The findings show that the Department of Higher Education needs to support the use of emerging technologies in the academic setting. The results indicated that more than half of the lecturers (54.2%) felt that they are influenced by others (colleagues) to use social media. For that reason, it was concluded that the lecturers below the age of 30 years could affect senior lecturers and professors to integrate social media in the academic setting. However, the majority of the lecturers (54.3%) indicated that the senior management did not support the use of emerging technologies in the academic environment. Moreover, these findings are similar with the outcomes from a previous study done by Oye et al. [9] where social influence was indicated as one of the predictors of lecturers to integrate ICT in institutions.

5.6 Facilitating condition

The majority of lecturers (71.1%) were positive that they have the resources necessary to use social media in academia. However, 49.4% of the lecturers were not convinced that social media is compatible with their other lecturing responsibilities, which could be attributed to the lack of training the lecturers reported. The faculty was measured against facilitating condition and the question "Using social media for

teaching and learning is not compatible with other lecturing responsibilities that I have" was statistically significant ($\alpha = 21.683$; $p<0.05$).

The findings from the study indicate that the facilitation condition influences social media use in the academic setting. Lecturers recognise that institutional and technical infrastructure exists to encourage the use of emerging technologies in the academic setting. Some faculties do not use social media as it is not compatible with the structure of their module. In faculties like Law and departments like Accounting, teaching and learning activities require a "hands-on" approach in the classroom where social media will not be useful. However, the technology can still be used outside the classroom to collaborate and increase communication among students and lecturers.

These findings are congruent with the results from a study done by Mbodila et al. [19] that found that facilitating condition was the most influential predictor of lecturers' use of Facebook in the academic environment. The majority of lecturers (73.5%) were positive that they would adopt emerging technologies in their academic activities shortly. Similarly, 71.1% of the lecturers expect to use social media in teaching and learning in the next 12 months. Furthermore, a majority of the lecturers (75.9%) plan to employ emerging technologies in academia in the next 12 months. This is because they found that social media is a useful tool, and most of the lecturers are knowledgeable about social media. The next section will discuss critical success factors.

6 Critical Success Factors

The study aimed to find Critical Success Factors (CSF) that are necessary to ensure the adoption and continued use of social media in teaching and learning at universities. Olszak and Ziemba [21] describe CSFs as aspects of a strategy that ought to be achieved to yield a favourable outcome of the study. The CSFs identified from the relevant literature were refined by the experts in teaching and learning. An openended questionnaire was sent to five experts who provided an extensive critical review of how the proposed CSFs could change the adoption of social media in teaching and learning. Their feedback was used to refine the final CFSs. These CSFs will be discussed in the next section.

6.1 CSF 01 - Management support

As identified in the discussion section, there is little support from management to use social media in the classroom The adoption which is taking place at the particular university is dependent on individual lecturer's willingness to use the technology. However, the majority (75.9%) of the lecturers plan to employ social media in academia in the next 12 months. Lubega et al. [22] indicate there is a need for management to provide adequate support to lecturers that are planning to integrate social media into the academic setting. The management requires a social media policy in place to govern the use of emerging technologies in the academic setting by lecturers in the teaching and learning environment.

Apart from social media policy, the university management should ensure that appropriate privacy and security measures are in place to protect personal information. Literature has indicated that there are concerns about security and privacy of students' profiles. While most universities do have a policy in place to protect students' privacy when using the university network, there is a need for a specific social media policy to protect students' profiles [10]. This is supported by Schlenkrich and Sewry [7] who state that the policies and standards must be in place to manage security risks associated with social media tools.

The university management should ensure that there is a group responsible for auditing, such as the ICT Governance Committee, in place to evaluate if lecturers are using emerging tools in the academic setting. Additionally, the auditing group must put in place measures to penalise lecturers failing to integrate and incentives for those that are incorporating ICT in pedagogy [22].

Also, university management should consider the use of social media through faculty appraisal. Universities do not have incentives to reward lecturers that have innovatively integrated social media in their teaching as role models to others. Nonmonetary incentives, such as ICT devices, certificates of recognition and employee of the year awards, should be used to recognise lecturers that are employing social media in teaching and learning at universities [23].

6.2 CSF 02 - Provide adequate resources for social media use

The majority (68.7%) of the lecturers indicated that they do not have sufficient resources necessary to make use of social media in teaching and learning. Shortage of infrastructure and technical assistance has a negative impact on the adoption and continued use of social media in teaching and learning. The university management must have a comprehensive budget for ICT infrastructure that supports sustained interest in the use of the social media in the teaching and learning environment at universities.

The integration of emerging tools in the academic setting requires policymakers to make informed choices when introducing social media learning at universities. The management may choose to incorporate low-cost technologies into development efforts, as they are readily available. Sustainability and maintenance of the physical infrastructure should be taken into account, as social media learning requires continuing financial assistance [22].

Lecturers stated that low bandwidth is one of the reasons for not using emerging technologies in academic activities. Management should prioritise students and lecturers' ICT infrastructure within the institutions [2, 6 and 22]. Also, universities should encourage lecturers and students to make use of their computing devices such as laptops, mobile phones and tablets, as well as strengthening Wi-Fi hotspots at campus and residence where students can access the Internet [24].

6.3 CSF 03 - Provide adequate training for lecturers

The lecturers indicated that they do not have sufficient knowledge and technology supported pedagogy skills to employ social media in teaching and learning. Providing proper training and support will allow lecturers to be prepared with the necessary information and pedagogical skills required to incorporate social media into the teaching environment. This could be achieved by encouraging lecturers to complete computer literacy courses and the Post Graduate Diploma in Higher Education for them to become more technically skilful and comfortable with social media tools in teaching and learning [23]. Therefore, university management must organise seminars and workshops regularly to enhance the faculties' knowledge on how to use social media in the academic environment.

Some of the lecturers have completed the training alone without the help of the university as they seek to improve their teaching skills. Universities ought to mobilise lecturers with these skills to train their colleagues (CSF 04 – Introduce a champion). The university management must prioritise education of lecturers in the educational technology related fields [22]. Therefore, lecturers will feel comfortable to include social media in their teaching practices.

6.4 CSF 04 - Introduce a champion

All the stakeholders in the teaching and learning field should be involved to ensure the successful implementation of social media at universities. Typical activities include education, raising awareness and engagement with the lecturers who will be making use of social media in the academic setting [25]. Social influence from colleagues was found to be influential (54.2%) towards the use of social media in the academic setting. Introducing a champion is one of the techniques that could be used to facilitate the integration and continued use of social media in the academic environment, as the objectives of making use of the technology will be communicated.

The findings of the study indicated senior management do not influence the lecturers, but colleagues could be used as champions. The champion must communicate with the different stakeholders such as the university management and academic staff. Thus the champion can act as a catalyst for innovation. Additionally, the champion can serve as an individual with knowledge and the understanding of the necessary social media technologies as well as the ability to embrace the objectives, thereby supporting technology-based solutions towards achieving excellent results. Thus, the champion should render assistance to lecturers and faculties facing challenges in using social media in the academic setting. The next section discusses the contribution of the study.

7 Conclusion

Mobile devices and emerging technologies play a vital role in academic activities at universities. Irrespective of the high popularity of social media for personal use, a low percentage of students and lecturers use them for educational purposes. The study has

highlighted that adopting social media in teaching and learning results in an improved throughput rate, student–lecturer interaction, student-centred learning and collaboration and student engagement. The research study set to develop CSFs to enhance lecturers' adoption and continued use of social media at universities.

The CSFs developed are the primary contribution of this study. The following CSFs were identified to enhance social media in the academic environment: Provide adequate resources, management support, introduce a champion, and provide sufficient training for lecturers. These CSFs were developed taking into account the various aspects that could hinder successful incorporation of emerging technologies in the academic environment.

One of the constraints to the research study is that data was collected from one traditional university, assuming that all universities in South Africa have the same teaching and learning context as this university. The sample size was small. Additionally, a survey method was employed in the research study. Therefore results are only based on quantitative data, and thus there was no follow up with qualitative interviews. Future research on adoption of social media in the teaching and learning environment in South Africa must draw a large sample including at least one traditional university from each province in South Africa.

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Augmented Reality User Interface Evaluation

Performance Measurement of Hololens, Moverio and Mouse Input

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Abstract—Recent innovation in the field of Augmented Reality (AR) and Virtual Reality (VR) has brought new devices on the market. The price for consumer products dropped significantly. Many industries see a big future in AR business and applications. The present research focuses on the user input performance of these AR-devices. This paper proposes an evaluation procedure using a server based input interface with a built-in assessment control. The evaluation is performed by test persons exposed to two AR devices: Microsoft Hololens and Epson Move- rio BT-200. A conventional mouse input is used as a benchmark. The assessment reveals a trend of strength and weaknesses of each device and can orient developers to create more optimized AR experiences and improve the user experience.

Keywords—Augmented Reality, Input, Performance

1 Introduction

New generations of AR device emerge at every major trade show. The market seems to advance to maturity and as the base of users increases many industries forecast a successful future in AR services, businesses and applications[1].

While the field of application is constantly increasing, a general problem in AR remains: human interaction. Research has been done to find appropriate, generic and new input methods for AR. These methods include gestures, voice input, trackers, markers or other haptic devices.

Although many methods have been proposed in this sector, not all interfaces proposed by AR devices are as easy and efficient as a mouse. The following can be observed: gestures are imprecise; input is slow; cloud processed voice input causes privacy problems; input methods require training similar to acquiring game skills[2]; input methods require custom content.

Manufacturers generally rely on their own Software Development Kit (SDK)s to provide interaction. Sensors and trackers are often so specific that content needs do be

developed with a target device in mind. Most of the time the experience will be related to a certain manufacturer of technology. Specific aspects of the performance or operation of AR devices have been evaluated for example for the Google Glass project in first experiences for lectures described by Ebner et al. [3].

The observation of these general problems and the underlying thoughts have motivated the present research. The purpose of this paper is to present an approach to a homogenized evaluation method in order to create a scientific assessment of the performance of existing input methods.

The most popular AR devices, Microsoft Hololens and Epson Moverio, have been selected for this research.

2 Previous Research

Most input devices are not specially designed for AR interaction. However some dedicated special devices exist for interaction with AR systems[4]. This section introduces some examples of so-called generic AR interfaces.

2.1 Tangible interfaces with tiles

This method was developed by Poupyrev et al. in early 2000 for AR, when the technology was in its infancy. Although performance of devices was very limited, many applications could already be foreseen [4]. This AR interface relied on a set of tiles. Acting like graphical boards, they could be overlaid by AR with symbols and custom designs. Since AR platforms imply awareness of the environment in form of video scanning, the idea behind this method is to use the mentioned tiles as optical markers. The computer system attached to the AR environment should then perform two tasks:

First, track the markers in the real works and map predefined object on them to give them a design and signification inside the computer application. The second task is to follow the interaction with theses semi-virtual objects. The tiles can be used to trigger actions. Such as for example copy, paste or delete. These tiles could not only serve to interact with one single application, but perform the same task in different applications[5].

2.2 Two handed interface for AR

Szalavári and Gervautz developed a specific AR interface called Two Handed Interface for AR[6]. Similar to the previous example, this interface is tangible. This means it can be interacted with by touch as if it was a real world object. Similar to the tile interface it is also of versatile appearance: the AR system is tracking the object and overlaying it the texture and interface elements that are desired for the interaction. This interface consists of a track pad with a pen pointer. Both are held in front of the view of the AR device, so they can easily be tracked and registered by the computer system. Multiple functions can be assigned to this pair of track pad and pen. Figure 1

shows a simulation in form of a stylus and a tablet. The shape of the interface can be changed as desired to give the user the impression to interact with simple buttons or if necessary with sliders allowing inputting more precise values.

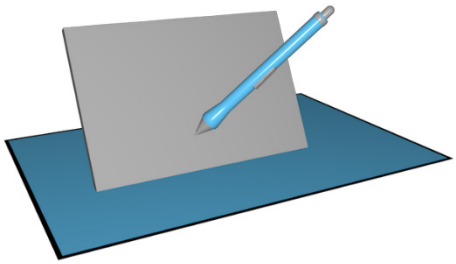

Fig. 1. Reconstruction of two hand interface for AR, Szalavári and Gervautz

The two handed interface for AR is an approach of tracking and mapping. It resembles in VR to the input sticks and trackers provided for the HTC Vive.

Another application using AR devices for tracking markers and hands are described by Menezes in his U-Academy learning modules showing how markers and hands can be used for advanced interaction in AR[7].

2.3 Palm Type

The human hand offers different possibilities for AR applications. Recent research shows how it can be used as an input or to visualize human hand anatomy as described by Boonbrahm et al.[8]. Wang et al.[9] developed a keyboard projected on the users hand to create a virtual input device as shown in figure 2. A similar approach had already been conceived by Dezfuli et al. for a palm based television remote control[10].

Palm Type was originally developed as an enhancement for the Google Glass project, which is similar to the Epson Moverio BT-200. Analog to the previously described methods, Palm Type provides a tangible user interface. In this case it the user's palm with little segments that remind a typewriter key board and using the body as a virtual input surface [11]. However, with some training the users can learn to map this mental keyboard to the lines and knuckles of the palm.

As opposed to the previously shown methods, the authors also perform a series of assessments to evaluate the performance of the new input method. The results are presented on the one hand as a numerical performance value, showing how many words per minute a user will be able to input on such an Palm Type keyboard for VR. On the other hand, the test persons are asked to rate the experience after the assessment. The evaluated is measured on a scale from zero to ten as shown in the results displayed in figure 3.

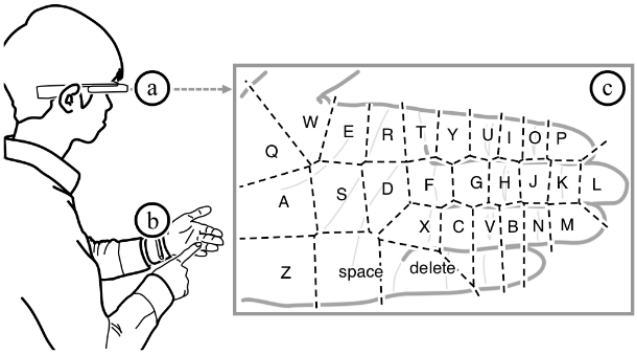

Fig. 2. Palm Type schema

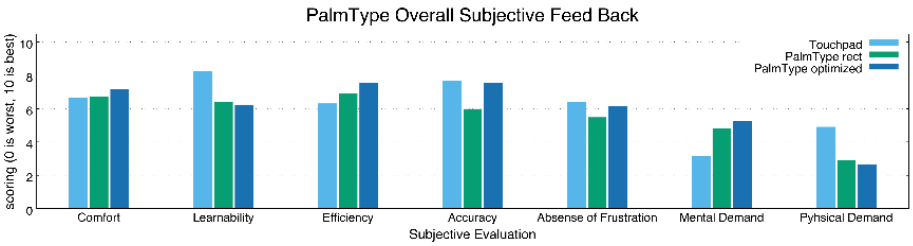

Fig. 3. PalmType subjective evaluation

The numerical results are published using the numerical benchmark Words Per Minute (WPM) ranging between 9.19 and 10.1. If word input is counted for AR devices, it is important to remember that writing performance is usually evaluated in Characters Per Minute (CPM)[12]. This is usually a requirement for typists. Real world values are 200 to 400 characters per minute entered on a keyboard, which corresponds approximately to one hundred WPM.

The work on Palm Type contains two important features that have inspired this research: First, tested devices are compared to an everyday device to set an independent benchmark. In this case, it will be a mouse attached to a laptop. Second, the performance is not only measured numerically, but it is followed by a subjective evaluation to reflect the overall satisfaction.

3 Method

Bach and Scapin state in their research [13] that a single assessment method for measuring Mixed Reality Systems (MRS) does not yet exist. According to the authors, this is due to the following factors: The field of AR is large and specialized. It is not easy to find experts who are competent for all systems. Many limitations lie in the technology itself, not easily to be measurable and traceable. The overall aim of the present assessment is to require as little instruction as possible and to give as much

introduction as necessary. The test persons should not be biased by the operators or the technology.

Therefore, the following measures were taken:

- Random order of experiments
- Instructions integrated in the assessment
- Test persons can run the assessment alone
- Test persons are chosen outside the lab environment

These precautions aim to eliminate most limitations in order to obtain significant evaluations. The following sections describe the different tests and methods that have been developed to perform the assessment.

3.1 Comparing and Benchmarking

The purpose of this research is an evaluation of the objective and subjective performance for AR input devices. For this a series of assessments using three different input methods as shown in figure 4 will be conducted:

(a)·mouse¤ (b)·touchpad¤ (c)·gestures

Fig. 4. Overview inputs methods for performance evaluation

3.2 Performance measurement

The following section describes the assessment user interface and the underlying server technology driving the assessment and collecting the results.

3.3 Assessment interface

The left part of figure 5 shows the interface visible to the user on the different AR devices. The top line (A) contains a small space for the instruction. In case of tasks with timeout, the background of the instruction space can optionally display a progress bar indicating the remaining time. Element (B) is a vertical slider. This element allows selecting values between 0 and 10. The lower part of the interface displays two large buttons. One labeled start (C) to begin the assessment. The other button (D) reads ok and can be triggered when the user has accomplished a task.

The assessment manager sees a different interface: It contains a text-field with the XML-assessment (E). The controls (F) for loading, starting the assessment and selecting the assessment devices. The lower side displays a real time log viewer (G) and a text-field displaying the XML-results (H).

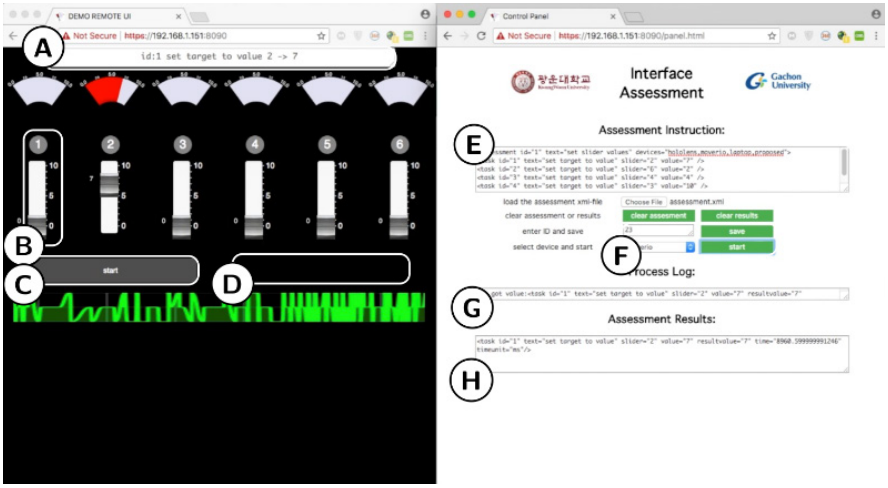

Fig. 5. Assessment interface: for user (left) and for manager (right)

3.4 Assessment server

In order to provide a reusable test environment for a large number of AR devices, the previously described user interfaces are generated by a server equipped with a wireless access point. The AR devices can connect to the access point and display the assessment interface using a web view element or web browser. In the present research server and access point were implemented using a Raspberry PI. This approach has two advantages: First, it assures a unified user experience. Second, it simplifies the assessment creation by not using any platform specific development environments.

3.5 Survey for subjective evaluation

The second part of the assessment consists of a subjective evaluation. Each test person is asked to answer questions and to rank their experience after having completed the tasks on the assessment server.

While many methods exist for such evaluations such as the Likert Scale [14] with a range form one to five or one to seven, these systems aim at identifying the affirmation of a certain hypothesis if form of statements such as: “I strongly agree” or “I strongly disagree”. While this method has many advantages to identify opinions and to reflect test person’s attitude, It is generally difficult to create a mean or to sum up a certain statement, which might even be contradictory [15].

For this reason, the test persons are asked to evaluate certain factors on a linear decimal scale ranging from zero to ten for these categories:

- Overall comfort (easiness to wear)
- Learning (effort necessary to learn operation)
- Efficiency (evaluation after own testing)
- Precision (evaluation after own testing)
- Frustration (description of level during testing)
- Mental demand (description of level during testing)
- Physical demand (description of level during testing)

The lower number describes a negative or uncomfortable experience. The higher number describes a positive or comfortable experience. The test persons are given unlimited time after the experiment to fill out a questionnaire for the survey.

Table 1. Assessment period

Phase	Start	End	Persons
Pretest	0	0	7
First Session	0	0	17
Second Session	0	0	10

4 Results

This section presents the results of survey and assessment. The first part describes composition and structure of the samples. The second part exposes results and subjective evaluation.

4.1 Overview and demography

The head of the questionnaire for the subjective evaluation includes general demographic information and an identification number to relate the subjective evaluation with the results measured by the assessment server. Most of the test persons are students in Seoul, South Korea. Other participants are partly teaching stuff, researchers and students whose major is media, converged software or information contents. Table 1 shows time ranges and sample amount of each assessment.

The assessment period took place between end of May and beginning of June in 2018. A series of seven pretests were conducted on 2018 May 18. These pretests had the purpose to identify ambiguities in the questionnaire and to optimize the survey. Tests on the user interface helped to identify problems and to improve the assessment process. The principal test session took place may 24 and 25 in the VR Medial Lab of the Kwangwoon University. The duration of each assessment was approximately 30 minutes for each device. Assessment assistants verified the proper functioning of the equipment. The test person received a brief introduction how to operate each device: HoloLens, Moverio BT-200 and a laptop with an ordinary office mouse served as configuration for benchmarking.

The first series of tests run for 18 persons without any timeout for the participants. They had all the necessary time to perform all the required tasks until they judged it completed. A second series of tests was performed on additional group of ten test persons on June 7 and 8. These test persons received the same questionnaire, but had to perform the tasks with a specific timeout for each device.

The order in which the participants assessed each device was chosen randomly in order to exclude this factor's influence on the participant's performance. Participants have not been selected by any criterion but accepted as a random group. Their participation was voluntary. The total number of participants is 27. Six of them were females, 21 were males. Table 2 shows the gender composition.

Table 2. Assessment participant gender

Gender	Amount
Female	6
Male	21
Total	27

4.2 Responses without timeout

The first set of results, as displayed in table 3, shows the mean interaction for each sample and device in absolute time in milliseconds. A resemblance in the pattern can be observed for all the samples: HoloLens has on average the longest response time, the mouse is in most cases the fastest input device.

The original aim to account for errors in the input methods, seemed biased by the fact that the test persons generally take as much time as needed in order to complete a task without any error. Table 4 reveals the mean and median response time for each device.

Table 3. Mean Response Time per Sample and Device in ms

Nr	Hololens	Moverio	Mouse
1	15375	8040	4690
2	10285	9858	4179
3	8544	8486	4100
4	17826	9121	3079
5	10050	12088	3894
6	32658	9424	4061
7	17670	7811	4532
8	25788	9711	2931
9	12368	15953	4319
10	15634	9866	3769
11	17925	24214	5096
12	17925	13252	3700
13	16364	8472	5010
14	7900	12180	3024
15	37937	9300	2621
16	24061	9545	3482
17	10756	21802	5300

4.3 Responses with timeout

The second set of samples was obtained by using the mean response time of each device as a timeout for the assessment. The second set of samples shows a much smaller deviation compared to the first one. Table 5 shows the mean response time and deviation of the first session without timeout and the second session with timeout.

The deviation of the response time remains much closer to the mean on all devices. Some people are still faster than the average limited by the timeout. Even if it is much smaller, the variance between test persons with fast and slow reaction times is the largest on HoloLens, and the smallest when using the mouse.

Table 4. Mean and Median Response Time per Device Data in ms

	Hololens	**Moverio**	**Mouse**
Response Time (median)	16364	9711	4061
Response Time (average)	17592	11713	3987

Table 5. Mean Response Time per Device and Standard Deviation in ms Data

Devices	**Mean without Timeout**	**SDV**	**Mean with Timeout**	**SDV**
Hololens	17592	8368	11867	2595
Moverio	11713	4754	10361	1473
Mouse	3987	793	3851	212

4.4 Subjective evaluation results

While most of the assessment performance could be measured in interaction and response time by implementation of an assessment server inside the user interface, the subjective evaluation occurred with no time constraint and requested the test person to rank their experiences.

Figure 6 shows the result of the subjective evaluation among all test subjects after the assessment. The result show some obvious effects: First, there seems to be a general order in all the categories, attributing the best properties to mouse as input interface followed by Moverio and eventually HoloLens. Second: While some device input methods are evaluated below the average, no input method is really evaluated with zero points. In all cases, the mouse as interactive input seems to represent the ideal case ranging in almost all cases at the top with eight or nine in average. Table 6 shows the subjective evaluation overview data.

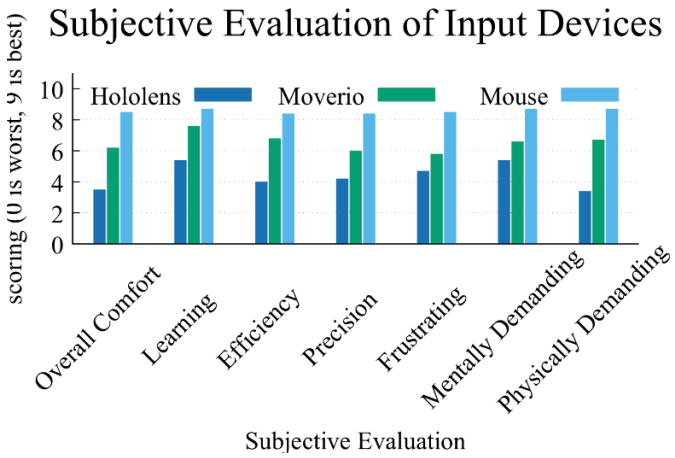

Fig. 6. Subjective evaluation results, all devices cumulative

Regarding the overall comfort, me mouse ranks at the top of the evaluation. Hololens is evaluated 3.5 as the most uncomfortable among the tested devices.

The results regarding learnability show HoloLens ranks last one on this category, meaning that most test persons considered it the hardest to learn how to correctly interact with the device.

Efficiency is evaluated below average on HoloLens with a score of 4.0. While the mouse is evaluated the most efficient input device with a score of 8.4, Moverio ranks above the average.

Regarding precision, all AR devices are evaluated less precise than the mouse. Among the AR devices, HoloLens ranks the lowest.

Table 6. Mean subjective rating overview, samples N = 27

question	Hololens	Moverio	Mouse
Overall Comfort	3.5	6.2	8.5
Learning	5.4	7.6	8.7
Efficiency	4	6.8	8.4
Precision	4.2	6	8.4
Frustrating	4.7	5.8	8.5
Mentally Demanding	5.4	6.6	8.7
Physically Demanding	3.4	6.7	8.7

The level of frustration is comparable to the previous scores. The test persons evaluate HoloLens with a score of 4.7, which is ranks in a neutral region of frustration. All other devices seem less frustrating to use.

The scores regarding mental and physical demand required for the operation of the device show again that the mouse ranks the highest. With a score of 3.4 HoloLens has the lowest ranking in physical demand, which means that the test persons judged it to require the most efforts in order to operate the device properly.

4.5 Future research

The present research shows a trend in the performance of the tested AR input devices. Future assessments should increase the amount of samples in order to gain a higher significance regarding operation and subjective results. The subjective evaluation was conducted after the practical assessment. Future research should include an additional questionnaire to measure the expectations of the user before the assessment. This would allow to draw additional conclusions toward expected and real performance.

5 Conclusion

The present research has proposed a method for objective and subjective performance evaluation using an assessment server in combination with user surveys. The present research indicates that performance and satisfaction of the contemporary AR devices far from being satisfactory. Although the technology makes big steps forward, assessment metrics indicate that there is a need for further improved human input devices. New input methods, such as gestures or touch devices emerge in AR, however most of them are ranked far behind traditional input methods such as the mouse. This research shows that performance of human input interfaces in AR still has large room for improvement of overall performance, satisfaction and user comfort.

6 Acknowledgement

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Design and Implementation of Bekantan Educational Game (BEG) as a Banjar Language Learning Media

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Abstract—The lack of recognition of the current Banjar language is one of the causes of knowledge and the introduction of children about the reduced Banjar language. In an attempt to recognize, introduce, and improve the re-knowledge of the Banjar language is to recommend the design and implementation of an educational game application called Bekantan Educational Game (BEG) containing material content and quizzes. Before this game application is used, it must be tested first. Test method used is black box testing, to test the functionality of game applications. Other tests are also conducted to obtain information about the material access frequency and reset quizzes by players. The result of black box testing is all the functionality in the BEG application in accordance with what is expected. The result of the frequency testing accessing the menu on BEG of Material Section is Wadai Banjar 2 Menu with 59 times, and the frequency reset on BEG of Quiz Section is a type of Drag and Drop quiz with 21 times and generate feedback from quiz in the form of final value with average 89.17%.

Keywords—Educational game, black box testing, game application, user interface, learning media

1 Introduction

South Kalimantan is one of the provinces in Indonesia that has a variety of art and culture. Today, many arts or cultures are slowly being forgotten. The interest of the younger generation to understand Banjar art and culture was reduced. The lack of recognition of Banjar art and culture since the early days has also been one of the causes of the lack of interest of children to learn and try Banjar art and culture, one of which is introducing and giving knowledge about Banjar language as one of Banjar art and culture that should be maintained [1]. Through the Culture and Tourism Office of Banjarmasin City, Banjarmasin Mayor directly instructed to preserve the art and culture of Banjar in particular continuously preserving the use of Banjar language in the daily life of Banjar people. Banjar language is very necessary to be preserved and reintroduced so as not to be eroded by the times. The introduction of the Banjar language is not enough only orally or in writing, it needs a solution to face the current era

by recommending the use of learning media technology to increase the interest and interest of the children to be more familiar with and learn Banjar language.

Educational game is a game application technology, which through the game, there are materials or information that is educational. Such material or information may be directly expressed in multimedia applications and may also be implied through the plot of the game in the application itself [2].

Quite a lot of research has discussed about educational games such as research by [5], [7], [10], [11], [12], [13], [15], and [16] which each deals with design, implementation, analysis, and identification of educational games, which distinguishes most of the educational game tools used and different materials.

Research that raised and discussed about educational game with element of art and culture of region that is research conducted by [14] which discuss about traditional art education game on story puppet by using digital story.

A highly relevant study is a study conducted by [4], which together promotes Banjar art and culture, which displays a character by the name of Si Palui who adventures to find the knowledge then at the end of the game will be given a quiz. However, for general content material covered from Banjar art and cultural subjects, not specified. Then to develop the game Si Palui this researcher [4] also uses Flash. One of the most widely used and easy-to-use programs for creating and developing learning media that contain animation, graphics, text and sound is the Flash application. With Flash Programming, we can create a variety of multimedia applications ranging from presentation, animation, learning media and even the making of games, especially educational games. In flash, use action script as its programming language [3].

What distinguishes the research [4] with the current recommended research is on the storyline of the game, game type, game background, and more specific material that is about the introduction of the Banjar language.

Based on some backgrounds above, then do the design and implementation of educational game application called "Bekantan Educational Game (BEG)". Where with this educational game can make the teaching-learning process more interesting and easy in understanding and expected in the future with this application, knowledge of Banjar language can increase. This application can also make it easier for teachers to explain the material of Banjar language. In addition, applications built later can be used as a tool or media for the introduction of art and culture of Banjar to students in schools and general public, especially in preserving the language of Banjar as a colloquial.

2 Educational Game

According to Thomas Grill defining about the notion of games is a game is structured playing, usually undertaken for enjoyment and sometimes used as an educational tool. Games are distinct from work, which is usually carried out for remuneration. Games generally involve mental and/or physical stimulation [6].

Educational game according to Andang Ismail in his book titled education games, which is a very fun activity and can be an educational way or educational tool. The functions of the educational game are as follows:

- Providing knowledge to the child through the process of learning to play while learning.
- Stimulate the development of thinking power, and creativity and language in order to foster attitudes, mental, and good morals.
- Create an exciting playing environment; provide a sense of security, and fun.
- Improving the quality of learning [8].

Educational game is a creative game that can help children in providing knowledge, education and how to solve problems. An educational game is also able to apply the logic of thinking for player and train the learning system on a positive effect on the brain of Pre Fortal Cortex. Educational games are widely used as a learning medium capable of supporting the wheel of education in the community with the concept of learning and playing along with an interesting visual for the players [16].

3 Banjar Language

The Banjar language is an Austronesian language of the Melayik language group spoken by the Banjar tribe in South Kalimantan, Indonesia, as the mother tongue. Some linguists argue the Banjar Language includes the Malay Local Borneo East group. The Banjar language is included in the list of dominant languages in Indonesia. In his native land in South Kalimantan, the Banjar language is an oral literary language divided into two major dialects namely Banjar Kuala and Banjar Hulu. Before known as the national language of Indonesia, in ancient times when making speeches, writing or composing Banjar people using Banjar Malay language using Arabic script. The writings or letters used are mostly Arabic letters or Arabic writing with Malay language (Banjar version). All ancient hand-written manuscripts such as poetry, Syair Siti Zubaidah, Tajul Muluk poetry, Karuang Bird poetry, and even Hikayat Banjar and Tutur Temple use Arabic Malay (Banjar). The use of Banjar language in daily conversation and interaction in South Kalimantan and its surroundings is more dominant than Indonesian language. Various tribes in South Kalimantan and surrounding areas try to master the language of Banjar, so we can also encounter Banjar language spoken with Javanese or Madura accents that still feel thick as we encounter in the city of Banjarmasin.

The Banjar language is still used in some Banjar settlements in Malaysia such as Kampung (Desa) Parit Abas, Mukim (Kecamatan) Kuala Kurau, Kerian District, Darul Ridzuan State. The language of Banjar is much influenced by Malay, Javanese, and Dayak languages. The similarity of lexical Banjar language to other languages is 73% with Indonesian, 66% with Tamuan language (Malayic Dayak), 45% with Bakumpai language, 35% with Ngaju language. Results of research Wurm and Willson (1975), kinship relationship between Malay and Banjar language reaches 85%. The kinship with Maanyan language is about 32% and with 39% Ngaju

language, based on Zaini HD research. The Banjar language is related to the language used by the Kedayan tribe (a dialect in Brunei) that is separated for 400 years and the Banjar language is often also called Banjar Malay. In its development, Banjar language is suspected to have contamination from Indonesian and foreign language intervention. The Banjar languages are in a fairly safe category of extinction because they are still used as a colloquial language by the Banjar community as well as by outsiders. Despite the decline in Banjar language playings, the rate of decline is not very subtle. Currently, Banjar Language has begun to be taught in schools in South Kalimantan as local content. The Banjar language also has a number of proverbs [9].

4 Research Methodology

There are several steps in doing this research as shown in Fig. 1. This is a general explanation of the steps in the research methodology.

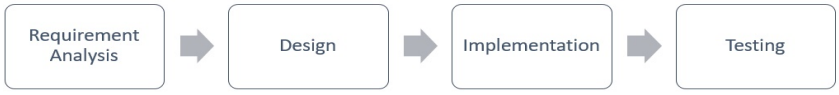

Fig. 1. Research Methodology

4.1 Requirement analysis

Initial stage is requirement analysis that is complete requirement gathering then analyzed and specified requirement which must be fulfilled by application to be built. This step analysis needs to be done in full to be able to produce a complete design. Collection of materials and reviews of art and culture textbooks to discuss Banjar language materials. In this discussion discussed about some function and purpose of making application so that later target more appropriate and as expected.

4.2 Design

After the results of the analysis of the data obtained into an idea in the development of applications, the problems that may occur, what needs are required in the development of this application. After all the needs are analyzed, the next step is to design the system and software, which is to design the system to be built such as the storyboard and wireframe design.

4.3 Implementation

Implementation is the stage of applying the results of design, interface design, and system into an application. The software used in making this application is Macromedia Flash 8, Photoscape, and Corel Draw X7.

4.4 Testing

The testing phase is done after the application is completed. This test is done using black box testing method. This test is performed to test the functionality of game apps as well as testing to get information about the frequency of accessing the menu on the BEG of the material part and frequency of reset the quiz on the BEG quiz section of the game app by selecting the player's sample to use this BEG.

5 Results and Discussion

5.1 Requirement analysis

This application is in the form of an educational game containing material content and quiz, players can learn by themselves visually about writing Banjar language at the same time see picture which is explained in Banjar language. The material presented is a Brief History of Banjar Language, Daily Language, Family, Fruit, Animals, Wadai Banjar 1 (Banjar Food 1), and Wadai Banjar 2 (Banjar Food 2). After the player finishes the material, then will be directed to work on the quiz in which the quiz system is random, consisting of 6 types of quiz: Drag and Drop, Fill in the Blank, Hot Objects, Hot Spots, Multiple Choice, and True or False. In this BEG application, a few menus are described and presented in Table 1 and Table 2.

Table 1. Features on the BEG menu of the material section

Id	Menu Features	Description
MU	Utama	Initial view of the BEG application of the Content section that contains some of the options menu.
M1	Petunjuk Aplikasi	Displays a page that contains the rules or guidelines for using BEG applications.
M2	Sejarah Singkat Bahasa Banjar	Displays a page containing a brief history of Banjar language.
M3	Bahasa Keseharian	Displays a page containing daily language materials that are often used daily by Banjar people who have been sorted from the letter A-Z.
M4	Keluarga	Displays pages that contain about family introduction materials, such as father, mother, sister, and so forth in Banjar.
M5	Buah	Displays a page containing the image and the name of the fruit in Banjar.
M6	Binatang	Displays a page containing the image and the name of the animal in Banjar.
M7	Wadai Banjar 1	Displays a page containing the pictures and writing of Banjar's unique food names in Banjar.
M8	Wadai Banjar 2	Displays a page containing the pictures and writing of Banjar's unique food names in Banjar (Continuation).

Table 2. Features on the BEG menu of the quiz section

Id	Quiz Features	Description
MUK	Menu Utama	Initial view of the Quiz section BEG app containing some selection menus. On this page provided the next button that serves to start working on the quiz.
K1	Drag and Drop	Displaying the quiz type by pairing or matching the image, this quiz system is the picture presented totaling 4 pieces on the left side and on the right side is where to put a picture of 4 pieces corresponding to the naming. Then, if the player wants to repeat the answer provided by the reset button, if the player is sure with the answer then click the check button answer, and raises the message in the form of: "Is your answer right or wrong?" This quiz system should not return to the previous problem and the appearance of quizzes between random players.
K2	Hot Objects	Displays the quiz types of the image guessed by the question asked. This quiz system is a picture presented totaling 6 pieces, the player will select the image that has been provided and adjust it. Then, if the player wants to repeat the answer provided by the reset button, if the player is sure with the answer then click the check button answer, and raises the message in the form of: "Is your answer right or wrong?" This quiz system should not return to the previous problem and the appearance of quizzes between random players.
K3	Fill in the Blank	Displaying the quiz type field, the player will fill in the answer on the text box that has been provided, and the system does not set case sensitive. So, the player can enter the answer whether it is uppercase or lowercase. If the player is confident with the answer then click the check button answer, and raises the message in the form of: "Is your answer right or wrong?" This quiz system should not return to the previous problem and the appearance of quizzes between random players.
K4	Hot Spot	Displays the quiz types of the image guessed by the question asked. This quiz system is a picture presented totaling 6 pieces; the player will select the image that has been provided and adjust it. Then, if the player wants to repeat the answer provided by the reset button, if the player is sure with the answer then click the check button answer, and raises the message in the form of: "Is your answer right or wrong?" This quiz system should not return to the previous problem and the appearance of quizzes between random players.
K5	True or False	Displaying a quiz type chooses whether the answer is true or false and only one correct answer, the player will choose between the true or false options that have been provided according to the instructions of the statement by clicking the option on the answer. If the player is confident with the answer then click the check button answer, and raises the message in the form of: "Is your answer right or wrong?" This quiz system should not return to the previous problem and the appearance of quizzes between random players.
K6	Multiple Choice	Displaying a multiple-choice quiz type, the player will select some of the correct answers that have been provided according to the instructions of the question by clicking on the options in the answer. If the player is confident with the answer then click the check button answer, and raises the message in the form of: "Is your answer right or wrong?" This quiz system should not return to the previous problem and the appearance of quizzes between random players.
QR	Quiz Results	Displays the results of a quiz work consisting of total correct, total incorrect, and total score.

5.2 Design with storyboard and wireframe

Storyboard game explains the storyline or plot of the game on a BEG app. One example of storyboard from BEG is shown in Fig. 2.

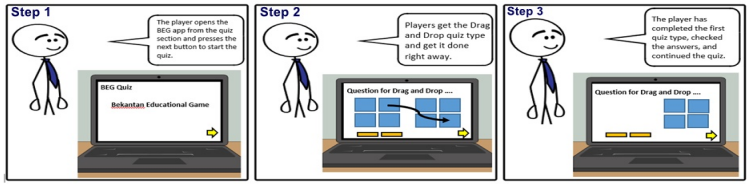

Fig. 2. Storyboard game for quiz section

The game's wireframe here visualizes the User Interface (UI) design of the games in this BEG app. This BEG application is divided into 2 main scenes namely Scene Material and Scene Quiz. The designed wireframe is visualized using a desktop and web-based and mobile-based. Examples of BEG wireframes from the material section are presented in Fig. 3 and Fig 4. Examples of BEG wireframes from the quiz section are presented in Fig. 5 and Fig. 6.

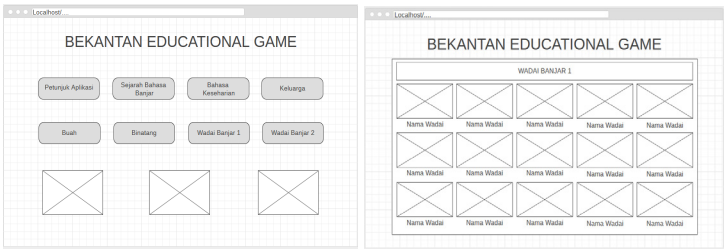

Fig. 3. BEG wireframe from the material section using desktop and web-based

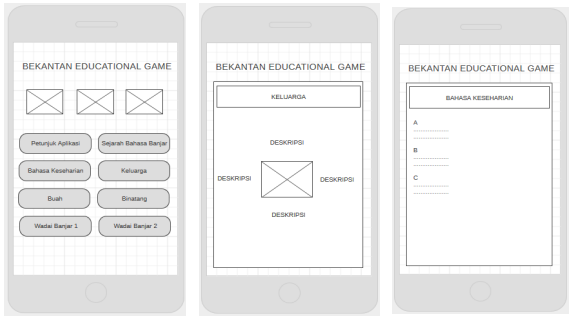

Fig. 4. BEG wireframe from the material section using mobile-based

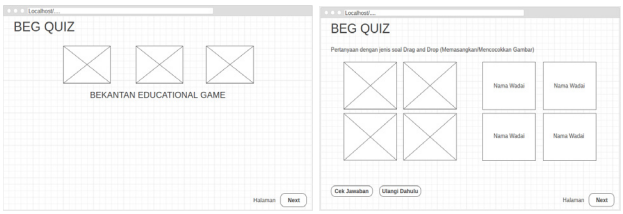

Fig. 5. BEG wireframe from the quiz section using desktop and web-based

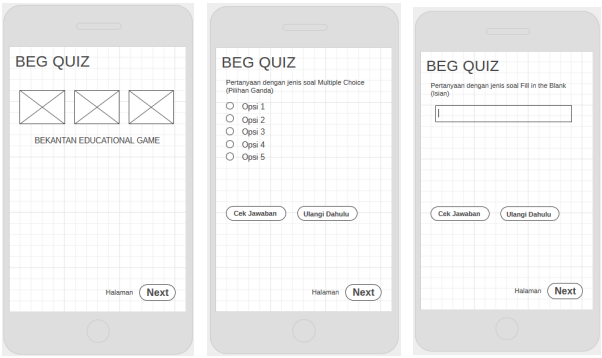

Fig. 6. BEG wireframe from the quiz section using mobile-based

5.3 Implementation

After the process of analysis and data collection, as well as system design, then made this BEG application using flash programming language. The following will present the results of the UI design implementation that has been made, shown in Fig. 7 for the BEG section of the material and in Fig. 8 for the BEG quiz section.

Fig. 7. Implementation of BEG from the material section

Fig. 8. Implementation of BEG from the quiz section

5.4 Testing

Test method used in this research is black box testing. Black box testing focuses on the functional requirements of the software. Thus black box testing allows software

engineers to get a set of input conditions that fully utilize all functional requirements for all programs. The software truths tested are only viewed based on the outputs generated from the data or input conditions provided for the existing functionality regardless of the process to obtain the output. From the output of the program's ability to meet the needs of users can be measured at once can be known errors. Trial with black box on this system aims to determine the function of how to operate, whether the input data output has been running as expected [17]. This test step uses two test cases that is when the system runs in accordance with expectations and when input error occurs. The black box testing results of BEG from Material Section are shown in Table 3 and the black box testing results on BEG from Quiz Section are shown in Table 4.

Table 3. Black box testing results on BEG of material section

Menu Features	Expected Results	Test Result
M1	Displays a page that contains the rules or guidelines for using BEG applications.	OK
Exit Button on M1	Return to Main Menu (MU)	OK
M2	Displays a page containing a brief history of Banjar language.	OK
Exit Button on M2	Return to Main Menu (MU)	OK
M3	Displays a page containing everyday language material that is often used daily by Banjar people.	OK
Exit Button on M3	Return to Main Menu (MU)	OK
M4	Displays a page containing family introduction materials in Banjar.	OK
Exit Button on M4	Return to Main Menu (MU)	OK
M5	Displays a page containing images and fruit names in Banjar.	OK
Exit Button on M5	Return to Main Menu (MU)	OK
M6	Displays a page containing images and animal names in Banjar.	OK
Exit Button on M6	Return to Main Menu (MU)	OK
M7	Displays a page containing pictures and writings of Banjar's unique food names in Banjar.	OK
Exit Button on M7	Return to Main Menu (MU)	OK
M8	Displays a page containing pictures and writings of Banjar food names in Banjar (continued).	OK
Exit Button on M8	Return to Main Menu (MU)	OK

The results of functionality testing on the BEG part of the material as shown in Table 3 shows that when a player successfully opens this game app that appears is the main page. Then press the Petunjuk Aplikasi (M1) menu, the system reaction displayed successfully with OK status showing the application's guide page that serves to provide information about how to use the game. Next pressing the exit button on M1, the system reaction shown succeeds with the OK status ie back to main page (MU) and close the page M1. Pressing the Sejarah Singkat Bahasa Banjar (M2) menu, the system reaction displayed successfully with the status of OK that displays a short history page of banjar language that serves to display a brief story of the history of the formation of banjar language. Next pressing the exit button on M2, the system reaction shown successfully with OK status is back to the main page (MU) and close the page M2. Pressing the Bahasa Keseharian (M3) menu, the system reaction displayed

successfully with the status of OK that displays a daily language page that serves to display a variety of Banjar languages are often used in everyday activities. Next pressing the exit button on M3, the system reaction shown succeeds with the OK status ie back to the main page (MU) and close the page M3. Pressing the Keluarga (M4) menu, the system reaction displayed succeeds with an OK status displaying a family page containing the names of family names in Banjar. Next pressing the exit button on M4, the system reaction shown succeeded with OK status ie back to the main page (MU) and close the M4 page. Pressing the Fruit menu (M5), the system reaction displayed succeeds with an OK status displaying a fruit page containing the image and names of fruit summings in Banjar. Next pressing the exit button on the M5, the system reaction shown succeeded with the OK status that is back to the main page (MU) and close the page M5. Pressing the Binatang (M6) menu, the system reaction displayed succeeds with an OK status displaying an animal page containing the image and names of the animal summoning in Banjar. Next pressing the exit button on the M6, the system reaction shown succeeded with the OK status is back to the main page (MU) and close the page M6. Pressing Wadai Banjar 1 (M7) menu, the system reaction displayed successfully with OK status showing Banjar 1 pawn page containing the pictures and names of Banjar pawn callers in Banjar. Next pressing the exit button on M7, the system reaction shown succeeds with the OK status ie back to the main page (MU) and close the page M7. Pressing Wadai Banjar 2 (M8) menu, the system reaction displayed successfully with OK status showing Banjar 2 pandemic page containing the picture and the names of Banjar pawn callers in Banjar language, this menu is a continuation of page M7. Next pressing the exit button on the M8, the system reaction shown succeeded with the OK status is back to the main page (MU) and close the page M8. Based on this it can be said that the results of functionality testing on the BEG of the material part as a whole is in accordance with what is expected.

The result of function testing on the BEG part of the quiz as shown in Table 4 shows that when a player successfully opens this game app that appears is the main page. Then press the next button, the system reaction is successfully displaying the first quiz page of Drag and Drop (K1) quiz type, then the player plays the quiz by pairing or matching between 4 pieces of Wadai Banjar with 4 names of Wadai Banjar by dragging to the right then drop it with OK status. Next press the reset button on K1, the system reaction shown is to successfully reset the quiz if the player wants to rearrange the quiz because it is caused by mistake put the object, any doubt about the answer given, or any other cause, with OK status. Still on page K1 if the player has been convinced by the answer, press the answer check button with the system reaction is lock the answer and bring up the information whether the answer of the player is right or wrong, with OK status. Lastly after working on the question and the information appears from the answer, the player is welcome to press the next button to proceed to the next quiz page and the player is not allowed back to the main menu.

After pressing the next button on the K1 page, the system reaction is successfully displaying the second quiz page of Hot Objects (K2) quiz type, then the player plays the quiz by guessing the picture of the fruit based on the question, available 6 pieces of fruit to choose, by clicking on the image of the fruit that is considered correct according to the instruction of the question with the status of OK. Next press the reset

Table 4. Black box testing results on BEG of quiz section

Quiz Features	Expected Results	Test Result
Next Button on MUK	Starts the quiz by displaying the first quiz page.	OK
K1	Displays the Drag and Drop quiz type by pairing or matching images, this quiz system is a picture presented as 4 pieces on the left side and on the right side is where to put 4 pictures in accordance with the naming.	OK
Reset Button on K1	Resetting the answer from the quiz K1.	OK
Check Answer on K1	Check out the answers from the quiz K1. Then bring up the statement whether the quiz that you answer is right or wrong?.	OK
Next Button on K1	Continue and display the next quiz.	OK
K2	Displays the Hot Objects quiz type in the form of an image that is guessed by the question asked. This quiz system is a picture presented as many as 6 pieces, the player will select the image that has been provided and adjust it.	OK
Reset Button on K2	Resetting the answer from the quiz K2.	OK
Check Answer on K2	Check out the answers from the quiz K2. Then bring up the statement whether the quiz that you answer is right or wrong?.	OK
Next Button on K2	Continue and display the next quiz.	OK
K3	Displaying the Fill in the Blank quiz type, the player will fill in the answer on the text box provided, and the system does not set case sensitive.	OK
Check Answer on K3	Check out the answers from the quiz K3. Then bring up the statement whether the quiz that you answer is right or wrong?.	OK
Next Button on K3	Continue and display the next quiz.	OK
K4	Displays the Hot Spot quiz type of the image guessed by the question asked. This quiz system is a picture presented as many as 6 pieces, the player will select the image that has been provided and adjust it.	OK
Reset Button on K4	Resetting the answer from the quiz K4.	OK
Check Answer on K4	Check out the answers from the quiz K4. Then bring up the statement whether the quiz that you answer is right or wrong?.	OK
Next Button on K4	Continue and display the next quiz.	OK
K5	Displaying the True or False quiz type is choosing whether the answer is right or wrong and only one correct answer, the player will choose between the right or wrong options that have been provided according to the instructions of the statement by clicking on the option on the answer.	OK
Check Answer on K5	Check out the answers from the quiz K5. Then bring up the statement whether the quiz that you answer is right or wrong?.	OK
Next Button on K5	Continue and display the next quiz.	OK
K6	Displaying a multiple choice quiz type, the player will select some correct answers that have been provided in accordance with the question instruction by clicking on the options in the answer.	OK
Check Answer on K6	Check out the answers from the quiz K6. Then bring up the statement whether the quiz that you answer is right or wrong?.	OK
Next Button on K6	Continue and show results from the quiz.	OK
QR	Displays the end result of the quiz work, consisting of true totals, total wrongs, and total score.	OK

button on K2, the system reaction shown is to successfully rearrange the quiz if the player wants to rearrange the quiz because it is caused by mistake pressing the object, any doubt about the answer given, or any other cause, with OK status. Still on page

K2 if the player has been convinced by the answer, press the check button the answer with the system reaction is lock the answer and bring up the information whether the answer of the player is right or wrong, with status OK. Finally after working on the question and the information from the answer appears, the player is invited to press the next button to proceed to the next quiz page and the player is not allowed to return to the previous quiz page.

Then after pressing the next button on the K2 page, the system reaction is successfully displaying the third quiz page of Fill in the Blank (K3) quiz type, and then the player plays the quiz by filling the answer in the text box directly input or typed in quiz question or quiz with status OK. In this type of quiz K3 is not disedikan reset button because the player such as doubt can directly delete the answer before clicking the check button answer. If the player has been convinced by the answer, press the check button with the reaction of the system is lock the answer and bring up the information whether the answer from the player is right or wrong, with the status OK. Finally after working on the question and the information from the answer appears, the player is invited to press the next button to proceed to the next quiz page and the player is not allowed to return to the previous quiz page.

After pressing the next button on the K3 page, the system reaction is successfully displaying the fourth quiz i.e. Hot Spot quiz (K4), then the player plays the quiz by guessing the animal image based on the question, available 6 pieces of animal image to choose, by clicking the picture animals considered true according to the instruction of the question with OK status. Next press the reset button on K4, the system reaction shown is to successfully rearrange the quiz if the player wants to reset the quiz because it is caused by mistake pressing the object, any doubt about the answer given, or any other cause, with OK status. Still on the K4 page if the player has been convinced by the answer, hit the check button with the system reaction is to lock the answer and bring up the information whether the answer of the player is right or wrong, with OK status. Finally after working on the question and the information from the answer appears, the player is invited to press the next button to proceed to the next quiz page and the player is not allowed to return to the previous quiz page.

Then after pressing the next button on the K4 page, the system reaction is successfully displaying the fifth quiz page ie True or False (K5) quiz type, and then the player plays quiz by selecting one answer between true or false based on query question or statement with OK status. In this type of quiz K5 is not disedikan reset button because the player can directly switch options on the radio button before clicking the check button answer. If the player has been convinced by the answer, press the check button with the reaction of the system is lock the answer and bring up the information whether the answer from the player is right or wrong, with the status OK. Finally, after working on the question and the information from the answer appears, the player is invited to press the next button to proceed to the next quiz page and the player is not allowed to return to the previous quiz page.

After pressing the next button on the K5 page, the system reaction is successfully displaying the sixth quiz page which is the quiz type Multiple Choice (K6) is the last quiz, the player plays this quiz by selecting some answers from 5 options provided based on questions or statements from the quiz, the correct answer will amount to

more than 1 of the players have to answer it, this quiz has succeeded with status OK. In the K6 quiz type is not disedikan reset button because the player can directly switch the option on the radio button before clicking the check button answer. If the player has been convinced by the answer, press the check button with the reaction of the system is lock the answer and bring up the information whether the answer from the player is right or wrong, with the status OK. Lastly, after working on the question and the information appears from the answer, the player is invited to press the next button to proceed to the final results page of the quiz and the player is not allowed to return to the previous quiz page.

Lastly after pressing the next button on page K6, the system's reaction is to successfully display the Quiz Result page (QR) which is a quiz result consisting of total true, total wrong, and total score. Once the player knows the final result on this QR page, the live gamer closes the game app and the final quiz is done successfully and finishes with OK status. Based on this it can be said that the results of functionality testing on the BEG quiz section as a whole is in accordance with the expected.

This stage is done after the application is finished designed. Testing is done by selecting the sample to use the application directly from the player. There are twelve people from university students in Malang City where they are native people of South Kalimantan who tend to be able to speak Banjar. Implementation of testing to one of the players is shown in Fig. 9.

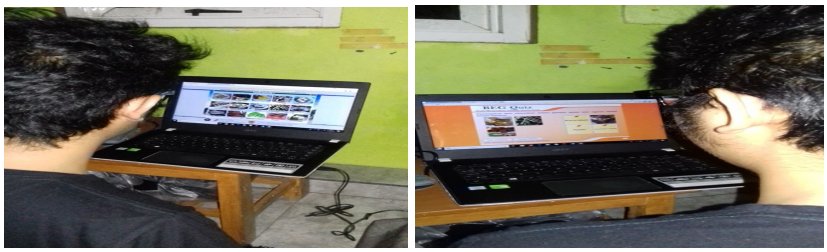

Fig. 9. Implementation of testing to one of the players

Twelve sample persons to use BEG applications with test results are presented in Table 5 and Table 6.

In Table 5 analyzed which menu is frequently accessed by players, the lowest or least accessed total is M1: Petunjuk Aplikasi with a total of 26. The Application Instruction menu is most likely not too often or rarely accessed because players tend to look for the way itself to playing apps and also the average player is an adult, so the App Guide Menu is only considered as a reference or regular instruction that indirectly does not read any player who has understood how to use the app. The menu is often accessed menu M8: Wadai Banjar 2 with a total of 59. Wadai Banjar 2 menu on the results of this analysis is a menu that is often accessed by players, the possibility that players like the form of material visualized in the form of images and text is good and interesting, and specificity in BEG applications This material section is located in Wadai Banjar 1 and 2 menus, as it is characteristic of regionalism.

Table 5. Result of frequency test accessing menu in BEG material section

Players	Initial Name	Menu Features							
		M1	*M2*	*M3*	*M4*	*M5*	*M6*	*M7*	*M8*
1	ZM	3	4	4	4	4	5	5	6
2	YA	2	2	3	3	4	4	4	5
3	SM	3	3	2	3	3	2	5	6
4	MN	1	2	3	3	4	5	4	7
5	MEiA	1	3	3	2	5	2	3	6
6	MEaA	2	2	3	4	4	3	3	5
7	MHA	3	3	2	3	5	4	4	4
8	MG	2	2	4	2	4	3	3	5
9	RAS	3	3	3	4	4	3	5	4
10	JI	3	2	2	2	2	4	3	3
11	LM	2	3	4	3	3	3	5	4
12	EPD	1	2	3	2	4	3	4	4
Total		26	31	36	35	46	41	48	59

Table 6. Result of frequency test accessing menu in BEG material section

Players	Initial Name	Quiz Features						Score
		K1	*K2*	*K3*	*K4*	*K5*	*K6*	
1	ZM	3	3	2	2	1	0	100%
2	YA	1	0	2	3	0	1	90%
3	SM	3	2	1	1	0	0	80%
4	MN	1	0	0	0	1	1	80%
5	MEiA	2	0	0	0	0	2	80%
6	MEaA	1	2	3	1	1	1	100%
7	MHA	2	2	3	1	1	0	100%
8	MG	1	1	1	2	1	1	100%
9	RAS	1	0	1	2	1	1	90%
10	JI	2	0	0	0	0	1	100%
11	LM	3	1	2	0	0	2	70%
12	EPD	2	1	1	1	0	1	80%
Total		21	12	16	13	6	11	89.17%

In Table 6 analyzed is how often players rearrange answers when answering a quiz based on quiz types. Based on Table 6, the quiz that is often rearranged by players is K1: Drag and Drop quiz with a total of 21 reset. Drag and Drop here may be a rather difficult quiz type because of the way layout between the image object and the name object that should match it, the player in this case tends to hesitate to put the image to the name object and is released to another name object, resulting in the player must reset the answer. Quizzes that rarely rearrange the answers by players are K5 quiz types: True or False with 6 reset totals. This type of quiz True or False is quite easy because there are only two choices of objective answers, and questions or statements presented there are some players tend to have been known. Then reviewed from the final result after the quiz works, the player provides excellent feedback as evidenced by the average score obtained is 1070/12 = 89.17%.

6 Conclusion

Through this research has been successfully done the design and implementation of educational game applications called Bekantan Educational Game (BEG) which can be recommended for use as a medium of learning Banjar language. It has been tested for twelve players. Based on testing with black box testing that all the functionality in the BEG application matches what is expected. Based on the results of the analysis of players, players are more interested in material that has visualization of images and text than text only because the proof is on the analysis of how often the menu is accessed in M8: Wadai Banjar 2 menu with a total of 59 times access. The result of player behavior analysis on frequency reset the answer on the quiz, got K1: Drag and Drop quiz with 21 times reset. With the quiz, the player has provided excellent feedback with an average end score of 89.17%.

7 Limitations and Future Work

Current research focuses on the design and implementation of Bekantan Educational Game (BEG), its implementation is still on BEG using desktop and web based, then testing is done by black box testing method, frequency of accessing menu test in BEG part of material, and frequency of reset quiz in BEG quiz section. In the future, BEG applications are also expected to be implemented on a mobile base, test white box testing, usability testing, and evaluate the implementation of BEG to the general public.

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Android-Based Mobile Application for Door-to-Door Product Delivery

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Abstract—Many companies, such as Aramex, FedEx, and SMSA, offer product delivery services. However, the delivery process through these companies is costly and/or requires the customer's physical attendance at the company to get the sent shipments. There is a persistent need to improve the delivery process in Saudi Arabia to reduce the effort, cost, and time that the customer spends to get the shipped products. This paper presents a new delivery approach in Saudi Arabia by developing an Android-based MobApp that allows the customers to use their mobile devices to send and receive shipped products at their doorstep by submitting online requests through the developed MobApp. The proposed MobApp, named as Door-to-Door (D2D) product delivery MobApp, guarantees fast and costless service among its competitors. The MobApp will provide its customers a reliable delivery process. It aims to provide a domestic delivery chain with whomever to wherever within Saudi Arabia. In addition, the proposed delivery MobApp allows the customers to create, update and track the delivery orders. Moreover, the proposed D2D delivery MobApp is easy to install and use, it provides a friendly GUI and has a powerful steady performance.

Keywords—MobApp, delivery process, shipped products, quality attributes, use cases.

1 Introduction

Mobile devices became the sole gatekeeper for many valuable personal information [1]. The global dissemination of mobile devices has changed the peoples' data utilization behavior during the last decade [2]. In addition, developing mobile applications (MobApps) has emerged as one of the most focused software industry areas [3]. Today, mobile applications are considered as an integral part of human's daily life [4]. The growing popularity of technologies and MobApps are leading many companies to de-

velop strong relationships with customers through MobApps [5]. Today, many companies are using MobApps to support various activities in several sectors, such as education and industry. Android OS incorporates third-party applications that run on the top of Android-based mobiles [6]. This OS has many advantages over simplicity, extensibility and flexibility [7].

Recently, people use the latest technology and devices to perform their daily duties. One of these duties is buying online by placing online product orders. People place online orders while they are at home. However, approximately 33% of consumers are away from their houses, and most of these people are below 35 years old [8]. The aim of this paper is to propose and develop an Android-based MobApp to integrate the features of different types of delivery services in one spot. The system will serve customers whom would like to receive commercial or personal products to their doorstep, which may include purchased electronic devices, household items whether from a supermarket or a local shop, as well as pre-ordered food delivery service. Additionally, customers may request an item delivery such as personal devices, furniture and envelopes directly from their work or residence to others within Saudi Arabia. The proposed MobApp provides a convenient and affordable delivery service that serves customers within the city boarder and between different cities within Saudi Arabia. It provides an alternative solution to solve some of the problems such as waiting in long queues at outlets to receive the sent items and to minimize driving and traveling times of customers by extending coverage of the delivery services.

The rest of this paper is organized as follows. Section 2 briefly reviews current MobApps in the area of product delivery. Sections 3 introduces the proposed D2D delivery MobApp. Section 4 presents the implementation and testing of the proposed MobApp. Finally, Section 5 draws the conclusion and possible options for future works.

2 Literature Review

It is worth mentioning that consumers still more commonly use mobile devices to place their orders for takeaway/home delivered meals rather than ordering by computer. A Survey work showed that 57% of respondents had ordered by mobile and 36% had ordered by computer [9]. Overall, 83% of respondents had ordered takeaways and other home-delivered meals directly from a restaurant at some time, while 43% had placed such an order through a third-party platform provider (such as Deliveroo or Just Eat) [9]. However, online ordering has increasing rapidly in recent years, and is expected to continue to do so. Domino's (the pizza chain) which has developed an advanced online ordering system and application generates almost 80% of all its UK deliveries from online ordering. Third-party platforms such as UberEats, Deliveroo and Hungry House also helped to facilitate growth in online orders and facilitated several smaller restaurants to attract online customers [8]. There are quite several good examples of delivery applications currently in business. Some of these applications, such as UberEAT, Careem, and Shop&Ship, have inspired the idea of creating the proposed delivery MobApp. These applications have different features. This section reviews three similar delivery applications and exploring the capabilities and services they provide.

2.1 UberEats

UberEats [10] is a food delivery service was extended from Uber limousine service. UberEats has hundreds of restaurants to choose from. When the customer uses the restaurant's application, he/she can scroll through the feed for inspiration or search for a particular restaurant. When the customer finds something he/she likes, he/she taps to add it to the cart. When the customer is ready to check out, he/she will see his/her address, the estimated delivery time, and the price of the order including tax and booking fees. When everything looks right, the customer just taps "Place order" and that is it. A nearby UberEats delivery driver–on a car, on a bike, or scooter–will go to the restaurant to pick up the customer's order. The customer will be able to see the name and the photo of the driver and track the order on the map. UberEATS guarantees about 30 minutes as a delivery time with no delivery fees [8]. Figure 1 illustrates UberEats application selecting "delivery pick up options" and "delivery location" screens.

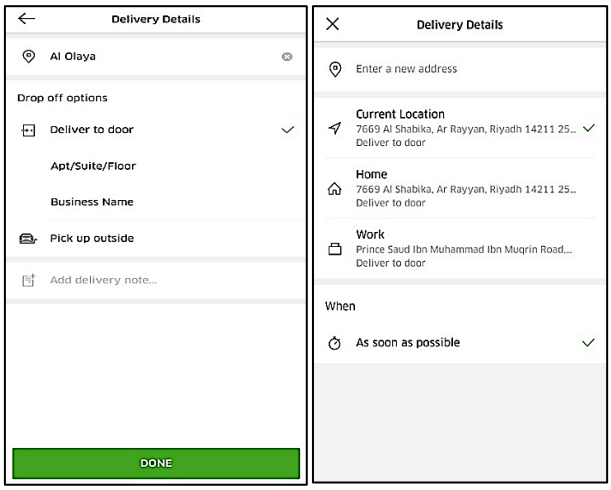

Fig. 1. UberEats application: Selecting delivery pick up options and delivery location

2.2 Careem box

Careem [11], which operates in major cities such as Riyadh and Dubai, has released a new delivery service called "Careem Box" for sending, tracking, and receiving small items, such as keys, documents, pharmacy pickups, and even a pair of shoes just booking a box. When you need an item to travel across a town, you book a box by selecting it from the car type menu. The nearest bike will be matched with you and you will see an estimated time of delivery and fare estimate. You can track your items in a real time as they travel. In addition, once the delivery is made, the delivery driver is charged to your Careem account and you can pay the way you want: cash, card or credit [11]. Figure 2 illustrates Careem application "user account menu" and "pickup location map" screens.

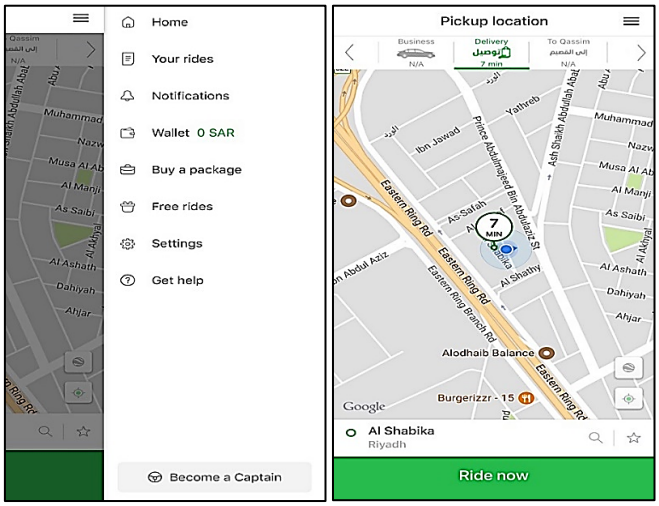

Fig. 2. Careem application: User account menu and pickup location map

2.3 Shop and ship

Shop and Ship [12] is currently available globally in over 80 destinations. Once registered with Shop and Ship, you get 24 personalized physical addresses in several global locations. You can use these addresses to shop from different countries and it will be delivered to where you live. The customer may order online from any retail shop located overseas or within the country using the provided address by Shop and Ship application for delivery. The requested items from Shop and Ship warehouse will be dispatched to the customer's home or work address as ordered. Figure 3 illustrates Shop and Ship application "Login page" and "user account" screens.

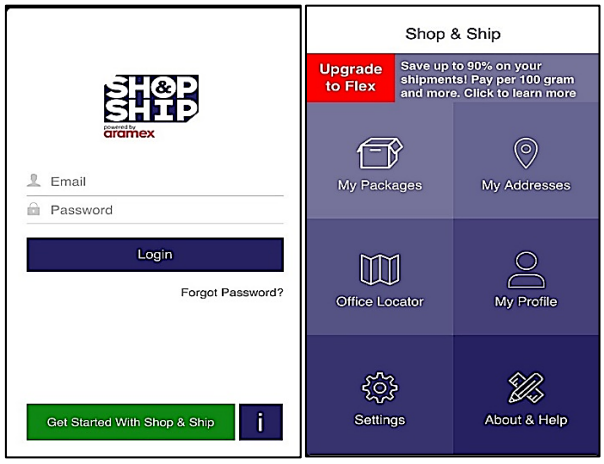

Fig. 2. Shop and Ship application: Login and user account pages

3 Proposed Product Delivery MobApp

This section provides a full description for the proposed D2D product delivery MobApp. The key functions of the proposed MobApp and the main services that provided to the customers along with the types of the users who can interact and use this MobApp will be discussed. The software requirements (Both functional and non-functional requirements) and the environment Platform and assumptions will be discussed in this part as well.

3.1 Proposed MobApp functions

The proposed D2D product delivery MobApp offers simple and effective navigational process through the application functions that include:

- New customer registration.
- User pickup and desired delivery locations.
- Flexible delivery schedule.
- Shipment tracker dialog.
- Notification emails upon shipment request approval.
- Summary of last requests.
- Different payment methods.
- Customer evaluation of the level of service.

3.2 Types of users and main services of D2D product delivery MobApp

Three classes of users will be able to use the proposed D2D product delivery MobApp; these types are customer, administrator, and employee classes. The customer is the primary focus class for the proposed MobApp where the main goal of this MobApp is to make customers able to send and receive product shipments by submitting online requests. The administrator has full controls over all activities being performed by customers. In addition, the administrator has the ability to view, edit, add and delete any service from that offered services list. Moreover, the administrator can handle the help requests, feedbacks, and complaints received from the customers. The Employee is responsible to pick up and deliver the package and the administrator assigns an employee for each shipment request. Figure 4 illustrates the key users of the proposed D2D product delivery MobApp.

The proposed D2D product delivery MobApp is where customers can send and receive shipments such as envelopes, household material and devices, and personal and business-related packages. The delivery process through D2D delivery MobApp does not require customer's physical attendance, rather, customers are able to send and receive the sent shipments at their doorsteps by submitting online requests. Upon initial installation of D2D delivery MobApp, a customer will have to register to the service. A new registration requires assigning unique customer ID, and during the registration process, customers will add their addresses and contact information, login password, and accept service terms and conditions.

Once an account is created, a confirmation email is sent to customer email address. Afterward, a customer will fill out a request form for each new shipment that include information about the package, as well as the required pickup and delivery address, and date and time of product delivery. Next, D2D MobApp admin will review the created shipment request and assign an employee for pickup and delivery this shipment. When the employee is assigned, the customer will receive a confirmation email with delivery timeline. D2D MobApp allow customers to track their shipments, and update and cancel current requests prior to be processed. The system provides two payment methods to close out the shipment request, a customer will choose to pay in cash upon delivery or at pickup time, or submit an online payment using a credit card. At the end of each delivery, the customer will be able to submit a service feedback, evaluate the service, and submit a complaint. Shipments' history record will be available under each customer account for preview and future references. Further, the customers of D2D delivery MobApp have the right to update their account information as required, and include their shipment address and contact details. The following subsections describe the main counterparts of the proposed D2D product delivery MobApp.

Customer: The customer can send and receive product packages through the D2D delivery MobApp. If the D2D MobApp serves the customer needs then the customer will use it repeatedly. Upon each request, a customer should provide details of date and time, and pickup location and the shipment destination. Cost is calculated based on the size of the package and the delivery destination.

Employee: The employee is the person who is responsible to pick up and deliver the package. To fulfil a customer request, the employee acquires accurate information to complete the task properly, such as package pickup location and delivery destination. In addition, he/she must check that the content of package meets the package information submitted online by the customer.

Administrator: The administrator sets rules and conditions of the delivery process, monitor package delivery and provide customer support. In addition, the administrator updates the MobApp features according to customer feedback and business demand, and updates the delivery cost when deemed necessary to maintain market share value.

Package: The package size and content depend on the customer selection. The package specifications must be described clearly in the customer delivery request including the dimension and weight, so the administrator can plan the delivery process and assign an employee for pickup process. Furthermore, the payment of the package delivery depends on the package specification, more specifically, on the package size and delivery distention.

Request: The request submitted by the customer contains the package size and content and the pickup and delivery location. The request specifies the time of pickup and the acknowledgment of receiving the package by the employee. When the customer submits the request, he/she can monitor the request status and evaluate the service once concluded.

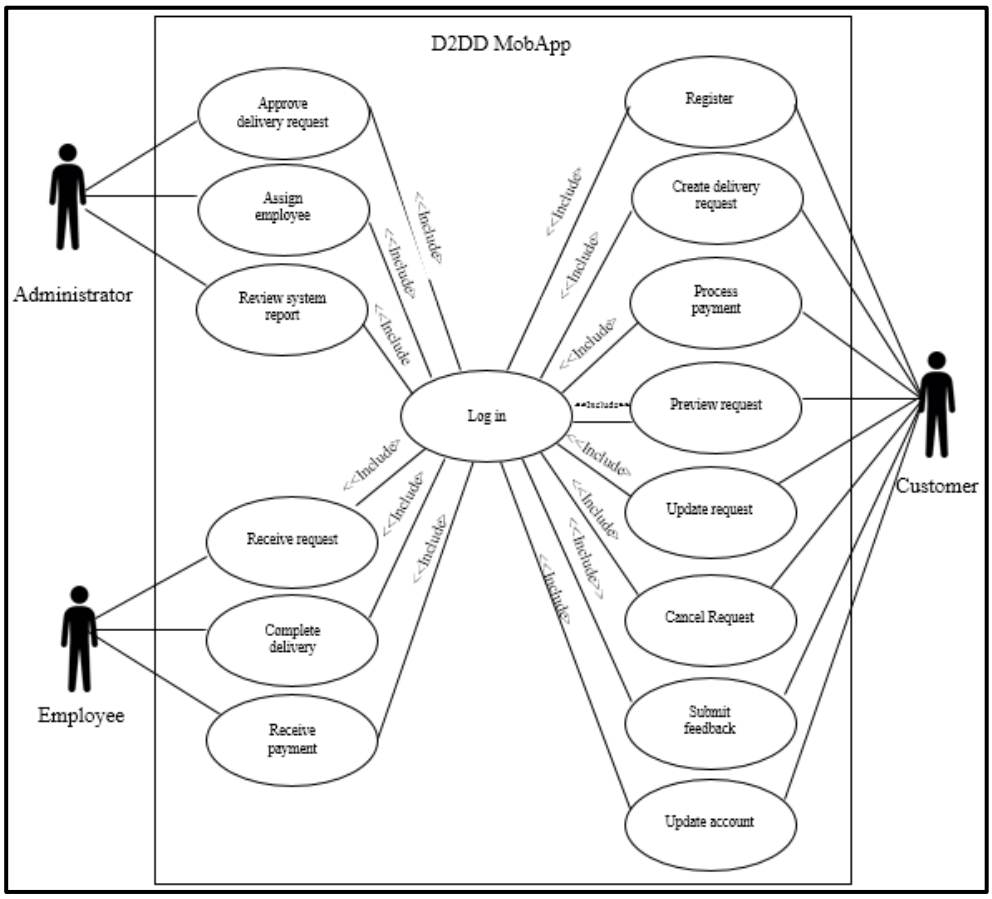

Fig. 3. Use Case Diagram of D2D product delivery MobApp

3.3 Software requirements

In this section, both functional and non-functional requirements of the proposed D2D delivery MobApp will be discussed.

Functional Requirements (FRs): As mentioned early, the proposed MobApp has three types of users: customer, administrator, and employee. Each user has different functional requirements. This part gives the key FRs for these users.

FR1: Creating a new user account (i.e., registration) including the following:

- Event/Use Case: Creating a new user account.
- Description: The MobApp allows users to create new accounts to use the application.
- Rationale: The customer needs to download the D2D delivery MobApp and enter valid data.
- Fit-criteria: The application successfully created a new account for the customer.
- Dependencies: None.

- Conflicts: None.

FR2: Creating a Delivery Request including the following:

- Event/Use Case: Creating a delivery request.
- Description: The MobApp allows customers to create a new delivery request. The customer fills up the request information (source, destination, time …) and receives a confirmation message after the request successfully submitted.
- Rationale: The customer needs to register to the D2D delivery MobApp.
- Fit-criteria: The application successfully accepted a new delivery request.
- Dependencies: FR1: Registration.
- Conflicts: None.

FR3: Paying delivery fees including the following:

- Event/Use Case: Paying delivery fees.
- Description: The MobApp allows customers to pay fees of their delivery requests. The customer reviews the request, the application displays the payment options, and the customer chooses and pays by a suitable method. The application validates the payment method and sends a notification message to the customer.
- Rationale: The customer needs to put a delivery request first through the D2D delivery MobApp.
- Fit-criteria: The application successfully accepted the payment process.
- Dependencies: FR2: Create a delivery request.
- Conflicts: None.

FR4: Track request including the following:

- Event/Use Case: Track request status.
- Description: The MobApp allows customers to track their active requests statuses.
- Rationale: The customer needs to create a delivery request and pay the fees through the D2D delivery MobApp.
- Fit-criteria: The application successfully shows the active requests statuses.
- Dependencies: FR2 & FR3: Create a delivery request and pay the delivery fees.
- Conflicts: None.

FR5: Update request order including the following:

- Event/Use Case: Update request.
- Description: The MobApp allows customers to update their delivery request orders. The customer changes the request information (source, destination, time …) as necessary and receives a notification message after the request successfully submitted.
- Rationale: The customer needs to put a delivery request through the D2D delivery MobApp.
- Fit-criteria: The application successfully accepts the update on the request order.
- Dependencies: FR2: Create a delivery request.
- Conflicts: None.

FR6: Cancel request order including the following:

- Event/Use Case: Cancel request order.
- Description: The MobApp allows customers to cancel their delivery request orders before the administrator confirms the requests.
- Rationale: The customer needs to put a delivery request through the D2D delivery MobApp.
- Fit-criteria: The application successfully cancels on the request order.
- Dependencies: FR2: Create a delivery request.
- Conflicts: None.

FR7: Submit feedback including the following:

- Event/Use Case: Submit feedback.
- Description: The MobApp allows customers to evaluate the service and submit feedbacks and complaints. Once a customer submitted a feedback or a complaint, the application validates feedback/complaint entry and accept the request.
- Rationale: The customer needs to create a delivery request and pay the fees through the D2D delivery MobApp.
- Fit-criteria: The application successfully accepts on the feedback/complaint request.
- Dependencies: FR2 & FR3: Create a delivery request and pay the delivery fees.
- Conflicts: None.

FR8: Update account including the following:

- Event/Use Case: Update account.
- Description: The MobApp allows customers to update their personal information. Once a customer submitted the new information, the application validates the information entry and sends the customer a notification message.
- Rationale: The customer needs to register to the D2D delivery MobApp.
- Fit-criteria: The application successfully accepts the new customer information.
- Dependencies: FR1: Registration.
- Conflicts: None.

Non-Functional Requirements (NFRs): The proposed D2D delivery MobApp has been developed to operate in different operating conditions, such as different supported screen resolutions and network bandwidth situations and network types (3G, 4G, and Wi-Fi). In addition, important technical issues were taken into consideration to achieve an acceptable performance level of the proposed D2D delivery MobApp. It is highly recommended for the user of the proposed MobApp to regularly check the Google Play Store for any new security updates. Additionally, the user should download a well-known anti-virus application to protect his/her mobile device from any Internet viruses, malware and unlicensed applications that may steal his/her identity. Moreover, a list of non-functional requirements (NFRs), known as quality attributes, were taken into consideration. This section presents these NFRs:

- Usability: The proposed D2D delivery MobApp is ease to use: users can perform the operations of the MobApp in a simple way.
- Availability: The proposed MobApp is available 24 hours a day, 7 days a week, and provides the delivery process during the working hours.
- Look and feel: The application interface is simple and does not contain many colors.
- Efficiency: The proposed MobApp performs all the required services properly.
- Compatibility: The proposed MobApp is compatible with Android-based devices with Android version 5.0 and above.
- Cultural: The language used in the proposed MobApp is a formal one (English).
- Security: The proposed MobApp allows users to access the application functions only after they login to the system. In addition, the proposed application sends the users a system message when any activity is executed, whether successfully or not. In addition, the users' private information is securely encrypted.

3.4 Environment platform, constrains, and assumptions

The proposed D2D product delivery MobApp will run on all Android devices with version 5.0 and above. The MobApp is developed using Android Studio platform and its supporting library, besides Java PL. A set of constraints were taken into consideration during the design and implementation stages. These constraints include the following:

- Customers and employees are responsible for their profile contents, usernames and passwords
- Customers should provide the accurate information of location and contents of packages.
- Customers have to approve the delivery process after the delivery.
- Employees are responsible for the package safety during the delivery process.
- Employees have to verify the payment accuracy.
- Employees have to guarantee pickup and delivery process.
- Verification of package recipient will be via a confirmation code.

To accomplish the success of delivery, the delivery process should stick on the requirements and follow some assumptions. These assumptions were selected to support the implementation and to avoid any problem might produce problems for the proposed MobApp. Following are summarizing a list of the selected assumptions:

- The mobile operation system is Android (v. 5.0 or later).
- The proposed MobApp supports English language.
- The proposed MobApp uses Map to serve the source and destination of delivery.
- Delivery scope will be initially in Riyadh city.
- Customers and employees should be familiar with Android operating system and Google Map application.

4 D2D Delivery MobApp: Implementation, Testing and Discussion

This section provides all the details about the implementation of the proposed D2D product delivery MobApp, the testing results and evaluation.

4.1 Implementing D2D product delivery MobApp

As mentioned before in the previous sections, customers can send and receive the sent shipments at their doorsteps by submitting online requests through the proposed D2D delivery MobApp. The proposed MobApp runs on all Android devices with version 5.0 and above. It is important to notice that to avoid any conflict and to make sure that the database will remains consistence all the time, the proposed MobApp was developed to be with a direct connection with the centralized database server. Moreover, using a direct connection will guarantee that any executed delivery process from the MobApp side will be directly reflected on the centralized database. This guarantees that the database will be always up to date. Figure 5 illustrates the structure of the D2D product delivery MobApp.

For successful operability and stability, the developed MobApp is linked to a sustainable online database, called "Firebase", which is provided by Google. The "Database Handler Java" classes created via Android Studio linked via Google API file. The database schema of the developed MobApp uses Firebase JSON tree structure; here are no tables or records. That is, when you add data to the JSON tree, it becomes a node in the existing JSON structure with an associated key.

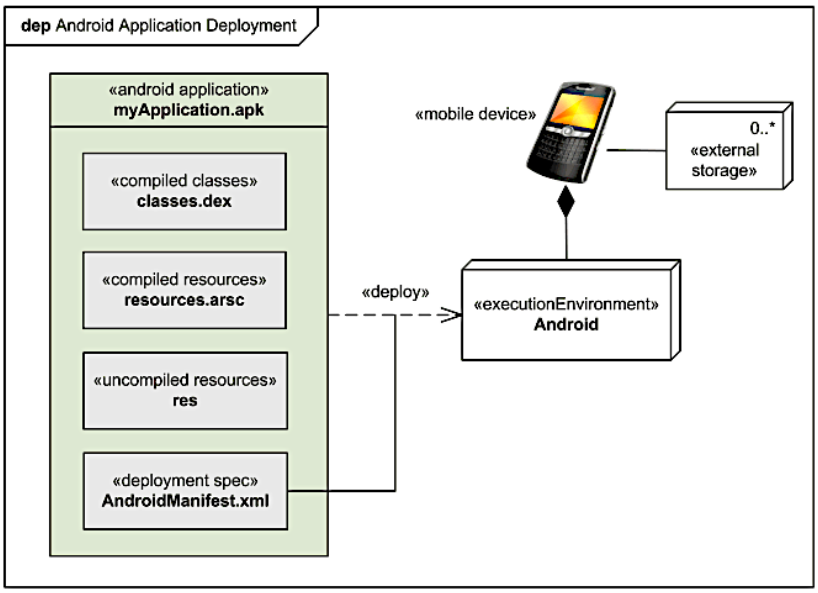

Fig. 4. The architecture of D2D product delivery MobApp

4.2 D2D delivery MobApp interface

The D2D product delivery MobApp successfully achieved all the mentioned requirements and services mentioned in Section 3. This sub-section illustrates the GUI for some of the MobApp services. Figure 6 shows the welcome and login screens of D2D MobApp. The welcome screen shows the first page the MobApp user will see when opening the D2D delivery MobApp, this screen splashes for 4 seconds then application switches the view to login home screen. The Login Screen allows the MobApp user to select whether to access as a customer, an administrator or as an employee. Upon selecting the user type, the second login screen will appear to allow user entering access cardinality.

Fig. 5. Welcome and Login Screens of D2D MobApp

Figure 5 shows the customer registration and homepage screens. The customer registration screen shows the case when the customer uses the D2D Delivery MobApp for the first time, he/she will be accessing the registration form through the user login page. The customer enters his/her details and click the register button. Upon clicking register, the customer is directed to the homepage of the D2D Delivery MobApp. The customer homepage screen allows the customer to preview his profile information, check the requests that he/she have created, and create new requests.

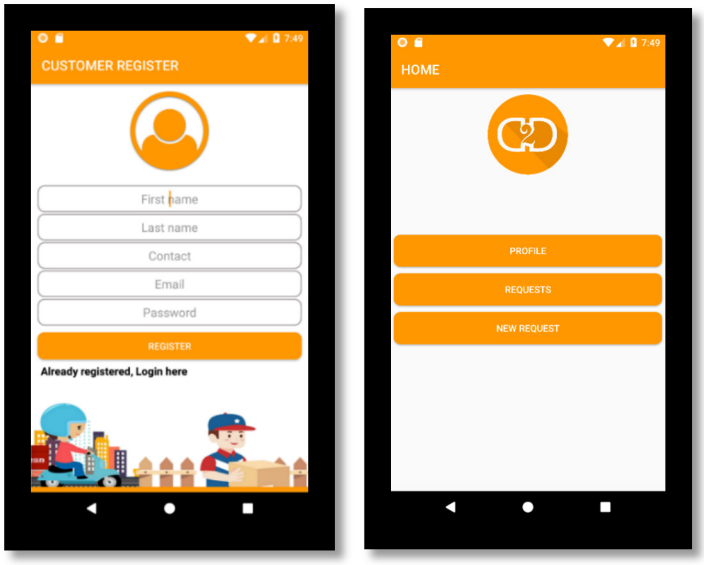

Fig. 6. The Customer Registration and Homepage screens

Figure 7 shows the screens of the new delivery request and the list of customer requests. The new delivery request allows the customer to add the details of the package, such as the package type, specific package weight and the package description. Additionally, the Google map appears to allow customer allocating his/her exact location for easy delivery process. The list of customer requests screen shows the created requests by the customer. The details of the request allows the customer to follow up on the request to the complete delivery.

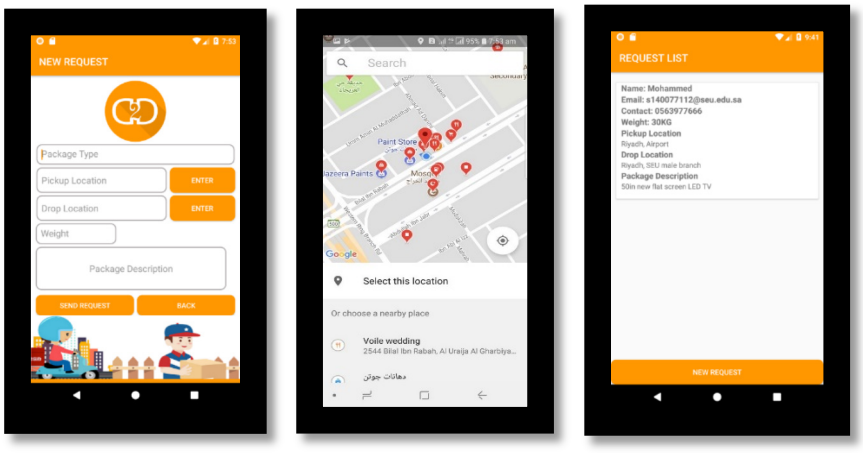

Fig. 7. The new delivery request and the customer requests List Screens

Figure 8 shows the screens related to the MobApp administrators and employees. The Administrator homepage screen provides two main functions: adding new employees and reviewing the customer requests in order to process the delivery requests. The list of new requests screen shows the list of all customers' requests that appear under the administrator account. The list contains detailed information about all requests. The employee homepage screen shows two main functions: the profile view that shows the employee information and the list of customer requests. The employee can preview the details of all customers' requests assigned to him.

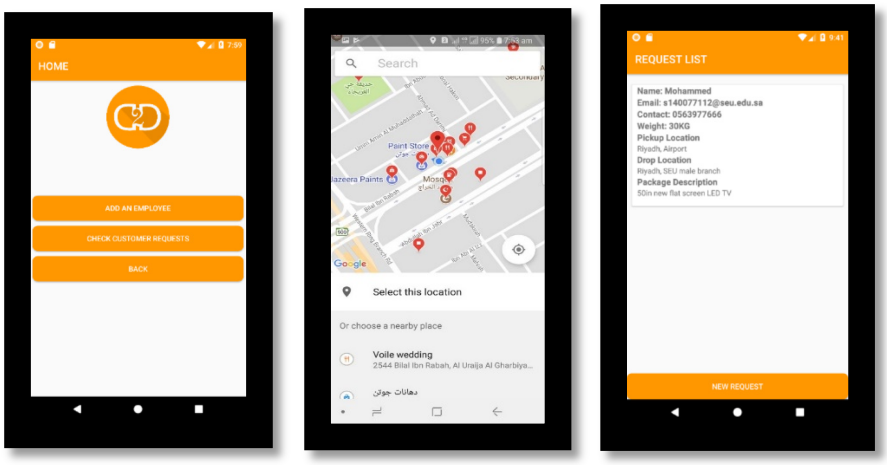

Fig. 8. The screens of the administrator Homepage, the list of New Requests, and the employee Homepage Screen

4.3 Software testing

Different tools and devices have been used to test the developed D2D delivery MobApp, such as Android Studio and mobile phones with Android operating system. Testing has been performed by using the Black Box testing, where the test cases were performed without any knowledge of the MobApp code. Testing was performed for all users, where different cases were performed. All services of the developed MobApp were tested to show their accurate functionality. In addition, regression test cases were performed to uncover any bug or defect in the existing functions of the MobApp after correcting the found errors. This section lists the conducted test cases related to the developed D2D product delivery MobApp functionality.

Table 1. Test Case 01: Customer Registration

Identifier	TC-1 (Customer Registration)
Priority	High
Related Requirement	UC-1 (Register)
Short Description	Customer Registration to D2D Product Delivery MobApp Test Case
Pre-condition	Welcome screen will splash, login homepage opens for selecting the user type, then at the user login screen, a button is pressed to register a new user.
Input data	User name, customer contact, customer email, customer new password
Detailed steps	The customer will add his name and contact number, email address and new password, then press signup button.
Expected results	The screen popups notifying a successful registration if the entered data is correct.
Post-condition	The user will click on login if registration is successful or update the entered information and click register again.

Table 2. Test Case 02: Customer Login

Identifier	TC-2 / Customer Login
Priority	High
Related Requirement	UC-1 / (Register)
Short Description	Customer Login to D2D Delivery MobApp Test Case
Pre-condition	The customer uses the registered email address to login to the service
Input data	Email address and password
Detailed steps	The customer enters the email address as registered and fill-in the password, then clicks sign-in button.
Expected results	The MobApp opens the customer homepage and a successful sign-in short message will appear to the customer screen.
Post-condition	Customer input valid information and click sing-in

Table 3. Test Case 03: Customer Create New Request

Identifier	TC-3 (Customer Create New Request)
Priority	High
Related Requirement	UC-2 (Create Delivery Request)
Short Description	Customer creates a new delivery request through the MobApp
Pre-condition	Customer logged-in to homepage.
Input data	Package type, pickup and drop-off location, package weight, and package description.
Detailed steps	Customer clicks the new request button, the new request layout view will appear, the customer fills-out the request form with package details, adds pickup and drop-off location and includes package description, and then customer clicks send request button.
Expected results	Short message appears with statement request sent successfully; the view will change to customer homepage.
Post-condition	Delivery request sent successfully.

Table 4. Test Case 04: Customer Review Request

Identifier	TC-4 (Customer Review Requests)
Priority	Medium
Related Requirement	UC-4 (Preview Request)
Short Description	Customer Review Requests List Test Case
Pre-condition	Customer has created a delivery request before viewing the request list
Input data	Click on requests button in homepage
Detailed steps	When customer clicks requests button, the MobApp opens requests list. The customer will scroll through the page to find a particular request details.
Expected results	The requests list appears and the list of all created requests are listed with the details of each request.
Post-condition	Details of all delivery request appear.

Table 5. Test Case 05: Administrator Add Employee

Identifier	TC-5 (Administrator Adds Employee)
Priority	High
Related Requirement	UC-2 (Create Delivery Request)
Short Description	Administrator Adds Employee Test Case
Pre-condition	Administrator logged-in to homepage
Input data	Employee name, employee email and contact, and temporary password.
Detailed steps	Administrator clicks add employee button, the add employee form will appear, the administrator adds the employee name, contact details, and the email address with temporary password to be change by employee upon first log-in. the administrator then clicks add employee button.
Expected results	A short message appears showing that the employee has been added successfully and the view will be changed to the administrator homepage
Post-condition	The employee has been added successfully.

Table 6. Test Case 06: Employee Log-in

Identifier	TC-6 (Employee Login)
Priority	High
Related Requirement	-
Short Description	Employee Log-in to D2D Delivery MobApp
Pre-condition	Administrator adds the employee to the employees list.
Input data	Valid registered email address and password
Detailed steps	When the employee accesses the MobApp main page, he/she clicks the employee access button, the employee login page will open and the employee will add the registered email address and password then click sign-in button.
Expected results	Employee homepage will display on screen.
Post-condition	The employee logged-in to the MobApp.

4.4 Discussion

The developed D2D product delivery MobApp successfully achieved all mentioned services that should be provided by it. The MobApp was developed with a friendly GUI and is ease to use, where the customer can easily create delivery requests and track the delivery process, and the administrator can perform and monitor the operations of the MobApp in a simple way. The performed test cases have discovered and corrected the

found defects and proved the correctness of the developed D2D delivery MobApp. Moreover, the MobApp was developed to operate in different operating environments and support different screen resolutions and networks. In addition, the quality attributes were taken into consideration to strength the developed application.

5 Conclusion and Future Work

This paper presented a MobApp that aims to enhance the delivery service experience in Saudi Arabia. The customers can use the developed D2D delivery MobApp to request delivery of endless list of permissible products. The proposed delivery MobApp allows its customers to create, update and track their delivery requests. The MobApp reduces the problems raised by using current ways, such as time and cost. The D2D delivery MobApp has been successfully designed and implemented and it offers a user-friendly layout and easy navigation. In term of the efficiency, security, and quality attributes, the developed MobApp is found useful and efficient. Some options for future works include the following: the proposed MobApp can be upgraded to support other smartphone's operating systems, such as Windows and iOS. In addition, the MobApp can support Arabic language to cover a wider range of customers in Saudi Arabia.

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Smart Home: Power Electric Monitoring and Control in Indonesia

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Abstract—The development of the Internet of Things Industry in Indonesia is increasing rapidly from year to year. One of the uses in this industry is being able to carry out monitoring, control, and analysis. The smart home is one of the applications of IoT that is used in households to make it easier for humans to monitor and control all devices at home. Most homes in Indonesia have various commonly used resources; these are water, electricity, and gas. These resources will run out quickly if humans cannot use them properly. Therefore we need to monitor and control the resources we have at home. One of the resources that will be monitored and controlled in this study is electricity resources because it is more widely used in every corner of the house and almost all household devices use these electricity resources.

This research proposes a way to do electricity use effectiveness with monitoring and power control using cloud-based IoT. The proposal discussed in the paper is expected to have other benefits besides saving electricity resources, but it is also expected to reduce the cost of energy use at home.

Keywords—Monitoring and controlling, power electric system, smart home, IoT

1 Introduction

Internet of Things (IoT) is a fast-growing topic because the concept of IoT can potentially affect the way we live, but it also affects humans at work. IoT provides a powerful tool not only connected with wireless communication devices but wireless sensors for utilities needed in homes are better for managing energy use [1].

Technology that is growing rapidly makes a role in building dream homes to increase the comfort and safety of residents. Home automation systems are currently very popular and widely used by many people. Human needs for electricity are also very high, almost all household appliances use electricity. Many people cannot control electricity usage in their own homes. In addition, the use of electric power cannot be seen in detail but can only be seen as a whole when paying electricity bills. Another thing that might happen is an electric leak that is unknown to the user.

Smart House can be one solution to the problems described above. Using Smart home, we can also monitor household appliances remotely [2]. Smart home networks

can be integrated to fulfill the functions needed in homes and buildings[3]. But smart homes are not enough to make users aware of the environment. In addition it is one of the major challenges that appear in the smart home system based IoT is security issues [4]. Demand to monitor environmental factors almost in all research institutes, industries and even for domestic purpose [5]. Energy efficiency is a key to being able to control all devices at home that use electricity. This research will try to design power savings with IoT control on smart homes. Devices to be controlled such as monitoring electric power on all home devices, controlling lights, TV, air conditioning, dispensers, and fan.

The design of electric power control that has been made, in the future can be implemented by utilizing existing smartphone applications such as telegram and other social media to make it easier for users to access and control all their home devices. The control can be done by making use of smart phones we have, using a Wi-fi signal [6]. Energy control can also be used to control room temperature when occupants of a house enter/leave home[1]. Besides that smart home also needs to be considered because it can improve the quality of human life [7]. Evaluation of datasets obtained through real life is also very interesting to discuss more deeply, this has been proven by other researchers [8] . The application of smart home will certainly have an impact on the behavior of residents and new perceptions [9]. This has been proven by other studies that prove that some people who have implemented this IoT-based smart home have their own motivations that need to be explored more deeply [10]. The results obtained from the existing smart home design implications can encourage future development [14].

2 Related Work

Smart Home can be interpreted as a residence that is equipped with the sophistication of information technology that can interact to respond to the needs of residents of the house by means of automating the device, comfort, security, savings. In conducting its operations, smart home needs to be assisted by computer devices and smartphone devices that we have [11]. Smart home designs can also utilize cloud platforms on household appliances [12]. The development of Smart home also needs to be learned about the habits of existing house occupants [13]. Smart home also needs to be seen in terms of security and privacy risk, previous research revealed that the risks found include risk with software and human behavior [10]. Smart homes will become one of the priority areas of strategic energy planning and national policy [14]. Monitoring can be accessed through the web or smartphone that we have. One of the uses of smartphone applications that can be connected with IoT devices is telegram [7]. Monitoring on a smart home can also be developed by creating a real-time schedule for home energy management [15].

IoT is a new concept that provides a series of services for the next wave of technological innovation [16]. The application of IoT has been widely used in various fields, one of which is health. In the world of IoT health combined with sensor devices, according to other studies, monitoring in the field of health based on distance can use

sensors to send data into software machines [17]. Data that has been collected from these sensors will be sent to the web server to be able to use web-based monitoring [18]. Wireless sensors are the main component, these devices affect the performance and accuracy of the network [19].

3 Purpose Method

This research will create a smart home design with the architecture described in Figure 1.

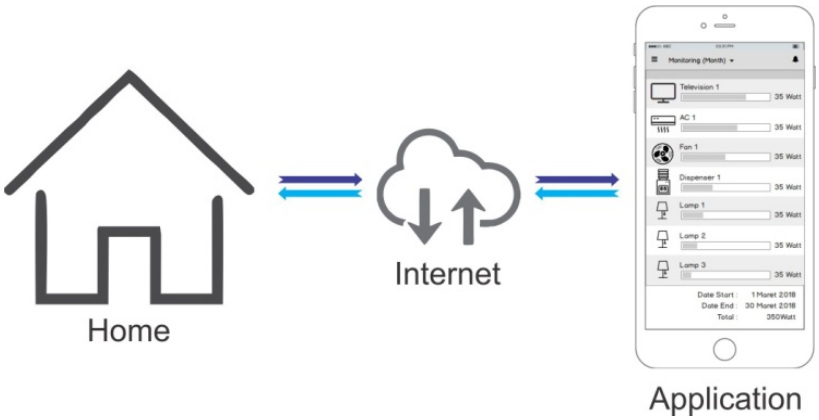

Fig. 1. System Architecture

In Figure 1 explains how the application can monitor and control the home via the internet, on each electronic device an electric current sensor will be installed to read the amount of electric current used by the device, then the data is sent via the internet and stored on the server so that the application can access the data, based on these data the application will process and display the results through notifications for power saving warnings. In Figure 1, there is 2-way communication, which shows that the application not only monitors the home but also can control electricity usage remotely.

3.1 Power save mode

Power saving mode is one of the methods used in this study in order to reduce excessive electricity usage based on the results of monitoring, this mode can be controlled manually on each household device or controlled through notification when the electricity usage has or will be over the limit, the working mode of power saving mode is using a PIR sensor and LDR sensor to monitor the state of the house, then the sensor data will be used by a microcontroller to turn off or turn on household devices via a relay automatically when the power saving mode is activated.

4 Results and Discussion

4.1 Smart home design

In this study, the design of the smart home on the side of the house was built using a set of microcontroller tools and sensors needed. In Table 1 will explain the details of the needs of the devices that will be used as the basis for the construction of a smart home.

Table 1. Microcontroller and Sensor Devices

No	Name
1	Microcontroller
2	Internet Module
3	AC Voltmeter
4	Relay
5	LDR Sensor
6	PIR Motion Sensor

The microcontroller is the main device that will be used in this study, which is a chip that functions as an electronic circuit controller. In the study [20][21] using the Arduino microcontroller in his research because it is an open source device so the costs used during implementation are quite cheap, in the study [22] they used the Raspberry Pi model B to build a medical treatment project at home, they also used the official Raspberry Pi operating system Raspbian, in this study [23] they use STM32F103 microcontroller for controlling smart home on a LAN network by utilizing wireless sensor network, According to this study [24] BeagleBone is a microcontroller that has high speed proccessing, and has a lot of input and output, but has a high cost. The internet module is a device used for communication between microcontrollers and servers on the internet, in the study [25] of welfare control and comfort in the room for aging population using ESP8266 and combining Arduino for processing and transmitting data to allow data to be accessed through web and via mobile applications in real time. AC Voltmeter is used to calculate the passing current so that power usage can be monitored properly. The relay is used as a circuit breaker that is carried out automatically through a microcontroller. LDR sensors are used to detect day and night through captured light and PIR motion sensors are used to detect the presence of people in the house.

Figure 2 shows the IoT architecture design that will be applied to the house, in that design uses examples of some common devices in Indonesia.

Figure 2 (a) is a part of the microcontroller in which wifi has been embedded to communicate with the server

Figure 2 (b) is a relay circuit that will function to disconnect electricity from the device, this relay will work in 2 conditions, the first condition is working according to the remote done by the user through the application, the second condition works automatically when the power saving mode is activated

Image 2 (c) is a voltmeter component installed in each channel of the socket, the purpose is to calculate the power used in each socket. Figure 2 (d) is part of a household device that is connected to a socket that has a voltmeter attached, this household device that will be controlled by electricity. Figure 2 (e) is a group of sensors that will be used as automatic relay control in Figure 2 (b), the sensor will only work if the power saving mode is activated, then the output of the sensor will rule the microcontroller to disconnect or connect the relay.

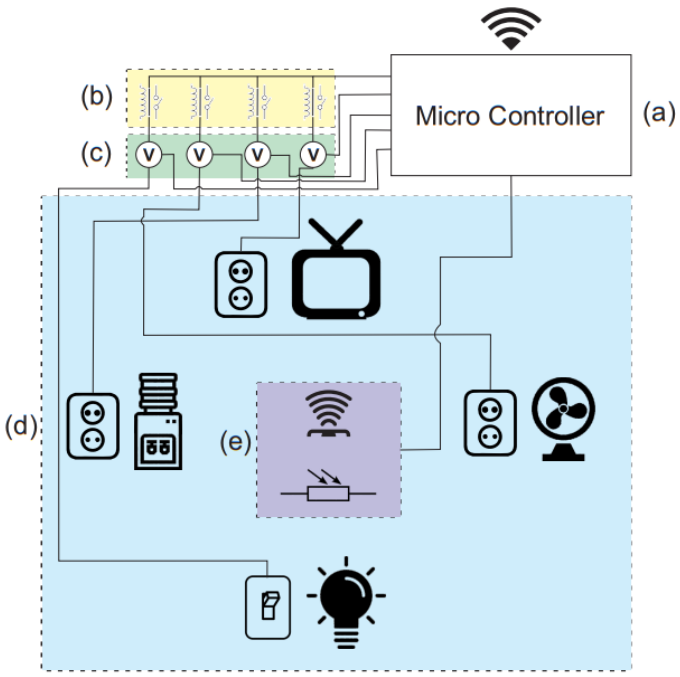

Fig. 2. Smart Home Design

4.2 Design of smart home applications

The mobile application is built to control and monitor household devices that have been connected to the microcontroller, each I / O pin number on the microcontroller is connected to the server so that on mobile devices only need to do pin number matching so that control and monitoring can be done with household devices right. In the application section, there are features that can be used to monitor the use of electric power and control electrical power, in Figure 3 will display the design requirements of the application.

Figure 3 (a) displays the main dashboard page of the application, on this page is displayed the total electricity usage for one month and a pie chart that contains data on the amount of electricity that has been used (marked with thick color) and the remaining electrical unused (marked with thin colors). Under the pie chart, there is data

that displays the total electricity usage for one day. At the bottom, there is a button to access important menus in the application. In figure 3 (b) displaying pages for adding household devices, household devices that can be added are devices that have been connected to a microcontroller and are connected to the server, based on the data server, then household devices can be connected to the smart home application using pin number I / O on a microcontroller.

In figure 3 (c) displays a page for controlling household devices, the control is to turn on and turn off household devices using the application, besides that there is a feature to edit and delete household devices that have been stored in the application. In Figure 3 (d) displaying a list of household devices connected with smart home applications, each household device can be seen for a total of one month's power usage, when the household device consumes too much electricity then the user can activate the save mode electricity by touching on the household device to be controlled, after that a popup will appear as shown in Figure 3 (g), the popup displays details of daily and monthly electrical power usage and a button to enable or disable the selected household device. In Figure 3 (e) displays the settings page to set the application to bring up a reminder in the form of notification as seen in Figure 3 (f), if the notification setting is activated the system will display a notification according to the electricity usage limit within one month and the percentage usage limit electricity. the electricity usage limit can be filled according to household needs, the goal is that he system is able to remind when the electricity usage is almost over the limit. By default the system will send a notification if the limit has been used above 80%, the percentage value can be set according to the user's wishes.

Fig. 1. Smart Home Mobile Application

4.3 Smart home application flowchart

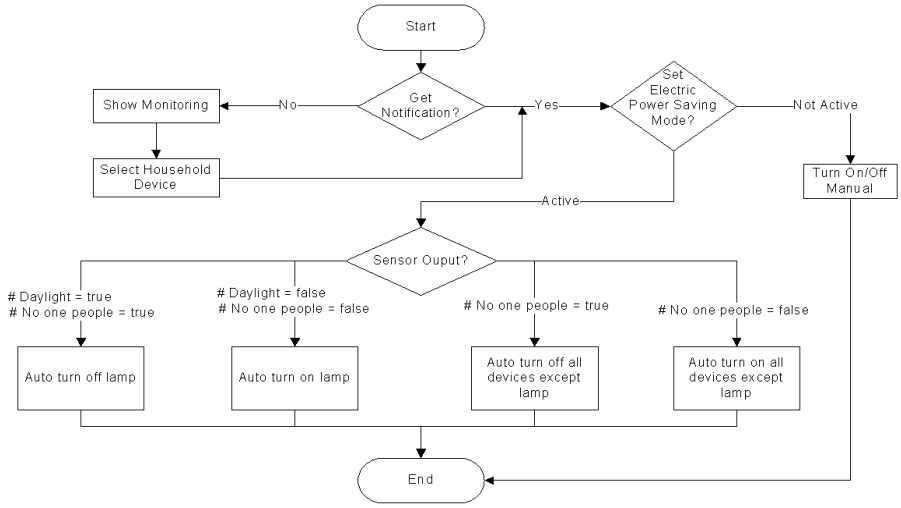

Fig. 3. Flow Smart Home Application

In this study, the application will be designed using a mobile application so that users can access from mobile devices. In Figure 4 describes the process flow of the smart home application in monitoring and controlling.

When the application is opened the first feature displayed is the power usage monitoring feature that has been used during the current month. In silent conditions the application still works and monitors power usage, if the power usage is approaching the limit automatically the system will give a notification to activate the electric power saving mode with the aim of reducing the level of usage of electric power. When the power saving mode is active, the output of the sensor will be noticed by the microcontroller, the infrared sensor will be noticed by the microcontroller to detect the presence of occupants in a space, the LDR sensor will be noticed by the microcontroller to detect daylight. If the room is uninhabited during the day, the microcontroller will order the relay to disconnect the power of the lamp so that the lamp device will turn off and come back to life when the occupants come back into the room during the day. If the room is not inhabited, the microcontroller will order the relay to disconnect all household devices except the lamp so that all household devices except the lamp will turn off and turn on again when the occupants reenter the room.

5 Conclusion

The steps and designs that have been made, are expected to be a new proposal, especially for the people of Indonesia in order to be able to control electric power using sophisticated equipment that can be controlled with a smartphone. This control can

affect the cost of electricity bills that must be paid every month. In the future, the application can be utilize GPS as a technique of tracking the position of the homeowner with smart home, so that the smart home can be detected when the homeowner will go home.

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