Delphi Technique Based Project Performance Framework for Mobile Phone Usage in Agricultural Practices

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Abstract

With the rapid development of Information and Communication Technologies (ICTs), data and information can be effectively generated, stored, analyzed, disseminated and used to support farmers and farming communities to improve agricultural productivity and sustainability. Information services for farmers at the national and regional level are a promising new field of research and application in the emerging field of e-agriculture. The development of ICT projects have increased in many agricultural fields to ensure that overall needs of farmer in business requirements are fulfilled. However, many ICT projects failed to take off such as a series studies produced. Reports suggest that the adoption rate of the small-scale farmers to technology is very low, in fact significantly about half in percentage. This is despite the significant impetus that phone and mobile driven gives to acquisition of necessary agricultural information. And yet, analyses of mobile phone based technology for agricultural development have presented significant gaps. Moreover, premised on the low adoption rates among farmers of all these mobile technologies, it has become apparent that a new mobile usage platform should be created and placed under keen consideration. There is evidently an impetus to initiate a mobile platform that would be built to take advantage and even synchronize all available technologies in order to present an efficient, timely, affordable and expedient mobile usage platform that would raise agricultural productivity. Using the Delphi technique is a way that such a technology can be conversed. A study was conducted on mobile phone communication in diffusion of goat rearing in Kitui in 2013. This study looked into the role played by the mobile phone in undertaking goat rearing. Another study conducted in Limuru sought to explore how dairy farmers can access credit better using mobile technologies. Though these aforementioned studies were focusing on mobile telephone technologies, there is limited evidence and information on developed framework for the mobile phone usage in agricultural practices in Kenya. Thus, a study on mobile phone usage and how it applied to agricultural practices was thus warranted. Thus, the aim of the paper was to use Delphi technique on development of a project performance framework for mobile phone usage in agricultural practices in Kenya.

Keywords: Delphi Technique, Performance Framework, Mobile phone, Project Performance

1. Introduction

Agriculture plays a significant role for economic and social development in most undeveloped countries. Information of adequate quality is a necessary condition for improvement of all areas of agriculture (Stoica & Brouse, 2013). With the rapid development of Information and Communication Technologies (ICTs), data and information can be effectively generated, stored, analyzed, disseminated and used to support farmers and farming communities to improve agricultural productivity and sustainability. Information services for farmers at the national and regional level are a promising new field of research and application in the emerging field of e-agriculture.

The development of ICT projects have increased in many organizations to ensure that overall needs of customers in business requirements are fulfilled. However, many ICT projects failed to take off such as a series studies (Ashraf, Sarfraz & Mohsin, 2010; Stoica & Brouse, 2013) produced. Stoica and Brouse (2013) states that due to the ICT project failure and its impact to the organization, researchers and practitioners are asked to specifically look at the history of how the project is carried out to find an effective approach and comprehensive to overcome this issue. Despite of having a lot of standard on project management methodologies in ICT, however up to most ICT project have yet to show a good track record of success (Marchewka, 2010).

As far as ICT project management tools for agriculture is concerned, farmers need to access information about new technologies before they can consider adopting them and thus look up to research and extension agents as sources of new technologies. Access to appropriate information and knowledge is an overriding factor for successful agricultural production and thus rural development. However, the traditional approach of providing agricultural information through extension services is
overstretched and under-resourced. Knowledge and innovation are now widely regarded as key drivers of economic growth and it is clear that information and communication technologies (ICTs) are deeply implicated in knowledge flow and innovation (Verlaeten, 2012). It is in working with and improving these information and communication systems that ICTs can be used to enhance the delivery of these services (ACACIA, 2012). They can do this by using mobile networks.

The Delphi technique has been shown to be an inexpensive way to combine knowledge from various experts who are spatially separated (McKenna, 1994; Mehnen, Mose, & Strijker, 2013; Powell, 2003). It has also proven to aid in facilitating group dialogue and the sharing of knowledge, while maintaining anonymity and minimizing group conflict (Gupta & Clarke, 1996; Stokes, 1997). One of the biggest strengths of the instrument is the ability to capitalize on expert knowledge about a particular topic (Mehnen et al., 2013). It is for these reasons that we employed the Delphi Technique in this study. The Delphi Technique has certain limitations. Researchers have argued that the ethical consideration of anonymity may reduce expert accountability, resulting in rushed and therefore less valuable insights from the expert panel (Gupta & Clarke, 1996; Powell, 2003). However, the Delphi Technique is also seen as a reliable alternative to generating ideas using focus groups, as panel members can freely express opinions without the potential judgment of others in the group (Mukherjee et al., 2015; Ruschkowski et al., 2013).

Delphi technique helped to achieve our objectives through its frame work, the Delphi, as a method for structuring a group communication process. This structure permits the process to be an effective way to allow a group of individuals such as farmers, as a whole, to deal with a complex problem.

2. Related Work

There are many previous studies on project management in which some were done as early as the 1950s whereas to date studies are still being conducted (Liu, Wu & Meng, 2012; Morris, 2010). However most of these studies had focused on organizations, people, procurement, technology, quality, philosophy, governance, value, performance management, knowledge management and project management office. Despite the focus given to various factors involved in project management, there still exists project failure mainly due to lack of methodology or technique (Stoica & Brouse, 2013).

Fitzgerald et al., (2010) observed in Cambodia and noted that it had developed a robust and cost effective “Electronic Marketing Communication System” (EMCS) based on text messaging. This enhances communication in agricultural areas and develops value chain by the use of SMS technology. It addresses the issues of cost, training and user literacy levels. EMCS project uses text messaging services to promote market communication and exchange between farmers and traders. EMCS using SMS technology to assist communication and exchange market information for better decision-making, between farmers and traders in the remote regions of Cambodia. Through SMS logs, researcher have a way of making a transactional information network, collecting data that can help them map and visualize transactions.

Accurate, timely and crucial information was central to the success of EMCS. It had the potential to improve outcomes for farmers and traders. This allowed retrieving information by sending predefined keywords to the SMS server via text messages. Auto reply content allowing what is referred to as Info-on-Demand sent by the requesting mobile user, the software automatically recognizes the keyword, retrieves the information from the built-in database and sends the requested information to the user. SMS server allows PUSH and PULL functionality, so users can retrieve information 24/7.

Similarly, in Bangladesh “Edu Phone” project is develop for farmers’ health care, education and agriculture business communication based on mobile ICT using TV and SMS from mobile phones. The system gives positive change in people’s life situations by providing means for increased control over everyday life. One prototype was developed to present information relevant to people over the mobile phone like information on diagnosing and treating diarrhea and handling arsenic-poisoned water. Furthermore African Sugar Research Institute collects weather data and generates irrigation advice that is automatically sent to local farmers by SMS. In the Indonesia, using an SMS-based contact center to support small scale farmers by SMS who receive automated price, weather information or can send questions via SMS to request information that are answered by agricultural experts (Hargreaves Dean M.G. and Toni, 2009).

3. Methodology

The proposed framework is made up of eight (8) components: that is, Agricultural database, Agricultural expert, User, User interface, Mobile phone, Front end, Back end and Agricultural practices. The dissemination of agricultural information is two-way where feedback is essential for the framework to work as shown by Figure 1.

A. Agricultural practices
This is the repository that contains the much needed information by farmers. It interfaces with the agricultural experts about agricultural inputs, soil data, research data, pests and diseases and information on market prices and the ICT tools in the dissemination of specific information.

B. Expert
This is the team of agricultural technical experts who should update the Expert KBS, interpret and disseminate the information to the farmers through ICT channels and information providers (extension services). The agricultural experts answer queries from the farmers.

C. Mobile phone
This is a device that is used by the farmers, agricultural experts and providers in the dissemination and exchange of agricultural information amongst themselves. The device interface between the various groups of stakeholders to deliver the much needed information and at the same time update the information from the database the mobile application is using the android operating system. By the use of android application the developer was able to develop the Delphi technique mobile application.

D. Database
This is used for the storage of information and processes the requests being made between the farmer, the Agricultural Expert, Knowledge Base information system and the mobile device, in the delivery of agricultural information. For example the extension workers, who have direct link to farmers can, benefit from agricultural expertise and information through the ICT devices. A database, My SQL database which is hosted locally through the local host XAMPP is used to store the information.

E. Database Structure
A database is an organized collection of data. Instead of having all the data in a list with a random order, a database provides a structure to organize the data. One of the most common data structures is a database table. A database table consists of rows and columns. A database table is also called a two-dimensional array. An array is like a list of values, and each value is identified by a specific index. A two-dimensional array uses two indices, which correspond to the rows and columns of a table.

In database terminology, each row is called a record. A record is also called an object or an entity. In other words, a database table is a collection of records. The records in a table are the objects you are interested in, such as the books in a library catalog or the customers in a sales database. A field corresponds to a column in the table and represents a single value for each record. A field is also called an attribute. In other words, a record is a collection of related attributes that make up a single database entry. Figure 2 gives an illustration of the database structure.
F. Database design
A good database design starts with a list of the data that you want to include in your database and what you want to be able to do with the database later on. This can be written in one’s own language, without any SQL.

G. Identifying Entities
The types of information that are saved in the database are called 'entities'. These entities exist in four kinds: people, things, events, and locations. Everything you could want to put in a database fits into one of these categories. If the information you want to include doesn't fit into these categories, than it is probably not an entity but a property of an entity, an attribute.

H. Identifying Relationships
The next step is to determine the relationships between the entities and to determine the cardinality of each relationship. The relationship is the connection between the entities, just like in the real world: what does one entity do with the other, how do they relate to each other? For example, farmer knowing animal diseases, plant diseases and their solutions.

I. Identifying Attributes
The data elements that you want to save for each entity are called 'attributes'.

| Expert | Farmer | plant | Animal |
|--------|--------|-------|--------|
| Name   | Name   | plant name | Animal name |
| Address| location| plant type | Animal type |

The experts give the required information that the farmers want to know, for example, what the animal disease is, plant diseases and their remedies. The Farmers register with their mobile numbers, their name, and address.

J. Database components

Software: This is the set of programs used to control and manage the overall database. This includes the DBMS software itself, the Operating System, the network software being used to share the data among users, and the application programs used to access data in the DBMS.

Hardware: consists of a set of physical electronic devices such as computers, I/O devices, storage devices, etc., this provides the interface between computers and the real world systems.

Data: DBMS exists to collect, store, process and access data, the most important component. The database contains both the actual or operational data and the metadata.
Procedures: These are the instructions and rules that assist on how to use the DBMS, and in designing and running the database, using documented procedures, to guide the users that operate and manage it.

K. Database Access Language
This is used to access the data to and from the database, to enter new data, update existing data, or retrieve required data from databases. The user writes a set of appropriate commands in a database access language, submits these to the DBMS, which then processes the data and generates and displays a set of results into a user readable form.

Query Processor: This transforms the user queries into a series of low level instructions. This reads the online user’s query and translates it into an efficient series of operations in a form capable of being sent to the run time data manager for execution.

Users: These are the farmers who use ICT devices (cell phone, computer) for voice based information and data for running their farming operations. The farmer can directly receive information but also sometimes through the information providers who can interpret information for them and advice on its application. User interface helps one to be able to register and login in into the application in order to access the needed service

L. Application developer
Helps in developing the application needed we used android mobile application in developing the Delphi technique for performance framework for mobile phone usage in agricultural practices.

Front end: The front end provides the interface to the users who are also farmers
Back end: The back end is used for the development of the application.

4. Results
Figure 3 shows the mobile application framework architecture where a farmer gets the Application service using a mobile phone, connected to the Internet. There is a Database where the farmer fetches expert information. The system operates on an Android operating system and uses MySQL as a database to be able to provide farmers with the necessary knowledge needed.

A. Mobile Framework Implementation
Figure 4 shows the startup interface. The farmer here signs up or logs in to be a user in the startup interface. This is the first interface that is accessible when a user loads the application. A user can either register or log into the system.
In the farmer registration user interface shown in Figure 5, the farmer gives his contact information.

In Figure 6, the login interface where the farmer or Expert gives the username and password is shown.

In the veterinary request help interface of Figure 7, the farmer requests a veterinary who is an agricultural expert for the service assistance. As shown here, the farmer clearly describes all the possible disease characteristics and the exact location, to assist the experts answer the farmer appropriately.
In the animal issue user interface of Figure 8, the farmer selects the main disease for the animal and the county where they are located within Kenya. This helps the experts to deduce the applicable cure for the farmer’s cow.

Other interfaces included plant issue user interface where the farmer selects the issues which he has with plants and his location, food and animal issue user interface in which the farmer selects the animal and food issues, the get Hotline issues services where the farmer gets hotlines services by a mobile phone registered in the system, and other issues interface in which farmers can give other additional issues they may be facing.

**B. Framework Database tables**

All tables contained in the database are displayed in the main interface. As shown in Figure 9, the database tables include counties, emergency issues, emergency reports, hotline contacts and user accounts table. The database is located in the local host (server) as XAMPP, containing any
C. Validation Tests of the developed Framework

To validate the framework, experimental tests were conducted on a mobile device—a smart phone—with android operating system, where the application was uploaded and several expert data inserted on the application. After installing the framework system developed (mobile application) several tests were done and resulted in the screenshots as shown. Figure 10 shows a query and result for a farm crop disease with yellow leaves and a response from the framework showing the disease is chlorophyll.

Figure 9: Mobile application database table stored in the Local Host-XAMPP

Operating system (X), an Apache server(A) for open source web hosting, MySQL (M) for the database, PHP (P) for web development and scripting language and Perl objects(P) for programming language.

Figure 10: Query and Response for Farm Crop Disease
Figure 11 shows a query and result for how to harvest maize and the result is to remove sacks.

![Query and Response for How to Harvest Maize](image1)

**Figure 11: Query and Response for How to Harvest Maize**

Figure 12 shows a query and result for types of irrigation.

![Query and Response for Types of Irrigation](image2)

**Figure 12: Query and Response for Types of Irrigation**

Figure 13 shows a query and result for best crop being maize and beans

![Query and Response Best Crops](image3)

**Figure 13: Query and Response Best Crops**
Other query and results included for a soil type as clay and a best crop for it as cassava, soil type and best crop type, which were loam soil and best crop being maize and beans.

D. Summary Experimental query and results of Framework tests done

Table 1: Testing farm crop issues

| Query                                      | Result                                      |
|--------------------------------------------|---------------------------------------------|
| Yellow Leaves                              | Chlorophyll                                 |
| Types of Irrigation                        | Sprinkling                                  |
| Best time to irrigate                      | Morning and Evening                         |
| How to harvest Maize                       | Remove sacks                                |
| Best Crops in Kitui County                 | Maize and Beans                             |
| Soil Type-Clay                             | Best in Cassava                             |
| Soil Type-Loam Soil                        | Best for Maize and Beans                    |
| Rotting of maize                           | fungus Colletotrichum graminicola           |
| wilting and drying up of middle leaves     | Not enough water                            |
| Browning leaf                              | Poor drainage holes                         |

Table 2: Testing Animal diseases

| Query                                      | Result                                      |
|--------------------------------------------|---------------------------------------------|
| the swollen of teats                      | Yeast infection                             |
| Swollen legs                               | injury                                      |
| Bloating                                   | Poor indigestion                            |

Table 3: Testing Poultry Diseases

| Query                                      | Result                                      |
|--------------------------------------------|---------------------------------------------|
| pecking in hens                            | Lack of calcium                             |
| slow growth in hens                        | Lack of enough diet such as phosphorous     |
| Poor of laying eggs                        | stress                                     |

Table 4: Testing Goats Diseases

| Query                                      | Result                                      |
|--------------------------------------------|---------------------------------------------|
| Limping in goats                           | Foot and Mouth Disease                      |
| Lack of Eye sight                          | Sign of illness                             |
| Bloating                                   | overeating lush                             |

Table 5: Testing sheep diseases

| Query                                      | Result                                      |
|--------------------------------------------|---------------------------------------------|
| Abortion                                   | Chlamydia                                   |
| Brucellosis                                | In infected ruminants                       |
| Fever                                      | bacterium                                   |

I. Maintainability Index

This research paper employed the maintainability index to measure how easy the developed expert knowledge base system is to change and support. The maintainability index computes an index value between 0 and 100 that denotes the relative ease of maintaining the code. Using this metrics, a high value represents better maintainability such that a rating between 20 and 100 indicates that the code has good maintainability while a rating between 10 and 19 indicates that the code is moderately maintainable. On the other hand, a rating between 0 and 9 and indicates low maintainability.
A. User Interface Maintainability Index

\[
\text{Maintainability Index} = 171 - 5.2 \times \ln(V) - 0.23 \times (G) - 16.2 \times \ln(LOC) \quad (1)
\]

Where:

\[ V = \text{Halstead Volume} \]
\[ G = \text{Cyclomatic Complexity} \]
\[ LOC = \text{count of source Lines of Code (SLOC)} \]

The first parameter, the Halstead Volume, was calculated using equation (2):

\[
\text{Halstead Volume, } V = N \times \log_2 n \quad (2)
\]

Where:

\[ N = \text{the program length, obtained by the summation of the total number of operators and the total number of operands.} \]
\[ n = \text{the program vocabulary which was obtained by the summation of the distinct number of operators and the distinct number of operands.} \]

The cyclomatic complexity measured the number of linearly independent paths through a program’s source code. Mathematically, this measure is expressed as shown in equation (3):

\[
G = E - N - 2P \quad (3)
\]

In this case:

\[ E = \text{the number of edges of the graph,} \]
\[ N = \text{the number of nodes in the graph and} \]
\[ P = \text{is number of connected components in the graph} \]

The source code of the developed expert knowledge base system’s interface modules contained 161 lines of codes. The operators used in this system are shown below.

```
EditText names, id, gender, phone, county, pass, pass2

findViewById(R.id.button_signup);  findViewById(R.id.login_textview); findViewById(R.id.regiser_memberlyt));

layout.findViewById(R.id.member_names);  layout.findViewById(R.id.member_id);  layout.findViewById(R.id.member_gender);  layout.findViewById(R.id.member_contacts); layout.findViewById(R.id.member_county);

names.getText().toString();    id.getText().toString();    gender.getText().toString();   county.getText().toString();

new Register_User().execute();

pass.setText(null); pass2.setText(null);
```
The total number of operands is observed to 35 while the number of distinct operands is 14. Going by these parameters, the inputs to the Halstead Volume are computed as follows:

\[ N(\text{program length}) = 36 + 35 = 71 \]  \hspace{1cm} (4)

\[ n(\text{program vocabulary}) = 29 + 14 = 43 \]  \hspace{1cm} (5)

Substituting in equation (2), the Halstead Volume becomes:

\[ \text{Halstead Volume, } V = 71 \times \log_2(43) \]  \hspace{1cm} (6)

\[ \text{Halstead Volume, } V = 71 \times 5.426 = 385.246 \]  \hspace{1cm} (7)

To determine the cyclomatic complexity, the control structures within the developed expert knowledge base system’s interface were employed as inputs. Thereafter, the control flow graphs were plotted. The first control structure checked whether all the fields had been filled as required; the second control structure checked whether passwords matched during the authentication process, the third one checked whether the registration process is successful; the fourth one checked all fields during user data collection; the fifth one checked against incorrect user input details:

As such, the complete control flow for the developed expert knowledge base system’s interface is as shown below.
Considering this control flow graph, the total number of nodes is 14 while the total number of edges is 17. As such, \( E = 17, N = 14 \) and \( P = 1 \).

\[
G = 17 - 14 + 2 = 5
\]

Using the obtained figures, the maintainability index is given as follows:

\[
\text{Maintainability Index} = 171 - 5.2 \times \ln(385.246) - 0.23 \times (5) - 16.2 \times \ln(161)
\]

\[
= 171 - (5.2 \times 5.954) - 1.15 - (16.2 \times 5.0814)
\]

\[
= 171 - 30.9608 - 1.15 - 82.3187
\]

\[
= 171 - 114.1995
\]

\[
= 56.5705
\]

The computed maintainability index of the developed expert knowledge base system’s interface is \(56.5705\) and this value lies between 20 and 100, the implication is that this system is the code has good maintainability.

**B. Application Logic Quality Metric**

\[
\text{Maintainability Index} = 171 - 5.2 \times \ln(V) - 0.23 \times (G) - 16.2 \times \ln(LOC)
\]

Where:

\( V = \) Halstead Volume

\( G = \) Cyclomatic Complexity

\( LOC = \) count of source Lines of Code (SLOC)

The first parameter, the Halstead Volume, was calculated using equation (2):

\[
\text{Halstead Volume}, V = N \times \log_2 n
\]

Where:

\( N = \) the program length, obtained by the summation of the total number of operators and the total number of operands.

\( n = \) the program vocabulary which was obtained by the summation of the distinct number of operators and the distinct number of operands.
The cyclomatic complexity measured the number of linearly independent paths through a program's source code. Mathematically, this measure is expressed as shown in equation (3):

\[ G = E - N + 2P \]  

(3)

In this case:
- \( E \) = the number of edges of the graph,
- \( N \) = the number of nodes in the graph and
- \( P \) = is number of connected components in the graph

The source code of the developed expert knowledge base system contained 442 lines of codes. The operators used in this system are shown below.

```java
ACCESS_FINE_LOCATION
ACCESS_COARSE_LOCATION
WRITE_EXTERNAL_STORAGE
SEND_SMS
RECEIVE_SMS
GET_ACCOUNTS
READ_PROFILE
READ_CONTACTS
findViewById
names.getText().toString()
id.getText().toString()
gender.getText().toString()
phone.getText().toString()
pass.getText().toString()
pass2.setText().toString()
pass.requestFocus()
URLEncoder.encode("mid", "UTF-8")
URLEncoder.encode("mgender", "UTF-8")
URLEncoder.encode("mphone", "UTF-8")
URLencoder.encode("mcounty", "UTF-8")
URLencoder.encode("mpass", "UTF-8")
names.getText().toString()
id.getText().toString()
gender.getText().toString()
county.getText().toString()
phone.getText().toString()
pass.getText().toString()
pass2.setText().toString()
pass2.setText(""")
pass2.requestFocus()
EditText names, id, gender, phone, county, pass, pass2
String mnames, mid, mgender, mphone, mcounty, mpass, mpass2
```

As shown here, the total number of operators was 35 while the total number of distinct operators was only 26. On the other hand, the developed expert knowledge base system employed the following operands.

```java
FINE_LOCATION
COARSE_LOCATION
INTERNET
CAMERA
EXTERNAL_STORAGE
SMS
ACCOUNTS
PROFILE
CONTACTS
mnames, mid, mgender, mphone, mcounty, mpass, mpass2
names, id, gender, phone, county, pass, pass2
mnames, mid, mgender, mphone, mcounty, mpass, mpass2
```
The total number of operands is observed to 30 while the number of distinct operands is 23. Going by these parameters, the inputs to the Halstead Volume are computed as follows:

\[ N(\text{program length}) = 35 + 30 = 65 \]  \hspace{1cm} (4)

\[ n(\text{program vocabulary}) = 26 + 23 = 49 \]  \hspace{1cm} (5)

Substituting in equation (2), the Halstead Volume becomes:

\[ \text{Halstead Volume}, V = 65 \times \log_2(49) \]  \hspace{1cm} (6)

\[ \text{Halstead Volume}, V = 65 \times 5.614 = 364.957 \]  \hspace{1cm} (7)

To determine the cyclomatic complexity, the control structures within the developed expert knowledge base system were employed as inputs. Thereafter, the control flow graphs of the system were plotted. The first control structure checked whether all the fields had been filled as required as shown below:

```java
if( mnames.isEmpty() || mid.isEmpty() || mgender.isEmpty() || mcounty.isEmpty() || mphone.isEmpty() || mpass.isEmpty() || mpass2.isEmpty() ){
    Toast.makeText(getApplicationContext(), "Please Fill all Fields to Proceed", Toast.LENGTH_SHORT).show();
    return;
}
```

The control flow graph of this validation can then be plotted as follows. The entry indicates the first part of the program before the first control structure is encountered. Depending on whether all details have been filled or not, the program ranches into two blocks. The second control structure checked whether passwords matched during the authentication process, as shown below:

```java
if(mpass.equals(mpass2)){
    // register user
    //      new Create_User().execute(mnames,mid,mgender,mphone,mcounty,mpass,mpass2);
    new Register_User().execute();
}
else{
    pass.setText("");
    pass2.setText("");
    pass.requestFocus();
}
```

The control flow of this program can then be plotted as shown below. The 2\textsuperscript{nd} entry represents the rest of the program code immediately after the first control structure till the beginning of the second control structure.
The third control structure involved the encoding of the inputs `mnames, mid, mgender, mphone, mcounty, mpass, mpass2`; the fourth control structure was that of checking the array elements; the fifth one was that filling the array with elements while the sixth one checked whether this process was successful; the seventh, eighth, ninth, tenth, and eleventh collected name, ID, gender, phone, county, and password data respectively. The last control structure checked if these fields have been filled with data. As such, the complete control flow for the developed expert knowledge base system is as shown below:

Considering this control flow graph, the total number of nodes is 23 while the total number of edges is 29. As such, 

\[
E = 29, N = 23 \quad \text{and} \quad P = 1.
\]

\[
G = 29 - 23 + 2 = 8.
\]

Finally, the maintainability index is given as follows:

\[
\text{Maintainability Index} = 171 - 5.2 \times \ln(364.957) - 0.23 \times (8) - 16.2 \times \ln(442)\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldOTS
5. Discussion

The objective of this paper was to use Delphi technique on development of a project performance framework for mobile phone usage in agricultural practices in Kenya. The results obtained indicated that the usage of a knowledge based system accelerated the availability of classification and analysis techniques for information extraction and decision techniques. The knowledge based system incorporated in mobile phone technology was used in solving farmers’ complex problems and helped in decision-making processes. Mobile phones have provided new approach to farmers to make tentative decisions much more easily than before.

Through Delphi technique the researchers were able to design and develop a mobile application for use in agricultural practices and the Expert Knowledge Base system build in the application was able to provide with the information that was able to help farmers to solve their problems. Hence we were able to test the application that will help farmers in decision making. Recognizing the need to incorporate a knowledge base expert system in agricultural practices was found to be useful to enhance farmers’ productivity and agricultural efficiency.

Comparing the maintainability index for the application logic (39.8021) and that of its interface (56.5705), it is clear that the maintainability index of the user interface was higher than that of the application logic. Consequently, the application logic was more difficult to maintain compared with the user interface.

6. Conclusion

Delphi Technique when fully implemented is effective in the development of a project performance framework for use in agricultural practices. The results in chapter four revealed that a performance framework integrated in mobile phones is able to effectively handle farmer’s issues in planning, organizing and coordinating the farming practices easily. Delhi technique enabled easier decisions be made by farmers through collection of expert judgments without the great costs and logistical difficulties of bringing many experts together in a face-to-face meeting. Furthermore, a database of farming practices helped farmers and experts reduce the costs of farm inputs and hence are able to share knowledge widely at faster rate.

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