Using ICT4D in Educative Training for Reducing Road Accidents in Developing Countries

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Abstract

All over the world road accidents are the major causes of death, it stems from reckless driving and poor driving culture. The rate of road accidents in developing nations is a lot higher than that of the developed nations. However, while observing the Finnish road users and their driving culture, where commuters respect road rules and pedestrians, inspired the thought of designing a platform more suitable for teaching road users and motorist in developing countries. Usually, majority of public road drivers in Nigeria, a developing country, are low literate; thus, they opt against using text-based road use highway-code information as they cannot read or interpret them due to their level of education. Therefore, they lack information that is supposed to serve as a guide in the prevention of road accident.

Consequently, this thesis explores the opportunity of using the knowledge of ICT4D in building an interactive prototype application for teaching road use and regulation. The application designed incorporates text-free UIs which afford users the use of image/graphics with audio annotations. In fact, text-free UIs has been previously used in making services available to low literate users in sectors such as health, banking and job search with success. Therefore, a text free prototype application is designed to aid drivers, especially low literate and literate but novice technology users, so they can easily learn road use and its regulations. The application will be in a quiz-game like format, designed in three phases which are; User centered design, application version Phido and (PhidoE with English language audio output) as Experiment 1 for literate participants and Experiment 2 (PhidoY with Yoruba language audio output version) for low literate participants. In addition, the application is strategized and gamified with game-like elements as the quiz game show “Who wants to be a millionaire”, to increase both learning motivation and performance.

Furthermore, designing and testing was done at Obafemi Awolowo University Ile-Ife, Nigeria. With test results showing that text-free UI on road use should be suitable for teaching road users in Nigeria, in that it provides access in learning road use for majority of low literate users and literate but novice technology users. Findings from research interviews, observations and questionnaire were used in generating design recommendation on text free user interface for road use.

Key words and terms: Text-free, Low literate, Road accident, Quiz-game strategy.

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Table of Content

List of figures

1. INTRODUCTION

Transportation helps in giving life to development. It acts as a catalyst and helps to facilitate movements for urban, rural, and national development. It provides the means for which goods and services are made accessible to consumers, thus creating social and economic interactions opportunities and employment. However, transportation also has an unavoidable negative consequence such as road accident in Nigeria and in the world at large. Of the four type ways for transportation, namely; the use of vehicles, trains, planes and ships. The one that poses the greatest risk of injury per kilometer to people is travelling on the road [Ismaila et al., 2009; Atubi et al., 2016].

Road traffic accident (RTA) is usually caused by the increased burden on road, with dilapidated infrastructure to accommodate the increased number of commuters. In addition, reckless acts such as driving dangerously, driving without license, driving with excessive speed, driving under the influence, misguided pedestrian belief and poor enforcement of traffic regulations constitute the major causes of road traffic accidents. This exposes people to an unsafe environment leading to traffic injuries and deaths [Adeloye et al., 2016; Ezenwa et al., 2001; Ifeoma et al., 2013]. According to Oladehinde et al. [2007], all over the world, problems derived from road traffic accidents are usually tragic. Although, occurrence in most developed countries has been on a decline, reverse is the state in most developing countries. We cannot give up mobility; therefore, efficient solutions that contribute to the quality of life of citizens are welcomed, solutions that introduce innovation, sustainable and energy.

Persistent injuries gotten from road traffic accidents has become a serious public health issue, and more of a health burden in developing countries, since rail and air transportation are either expensive or unavailable, and the most affordable means of mobility is the road transportation [Adeloye et al., 2016]. These injuries on the road are among the leading causes of death and lifelong disabilities and the number of injured and the dead has been increasing over decades in Africa and especially in Nigeria. "*According to the global status report on road safety in 2015, the W.H.O African region rate of fatalities from road traffic injuries worldwide was 26.6 per 100000 population for the year 2013"* [WHO, 2015]. Most accident victims in Nigeria are young adults; therefore, efforts have been put in place to checkmate the rate of fatalities from road accidents by the government. The Nigerian government has some mandating laws on measures to prevent road accidents but the compliance is not universal [Sangowawa et al., 2010].

In Nigeria, law-enforcement agents are empowered to penalize and stop drivers that are non-compliant. The agency that is mandated with the responsibility of enforcing this law is the Federal Road Safety Commission (FRSC). Demonstrative teaching methods such as campaigns on health education and incentives for road users have been combined with legislations and these have reportedly succeeded in reducing and preventing road accidents in many countries. Even with these strategies combined with legislation in Nigeria, studies have shown that public transport drivers have little or no

knowledge on issues, such as the age one can apply for driver's license, road signs, maximum speed limit [Okafor et al., 2013; Sangowawa et al., 2010].

"*The oldest, least educated and least experienced drivers had the poorest level of knowledge on road use*" [Okafor et al., 2013, p 34-39].

The highway-code serves as a guide to road users in Nigeria, it is available to the population to be studied both in electronic and paper version. Users must be able to read to be informed about road use. However, their level of education is a major threat to utilization of this information for majority of public transport motorist. According to Ogunmodede et al., [2013], 81.8% of Nigerians do not possess a copy of highway-code because majority of public road users are low literate and cannot access information which ought to serve as a guide in the prevention of accident, which accounts for why majority of them are prone to accidents. It is obvious that the reason why few public transporters have the highway-code booklet is that it is mandated by the authority and they only keep it at home because they cannot read and understand its contents.

Therefore, designing an application that is usable and less reliant on text is needed for this group. Research has shown that interfaces that are mostly text based are ineffective to first-time low-literate users, and error prone to literate but novice users of technology. Impacting/teaching this group of people demands designing an application that suits them. A text-free application with images/graphics and audio output has been shown to be efficient in this regard, it helps low literate and literate, but novice users access the information they ordinarily cannot access. It has been used in the context of healthcare, mobile banking, job search and many more with success [Medhi et al., 2007a; 2007b; 2008; 2011].

This research focuses on using the graphics and audio user interface on a mobile device in teaching road use and regulation for low literate users in a quiz like format, and to observe participants attitudes and emotion when they use the system or service. It been proven that interacting with technology can help to improve motivation for learning, and a design that helps to make learning process mirror playing a game does enhances even more the learning motivation. Furthermore, appropriate challenge is important in enhancing learning information i.e. with a very difficult challenge, learners will feel they have little chance of overcoming the difficulties and therefore it could lead to turn off as they will give up the chance to further the challenge; if it is too easy, it could lead to learners becoming distracted which could lead to loss of interest in participating in the challenge [Wang et al., 2008].

Therefore, a quiz game strategy was used during this research testing in simplifying the difficulty level of tasks for the low literate and literate but novice users' knowledge on road use. This helps to motivate them; thus, making their learning experience like that of a related game "Who wants to be a Millionaire", a television game show where the use of 50/50 chance is popularly used. It allows participants to request for two incorrect answers to be removed, leaving a correct and an incorrect answer. This method is related to prune strategy described by Wang et al., [2008], as a strategy which is used to

make an item less difficult, as it removes one incorrect option thereby making it into a 3-option item from a 4-option item.

Another idea that was used in this application is gamification, which helps to maintain and improve application users' interest in the application. Gamification involves gamifying activities or teaching an idea, it includes procedures such as badges for achievement during tasks for mastering a level. This increases commitment without ties to the specific game. Therefore, it is suggested that the concept of gamification needs to be part of a professional tool box in games, as it provides meaning and context to users with a set of boundaries to explore; thereby allowing enabling thinking and trying things out in a safe environment. This road use and regulation application is a prototype on PowerPoint and it will be used for user testing, enhanced with either text or audio recorder. The recorded audio is then used as an audio output for the text-free application for participants. If the test is successful, the eventual goal would be to have it on a mobile device as an application for teaching low literate users.

In fact, mobile devices have their flexibility in their input and output modalities and have been known to have a rich design space for alternative user interfaces. Where input method comprises of typing, structured speech and free form speech, while output method comprises of text, audio and graphics plus audio.

1.1 Research Hypothesis

This thesis aims:

1. To explore if text-free UI about road use and regulations, aids and improves driving culture in developing countries for low literate and literate novice users, and to
2. Compare the results of all the design conditions on the road use applications:
    - Phido (image with text options only) and PhidoE (image with audio questions and options in English language) for literate users.

    - PhidoY (an image and audio questions with options in Yoruba language) one of the indigenous languages in Nigeria, spoken majorly by over 40 million people in the southwest of Nigeria, for low literate users.

A secondary goal is to find out whether participants using PhidoY are able to gather the same information as participants who use Phido and Phido E. That is, for low literate users and novice but literate users, there is no loss of information when presented image and audio (and no text).

1.2 Research Methodology and Contribution

"*Understanding precisely how ICTs can make a difference to the lives of the poor and the marginalized does indeed depend on the part of their contribution to the economic growth, but it is also concerned with issues to do with the access that people have to information about the ways in which those from different background communicate with each other and about the content requirement that poor people need if they are*

able to transform their live and livelihood". [Cambridge Learning Unwin, 2009, pg. 1]. The focus of this research is to make use of the ICT4D knowledge by creating an application that guides road users, especially the low literate and the literate but novice drivers, about the knowledge of road usage and laws on measures to prevent road traffic accidents.

The application will be used in bridging the digital divide; thus, providing equitable access to information and technology for citizens that are normally left out due to their educational status in developing countries. The application was designed in a user centered design group with members recruited through connection from the Department of Electrical and Electronics Obafemi Awolowo University Ile-Ife. With the assistance of a lecturer at the University, ten students were recruited in the design process. They came up with fifteen scenarios based on the Nigerian Highway Code[1] and all scenarios are available in appendix 3.

After the scenarios were built, five newly recruited participants tested the prototype scenarios of the application in Experience 1 which is the Phido application and PhidoE English audio output version application for literate users. Also, another five low literate participants tested scenarios in Experience 2 (PhidoY application, designed for low literate users). Participants were requested to fill in a consent form and informed about the processes during testing. Testing the application took one hour for participants of each experiments. Data was collected and evaluated from the application testing, interviews, observations and questionnaires. The evaluations and observations provided by each participant gave an insight into user preferences, behaviors and challenges from both the users' and observers' perspective allowing for critical comparisons with previous research.

1.3 Thesis outline

This thesis consists of six chapters. Chapter two provides a background for the reported study. It starts with a brief overview on the history of ICT4D, its influence with livelihood to developing countries, followed by the challenges in promoting road safety in Nigeria, extensive literature review of previous researches relating to text-free UI, testing quiz-game-like formative assessment, gamification for learning, and usefulness of mobile phones if the prototype application testing is positive. Chapter 3 summarizes the motivation for this work explaining why a Text-free based UI solution was chosen. It also explains the implementation on details of the application used in the experiment and presents the research method used in the evaluation. The results are shown in Chapter 4. Chapter 5 provides a detailed discussion on the findings of this thesis. Finally, Chapter 6 contains the conclusion, which is a summary of the research's contributions and further works that could be done on the study.

[1] https://www.highwaycode.com.ng/

2. RELATED WORK

This chapter introduces ICT4D, text free UI, quiz-game strategies as well as gamification of educative application to ensure that users practice and actively learn until they master the concept. Research is done using the knowledge of ICT4D to aid low literate and novice but literate users to have the information they do not have. ICT4D is usually a quick off-the-shelf solution that can be repeated in developing countries. The earlier use of ICT4D was focused on application emphasis; governmental use and application of IT to internal administrative functions of public sector with successes in underdeveloped nations. With road safety being a major issue now in the developing countries, the use of the knowledge of ICT4D could be the well-deserved way in reducing road accidents.

2.1 Challenges of using the Nigerian highway code

The Nigerian Highway Code serves as a guideline for motor car users, motorcycle, bus and lorry drivers. It is majorly text based and written in the English language, it is modelled from successful similar solutions used in the developing world for teaching roads use and regulations. Unfortunately, most commercial drivers in Nigeria are low literate, therefore they cannot use the application. Hence, replicating those successful results from developed countries in Nigeria is unattainable as their suitability needs to be considered along with problems and conditions prevalent in Nigeria [Atubi et al., 2016]. Therefore, Nigerian government intervened and empowered the FRSC (the body responsible with enforcement of road use laws), to encourage and enforce programs and policies initiative that lead to rapid decline in deaths associated with road traffic injuries.

Examples of such interventions includes the children's car seats, use of seatbelt, helmets use for motorcycles, alcohol control policies and many more has been proven to be effective in reducing road injuries and prevented crashes worldwide [Atubi et al., 2016]. According to Sangowawa et al., [2010], seat belts use is one of the interventions that reduces severe injuries and death by 45-60%, however, even with the mandatory laws in Nigeria on the use of seat belts, drivers' and passengers' obedience on the use is not total. The overall rate of seat belt use rate among vehicle occupants and drivers who are primarily men is 18.7% in Nigeria, which is a little less than the rates of approximately 70% achieved in the USA by vehicle occupants in 2000. Although, a non-scientific report suggests progress in the use of seatbelt among drivers went above 70% in parts of Nigeria because officials of FRSC enforced the compliance of seatbelt use [Sangowawa et al., 2010].

Furthermore, sustaining such disciplined level of enforcement has been difficult because FRSC staff do not have sufficient resources to set up patrol on all Nigerian roads at every hour of the day, also the unavailability of CCTV cameras for monitoring the behaviors of road users in most places in the country. In fact, other ways were explored to complement the FRSC efforts which included: increased enforcement of the seat belt use by allowing the involvement of FRSC special marshals. FRSC special marshals' members are those that offer voluntary services with integrity and interest in ensuring that road use laws are obeyed. They are to assist everyday uniformed FRSC workers, with powers to arrest and prosecute offenders. They can also give lectures on

road use information, give advice to road users in the areas of their competence. Nevertheless, accident rates are still high in Nigeria due to lack of road use knowledge by most road users while driving.

Therefore, to replicate the developed world road safety success rate in Nigeria, this thesis explores the use of a text-free application where users can learn all about the causes of road accident, forms of intervention available to them and the result of ignoring it irrespective of age, sex, and the literacy level of the road user can have a fatal effect. Delivering such information in a text-based format to non-literate and the low literate has been proven impracticable [Medhi et al., 2007]. To impact/teach this group of people, demands designing an application that is usable to them. An application form which has been successfully used in teaching low literate and literate but novice technology users in banking, job search and many more with reasonable success for low literate and literate but novice users of the application. **[**Medhi et al., 2006; 2007a; 2007b; 2009]

2.2 Text free UI for Low Literate Users

Information and technology-based tools is increasingly important, it gives access for people to participate fully in the society. Although, there is a need to think on how these tools can help users better at all levels of literacies. Interfaces that utilizes one of graphical, audio and numerical contents have been shown to improve usability for low literate users unlike those that have little or no text. Earlier interface design work for illiterate and low literate focused on populations broad principles; thus, it recommended use of graphical icons, voice note, clear and easy navigation and numeral use for people who may be innumerate but still illiterate. These principles have been applied to applications in the areas of job search, healthcare map navigation and microfinance. [Medhi et al., 2008]

With the principles stated above, some work has been done in designing, with notable success which highlights the usefulness of text-free user interface for illiterate and low literate users.

Text-free UI designed for low literate users for employment search and map: In this research, an application is designed which will aid low literate in employment search, the job schedule and navigation to the workplace. The application design guidelines are drawn from ethnographic design, this technique helped in understanding participants specific goals during the experimental design. Using information gotten from ethnographic design, the research derived guidelines and practical principles in designing for text-free UIs. Some of the design principles for this employment search and maps-based application includes; avoiding text but using numbers may be ok, use of graphics, paying attention to subtle cues, provision of voice feedback, provision of help on screen. The study concluded that, several design details should be integrated with a text free design for low literate, that it should include attributes such as voice feedback, graphical icons, little or no text use, and more importantly observable feedback on mouse-over. [Medhi et al., 2005]

Text-free UI designed for low literate users for health information: The study by Medhi et al., [2007], presents answer to these questions for a text free UIs: which is better between hand-drawn graphics or photographs, are static images more suited than videos or animations, what effect do the visual representation have when used along with a clear voice annotation. The text-free UI used in this research was designed for monitoring information on health, where patients filled out a form on their health information themselves. These forms afford patients the use of videos, animations, and static imagery. The medical practitioners and the public health care department are now sent data to be able to effectively identify the disease and provide useful information. The findings from the research shows that; speed of comprehension is generally helped by voice annotation, audio-visual information sometimes is confusing for illiterate users; application with richer information does not usually make it a better platform overall, real photo representations fared less better than hand-drawn cartoons; and many factors determine the importance and preference of static images (photo and drawings) against that of dynamic images (video and animation).

Text-free UI designed for low literate users in banking: The user interface design presented in this study, is shaped to help people who do not have a bank account; that is those that usually operate with cash only. This limits them and creates the inability for them to take loans, save, and make distant payments, these limits their financial and economic opportunities. If mobile phone can deliver these monetary services then these obstacles could be partially controlled, because in the developing world there are more people with mobile phones than with bank accounts. Participants of Medhi et al., [2009] research study, experienced several usability barriers while interacting and operating mobile phones for the use of these banking services and in general. These difficulties include; soft-key mapping, syntax construction, scrolling and hierarchical navigation, understanding receipts, manuals and banking concepts. In conclusion, it was confirmed that the completion rate for task were better with rich multimedia UI.

From all these studies of UI design for non-literates and low literate users, it confirms that first-time low-literacy users and error prone literate, but novice users usually avoid using textual interfaces. Therefore, the interface which makes use of graphics, advocate and that recognizes the value of images is recommended. It is also noted that audio annotations with voice instructions is also powerful, and interestingly much focus is on the use of audio and graphics to design a usable interface [Medhi et al., 2007; 2009; 2011]. Furthermore, it will be interesting to see if the use of graphical image and audio text free UI have an impact on commercial road workers in Nigeria who are majorly low literate. This text free UI will be designed in a quiz-game like format like “Who wants to be a Millionaire.”

2.3 Game assessment module (GAM) and Test Analysis System

Game formative assessment helps in providing a lot of opportunities for self-assessment performance in revising mistakes and getting feedbacks. Wang et al., [2008], suggested the use of strategies such as ‘all pass and then reward’, ‘monitor answering history’, ‘ask-Hint strategy’, ‘repeat the test’, as well as ‘correct answers are not given’, and ‘query scores’ and ‘ask questions’ in module of game assessment for constructing test

analysis system. These strategies assist test to learn and choose the right answers during testing. The game assessment test design in module analysis system have been used in constructing the 'game mechanism' and 'challenge mechanism', which helps in executing a quiz like games within an e-Learning environment.

Integrating strategies such as; 'repeat the test', 'correct answers are not given' and 'all pass and then reward', to participants in a quiz like game could help in making sure that they truly understand the questions from the quiz. This process involves engaging subject during testing, by noting if their response on a topic is correct three times, then it is successful the subject will not be presented for further testing. If the right response is not consecutive in three trials, the system/game will assume that the correct answers from previous tries was through guessing. Furthermore, the items that are answered thrice consecutively right are then taken out from the test; thus, the test number of items that requires solution decreases as the test is repeated. Eventually, if this continues with answers been correct three times in a row there will be no questions that has not yet been answered. Therefore, subjects will then be assumed to have passed the test and then the application rewards.

The main challenge of a quiz game application is usually how difficult the items in the quiz are. With the 'Ask-Hint strategy' another strategy used in this quiz game like application, helps participants in answering difficult questions during testing. When the items are too difficult there is tendency that participants feel they have little chance in overcoming the task and it might make them give up on the challenge. Using 'Ask-Hint strategy', prevents this from occurring as they provide hints (feedback) online for those participants when they have difficulties in answering questions rather than giving correct answers. Ask-Hint Strategy has two designs types which are; Prune Strategy and Call-in Strategy.

Prune strategy: The 'Prune Strategy' influences the multiple-choice difficulty on items by the number of options, it is believed that by reducing the options also reduces the item difficulty. In a test setting the 'Prune Strategy', if one incorrect option is removed from the original 4-option item, these leaves a 3-option item; thus, reducing difficulty of the question, as subject now has a 33.3 percent chance at the answer unlike before which was at 25 percent.

Call-in Strategy: 'Call in Strategy' is used when participants are not sure about the answer in a quiz-game like situation. Subjects observes other participants behavior and take it as an important guide to gather information for their own behavior, as they do not know which options are correct, or what opinion to express. 'Call-in Strategy' helps provide a guide that shows how the options chosen for specific item from previous test takers. When participants experience difficulties while answering a question, by using this strategy they have the opportunity of knowing what the choice of their peers was. This information is then used in deciding which option they choose from.

For this study, the use of 50/50 will be used where two wrong options are removed

from the quiz-game; one correct answer and one incorrect answer. This is similar to the 'Prune Strategy' where one incorrect option is removed at a time.

2.4 Gamification for Learning

Gaming, both in virtual and real worlds has been used to provide motivation for test subjects in completing tasks. For 21st-century learners, a well-designed game can engage players in complex and critical thinking. 'Game-based learning' (GBL), is used in teaching purposes, it has an effective way of enhancing both learning, helps in motivating, which then leads to improved performance. Game based learning skills allows information and communication technologies (ICTs) to be more user and social-centric, where with internet usage users could also produce information instead of just being sole consumers of the information. Furthermore, gamification involves enabling a teaching concept that includes mechanics such as badges for achievement, level completion, and 'XPs' after mastering a level. This process increases engagement without the subject having ties with any specific game. These needs to be part of games professional tool box as it provides meaning and context for users, also it further helps in providing a new set of boundaries.

Gamification can help application participants learn the content, aids retention and while they are also practicing their literacy skills when playing the game; thus, making the educational experience both challenging and fun. Gamification helps in capitalizing on multi-literacies, as it helps shifts mind-set from schooling, in that if incorporates play, imagination, learning unpredictability and a learning environment that is fun [Kingsley et al 2015]. Furthermore, gamification provides an ideal learning process in a creative environment, one that incorporates playing, imagining, learning predictability, and having fun. In a multitude of ways, a gamified tool acts as a teaching vessel for wide range of skills such as 'critical thinking', 'creative thinking', 'collaboration', and 'communication'. It helps users become the master of their education as learning dynamics shifts from 'teacher to student-centric'. Over time the effect of gamification reduces, as superficial rewards gained during the game participation such as 'badges', 'points', 'leaderboard' subside after short period of time. [Kingsley et al 2015; Kapp et al 2012; Looyestyn et al 2017]

Using this gamification knowledge in designing an information based on road use tool, which will impact, aid retention, reward right answers with points and help users know more about road use information and instructions is important in text free platform. In conjunction with 50/50 strategy like prune strategy discussed above in a quiz-game. Furthermore, if the application is useful and suitable for low literate road users, then having it on a mobile device should be the next step as mobile devices help deliver development services. It is a readymade platform as most of the target users, who are commercial drivers and low literates have access to mobile phones in developing world.

2.5 Importance of Mobile Phone in ICT4D

One of the most important development trends in past decades is the mobile phone use and it has had an explosive growth. Telecommunication network coverage is extended to most of poor communities and their populations; thus, enabling mobile cellular

technologies. Mobile phone use aid communication through technology, we could pick and choose whatever we want to communicate about, learn from others and our environment [Duncombe et.al 2009]. Furthermore, global developmental focus has turned to the mobile phone technology which can serves as a platform that brings development services, in areas covering education, finance, health, governance and agriculture. Although, there are challenges in delivering such services, because nearly 41% of the population in the developing countries are non-literate and even the literate among them are usually novice users of technologies.

Therefore, having a text free UI on a mobile phone can help to bridge this gap, because mobile devices have a capacity as shown in figure 1, which allows an appropriate design space for an alternative user interface. This mobile device capacity can be divided along two axes according to the flexibility of their input and output modalities. [Medhi et al., 2007]

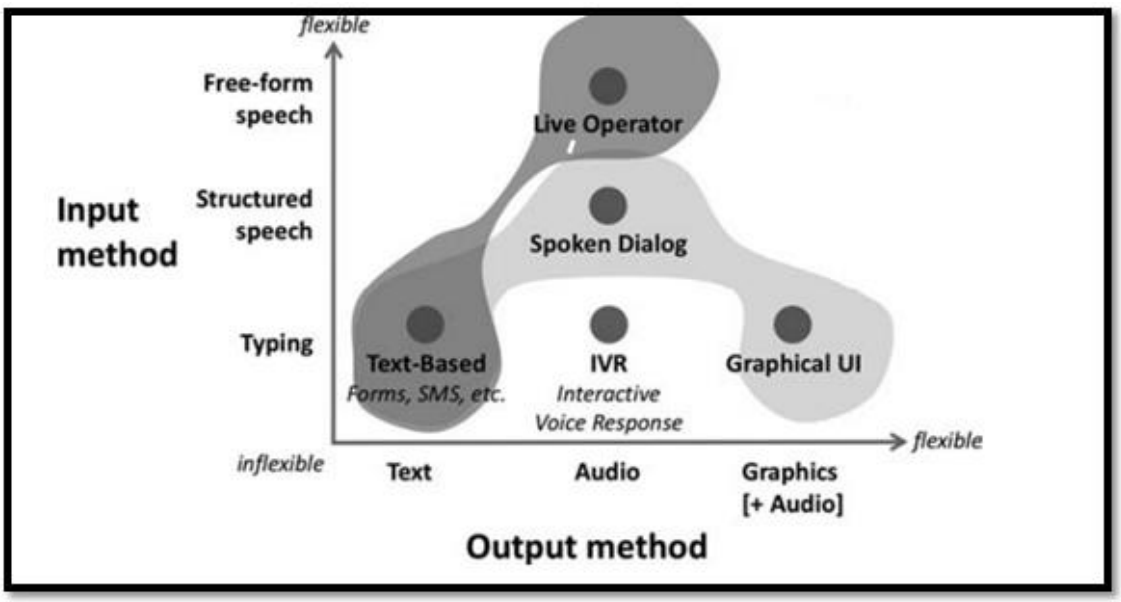

Figure 1 Design space of mobile users' interfaces [Medhi et al., 2007]

In summary, a text free user interface application has been successfully used over time to assist low literate and novice users in making sure they use service they normally will not use, it will be interesting if coupled with a gamification tool and a game assisted strategy help user to learn, remember and be engaged on road use information and laws in developing countries.

3. DESIGN AND METHODOLOGY

This chapter introduces the methods, procedures and demography of the test participants that were a part of this research. The observational study was conducted at the Obafemi Awolowo University (OAU) in January 2017. It is a federal government owned institution founded in 1961, located at the ancient city of Ile-Ife, Osun State, Nigeria. The main modes of transportation are; driving private owned vehicles, taxis, commercial motorcycles and walking within the city.

This application design and testing includes these process; User centered design, a process which focuses on the requirements and needs of users, in producing a highly accessible and usable systems, that aims for users' satisfaction while forestalling a negative effect on performance, health and safety. Test scenarios designed from the user centered design for the quiz-game like application was made into two experiments experiment 1 and 2. Experiment 1 includes Phido version (A text-based quiz-game like game format with question and options) and PhidoE version (A text-free quiz like game format, with a picture and English language audio output for its question and options). Meanwhile, experiment 2 the PhidoY version (A text-free quiz like game format, with a picture and Yoruba language audio output for its question and options). Furthermore, testing was conducted after application design with literate participants for experiment 1 and low literate participants for experiments 2. Afterwards, data was collected from interviews, questionnaires and participants observations. Each of this process is enumerated in detail below;

3.1 System Design

The user centered design (UCD) process for the road use application design was conducted at the Obafemi Awolowo University Ile-Ife, where ten final year students were recruited for the UCD from the department of Electrical and Electronics through a lecturer of the department. Recruited participants for the user centered design were informed about the goal of the research and the need to design test scenarios based on their driving experience on roads and in line with the Nigerian highway-code used by car drivers. Therefore, the user centered process for application design was conducted at a lecturer's office, where students were grouped into three, three, and four members by the moderator.

The stepwise process employed by the moderator during the user centered design for the application scenarios are enumerated below: Participants are introduced to the user centered design concept and it aims; they were shown a readymade version already done by the moderator which is shown in figure 2, and the stepwise process that was taken to construct the said example. Member of UCD were expected to follow the step wise process while designing this application scenarios in their groups.

Figure 2 Sample of the scenario for the application shown by the moderator

Each group using their laptop were expected create five scenarios each with four answers based on these processes enumerated described below:

- The first step by the moderator is explaining how user centered participants check for text only information that is available to road users to learn from the highway code web page http://www.highwaycode.com.ng/ , example of such is shown in figure 3a. The figure shows information available on the electronic text-based version of the Nigerian highway code which teaches car driver what to do when driving in the harmattan, misty and foggy condition[2].

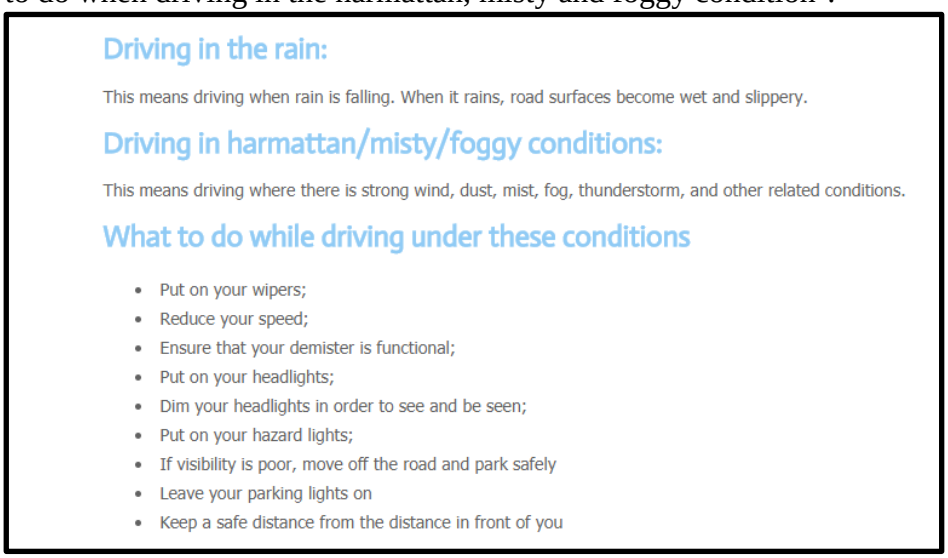

Figure 3a Typical example of a text only information on the website

- Secondly, they were shown how they could refine this information gotten from the web based Nigerian highway code into a quiz like format, example of such is shown to them in figure 3b. This figure shows the refined version of the quiz like format with options 1 to 4, designed based on the information gotten from the web based version of the Nigerian highway code from figure 3 above.

[2] http://www.highwaycode.com.ng/section-d-driving-under-special-conditions.html.

During harmattan/misty/foggy conditions which of this is not right for a drive to do in the conditions stated above

1. The person honks so that people know he/she is driving on the road with same speed
2. Put on the car wiper
3. Reduce the car speed
4. The driver should keep safe distance from the car next in front of him.

Figure 3b Typical example of a refined text only information from the website

- Participants suggested that the use of options 1 to 4 as options in the application do not follow the mental model people are familiar with in Nigeria during a question and option in testing, as usually most quiz is presented in the alphabet A to D format. They argued that alphabet A to D should suit users better and that even the low literates are familiar with the English alphabet as it is like the Yoruba alphabet. They highlighted that this format is often used in the Yoruba television quiz program for the native speaker

- Furthermore, the moderator told the participants to add a relevant picture which depicts the information from the quiz like application version to enhance the application further as shown in figure 4 below. They are to follow this specific approach in designing test scenarios in their groups for the Phido text-based quiz like version. With supervision from the moderator each group came up with five scenarios in a one and half hour. These scenarios are available in appendix 3.

From the image which is a harmattan/misty/foggy condition, users are asked to choose which one of this is not right for a driver to do under these conditions.

A. Put on your wiper
B. Reduce your speed
C. Keep a safe distance from the next car in front of u
D. Honk so the people know you are driving on the with same speed.

Figure 4 Phido version of the application created from the highway-code

The Phido design in the picture and text options version of the application, it consists four options A to D in which participants can choose from as shown above. From all the designed scenarios in the user centered design, 10 were chosen to be presented to each participant for testing in a quiz-game like format, which was emailed to the moderator for the implementation of 50/50. The 50/50 is a lifeline afforded to participants to help them if they are not sure of the options. Test participants have the opportunity of removing two wrong answers from the options. The 50/50 opportunity could be availed twice during the duration of the test, leaving a correct and an incorrect answer to choose from each question. Right answer is then displayed after the user chooses his/her option. A complete list of scenarios is presented in appendix 3.

Figure 5 shows another of the designed scenarios that will be used in showing how the lifeline 50/50 works. After the 50/50 lifeline has been used which is shown in figure 6a, where two wrong answers are removed from the options leaving a right and wrong answer. Furthermore, after the use of 50/50 the participant is then told to choose from the two options available left. After test participants have chosen correct answer from the available options, the right answers to questions for designed scenarios are displayed in figure 6b.

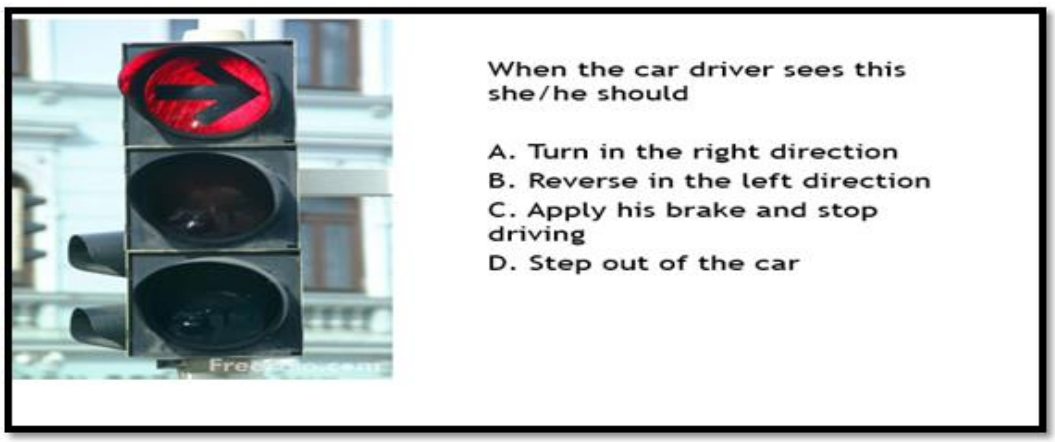

Figure 5 A typical example of the Phido scenario for the application

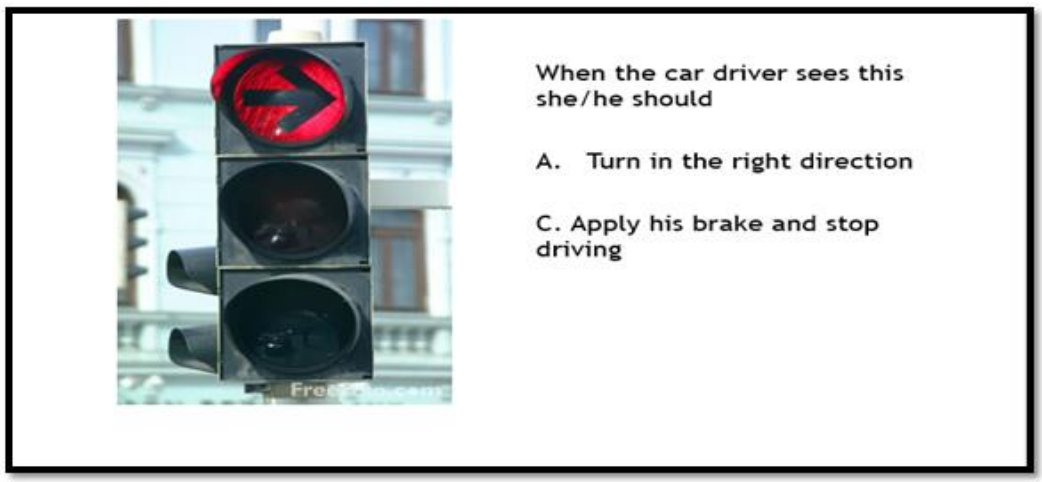

Figure 6a After the 50/50 has been used by participant during testing

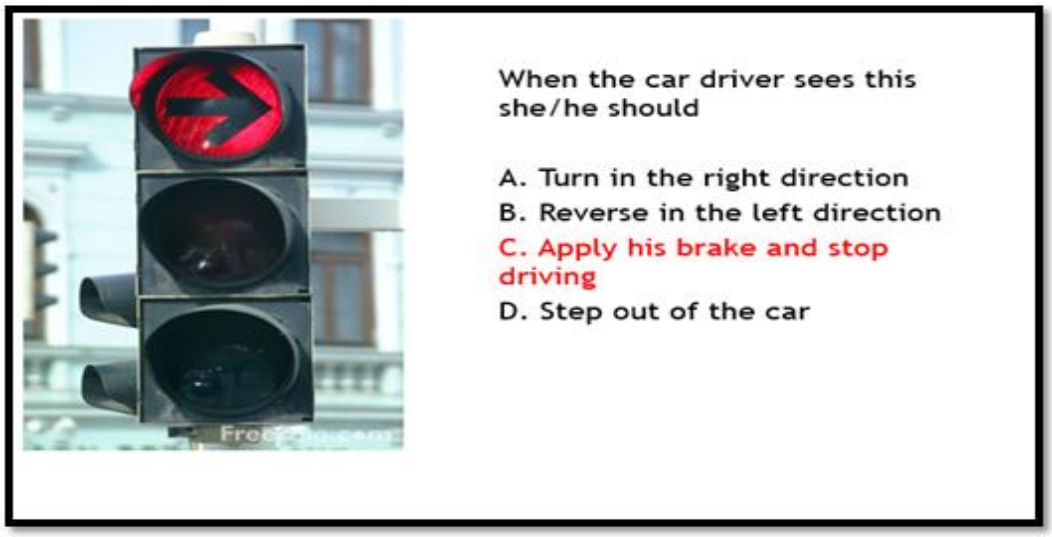

Figure 6b Showing the right answer for the question in Fig 5

However, previous research by Medhi et al., [2007], has shown that low literate users and novice but literate users generally avoid or favor graphic and audio without text. In fact, many commercial road users in Nigeria are of the said category. Therefore, designing an application that favors graphic and audio from the Phido quiz like conditions, will enable application testing for this same category of people as it should aid usability for them. Therefore, the text-free application is made from the Phido version above, it consists questions and options in audio format for English and Yoruba languages replacing the text only options in Phido version.

The procedure used in designing the textfree options are enumerated below:

- The English text options from the Phido version in figure 4, is read and recorded by the moderator with a recorder on a mobile phone and made into an audio format to be played simultaneously with the picture matching the audio information which is the PhidoE. This is the text-free design, it contains only the picture, the played audio output option is used in presenting questions and options relating to the picture. An example of the text free format is in figure 7 below.

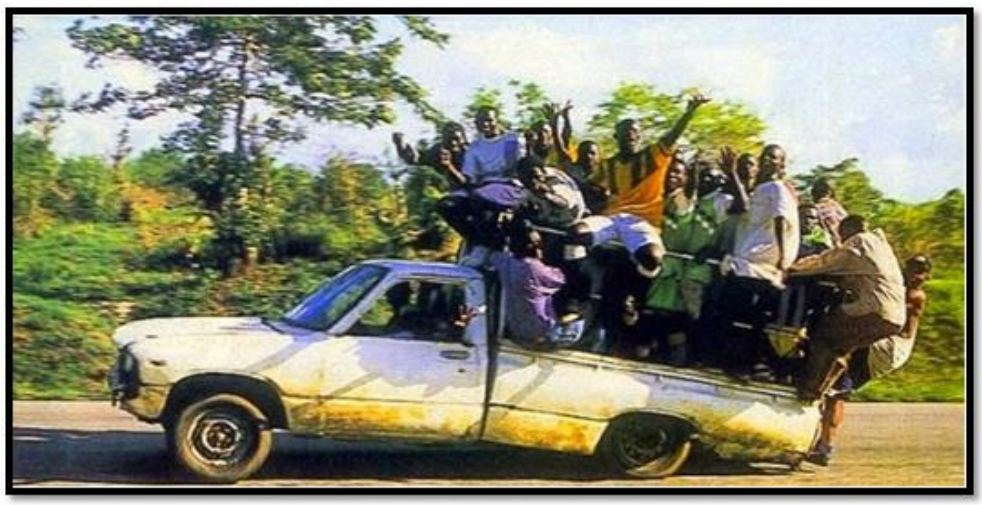

Figure 7 Picture and Audio file for Text-free (Picture + Audio)

Textfree question with four options
Textfree question with two options after the use of 50/50

- In addition, the text-free application user interface is of two versions, the one with English audio for literate participants (PhidoE) and the one with Yoruba language audio for low literate participants (PhidoY). Text from the Phido text-based version is translated in Yoruba text by a student studying Yoruba language at the Obafemi University Ile-Ife. This text then is read and recorded as the audio output for PhidoY version of the application for the low literates.

Moreover, the Yoruba language audio content produced from the text translated Phido version replaces the text Phido application as PhidoY. That is the PhidoE is the text-free version it contains English language audio output with relatable image. PhidoY is the text-free version it contains Yoruba language audio output with relatable image. The aim of the text-free design is to see if it is helpful for low-literate and novice but literate users in learning and mastering information on the signs and regulations of road use in Nigeria and to observe if literate users find the text-free PhidoE useful like the text based Phido version. In other words, low-literate and illiterate road users in Nigeria presently do lack this information on road use and laws governing it, because of their inability to be able read and write thereby learning and having their experience on the road which usually is fatal. These scenarios are available in appendix 3, and links to audio files for the design.

In conclusion the audio files included were recorded audios with four options to each scenario question. There is the opportunity to remove two incorrect answers from four options on each question, twice during the test duration. Afterwards, right audio answer is then played after the user has chosen their option. This application on the road use and regulation is a prototype and it is designed by using the PowerPoint during the user centered design section. Phido version is an image and text in a quiz like format, PhidoE and PhidoY versions are image with audio that describes or asks question about the image both in English and Yoruba language. The audio was recorded with an audio recorder that is played simultaneously as the image is displayed.

3.2 System Setup

For the setup, the equipment used includes a Laptop for the display of the scenarios. Mobile phone with recorder for the audio output in the text-free user interface, PowerPoint slides with questions and options, the 50/50, and then answers. For audio output: audio from mobile recorder with question and options, and question with 2 options. In the second experiment, it was observed that the audio for the Yoruba version (PhidoY) was unclear as it is how people write and not how they speak. Therefore, moderator used the text version (Phido) and translated on the fly using colloquial Yoruba. So, the audio output PhidoY was not used for experiment 2 (decision made in the first session).

Recruitment: Recruiting for the test was done through two known people, a lecturer from the Obafemi Awolowo University Ile-Ife and a driver of public transport. For the experiment 1, the lecturer whom I have known from my time at the University as a formal student of the university introduced me to a final year student of the department

of Electrical/Electronic of the University. The student contacted nine other colleagues who joined and participated in the user centered design for the experiment. After designing the scenarios, five other students who are not part of the user centered design were recruited and joined in testing for experiment 1. For experiment 2, a commercial car driver known to me introduced me to four other colleagues in the transportation business. Usually commercial drivers are low literate, as shown from the demography of Olugbenga-Bello et al., [2012] research participants, which shows only 3.5% of the participants in that study, studied above secondary school level among the public driver; thus, participants of experiment 2 PhidoY assumed that majority of public drivers are low literate, because it is observed as rude dividing test participants in Nigeria based on their educational level. Lastly, all participants in the user centered design experiment 1 testing and experiment 2 were each compensated with #1500 which is approximately 4 Euros, as there was the need for compensation for their time away from their work and normal schedule.

***Application testing*:** Application testing was divided into two experiments:

1. Testing Phido and PhidoE English audio version for literate users. The aim is to see which version of the application suits literate user in Nigeria more in relaying highway-code information to literate users.
2. Testing PhidoY Yoruba audio version for low literate users. The aim of the experiment is to see if it aids low literate users in understanding and learning about road use through the application.

Experiment Setting: Experiment were done in a lecturer's office at the yellow house in Mathematics department (O.A.U, Ife), with the participants and moderator present, using the moderator's laptop that contains and run the application in PowerPoint format in all the scenarios of the Phido, PhidoE, and PhidoY application. The audio for the textfree version (PhidoE) and (PhidoY) was played manually by the moderator. The mModerator stood while each participant sat on the chair as shown in figure 8.

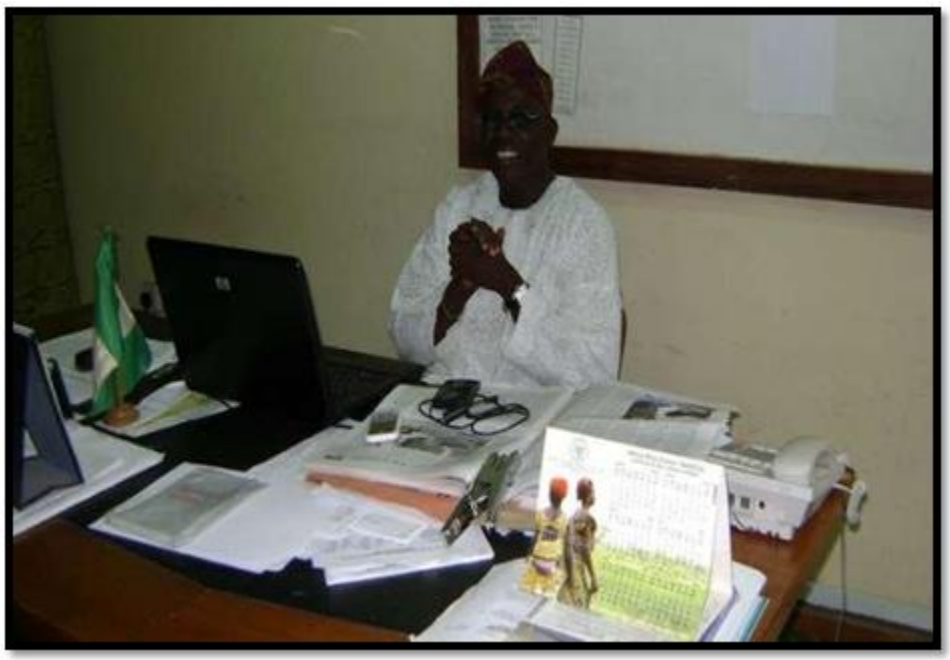

Figure 8 A typical office setting at Obafemi Awolowo University Ile-Ife

Experiment 1: The procedure used during testing for Experiment 1 (Phido and PhidoE) version for literate users included participants being informed at the beginning of the test the purpose of the research and they were each given a consent form to sign. Test participants had time to read the instructions, and were told that the testing is majorly to know if both applications are useable and to know which of the applications suits them best on how to learn road use but not to test theirs' or the moderator's competency. Each participant spent an hour duration for testing. Questions and answers section was carried out for both Phido and PhidoE version of the application. After which post-test evaluation; interview, observation and questionnaire were conducted.

Experiment 2: The test procedure for experiment 2 which is PhidoY) version, for low literate participants. Five participants were recruited for testing the prototype application from public transport service secretariat located at Mayfair Ile-Ife. One of the public transport driver was known before, and he helped with recruitment of other four participants for the test. Test duration was for an hour, at the beginning of testing participant were informed of the purpose of the research and they were given a consent form, with their help it was filled for them by the moderator. Language of interaction for the test was the Yoruba language, as most of them do not master the use of the English language; thus, it is easier to communicate using the Yoruba. Furthermore, the audio instructions which is also in Yoruba language was played to participants before testing began and they were told that the testing is to know if the application is usable for them but not to test theirs' or the moderator's competency. Post-test evaluation includes interview, observation and questionnaire like experiment 1.

3.3 Demography

User centered design demography: User centered design was conducted with ten students of the Obafemi Awolowo University. Participant were asked to design 15 scenarios for Phido version of the application, during the participatory design. The user centered design study was conducted with 10 participants. Although, participants of the participatory design group had previous driving experience and driver's licenses, but they had not previously read the highway-code. They were aged between 19 to 30 years (age M=22, SD=2.26) and were all male. Participants had studied up till university level in the Nigerian education system.

Demography experiment 1 - Phido and PhidoE version: The quiz-game like application designed by the UCD group is the Phido version, it is text based. From the Phido version the PhidoE version was designed- the text in the Phido version was converted to audio output for PhidoE version. Therefore, literate users were tested with (Phido and PhidoE) version of the application as experiment 1. This testing was conducted with 5 participants (3 Males and 2 Females), none of whom had any previous experience of using the highway-code. Two had driving experience and three did not. They were aged ranges from 19 to 30 years (age M=25.4, SD=4.45). Participants had studied up till university level in the Nigerian education system.

Demography experiment 2 - PhidoY language version: The experiment 2 of the application is PhidoY with Yoruba language audio output. The user study was conducted with 5 participants (all Males), four participants are low literate and a literate with University education. They all lack digital literacy, the ability to use modern day

technology. None of the participants had any experience of using similar text-free educative platform. Not all participants provided their age, but generally, the range was 19 to 56 years, and four of participants are considered low literate as they had studied till primary school in the public education system, equivalent to six years of education after kindergarten, while the fifth participant has a university education. The reason for this is because occasionally literate individuals (that is people with education level above the secondary school) join the commercial transport system for a short fix transportation job before they could get a better opportunity elsewhere. This fact is also corroborated by research done by Olugbenga-Bello et al., [2012], where only 3.5% of the participants were literate members and others were low literate. It should be noted that age, pay, and level of education are usually sensitive topic not used in categorizing test subjects in Nigeria, since it is perceived as rude, therefore, it was difficult to ask participants for experiment 2 only to be low-literate.

3.4 Data Collection

Data was collected from questionnaires, interviews, questions and answers, and moderator's observation. Verbal feedback was also written down from participants. These methods of data collections are discussed in detail below:

***Quiz-game Application Questions*:** For the application testing, participants are required to answer ten questions for both experiment 1 and experiment 2.

- Questions and answers for Phido version, contains ten questions with four answers option. User can remove two wrong options from the options in each question, twice during the duration of the test. It is expected to last for 30 mins. Also for the PhidoE version of the application contains ten audio questions with four answers options. Participants had the opportunity of using the 50/50 options; thus, removing two wrong answers form the options twice during the duration of the experiment. They also filled their chosen answer in the answer sheet provided by the moderator, this was used to keep track of what each participant scored after the testing for analysis.

- Questions and answers for Text-free version (PhidoY) of the application contains ten audio questions with four answers options. Participants can also make use of the 50/50 options; thus, removing two wrong answers form the options twice during the duration of the experiment. Samples of questions and answers used for the testing are all in the appendix 4. They were assisted with filling their chosen answer in the answer sheet provided, they gave answers verbally by choosing from options A to D. The answer sheet helped in keeping track of what each participant scored after the testing for analysis.

Questionnaire: After the application testing, participants were asked to fill anonymous questionnaire based on their experience using (PhidoE and PhidoY) version of the application. PhidoY low literate participants unlike the literate ones needed help in filling their questionnaires as Yoruba language is not developed enough to interpret some of the scale of the questionnaire, the moderator assisted them in filling the questionnaire after they had chosen their option. The questionnaire utilized the 5 way Likert scale, ranging from totally disagree (1) to totally agree (5). The aim of the questionnaire is to assist with understanding their subjective view of using of the

prototype application. Some of the questions from the questionnaire included; if the application is clear, easy to use, correctly effortless. A copy of the questionnaire is available in appendix 2.

Interviews: Interviews were conducted after application testing for both experiment 1 and experiment 2. It was conducted after participants filled the questionnaire on the text-free application. Comments and ideas were shared during application interaction and discussions were noted both in English and Yoruba language from experiment 1 and experiment 2 respectively. Interview questions users were asked informally in English for PhidoE participants and translated to Yoruba for PhidoY participants only are:

- What are best features of the application?
- What are the worst features of the application
- How do you think the application could be improved?
- Do you have a laptop/mobile device? Do you play games on it?

In conclusion, the prospect the data gathered from all the research methodology highlighted above that describes: how the application is designed from participatory design process, the application testing, questionnaire to have participants subjective views about the application, interview and observation while testing the application will be able to answer this thesis research hypothesis.

1. Can Text-free UI on road use and regulations aid and improve driving culture in developing countries for low literate and literate novice users, and
2. Is there a significant difference in the results of comparing the design conditions on the applications.

4. RESULTS

In this chapter, the data and results from application testing are presented. This application testing consists of two experiments; experiment 1 and experiment 2. The experiment 1 was divided into two sessions: wherein literate participants evaluated ten scenarios based trials for both the Phido and PhidoE test conditions. Likewise, experiment 2 session contains ten scenarios based trials for low literate PhidoY test condition. Data gathered from the application testing includes answers to the quiz game, interviews, observations and questionnaires. The data is interpreted, analyzed and presented to ascertain if the text-free application can help low literate learn road use information they usually lack due to their inability to use the text based highway code. Also, to know if literate users can gain from the information using text free version of the application as they would be using text based application only. The results are presented in this chapter and the discussion of the implications of the results are in Chapter 5.

4.1 Quiz-game like application responses

Phido, PhidoE and PhidoY users' responses in Experiment 1 and 2 were analysed. Each application version had ten questions. Correct responses percentage for five participants for experiment 1 (Phido and PhidoE) were plotted along with that of five low literate participants in experiment 2 (PhidoY) with result in figure 9 below.

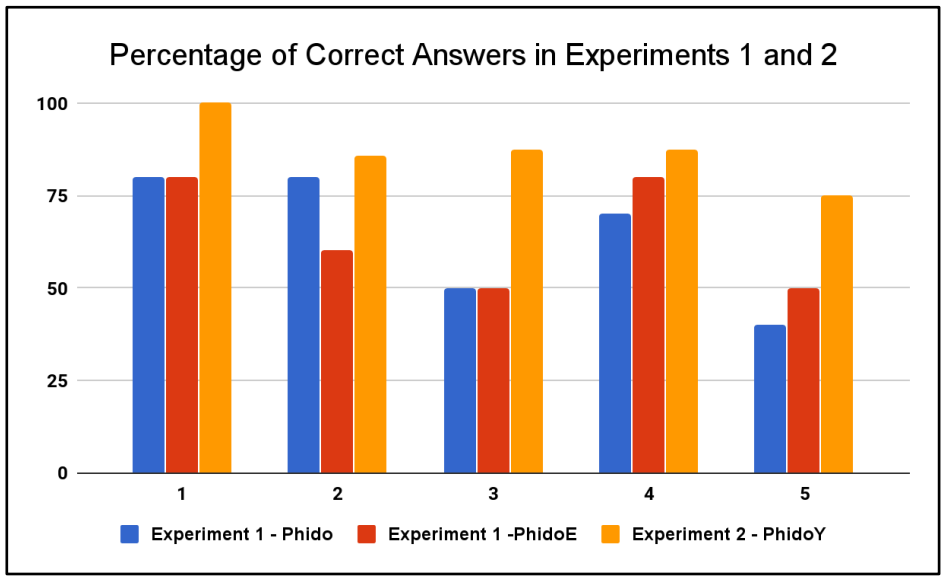

Figure 9 Percentage of correct responses for Phido, PhidoE, PhidoY

In the Phido version the blue column with mean and standard deviation (Avg=64, Sd=18.17), shows the percentage of the right answer chosen by participant using the text based version of the application, likewise, PhidoE is the Red column with mean and standard deviation (Avg=64, Sd=15.17), showing percentage of the right answers chosen by participants using English language version of the recorded audio output for the text-free application in experiment 1. Lastly, PhidoY is the Orange column with mean and standard deviation (Avg=84.14, Sd=8.88), shows the percentage of the right answers chosen by participants using the Yoruba language version of the text-free application in experiment 2.

Comparing the participants percentage of correct responses from Phido (the text based

version of the application) with PhidoE (the English audio based application) versions from the figure 9 above, it was noted that both version had the same average score (Avg= 64), with little difference in their standard deviations (Phido Stdev=18.17, PhidoE Stdev=15.17) respectively. Even though literate participants were using the PhidoE application format for the first time, they found it useful as much as Phido application version in informing literate users. It could be demonstrated from this result that having both version inculcated into road use and regulation application designs could be a plus for novice but literate users in developing nations, as it could aid usability for those who are error prone when using text only based UIs. In fact, this is also corroborated by Findlater et al., [2009], that audio augmented with text has benefits for semi-literate users in that text interface that is augmented with video do provide a concurrent learning opportunity for user. Although, user's reliance on audio as they get familiar with the augmented interface decreases over time.

Another interesting finding from figure 8 occurs when comparing mean and standard deviation for correct answers in PhidoY version (low literate participants) in experiment 2, with the mean and standard deviation of percentage of correct answers for Phido version (text based version for literate participants) in experiment 1. The mean and standard deviation for low literate participants of PhidoY version is (Avg=84.14, SD=8.87) which is significantly higher than the mean and lower standard deviation than that of the literate users in Phido version (Avg=64, SD=18.17). Therefore, this result suggests that with the application PhidoY low literates could get as much information as literate users would get using a text based application, as low literate participants results has more consistent scores with higher mean and lower standard deviation.

Lastly, analysis from both experiments completion rate which is defined at the percentage of question answered during the allocated time for the test by each participant in experiment 1, which is the Phido and PhidoE versions participants completed all their tasks in the question and answers section, while participant from experiment 2 PhidoY average completion rate is 76 percent for the same testing duration. However, higher success rate in experiment 2 could be as a result of lower completion rate, as low literate participants took their time, while making use of think aloud to walk (without being asked) through the process before choosing their answers.

4.2 UX Questionnaire

The questionnaire utilized the 5-way Likert scale, ranging from totally disagree (1) to totally agree (5). The system was received well by literate test participants. It was noted from figure 10 of the questionnaire section that the average user's rating for elements of experience of the application is higher in every of their experience in experiment 2 than experiment 1 except; hints are helpful, hints are annoying, hints are enough. Although, higher rating for Experiment 2 could be because of Likert scale being new to low literate users and there is no suitable terminology in the Yoruba language to describe how it works to test participants. It was difficult for participants in Experiment 2 to pinpoint what is their true level of experience for the application. Moreover, the likert scale might not be the best tool for capturing UX data from the low literate. Therefore, participants suggested a newer tool which is discussed in detail in chapter 5. Figure 10 below shows result of the questionnaire section in experiment 1 and 2. Sample of questionnaire used for testing is available in appendix 2.

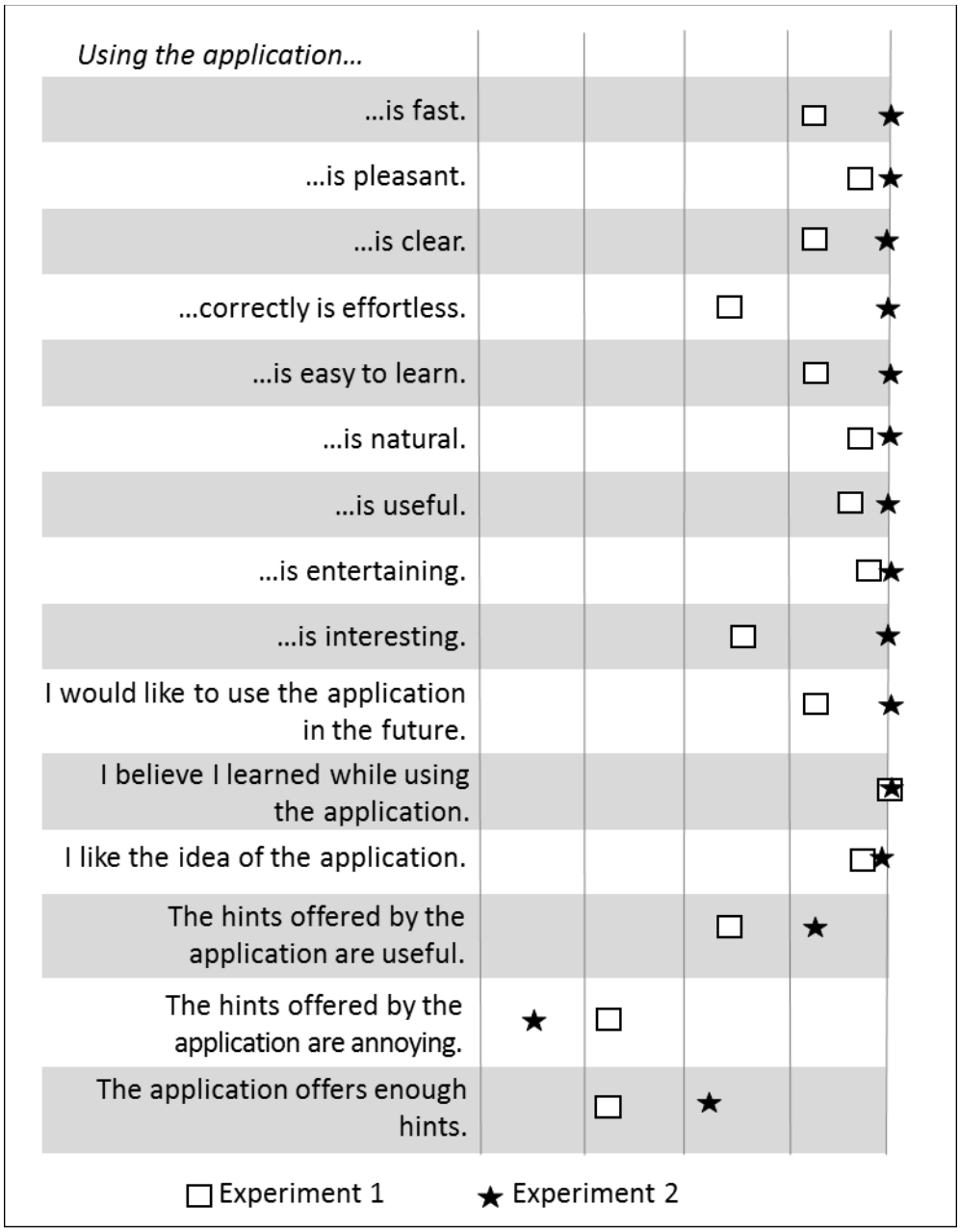

Figure 10 Result Questionnaire for Experiment 1 and Experiment 2

4.3 Interviews

After conducting the application testing, participants were interviewed about their experience while using the application. Notes and comments from the interview reveal that users enjoyed playing with the prototype of text-free quiz-game like application. They also express delight in its simplicity, and if utilized well it could aid in the learning of road uses and signs at one's comfortable time. Some said it helps practicalize highway-code without having to read both paper or electronic based versions. Therefore, it was argued that if it is utilized well it can be a useful tool for road users and prospective users of the application. Participants highlighted the potentials of using such a system in educating road users, that is the expert users can teach others.

Furthermore, participants indicated that the application can help improve driver's

ability to remember road use information after long the use of the application, as recalling picture seen before is quite easier than words once read. Overall, the text-free application was well received by both groups. With suggestion on how to improve it, such as audio clarity, that it should not drain the battery of the device and introduce complexity for expert users, give rewards in form of points as users move from novice to expert level.

Lastly, during experiment 2 testing in the text-free PhidoY version, user commented their preference after using the 50-50 strategy. For example, during testing a participant asked for the use of 50/50, where two wrong options removed for the question are options B and D from the possible options A, B, C, D sequence, with options A or C remaining as only available options, participant argued it is better the remaining options to choose from follows the same sequence A, B, C, D, that is suits him if options is the form A or B not A or C.

4.4 Observation

During application testing, test participants were observed. The aim of the observation is to examine how participants interact with the application and provide solutions to the problems identified. This helps in improving the final application design, also guides with recommendations for designing for text-free UIs on road use. Using the affinity diagram the observations were categorized into five categories; language and translation issues, system interaction, concerns, completion rate, assistance.

Language and translation Issues*:* The language used for the experiments are English and Yoruba for Experiment 1 and Experiment 2 respectively. Experiment 1 users are learned participants and had studied using the English language, while low literate participants of the application in Experiment 2, could communicate only communication with the indigenous language. The audio form was how they write not how they talk. Consequently, the moderator decided to translate the text from the Phido version to speech in the way people would speak.

System interaction: This experiment was done on a laptop, after each scenario was displayed and answered, participants were expected to navigate to the next scenario. This was done with ease by literate participants as they are most accustomed to using the computer, they needed no assistance. While low literate users asked to be helped in navigating to the next scenario. Although, this might not be a problem when the application is eventually on a mobile phone as the scenarios automatically changes after users have chosen their answer and they have been informed of the right answers.

Concerns: Several of the low literate users assumed that this study was a part of the Nigerian government's intervention towards improving road safety. They also assumed that soon they would be required to buy a mobile phone to learn the road safety rules before they could drive an actual car. Even after repeated assurances that this is a student study and not related to the government in any way, it is uncertain whether the users changed their minds.

Completion rate: The completion rate during testing for the question and answer section was 100% for literate users, none of the low literate users had 100% completion

rate. It was observed that low literate users took their time, walked through each scenario practicing think aloud before choosing the answers most suitable from the options to them; thus, they used more time on each scenario before giving their answers.

***Assistance**:* Literate users needed no assistance as they are familiar with other similar application interactions, while low literate users had low confidence interacting with the application thereby needing assistance. Therefore, assistance such as pointers/graphical cues to give clarity on the part of the image being discussed for low literate users is necessary.

In summary, the result from question and answer section, observations, interviews and questionnaire were presented in this chapter. The result from the question and answers section illustrated that low literate users can learn about road use and regulation information using a text-free application as it affords them usability like literate users have using text based application. In addition, the likert scale used in the questionnaire section is not be the most suitable scale for low literate users as it is difficult for them to suggest their true level of expectation using the system. Furthermore, observing and interviewing the participants shows how they felt using the application, how the application could be used effectively; thus, it helps to understand how users will operate the application, the challenges users might face, ways of improving it and how eventual design could compensate for that.

5. DISCUSSION

As mentioned earlier, it seems that the use of a text-free application in teaching low literate users in developing countries about road use and regulation, is the next logical step as it has been used in educative learning for job search, healthcare, map navigation and microfinance with success for those group of users who normally do not have access to this information because of their inability to read text only applications [Prasad et al., 2008]. This text-free application on road use and regulation was tested with five participants in each of experiment 1 and 2. Data was then collected from questionnaires participants filled after testing and using the application, their answers to interview questions about their experience of using the platform and ways of improving it. Notes were taken while observing participants interacting with the platform, results was also collected and analyzed for question and answers after testing the application. This section discussed the main findings from the research work.

5.1 Challenges with the Likert scale

Feedback is a useful tool in research as it impacts on learning and teaching [Hattie et al., 2007]. Therefore, tools such as questionnaire, used in obtaining data for analysis should be understood by participants. During the user testing for this road use and regulation application, low literate users showed that they had little or no exposure to workings of likert scale. After explaining how the likert scale works, it was observed PhidoY participants in Experiment 2 approach to scaling responses in the survey research was not suitable for boundaries of the Likert scale. (5) when they totally agree and (1) when they totally disagree. They argued that rating 4 is as bad as rating 1, also rating 2 is no better than rating 1.

From the discussion participants suggested that instead of using dimensions such as totally agree, agree, neither agree nor disagree, disagree, strongly disagree, it might be more appropriate for their user group if dimensions are based on likelihood of them using the application again or not. They queried that Likert scale is more for users who have used a similar application or have a relatable experience to the one being tested and can compare their experience to decide on the most suitable dimension on the Likert scale. However, as they had no access to text based highway-code or similar applications, it is difficult for them to compare the text-free application on road use against highway-code. A sample of the scale based on likelihood of low literate using the application again is shown below Figure 11. (Full table in appendix 5)

Element of experience	**Yes, I will like to use/play it again**	**Yes, I will not like to use/play it again. why?**	**No, I might be interested in using/playing it if improved.**
Playing the game/Application is fast			

Figure 11 Suggested scale boundaries for low literate in questionnaire

Read et al. [2006], suggests likewise other forms of suitable scales, one of such is the “Again - Again” table used for children. The research presented is concerned with using the usual survey methods. It investigated Child Computer Interaction and how it reflects on children studies. Therefore, the research noted that using an Again - Again table is

potentially less flawed when there is a comparison of items, features, or products. The Again - Again table as shown in the figure below reveals similar layout to suggested scale boundaries by low literate participants on text free application for road use and regulation. The intention is to gather opinions to improve or modify a product. Figure 12 shows an example of Again-Again table

Would you like to do it again	Yes	Maybe	No
Activity 1	X		
Activity 2		X	

Figure 12 Example of Again-Again table [Read et al., 2006]

5.2 Challenges with formal vs colloquial language

Another challenge experienced during testing was that the use of Yoruba Language as language of interaction for low literate participant is not developed to interpret boundaries of Likert scale, in some terminologies used in interviews and the question and answers section. The language is the indigenous language spoken by all participants of PhidoY in experiment 2. During testing, for participant of PhidoY version, it was observed that the written form of the Yoruba language is different from it spoken form; thus, it created some usability issue for them, while using it in an audio form. They basically found it a little confusing in following the written version of the audio output.

Therefore, the written Yoruba text was then made into Yoruba audio by the moderator; thus, the audio form was from how they write not how people talk. Consequently, during testing the moderator observed that there was a usability issue as participants found it hard to understand the Yoruba audio form. It was then decided that it is better translating directly from the English text in the Phido version of the application to the Yoruba speech style, that is the way people would speak. Therefore, for implementation of a text-free design on road use, the right form of audio output is very important. An ethnography study should be conducted to ascertain the language form before creating the audio output form.

5.3 Challenges with text-free audio options after 50-50:

During experiment 2 testing in the text-free PhidoY version, users commented about their preference after using the 50-50 strategy. They argued for example, when they asked to use the 50/50 and two wrong options were removed from the possible options A, B, C, D sequence, for example option B and D, with options A or C remaining as only possible options available, they argued that it will be better that the remaining options to choose from follows the same alphabetical sequence A, B, C, D, that is suits them if it is options A or B after 50/50 not A or C.

5.4 Opportunities for learning by experience or visually

Furthermore, from the result in chapter 4 it was observed that even without little formal training on the road rules and regulations, the mean and standard deviation of participants in figure 8 shows that the percentage of correct answers given by PhidoY participants was better than Phido and PhidoE during the testing of the application. Although, the reason for their performance is not known from this experiment. PhidoY

participants suggested that it might be that they have experienced similar situations to the scenarios used during testing while driving on the road, some with costly consequences. They argued this gave them an edge over literate private drivers with less driving time, who might have read the highway-code or not while learning to drive. Designing a text free based application on road use for low literates which gives them the opportunity to learn on a platform where making fatal mistake is desirable.

Balogun et al., [2012] supports this argument, "*It is pertinent from the foregoing that driver training and retraining need to be redesigned to address the peculiar needs of private and commercial drivers in Nigeria. This is based on the realization that the needs of commercial and private drivers may not necessarily be the same. In the same manner, traffic regulatory authorities should be able to develop driving control strategies that recognizes the different driving behavioral tendencies"*.

Finally, the successful use of text-free based UI on road use and regulation for low literate, has shown that it could help to easily learn road use, regulation. It might be the solution that is yearned all along towards a good driving culture.

5.5 Design Recommendations for designing a Text-free UI Road Use and Law Application

During the designing and testing of this text-free user interface about road use and regulations, notes taken on all the challenges low literates and literates but novice users faced while using this text-free user interface during testing were noted. Hence, some design recommendations on how to cater for the challenges text participant faced when they were using a text-free UI design for road use and laws in developing world.

Provide pointers for clarity: The use of pointers is a necessity for a text-free application for road use, as it aids discoverability and clarity. It helps users to be sure of the exact part of the user interface the audio output is describing. If an audio output from the application is asking users the interpretation of a road sign in the provided image, the pointer helps in clarifying and locating in case there are more than one road signs on the image. For example, if an image of a sign post on the road and a zebra crossing near it, and an audio output asks user to describe the purpose the road sign on the image, without the pointer to the road sign, this could confuse the users as it is not clear which sign they are to describe - the zebra crossing or the sign post. Unless for expert users of the application, where the pointer will give away the answer to the question, provision of pointers is necessary. This recommendation is supported by Medhi et al., [2011], where it encourages the use of graphical cues to help break down usability barriers.

Avoid the use of task completion time: From the result section in the previous chapter completion rate for low literate participants in the question section of the application testing on this shows that when designing educative text-free interface on road use and regulations, it might be better to avoid the use of time bound for novice user. Although, as the difficulty level in the game like application increases, time restriction could be added to increase gamification experience. This is supported by Findlater et al., [2009], the use of time at the difficulty level help users gain. With increases familiarity completion time for application users decreases the more as semi-literate users get use to an application.

"*The use of task completion time in transition from audio text to text-only interaction decreases as participants familiarize with the task. And this improvement and time reduction in application use could have been due to several factors, which include a general increase in familiarity with the experimental task and setup, also the reliance on short-term memory versus longer-term learning*". [Findlater et al., 2009 pg 1759]

Authenticate audio output form: Previous research on text-free based UI design by Medhi, I et al., [2011], suggests local language support, both in text and audio should be provided by an application designer. Likewise, this research has informed us not to only provide local language support, but it should also be in the same form as the spoken form of the language as there is a difference usually in spoken and written form of most languages. For in app support clear audio that is not misleading is also needed, so users can know and understand what is expected of them. An application with a written language form as audio output might create a usability problem for application users as that form is not usually used in speech interaction.

Provide users with alphabet based answer options*:* Experience from this study shows that sometimes participants input audio answers that are based on their experience on the road, but their choice of answer is not an option for the question they are answering. Therefore, answer options should be alphabet based, as most participants were familiar with the alphabet and can easily recall the alphabet option no matter their level of literacy because the alphabet script in the Yoruba language is similar to that of the English-language. The only reason for numeric text input is when they are making a list as user input. For instance, the use numerals as options during testing confused participants, they thought it was a list and not options. Although, this contradicts Medhi et al., [2009], which states that an application designer should avoid non- numeric text input, that application users are then more familiar with numbers, as Hindi script is different from English language alphabet. Therefore, it suggested that numbers should be used with subjects who are not fluent in English, as they could identify number and what those number are.

Avoid designing platforms that require scrolling: It is clear from the research that most low literate participant in experiment 2 had problem with the system interaction, moving from one scenario to another. It is advised that the information that is being passed across should be concentrated around the center of each scenario of the application, else they miss it. Interaction such as navigation, dragging, zooming, double tapping might be too much for them to achieve if eventually this application is made into a mobile application, as they have little to no use of technological skills. According to Medhi et al., [2009], vertical scrollbars was not initially understood by low literate, non-users and voice only users and they did not realize what other functions were beneath what was displayed due to not being technologically enlightened.

Therefore, there is no doubt that designing takes practice and patience but following these guidelines in designing an application on road use and regulation, can help road users avoid many of the common errors they make while driving on the road as they get to use an efficient application that teaches them all the required information.

Provide icon tabs for options to application questions: Provision of icon tabs for options on the road use user interface could help resolve confusion caused during experiment 2 testing of the text-free PhidoY version. Even if the options A, B, C, D sequence order is not followed the use of icons can compensate as it creates some visual representation for when and how two wrong options are removed. This is supported by Gatsou et al., [2012], which states that "*graphics and icons, are essential elements of user-device interaction, they are used extensively in interface design on the assumption that visual icons are capable of transcending language barriers and of presenting meaning in condensed form".*

5.6 Limitations of the work

1. The application itself was used on a laptop and not on a mobile phone. Thus, the results gotten from the application testing are from laptop but should potentially be similar with mobile phones. More research is required to validate this.

2. The Text font on application design was not consistent for literate users: The reason for this is that the text volume and picture quality varies for scenarios in Experiment 1, text font used were Trebuchet MS 18 and 20. Pixel to text ratio was considered so as to prevent participants undergoing interaction such as navigation, scrolling, zooming on the interface to read text or having a pixelated picture which participants can't interpret. All text scenarios are available in appendix 3.

3. Participants recruitment is from known sources: Two contacts helped with recruitments; a lecturer and a public transportation driver. The lecturer introduced me to a final year student who contacted nine other fellows for user centered design. Also, participants recruited for experiment one version of the application are students who are not members user centered design group. For experiment 2 recruitment, the known public transportation driver brought others commercial drivers in their union as participants for experiment 2. During testing participants were informed and were expected to give feedback based on their experience using the application, this enables the research to know if the tool was effective, and how it may be improved on. They were informed that they are not been tested and their feedback be it positive or negative is important.

4. The small number of participants, which means that the results are based on a very small sample size, this in effect can increase the margin of error.

6. CONCLUSION

This thesis presented a text-free educative platform for the developing nation, which enabled road users to learn road use and regulation to prevent accident. Majority of road users in developing world are low literate, therefore cannot access text based road use and regulation made available to them due to their illiteracy. Therefore, this create a gap; thereby making a chance of accident occurring higher as most of them learn from their experiences on the road. The use knowledge of ICT4D helps in creating a text free user interface for this group of users. This chapter summarizes the thesis by restating the finding that answers to the research question that motivated the study.

1. Can text-free UI on road use and regulations aid and improve driving culture in developing countries for low literate users.

Testing if a text-free user interface (graphics and audio annotation) on road use and regulation inform low literates car users, from result in chapter 4 it shows that they could access information that normally were not available to them due to the information being text based. This information can be used in teaching present and aspiring public road users who are majorly low literate on road use instead of them learning from their experience on the road which is usually fatal. If this information is followed and adhered to by this group, this will go a long way in ensuring safety as majority of passengers, goods and services are transported using public transport system.

2. Results of comparing two design conditions on the applications:
    - Phido (image with text options only) and PhidoE (image with audio questions and options in English language)

    - PhidoY (image and audio questions with options in Yoruba language) one of the indigenous languages in Nigeria, spoken majorly by over 40 million people in the southwest of Nigeria.

And to see if the information literate participants could get from the Phido version of the application can also be presented to low literate/semi-literate or novice but literate in the text-free form of the application with the same result after participant testing.

This research result in chapter 4 shows that literate participants could make use of both forms (Phido and PhidoE) of the application. Although, it is difficult to state which one is the most preferred for them as they had the same mean score with little difference in their standard deviation. It can be deduced that if both version is available then it should be usable to then. In fact, having both forms for literate but novice technology users will be very useful for them. They can use the text-free application version of the same application till they become expert. Secondly, low literate could use the application PhidoY as their result showed in chapter 4. Participants of the PhidoY testing had better mean and lower standard deviation than that of both Phido and PhidoE participants. This result shows the success of text free UI; it replicates a text based user interface into one without text for participant who cannot use text based application.

Therefore, this study designed a set of guidelines for low literate on road use and

regulation which were presented in chapter 5. They include providing pointers for clarity: elements in the visual (image) should be clearly understood, avoiding the use of task completion time: tasks solution should not be time dependent, although it can be introduced as a level of difficulty, provide users with alphabet based options, authenticate audio output form. Although, these guidelines are not a direct result of the empirical study conducted as part of this thesis. Instead, they were drawn from prior literature and experiences while observing participants interaction on this thesis. These guidelines are aimed at overcoming the challenges faced during interactions with text-free road use and regulation application. However, it should be noted that further research would be required to validate these design guidelines.

In summary, this thesis presented a comprehensive literature review of studies related to text-free UIs and how they have been successfully used, challenges in promoting road safety in Nigeria, game assessment module test analysis system, gamification and importance of mobile phone in ICT4D. Therefore, a prototype system for teaching road use and regulations for low-literate and literate but novice users was introduced. This system was then used to evaluate two experiments, the (Phido and PhidoE) for literate users and (PhidoY) for low literate to ascertain how useful the applications were for this groups of users. Future work would involve implementing this system on a mobile device as most target users of this application have a mobile phone and can learn during their leisure time. I hope this work inspires more future work aimed at seamlessly improving road safety in the developing world.

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APPENDIX 1

University of Tampere

Date: ___ /__ / 2017

CONSENT TO RECORD A USABILITY TEST

I ask you to participate in a usability test that is part of my master thesis work at the University of Tampere. By participating in the usability test you will help me to evaluate the usability of an application, designed to improve road use and reduce accident rate on road in developing countries.

You will be asked to perform different tasks using the service (prototype version of an application) and to think out loud while doing the tasks.

In addition, we will ask you to fill in questionnaires and we will interview you about the use of the service.

You can stop participating in the usability test at any point.

By signing this form, you will accept the above terms.
Date and place: _____
Signature: _____
Name clarification : _____

APPENDIX 2

Questionnaire

Date: _____ Evaluation code: _____ Age: _____ years ☐ Girl ☐ Boy

Years of studying English: _____ Years of computer Studies: _____

Using the application...	Totally disagree		Neither agree or disagree		Totally agree
1. ...is fast.	☐	☐	☐	☐	☐
2. ...is pleasant.	☐	☐	☐	☐	☐
3. ...is clear.	☐	☐	☐	☐	☐
4. ...correctly is effortless.	☐	☐	☐	☐	☐
5. ...is easy to learn.	☐	☐	☐	☐	☐
6. ...is natural.	☐	☐	☐	☐	☐
7. ...is useful.	☐	☐	☐	☐	☐
8. ...is entertaining.	☐	☐	☐	☐	☐
9. ...is interesting.	☐	☐	☐	☐	☐
10. I would like to use the application in the future.	☐	☐	☐	☐	☐
11. I believe I learned while using the application. *What did u learn?*	☐	☐	☐	☐	☐
12. I like the idea of the application.	☐	☐	☐	☐	☐
13. The hints offered by the application are useful.	☐	☐	☐	☐	☐
14. The hints offered by the application are annoying.	☐	☐	☐	☐	☐
15. The application offers enough hints.	☐	☐	☐	☐	☐

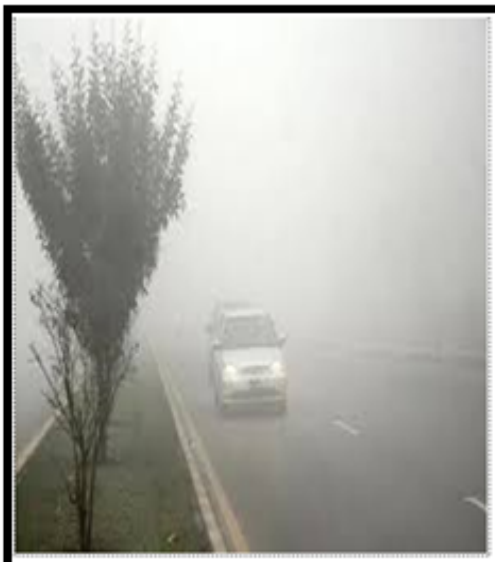
1. What are the best features of the application?
2. What are the worst features of the application?
3. How do you think the application could be improved?
4. Do you have a laptop/mobile phone? Do you play games on it?

APPENDIX 3

List of Phido version of the scenarios for testing

What does this sign symbolize?

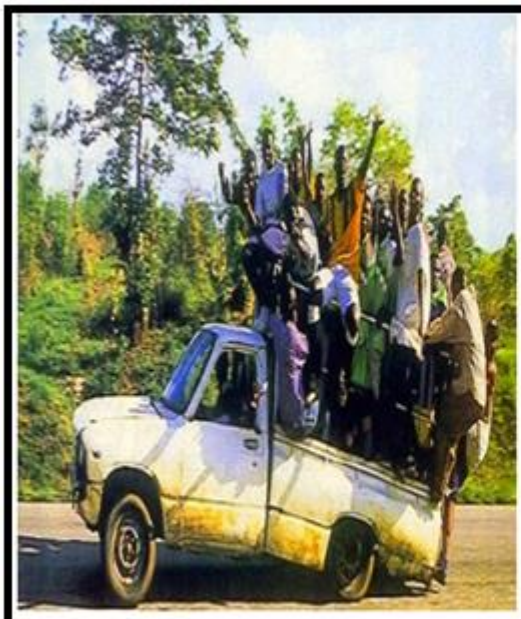
A. Road closed ahead
B. No left turn
C. No U-turn permitted
D. No passing zone



From the image which is a harmattan/misty/foggy condition, users are asked to choose which one of this is not right for a driver to do under these conditions.

A. Put on your wiper
B. Reduce your speed
C. Keep a safe distance from the next car in front of u
D. Honk so the people know you are driving on the with same speed.

APPENDIX 3



- Which of the terms below best describe the scenario in the image

A. Overtaking

B. Flexing

C. Overspeeding

D. Overloading

When the car driver sees this she/he should

A. Turn in the right direction

B. Reverse in the lest direction

C. Apply his brake and stop driving

D. Step out of the car

APPENDIX 3

What does this sign imply about the road you are approaching?

A. The road ahead has poor traction
B. Winding road ahead
C. Hilly road ahead
D. Road ahead gets slippery when wet

What would you interpret this sign as implying?

A. No trucks allowed
B. No passing zone for trucks
C. Trucks must yield to other vehicles
D. Hill ahead

During braking one of these is not required for a car driver to observe

A. Never get too close to the vehicle in front.
B. Sudden braking could result in loss of control
C. The driver can apply brake when needed, other driver are not blind.
D. Always try to brake gently and in plenty of time

On a typical express-way in Nigeria which is right and can not cause to accident.

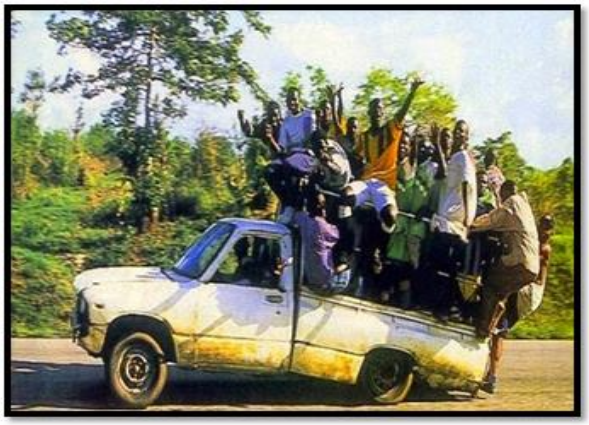
A. Pedestrian crossing is not forbidden
B. Animals roaming on the road is ok
C. Speed limit is usually above 80km/H unless otherwise stated, therefore animals, pedestrian are forbidden
D. loading and unloading is allowed

During take off , which of this must you as a driver observe except one

A. The driver should observe the mirror and ensure that the road is clear.
B. The driver should observe the car is moving gradually
C. The driver should shift the gearbox to drive or gear one and speed off
D. Keep your eye on the road when the vehicle moves on

APPENDIX 4

Text-free PhidoE version - Instructions



Question 1 with four options

Question 1 with two options after 50/50

Question 2 with four options

Question 2 with two options after 50/50

Question 3 with four options

Question 3 with two options after the use of 50/50

Question 4 with four options

Question 4 with two options after the use of 50/50

Question 5 with four options

Question 5 with two options after 50/50

Question 6 with four options

Question 6 with two options after the use of 50/50

Question 7 with four options

Question 7 with two options after 50/50 use

Question 8 with four options

Question 8 with two options after 50/50 use

Question 9 with four options

Question 9 with two options after 50/50 use

Question 10 with four options

Question 10 with two options after 50/50

APPENDIX 5

Suggested scale for low literate users

Element of experience	**Yes, I will like to use/play it again**	**Yes, I will not like to use/play it again. why?**	**No, I might be interested in using/playing it if improved.**
Playing the game/Application is fast			
Playing the game/Application is pleasant			
Playing the game/using application is clear			
Playing the game/Application is easy to learn			
Playing the game/Using application is useful			