Examining the Perceived Reliability of Cost Effective E-learning Handsets for Teaching and Learning in Schools

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DECLARATION

I, Mayowa Abiola Sofowora, hereby declare that this dissertation is original and all the materials used are appropriately acknowledged and explicitly referenced. A bibliography is appended to the dissertation.

I also certify that the dissertation has not heretofore been submitted in any of its part or entirety for a degree in any other institution of higher learning locally or internationally.

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Supervisor Date

Professor Seraphim, D. Eyono Obono

DEDICATION

This dissertation is dedicated to my parents and siblings for their unwavering support, and unrelenting motivation throughout the duration of this study.

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I would like to express my sincere appreciation to the Almighty God, for infinite mercies, strength, and grace throughout the duration of this study.

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ACRONYMS

IEC	International Electro-technical Commission
MTBF	Mean Time Between Failure
MTTR	Mean Time To Repair
MTTF	Mean Time To Failure
PDA	Personal Digital Assistant
PIN	Personal Identification Number
SMS	Short Messaging Services
MMS	Multimedia Messaging Services
Tx	Transmitter
Rx	Receiver
LCD	Liquid Crystal Display
PCB	Printed Circuit Board
IC	Integrated Circuit
CPU	Central Processing Unit
RAM	Random Access Memory
CFRI	Consumer and Fashion Research Institute
EPA	Environmental Protection Agency
ICTs	Information and Communication Technologies
EDT	Expectancy Disconfirmation Theory
CCB	Consumer Complaint Behaviour
SPSS	Statistical Packages for Social Sciences
ANOVA	Analysis of Variance
IMF	International Monetary Fund
α	Cronbachs alpha
β	Beta
λ	Failure rate

ABSTRACT

The use of mobile devices such as cell phones, smartphones, personal digital assistants and tablet computers is becoming prevalent in today's world; and it is facilitating access to a vast amount of data, services and applications for the improvement of people's lives. Advances in electronics and manufacturing technologies usually lead to the rapid release of newer and sleeker models with new features and capabilities. These newer models therefore render older models obsolete, and this pushes people to frequently replace their devices. The drawback of such frequent replacements is that a large number of devices are disposed and they end up as e-waste. The fact that e-waste constitutes a major hazard to human health and to the environment is the motivation behind this study whose aim is to examine the factors affecting the perceptions of teachers on the durability of cell phones in the e-learning context. This research aims was achieved through the content analysis of existing literature and through a survey of 67 secondary school teachers from the iLembe and UMgungundlovu district municipalities in the KwaZulu-Natal province of South Africa. The attribution theory was selected as the theoretical framework for this study, and it led to the identification of four independent variables (Demographics, Intention, Knowledge, and Actual use) and of one dependent variable (Perceived Durability). The results of this study indicate that teaching experience and school location are the only two demographics that affect other variables from this research: School location affects cell phone durability, and teaching experience affects cell phone usage intentions. These results also indicate that all the variables of this research are linked except for the relationship between knowledge and perceived durability. One of the recommendations of this study is the proposal of a three year cycle for cell phone renewals in schools mobile learning projects in order to manage e-waste through e-recycling, and this recommendation is based on the finding of this research that teachers believe that cell phones generally lasts between two to three years. The main contribution of this study is to have examined the durability of mobile phones in the e-learning context and this is something new compared to all the studies reviewed by this research.

CHAPTER I

INTRODUCTION

The aim of this study is to conceptualize the factors influencing teachers' opinions on the durability of cellphones when used by learners. The purpose of this introductory chapter is therefore, to present an overview of dependability concepts and their application to the domain of ubiquitous computing, before presenting the objectives and rationale of this study, having in mind that durability is an attribute of dependability and mobile handsets belong to ubiquitous computing. The term cellphones will be used interchangeably with cost effective e-learning handsets (CEEHs) throughout this study.

1.1 Dependability of Products

The English dictionary defines dependability as an attribute of consistent quality, performance, or trust (Oxford Dictionary, 2013). The history of product dependability goes back to World War II where it was observed that "50% of all stored [US] airborne electronics became unserviceable prior to use" and the "US Air Force reported a 20 hour maximum period of failure-free operation on bomber electronics". It was also observed that "the US Army was plagued by high truck and power-plant mortalities, while the US Navy did not have a dependable torpedo until 1943. Horror stories persisted (and still do) about the large fraction of military electronics that failed to operate successfully when required", and "until the early 1950s the problem of unreliability was met by increasing spare parts inventories". The first solution proposed by the US defense department to its reliability problems was the introduction of the Military Handbook 217 (MIL-HDBK 217) which contains information on the failure rates of various devices such as semi-conductor devices and integrated circuits, based on certain variables or factors such as the temperatures and voltages (Ohring, 1998). This short extract from the history of product dependability shows that product failure is central to the concept of product dependability. Dependability of a system or device can be defined as the ability of that device to deliver trusted services, or the ability of a system or a device to avoid unacceptably frequent and severe service failures (IEC, 2014). Dependability can be described according to three characteristics: the attributes of dependability, the means towards achieving dependability, and the threats to dependability (Avizinesis, 2004).

1.1.1 Products' Dependability Attributes

There are six attributes of product dependability: Availability, Reliability, Maintainability, Safety, Security, and Integrity.

1.1.1.1 Products' Availability, Reliability and Maintainability

Product availability can be defined as the probability that a product or device and its components will perform its necessary functions when required (Dekker, 2003); in

other words, it is the ability of a system to be ready for correct and accurate service. On the other hand, products, systems, or devices are deemed to be reliable if they are able to regularly execute the tasks for which they were designed and based on specific assumptions (Evans, 2014). As for maintainability, it can be defined as the ability of a product or device to undergo repairs and modifications, or to be quickly repaired and be restored back to its correct functioning state after suffering from damages or faults (Alven, 1964). Maintainability also refers to the maintenance processes and procedures necessary for restoring a failed product or device to its correct operating condition (Ohring, 1998). Maintainability has two sub-attributes, namely, serviceability and repairability. Serviceability can be defined as the ease and speed in which maintenance services and repairs can be conducted on a device when it fails, or how easily serviced or repaired a device can be in order to restore it back to its normal operating state (Tallman, 1980). Repairability, on the other hand, is the ability for a product, a system or a device to be fixed and reinstated to its original operational state whenever damaged or when it fails. It can also be defined as the ability of a device to be restored to its original operating conditions after it fails (Dhillon, 1999).

1.1.1.2 Products' Safety, Security and Integrity

Safety can be defined as the probability of non-occurrence of disastrous consequences to the user, to other devices, or to the environment, as a result of device failures. Product safety is concerned with the reduction in the probability that using a product will result in illness, injury, death and other negative consequences to people, properties or equipment. Product safety issues can be as a result of design errors, manufacturing or processing defects, and packaging errors, or a combination of these factors (Marucheck *et al*., 2011). Product security describes the ability of a product or device to protect itself from accidental or deliberate intrusions, and interruptions that can lead to damages and total failure of the device (Sommerville, 2004). Product security problems can arise as a result of deliberate replacement of materials and components during manufacture, contamination and corruption of a product, and distorting counterfeit products with the aim of making them look authentic by using counterfeited labeling and packaging.

According to Clark and Fujimoto (1990), product integrity refers to the consistency between a product's functions and its structure. It also refers to the consistency between a product's performance, and the users' or customers' expectations for that product before purchasing and using it. Products with integrity perform flawlessly and superbly, they satisfy customers' expectations, and also provide good value for money spent on the product, in other words, the buyer is receiving exactly what he or she paid for and not something else of equal or lesser quality and performance.

1.1.2 Products' Dependability Threats

There are three main threats to the dependability of products: Faults, Errors and Failures. Measures used to quantify these dependability threats are: Failure Rates, Mean Time to Failure, Mean Time between Failures, Mean Time to Repair, and Durability or Expected Lifetime.

1.1.2.1 Products' Faults, Errors and Failures

A fault is defined as a cause for an error, whereas, an error is a deviation in the behaviour of a device from the norm (Avizienis *et al*., 2004). A fault can either be a temporary fault or a permanent fault. Permanent faults cannot be repaired or fixed. They are either caused by design and manufacturing errors, or by irreversible physical damages to a product. On the other hand, temporary faults occur as a result of short-term malfunctions in a product, and products suffering from temporary faults can be repaired and restored to their original or normal functioning state. Products suffering from too many errors may ultimately experience total failure requiring replacement (Shiffel, 2011).

1.1.2.2 Products' Failure and Repair Rates, Mean Time to Failure, Mean Time between Failures, Mean Time to Repair

The failure rate of a product can be defined as the frequency with which that product or device fails. It can also be described as the conditional probability that a product will fail within a given time interval, given that the product was in a good operating condition at the start of the interval (Lawless, 1982). The failure rate of a product usually increases as its expected lifetime increases, for example, the failure rate of an

automobile in its fifth year of service may be many times greater than its failure rate during its first year of service, due to wear and tear of its components, such as the exhaust pipes, brakes, etc. (Nema, 2012). Some other related product failure rate measurement parameters are: the mean time to failure (MTTF) of a product which is the average expected time between the start of use of a product or until the first failure of that product; the mean time between failures (MTBF) of a product is the expected time between two consecutive failures in that product (Relex, 2009); and the mean Time to Repair (MTTR) which is the estimated time period between the time of failure of a device and the time of completion of its repair (Bowles, 1995). The failure rate of electronic components and devices is denoted by λ. It measures the numbers or frequencies of failures that occur in a device over a period of time. A device's failure rate, mean time between failures and mean time to failure are all measures of its reliability. There is an inverse relationship between the failure rate and the mean time to failure or mean time between failures of electronic devices and components given by $\lambda = 1/\text{MTBF}$, or $\lambda = 1/\text{MTTF}$….(equation 1.1.2.2) (Ohring, 1998).

1.1.2.3 Products' Durability or Expected Lifetime

The durability or expected lifetime of a product is defined as the time duration for which that product can be expected to perform its function(s) properly without failure, despite accidents and abuse by users. Product lifetime is the time duration, starting from the time of purchase to the time of replacement or discard or end of life of the product (Van Nes and Cramer, 2006). The expected lifetimes for some classes of products have increased due to improvements in the design of materials and manufacturing technology, but, in recent years, the life expectancy of some classes of products, such as mobile phones, have decreased (Yun, 2013). The expected lifetime of a product or device is the same or approximately equal to the device's technical lifetime; which is the total time for which a product is technically designed to operate or perform its required functions and device replacement usually occurs at the end of the device's technical lifetime (Ricardo, 2014).

1.1.3 Products' Dependability Means

There are four main means or processes that can be used to achieve product dependability: Fault Prevention, Fault Removal, Fault Forecasting, and Fault Tolerance or Survivability

1.1.3.1 Products' Fault Prevention

Fault prevention is the means towards preventing the introduction or the occurrence of faults in a system or device. Fault prevention is achieved by the use of quality control measures or techniques during the design, development and manufacturing of a device or product (Dubrova, 2013). Fault prevention applies both to the hardware and software components of a product or device. Preventing faults for a product's hardware involves processes such as hardware design reviews, and hardware screening or testing (Tumer, 2005). On the other hand, processes such as structural programming, software modularization and other formal software verification techniques are used to prevent faults and errors in a product's software (Yu, 2002).

1.1.3.2 Products' Faults Removal

Fault removal is the means used to reduce the amount and severity of faults in a product. Faults can either be removed during the product manufacturing phase before a product is put into use, or they can be removed during the product use phase through maintenance practices. Fault removal in products is achieved by means of corrective maintenance or preventive maintenance. Preventive maintenance is performed during the product design and development phase, while corrective maintenance is performed during the operational life or use phase of a device. Corrective maintenance aims to remove faults that have been reported, but preventive maintenance aims to uncover and remove faults before they can cause errors in the product's normal functions (Avizienis *et al*., 2001).

1.1.3.3 Products' Fault forecasting

Fault forecasting describes the techniques that are used to estimate the total number of faults present in a device, the possible future occurrences of faults in a device, and the resulting consequences of the occurrence of such faults in the device. Fault

forecasting techniques can either be qualitative or quantitative. Qualitative fault forecasting aims to rank the types of device faults and errors or a combination of other events that lead to total product failure according to their severity levels, while quantitative fault forecasting aims to evaluate the probability for a product to satisfy some of the product dependability attributes such as reliability, availability, and maintainability (Dubrova, 2013).

1.1.3.4 Products' Fault tolerance or Survivability

Fault tolerance is the means to avoid service failures in the presence of faults. It can also be described as the ability of a product or device to protect itself, to tolerate, and to quickly recover from abuses, damages, and wear and tear while still in use, and to continue to providing the expected correct service(s) in the presence of such abuses and damage. The aim of a fault-tolerant system or device is to tolerate faults and still continue to function properly without interruptions or failure. In order to make a system or device fault-tolerant, redundancy must be used (Gartner, 1999). Redundancy is the process of duplicating critical components of a system or device including software components such as the operating system and critical software applications, and hardware components such as resistors, transistors, integrated circuits, logical gates, etc. (Geoffrey and Motet, 2002).

1.2 Dependability of Mobile Handsets

The first part of this chapter focuses on the dependability of products, in general but this section will now focus on the dependability of mobile handsets and ubiquitous computing, in line with the aim of this study. The structure of this section is adapted from that of product dependability.

1.2.1 Mobile Handsets' Dependability Attributes

This section briefly discusses the main mobile handset dependability attributes such as the availability, reliability, maintainability, safety, security and integrity of mobile handsets when considered as being part of ubiquitous computing.

1.2.1.1 Mobile Handsets' Availability, Reliability, and Maintainability

The availability, reliability and maintainability of mobile handsets are affected by ubiquitous computing dependability threats to its critical components such as the network, power, software, display, keypads, housing and memory components. These threats will be further described in the section below on the dependability threats to mobile handsets.

1.2.1.2 Mobile Handsets' Safety, Confidentiality and Integrity

The safety, confidentiality and integrity of mobile handsets can be compromised by ubiquitous computing ethical issues such as loss or theft, unauthorized access, malware and viruses, and electronic eavesdropping and tracking (Jansen and Scarfone, 2008).

Loss or theft: Due of their small sizes, handheld devices can easily be lost or misplaced. They are also an easy and attractive target for thieves, and if proper care or safety measures are not taken, the device can be stolen, making it easy for intruders to gain unauthorized access and expose sensitive or confidential data stored on the device. According to a survey by the Gartner Group in 2001, an estimated 250, 000 cell phones and other handheld devices were lost in several airports around the world, and less than 30% of them were recovered (Bennet, 2003). Another survey study conducted by Check Point (2005) of many taxi firms in Australia, Denmark, Finland, France, Germany, Norway, Sweden, UK, and the US indicated that tens of thousands of mobile devices were mistakenly left behind by commuters in 2007. Furthermore, a survey study by Shanahan (2007) in the US also reported that about 85,619 cell phones and around 21,460 Personal Digital Assistants were left behind in one Chicago taxi firm's vehicles all within a six-month period of study.

Unauthorized access: Unauthorized users may gain access to a device and its contents even if security measures are put in place. By forging or guessing authentication codes such as the PIN code or password, intruders can bypass the device's authentication mechanism entirely (Jansen and Ayers, 2007). For example, when carrying out investigations involving mobile devices, forensic detectives often attempt to gain entry into locked devices by entering commonly used PIN codes,

such as 0000 or 1234, as two of the three PIN code entry attempts allowed by the device before it is totally locked down (Van der Knijff, 2010).

Malware and Viruses: Mobile malware and viruses are generally targeted towards mobile devices mainly over the mobile communications networks. There are several ways in which malwares/viruses are spread to handheld devices, but prominent examples include: via downloading of files (infected music, video, documents, etc.) over the internet; via messaging services (e.g., malware attached to emails, SMS, MMS, and other instant messaging services); and via Bluetooth and Infrared connections. The most common types of malware attacks on mobile devices are: spoofing, data theft and data interception, network service abuse, worms, system unavailability, and unauthorized network access (O'Connor, 2007). The effects of malware attacks on mobile devices are less severe than those on desktop and laptop computers, but, in recent times, malware attacks on mobile devices have been increasing rapidly and are expected to continue expanding if adequate countermeasures are not put in place (Naraine, 2004).

Electronic Eavesdropping and Tracking: Electronic eavesdropping describes the process of attempting to access and eavesdrop on transmitted information over an active communications network. The most common method of electronic eavesdropping is for spy applications to be installed on a device in order to intercept information and transmit it to another mobile device or server (Jansen and Scarfone, 2008). Nowadays, spy software applications installed on mobile devices are commonly used by individuals to monitor their child's or spouse's activities and eavesdrop on their phone conversations without their knowledge and consent (Jansen, 2009).Telecommunications companies and law enforcement agents also make use of these spy software to intercept cellular traffic and conversations during criminal investigations. Electronic tracking applications are used to track a device’s location. These applications are commonly used by users to track the whereabouts of their family and friends, and are also used by some firms to track the whereabouts of their employees (Jansen and Scarfone, 2008).

1.2.2 Mobile Handsets' Dependability Threats

This section briefly discusses the main components of cell phones and the common types of faults, errors and failures that affect each component. The section ends with some statistics on the dependability of mobile handsets in terms of their failure rate, mean time to failure, mean time between failures, mean time to repair and durability/expected lifetime.

1.2.2.1 Mobile Handsets' Faults, Errors, and Failures

The durability or life expectancy of a mobile handset is a function of the effects of the failure of its individual components (Tiwari and Roy, 2013). In other words, the duration of time a given handset will last is determined by how long each of its components functions well without faults and errors that may lead to total failure of the device. According to Sands and Tseng (2008), cell phone faults, errors and failures can be generally categorized into the following main failure categories: Network, Software, Power, Screen, Keypad, Casing or Housing, Speaker, and Memory.

Network: The network component is responsible for facilitating voice and data communications between several devices over the cellular network. There are many different types of faults that can occur in a network connection between mobile devices. The most common examples of network faults include network bandwidth insufficiency, network signal transmission interferences, frequent call cuts, network latency or network signal delays; poor call quality/reception, and frequent call drops calls (Deepak and Pradeep 2012). Network failure occurs when there is a total outage of cellular signal or network service on the device. It can be as a result of a device's transceiver (TX/RX) integrated circuit failure, device antenna failure, or as a result of erratic or unreliable network service from the network service providers.

Software: Mobile software refers to the software applications designed to run on handheld devices. It consists of mobile operating systems and the mobile applications designed to run on these devices. Mobile device software faults are generally caused by bugs and viruses. Software bugs are programming errors or

mistakes in the software program's source code and design that cause it to produce unexpected or wrong results (Allen, 2002). On the other hand, software viruses or malware programs are malicious computer programs that replicate themselves into other computer programs in order to perform harmful activities on the infected host devices. Bugs and viruses in mobile devices result in operating system lockups and freezes, frequent software applications freezes, frequent self restarting or rebooting of the device and, eventually, total device failure or dead phone (Cinque, 2007).

Power: The mobile phone battery and battery charger are the components responsible for powering on the device. The charger point is the component that acts as an interface between the cell phone charger and the batteries used to power on the device. Power failures will usually occur when the device batteries fail to retain charges, discharges easily or when it does not charge at all. It can also be as a result of faulty or failed charging port connectors, and faulty or damaged battery chargers.

Display: The display screen or Liquid Crystal Display (LCD) is one of the important components of a cell phone. It is the cell phone component that presents visual information to the user. It can either be touch screen or non-touch screen depending on the type of mobile device. The screen size varies by device model and it is usually described by both the screen height and width in pixels, or by the screen diagonal measured in inches (Huang, 2010). It enables all the images, documents and text entries in the cell phone visible to the user. Mobile device screen failure will usually occur when the display device exhibits screen burn-in, screen spots, dead pixels, and blank screen (Tiwari and Roy 2013). The most common cause of screen failures in mobile devices is due to intentional damages caused by the user, or it can also be as a result of unintentional or accidental damages.

Keypads: The keypads allow the users to interact with the mobile phone. The keypad is the most common data entry mechanism on most mobile devices, but touch screens can be found in some high-end smartphones (Zheng *et al*., 2012). Mobile device keypad faults will usually occur when the user is unable to type characters (numbers, letters, and symbols) using the keypads; when he or she can type some characters, but not all, using the keypads; when typing a character results in another

character being displayed, when characters are displayed on the device screen without pressing the keys; and when characters keep getting displayed repeatedly on the screen due to stuck keys. Keypad faults are commonly caused by moisture or dirt, or as a result of physical damage to the mobile device keypad or housing.

Casing or Housing: Casing problems usually occur when there is physical damage to the device's structural protection hardware or housing of the device. Due to everyday or daily usage, physical damages can happen to mobile devices; and it may be intentional or accidental. Intentional damage occurs when the device owner uses the device carelessly or mishandles it, while accidental damages occur as a result of unintended circumstances beyond the control of the user. Physical damages can result in damaged casings, allowing moisture and dirt into the device which leads to failure in the mobile device's Printed Circuit Board (PCB) and Integrated Circuits (Geoffrey and Motet, 2002).

Speakers: Cell phone speakers and microphone are the voice input and output mechanisms of a cell phone. The cell phone speaker or earpiece is the cell phone component that converts electrical signals to sound signals, while the microphone or mouthpiece is a component that converts sound signals to electric signals (Zimmer, 2010). The speaker and microphone allow the cell phone user to speak and hear from other people on the cellular network. Mobile device speakers' faults or errors occur when the device does not ring out or produce any audio sounds, or when the callers cannot hear each other's voice on both ends of the line; and it can be as a result of damaged or malfunctioning ringer and earpiece/mouthpiece (Sand and Tseng, 2010). Speaker errors can also be as a result of electromagnetic interference or electromagnetic induction generated by the radio frequency signals in a cellular network.

Memory: Mobile devices also have central processing units (CPUs) and other internal memory storage devices similar to those in desktop and laptop computers, but with lower capabilities in terms of size, processing power and speed, and optimized to perform on handheld devices. Memory problems are commonly caused by hardware defects in the memory components as a result of manufacturing errors

or defects, overheating, and power surges or fluctuations. Memory failure occur when the internal memory devices such as the CPU and RAM malfunctions resulting in slow device boot-up process, slow applications processing speed in the device, and dead phone (Sands and Tseng 2008).

1.2.2.2 Mobile Handsets' Failure Rates, Mean Time between Failures and Mean Time to failure

Previous studies have reported on the failure rates of mobile handsets and their components. For example, Jacobson and William (2004) analysed the failure rates and mean time to failures of two mobile devices to be used as part of an advanced weapon system. The study reported the failure rates (λ) and mean time between failures (MTBF) for the PDAs' components as follows. The failure rates for the PDAs' processors, an Intel PXA255 CPU, and an ARM CPU, were, respectively, estimated to $\lambda = 0.01528$, and to $\lambda = 0.01528$. The failure rates for the PDAs' battery, a Lithium-ion Battery were estimated to $\lambda = 20$; and the failure rates for the PDAs' LCD, a 320 x 480 pixel LCD were estimated to $\lambda = 4$. The overall failure rate for both PDAs was estimated to 0.5. These different failure rates show that batteries are more likely to fail, followed by LCD screens, and processors are the least likely to fail. The mean time between failures for the PDAs' processors, an Intel PXA255 CPU, and an ARM CPU, were, respectively, estimated to 6 years and 5 years. The MTBF for the PDAs' batteries was estimated to 0.005 years or 1.825 days, the MTBF for the PDAs LCDs was estimated to 0.25 years or 3 months, and the overall MTBF for both PDAs was estimated to 2 years. Again, it is clear that the MTBF for the battery is the shortest, followed by the LCD screen, and the CPU has the longest MTBF.

1.2.2.3 Mobile Handsets' Durability and Expected Lifetime

The replacement process for mobile handsets is known as the handset replacement cycle, and it can be defined as the time duration or length of time that the owner of a handset keeps his or her handset before replacing it (Entner, 2011). According to a survey on handset replacement cycles carried out by International Monetary Fund in 2010, and Recon Analytics in 2011; the United States has the shortest handset replacement cycle in the world, while India and Brazil have the longest. On average,

individuals in the United States replace their handsets within 1 year and 9 months, followed closely by people in the United Kingdom who replaces their mobile handsets within 1 year and 10 months. Furthermore, the study also reported that people in Korea replace their handsets within 2 years and 3 months. On the other hand, people in India and Brazil tend to keep their mobile handsets for longer periods of time than most countries in the world. The study found that people in India replace their mobile longest handset within 7 years and 10 months, while people in Brazil replace theirs within 6 years and 8 months.

In recent years, evidence from existing literature has shown that handset failure has been a key contributing factor to the decline in the duration of time people keep/use their handsets before replacing it. For example, Jones (2013) conducted a survey study on handset replacement in some European countries, and reported that majority of respondents who participated in the study replace their mobile phones because of device malfunctions and failure, rather than by advances in technology or by changing fashion trends. Another survey study by the Consumer and Fashion Research Institute (CFRI) in China also discovered that the average handset replacement cycle has dropped from around 1.73 years in the year 2008 to about 1.47 years in 2010, and it is interesting to note that over 43% of these respondents attributed the drop in replacement cycle to the need to replace their malfunctioning or failed handsets. Over 80% of these respondents reported that their handsets began to exhibit software problems within six to twelve months of purchase, 70% of the respondents also reported that they experienced handset operating system crashes, about 63% reported that they experienced screen failure, 51% found out that their device software did not function properly, and 34% experienced unreliable network connectivity, all within the first six to twelve months of purchasing their mobile handsets.

1.2.3 Mobile Handsets' Dependability Means

This section briefly discusses the main issues on mobile handsets dependability means , their fault prevention, fault removal, fault forecasting and fault tolerance, when considered as being part of ubiquitous computing.

1.2.3.1 Mobile handsets' Fault Prevention

Fault prevention in mobile devices can be very challenging. Due to their portable nature, mobile handsets' availability, one of their dependability attributes, can easily be compromised when the device is mistakenly forgotten or lost somewhere (Bohn, 2006). There are some useful interventions that can aid individuals in preventing mobile device loss. Computer-based memory aids, reminders and alarms can be integrated in mobile devices to help prevent unintentional losses, for example, Boriello *et al.* (2004) developed a wristwatch-sized device that reminds users about objects they are about to leave behind unintentionally using radio frequency identification. Such fault prevention tools can also be integrated into mobile devices to prevent handset unavailability. Security threats to mobile handsets can be prevented by restricting unauthorized access to handset functions using security tools such as digital security certificates, file encryption and cryptography, anti-spam, anti-malware and anti-virus software, password lock, touch-screen or keypad locks, and call barring.

1.2.3.2 Mobile handsets' Fault Removal

The above described faults, errors and failures in mobile devices can be removed or fixed by maintenance and repair activities, and this can be done by taking the faulty phone to a service centre for repairs. Hardware problems are usually fixed by replacing the malfunctioning components such as the screen, keypads, memory, speakers, network, and power components. Software problems, such as viruses and malwares, can also be removed in the mobile device service centres. Other less severe software problems can be fixed by some user initiated recovery actions such as restarting the phone, removing the cell phone battery and fixing it again when the device freezes or hangs (Cinque *et al*., 2007).

1.2.3.3 Mobile Handsets' Faults Forecasting

The human and environmental factors that are involved in the use of mobile devices make it very difficult to forecast faults and errors in mobile devices. Forecasting the device user's intentions, behaviours and actions with the aim of estimating or determining the future occurrence of faults, errors and failures is practically

impossible. Moreover, the prevalence of cheap mass produced mobile devices with comparably unreliable and failure-prone components has also made it very difficult to forecast faults and failures for these devices (Bonn, 2006).

1.2.3.4 Mobile Handsets' Fault Tolerance or Survivability

Fault tolerance in mobile handsets is usually accomplished by using hardware redundancy techniques or software redundancy techniques, or a combination of both, but achieving software fault tolerance is very costly and time consuming. Therefore, in order to achieve mobile handset redundancy, hardware redundancy is the only practical means of achieving fault tolerance (Storey, 1996).

There are two major ways of achieving hardware redundancy in a product or device, namely: homogeneous redundancy and heterogeneous redundancy. In homogeneous redundancy, the user can replace the failed component of the device, such as the batteries, screen, and housing, with another component of the same kind with the same features and functionality. On the other hand, in heterogeneous redundancy, the user replaces the failed component with a different type with similar features, but not identical functionality (Bonn, 2006). Another way of achieving fault tolerance in mobile devices is by using functional redundancy; functional redundancy aims to exploit the diversity of resources between different devices in a ubiquitous computing environment with the aim of improving the dependability of these devices. A device possesses functional redundancy if it possesses diverse resources that overlap with regard to a particular functionality, for instance, a battery-powered mobile device using solar cells for light intensity measurements can also revert to using the same solar cell for generating power. In this case, the solar-cell yields a functional redundancy for light intensity measurement and energy generation for powering the device (Bonn, 1973).

Nowadays, due to the increasing demand for mobile devices, these devices are being mass produced by the device manufacturers in order to reduce production costs and still be able to meet the market demands for these devices. Consequently, these devices do not have redundant capabilities and later become unreliable, which means they are likely to fail completely within a short time period in the event of faults and

errors. However, in order to ensure that these devices last longer, they must be designed in such a way that they can be able to tolerate faults and resist failures.

1.3 Problem Statement

The main problem motivating this research effort is centred on the increasing levels of e-waste being generated in the environment as a consequence of the frequent replacement and disposal of non- durable mobile devices. In developed countries such as the United States, it was reported by Folke and Thorgesen (2006) that "there are over one billion cell phones in use, but only about 10% of unused or unwanted cell phones are recycled each year. In the context of developing countries, for example in South Africa alone, about 2 million tons of electronic waste from household consumer electronics and information technology devices such as computers and cell phones are generated annually". As a matter of fact, according to Nnorom and Osibanjo (2009), most developing countries are facing serious challenges in the management of electronic wastes that are being generated due to lack of suitable or necessary waste management infrastructures in these countries, and, as a result, a vast amount of these e-wastes are being discarded or dumped into open refuse dumps, and surface water bodies. Electronic wastes such as mobile phones and computers may contain toxic metals such as lead, mercury, copper, arsenic, antimony, beryllium, cadmium, nickel and zinc (Most, 2003). This problem of lack of adequate waste management infrastructure in developing countries is a major contributor to the growing problem of toxic materials and pollution in the environment, and is a major cause of serious health hazards to humans, for example, infertility in men, physical developmental problems in children, and cancer are all consequences of exposure to toxic materials from e-wastes. In addition, elements such as lead can also cause adverse problems in the human kidneys as well as in the human central nervous system and immune system (EPA, 2009).

These problems of increasing levels of electronic-waste in the environment, as a consequence of the frequent replacement of non-durable mobile devices when applied to the e-learning context, raise the following main research question of this

study on the factors that affect the opinions of teachers on the durability of cell phones when used by learners.

1.4 Research Questions, Research Aims and Objectives

The first section of this chapter has described the concept of dependability of mobile devices in terms of the attributes of dependable mobile devices, the threats to mobile device dependability, and the means or processes that can be used to achieve dependability in these devices. This section will now present the aim, objectives, and research questions for this study on examining the opinions' of teachers on the durability of cell phones in the e-learning context.

1.4.1 Main Research question

The main research question of this study can be stated as follows: What are the factors that can affect the opinions of teachers on the durability of cell phones when used by learners?

1.4.2 Research Sub-questions

The above-stated research question will be further expressed into four research sub-questions as follows:

Research sub-question 1: What are the theories that can be used to explain the opinions of teachers on the durability of cell phones when used by learners?

Research sub-question 2: How can these contributing factors identified from the review of relevant theories that can explain opinions of teachers on the durability of cell phones when used by learners, be shaped into a hypothetical model?

Research sub-question 3: How can this hypothetical model of the factors that can affect the opinions of teachers on the durability of cell phones in the e-learning context, be empirically validated?

Research sub-question 4: What recommendations can be made from the knowledge of the factors affecting teachers' opinions on the durability of cell phones in the e-learning context?

1.4.3 Research Aim

This study aims to model the factors that can affect teachers' perceptions on the durability of cell phones when used by learners, with reference to the developing countries.

1.4.4 Research Objectives

The above described research aim will be further sub-divided into the following listed research objectives:

- To select from existing literature relevant perceptions' theories that can be used to investigate teachers' perceptions on the durability of cell phones when used by learners;
- To design a model of the factors affecting teachers' perceptions on the durability of cell phones when used by learners;
- To empirically test this model of the factors; and
- To make recommendations for improving the durability of cell phones when used by learners.

1.5 Study Rationale

This study is motivated by the need to examine existing trends in the use of cell phones so as to minimize e-waste, as highlighted by the following extracts from Wilhelm *et al.* (2012): "Current […] practices need to be examined […] with regards to how they may encourage short replacement live cycles for cell phones".

1.6 Structure of Dissertation

This dissertation on the perceptions of teachers on the durability of cell phones in the e-learning context will consist of five chapters; a brief outline of each chapter one of these chapters is described as follows:

Chapter One: Introduction

This chapter introduced the concept of product dependability in general, and gave a detailed description of the dependability of mobile devices as part of ubiquitous computing. It also presented the aim, objectives, research questions, and the rationale of the study on teachers' perceived durability of cell phones in the e-learning context.

Chapter Two: Literature Review

Relevant theoretical frameworks connected to product failure will be presented in this chapter. These theoretical frameworks are then examined with the aim of identifying and selecting some of the relevant constructs that can be used for designing a new conceptual model of factors that can affect teachers' opinions on the durability of cell phones used by learners.

Chapter Three: Research Design

This chapter will provide a detailed description of the survey and experimental studies conducted by this research in order to validate the proposed conceptual model of factors that can affect teachers' opinions of durability of cell phones used by learners.

Chapter Four: Results

This chapter will present the results of the survey and experimental studies conducted by this study on the durability of cell phones based on the educators' perceptions, and present a new model of factors influencing teachers' opinions on the durability of cell phones for teaching and learning.

Chapter Five: Discussion and Conclusion

This chapter will compare the results of existing empirical studies with the research results of this study presented in chapter four. It will also discuss possible strategies and recommendations for improving the durability of cell phones for e-learning purposes.

1.7 Conclusion

This chapter presents the main issues around the concept of product dependability: dependability attributes; dependability threats; and dependability means. Products' dependability attributes include reliability, availability, maintainability, and safety. Products' dependability threats include faults, errors and failures, durability or expected lifetime, and products' dependability means include fault prevention, fault removal, fault forecasting, and fault tolerance. After the presentation of concepts on products dependability, in general, a detailed description of the dependability of mobile devices is given in this chapter because of the main aim of this study on examining the perceived durability of mobile devices in the teaching and learning context. The dependability of mobile devices is mainly affected by faults, errors, and failures in the handsets' critical components such as the network, power, software, display, keypads, housing, and memory. The safety of mobile devices can be compromised by issues such as loss or theft, unauthorized access, software viruses, and electronic eavesdropping or tracking. The task undertaken here to study the perceived durability of mobile devices in the teaching and learning context can contribute towards solving the e-waste problem which is an unintended consequence of the pervasive use of ICTs. The next chapter focuses on the literature review of this study.

CHAPTER II

LITERATURE REVIEW

The aim of this chapter is to present relevant theories that can be used for examining the perceptions' of teachers on the durability of cell phones when used for teaching and learning purposes in line with the first objective of this study. Suitable theories on cell phone perceived durability were found from existing literature using the Internet search keywords *"product failure"* + *"theory"*. This search was then directed to a dissertation by Donogue (2008) that identified some theories on the performance failures of major household electrical appliances: the consumer complaint behaviour theory, the expectancy disconfirmation theory, and the attribution theory. The attribution theory explains the causes of things that happen to us and to others, and it also explains the causes of behaviours and events (Alder, 1980; Chinn, 2002). Therefore, attribution theory can be used to explain the causes of product failure. Hence, the last part of this chapter will present a selection of constructs from the attribution theory for their ability to explain the perceptions' of teachers on the durability of cell phones for teaching and learning, in line with the second objective of this study.

2.1 Expectancy Disconfirmation Theory (EDT)

According to Oliver (1980), consumer satisfaction can be defined as a consumer's fulfillment response. It is a "judgment that a product's features, or a product itself, has provided (or is providing) a pleasurable level of consumption-related fulfillment to the consumer, including levels of under- or over- fulfillment". When a consumer is satisfied with a product, he or she will express positive emotions such as happiness, pleasure or delight (Westbrook and Oliver 1981; Bhattacherjee, 2001), but, when a consumer is dissatisfied, he or she will express negative emotions such as sadness, frustration, anger, and regret. Hence, the expectancy disconfirmation theory attempts to explain how consumers arrive at decisions concerning their satisfaction or dissatisfaction with a product based on three constructs: Expectations, Performance, Disconfirmation (Oliver *et. al.*, 1980).

Readers are reminded that cell phones' durability is the focus of this study, and cell phones are products whose durability or actual duration of usage may partially depend on the fact that their users are either satisfied or not with their performance compared to their initial expectations. This can, therefore, explain how the EDT can be useful for this study, since the EDT links consumer satisfaction to their expectations and to products' performance.

2.1.1 Expectations

Expectations can be defined as the beliefs or predictions about products' expected or anticipated performance (Churchill and Suprenant 1982). An individual's expectations for a product's performance are based upon his or her own prior experiences with the product, upon word-of-mouth endorsements and/or criticisms, and on firms' marketing strategies and efforts (Woodruff *et al.*, 1983). In addition to consumers' prior experiences with a product, his or her personality and situational factors can also affect the consumer's expectations for a product's performance (Day, 1977). According to the EDT model, if the actual product performance is better than what the consumer had initially expected, then he or she will be fulfilled or satisfied with the product, but if the actual product performance does not meet the consumer's

initial expectations, then he or she will be under-fulfilled or dissatisfied with the product (Oliver, 1977).

2.1.2 Performance

Performance, on the other hand, refers to the actual operational capacity of the product. It is a consumer's judgment about a product's fault-free and long-lasting physical operation, as well as faultlessness in the product's physical design and construction (Lassar *et al*. 1995). Product performance can be categorized into two different performance types: functional product performance and symbolic product performance (Swan and Combs, 1976; Brown and Rice, 1998; Hawkins *et al*., 2001). Functional product performance relates to the physical functioning of products, i.e., the ability of the product to perform its required functions (Donogue, 2008). Functional product performance also refers to the product attributes such durability, maintainability, and physical performance, i.e., how well the product does what it is supposed to do. Conversely, symbolic product performance refers to what the product symbolizes or means to the consumer, i.e., the psychological level of product performance (Erasmus and Donoghue, 1998). Symbolic product performance is determined from a consumer's emotional response to the physical product when he or she uses it (Erasmus *et al.,* 2005). According to the EDT (see figure 2.1), satisfaction and dissatisfaction are differently linked to the two types of performance: symbolic performance yields greater consumer satisfaction compared to functional performance.

2.1.3 Disconfirmation

Disconfirmation can be defined as the difference between the customer's prior expectations for a product's performance, and the actual product performance (Bhattacherjee and Premkumar 2004). Disconfirmation can be either a positive disconfirmation, or a negative disconfirmation. According to the EDT (see figure 2.1), when the actual performance of a particular product does meet customers' expectations, negative disconfirmation occurs, and this leads to consumer dissatisfaction. On the other hand, when the actual product performance exceeds the customers' expectations, positive disconfirmation occurs, which leads to consumer

satisfaction. One can see from the definitions of disconfirmation and of satisfaction that satisfaction has an emotional dimension but disconfirmation has a cognitive dimension.

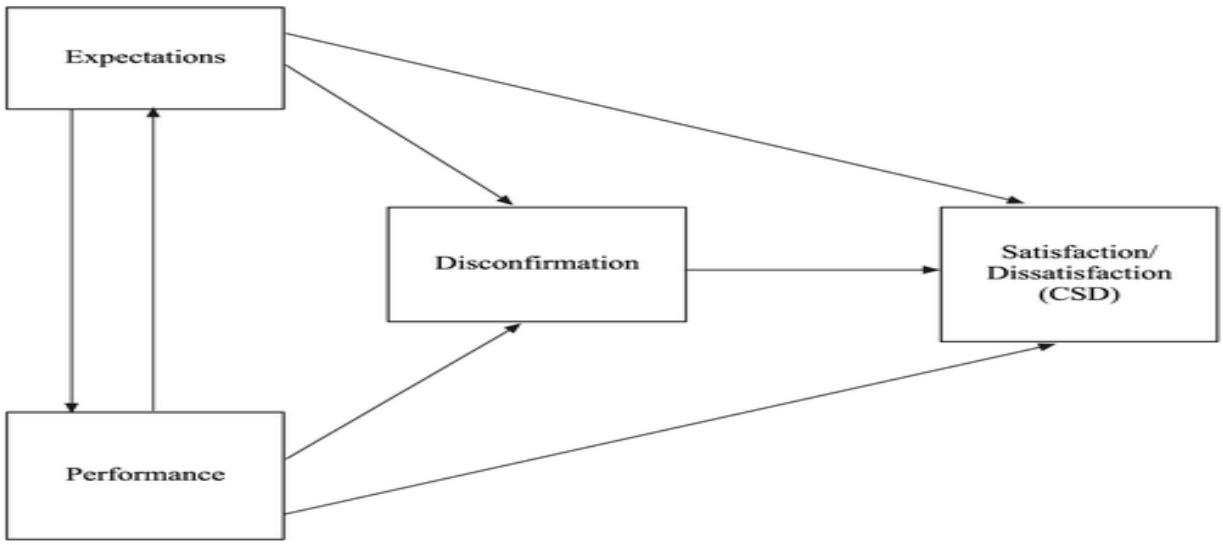

Figure 2.1: Expectancy Disconfirmation

2.2 Consumer Complaint Behaviour (CCB)

This theory explains how consumers respond to dissatisfaction with a product. It describes the consumer behavioural and non-behavioural responses that directly convey an "expression of dissatisfaction" with a product (Landon, 1980; Singh, 1988). When a consumer is dissatisfied with a product, he or she may engage in behavioural or non-behavioural responses to resolve his or her dissatisfaction. Behavioural responses include formal complaints directed at product manufacturers and retailers, at public consumer protection agencies, and at voluntary organizations and courts. Behavioural responses also include informal complaints such as boycotting retailers and products, changing brands, and negative word-of-mouth marketing. Previous empirical studies on word-of-mouth consumer complaint behaviour have shown that a typically dissatisfied customer will tell around eight to ten people about a problem (Li and Honda, 2005). The likelihood that a consumer will complain about a product failure can be determined by product-related factors

and by consumer-related factors. Consumer-related factors include consumer variables such as demographics, personality, attitude, knowledge, experience, and culture (Wiener, 2000; Tronvoll, 2007). Product-related factors include product variables such as cost, type, and durability. Consumers may refrain from complaining if they think that such complaints will result in some sort of trouble or psychological costs and this is what causes non-behavioural responses to dissatisfaction (Huppertz, 2003; Kau and Loh 2006). Non-behavioural responses refer to situations where dissatisfaction with a product does not lead to any formal or informal complaint (Day and Landon 1977). There are three main models of consumer complaint behaviour: Hirschman's exit, voice, and loyalty typology; Singh's taxonomy of consumer complaint responses; and Day and Landon's taxonomy of consumer complaint behaviour.

Let us recall that this study seeks to examine teachers' perceptions on the durability of cell phones and one way for teachers to evaluate such durability is by echoing the presence or the absence of complaints from their learners, colleagues, family, friends, etc. This might justify the relevance of the CCB theory to this study, since the CCB theory theorizes how people deal with complaints about a product.

2.2.1 Hirschman's Exit, Voice and Loyalty typology

According to Hirschman (1970), consumers' dissatisfaction results into two possible outcomes: one option is to stay loyal to the product in question and the second option is to discontinue the use of that product. In both cases, consumers may decide to voice or to stay silent about their dissatisfaction (see figure 2.2.1).

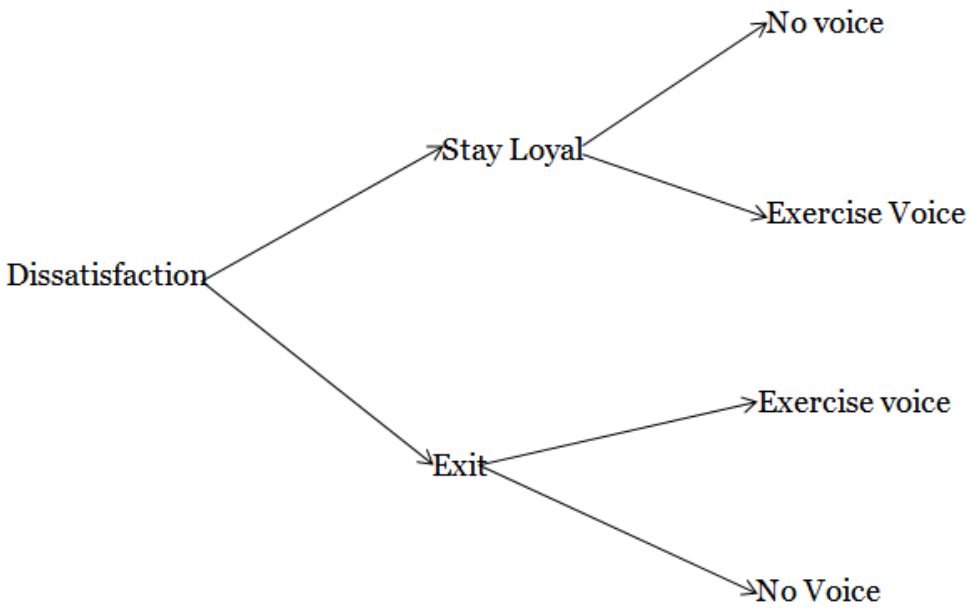

Figure 2.2.1: Hirschman's exit, voice and loyalty typology

2.2.2 Singh's taxonomy of Consumer Complaint Responses

According to Singh (1988), consumers can express their dissatisfaction or complain about products' failures in three different ways: voice complaints, private complaints, or third-party complaints. Consumers voice their complaints by seeking redress or compensation for a failed product from the product retailers, wholesalers, and manufacturers. They may also complain about a product in private to family, friends, and colleagues (Landon, 1988).There are also instances where formal complaints are addressed by consumers to third parties such as consumer agencies, legal courts, and to the mass media (e.g., newspapers, television, etc.).

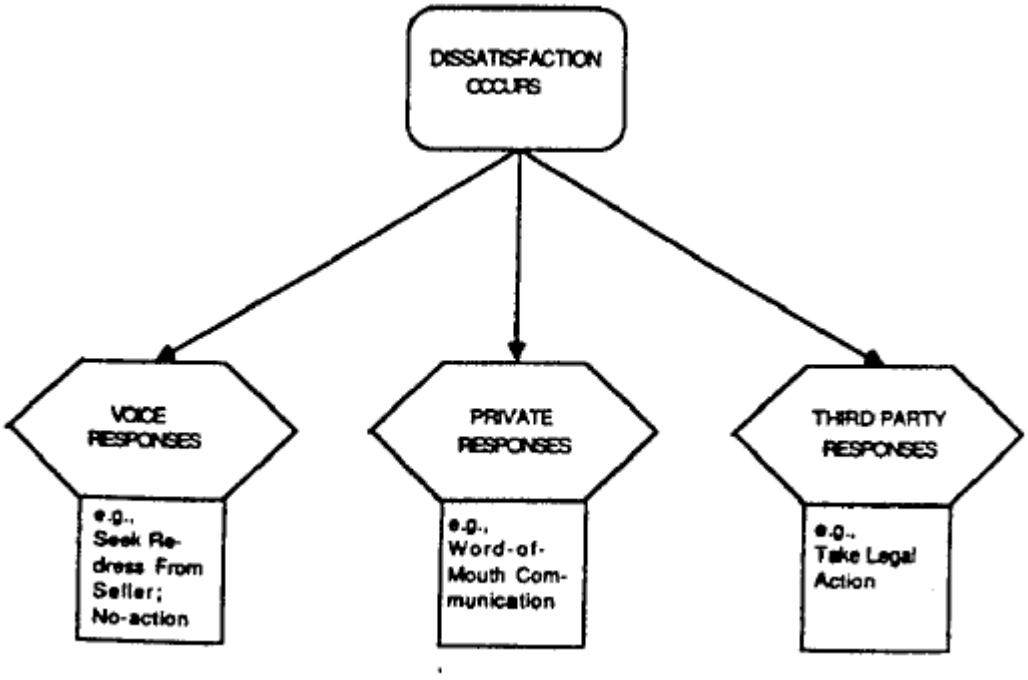

Figure 2.2.2: Singh's taxonomy of consumer complaint behaviour

2.2.3 Day and Landon's taxonomy of Consumer Complaint behaviour

Day and Landon's (1977) taxonomy describes the action options that are available to a consumer who is dissatisfied with his or her product. He or she may decide to take action or not to take action. There are two different types of actions that can be taken by a dissatisfied consumer: Private actions and Public actions. One example of private action is a warning given by a consumer to his or her family and friends about a particular product brand or product seller. Another example of private action is the boycott or the switching of a product brand or retailer. Examples of public actions that can be taken by dissatisfied consumers include seeking for a refund, requesting for free repairs or for the replacement of the faulty or defective product. Public complaints can also be directed to consumer protection agencies and the mass media. In addition, the consumer may decide to take legal action against product retailers and manufacturers (Day and Landon, 1977).

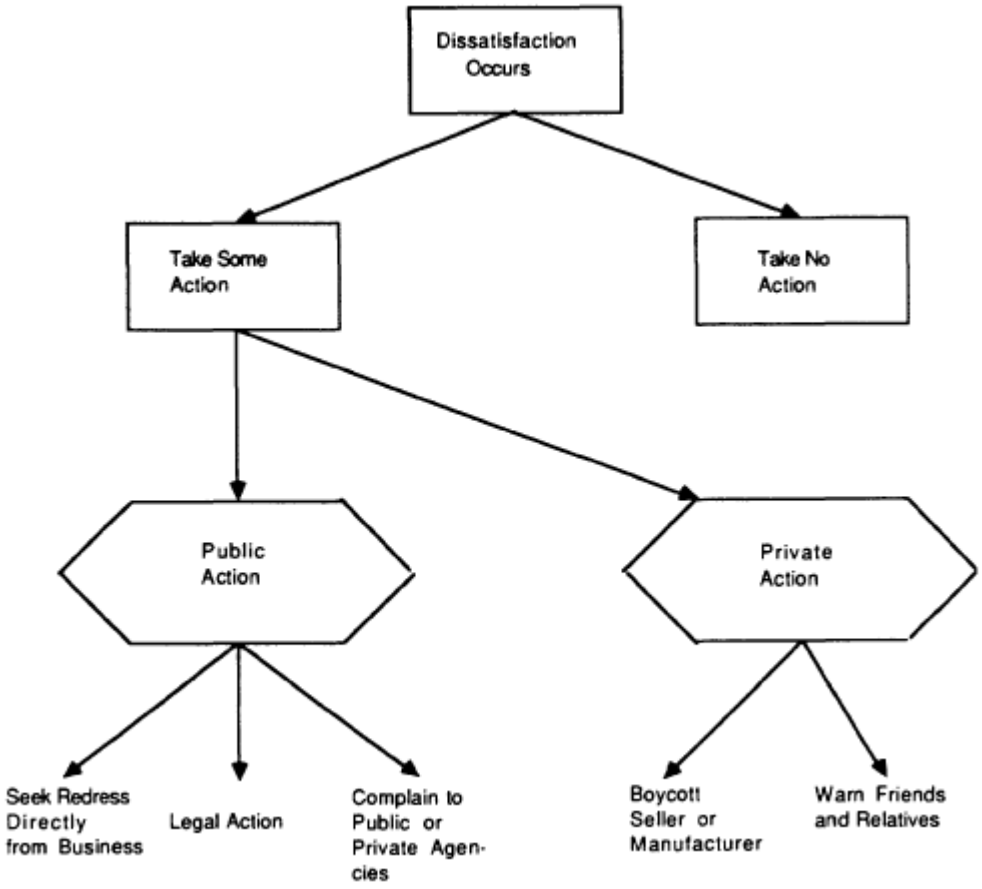

Figure 2.2.3: Day and Landon taxonomy of consumer complaint behaviour

2.3 Attribution Theory

Attribution can be defined as the process of inferring and assigning a cause to a behaviour or event (Kelley, 1973). The study of these perceived causes is known by the term "attribution theory" (Kelley and Micheda, 1980). Attribution theory attempts to describe the process by which individuals explain the causes of behaviours and events (Alder, 1980). It also describes how we explain to others and to ourselves the causes of things that happen to us (Chinn, 2002). According to the attribution theory, people are continuously searching for reasons to explain why events turned out the way they did. Attribution theory is an extension of the expectancy theory and it is a theory of perception. The attribution theory also aids in the perceptual interpretation or understanding of behaviour and events by focusing on how people assign responsibility for the outcome of events, and it also focuses on how people evaluate

the personal characteristics of other people involved in such events (McCuddy, 2005). The general model of attribution is illustrated by figure 2.3.

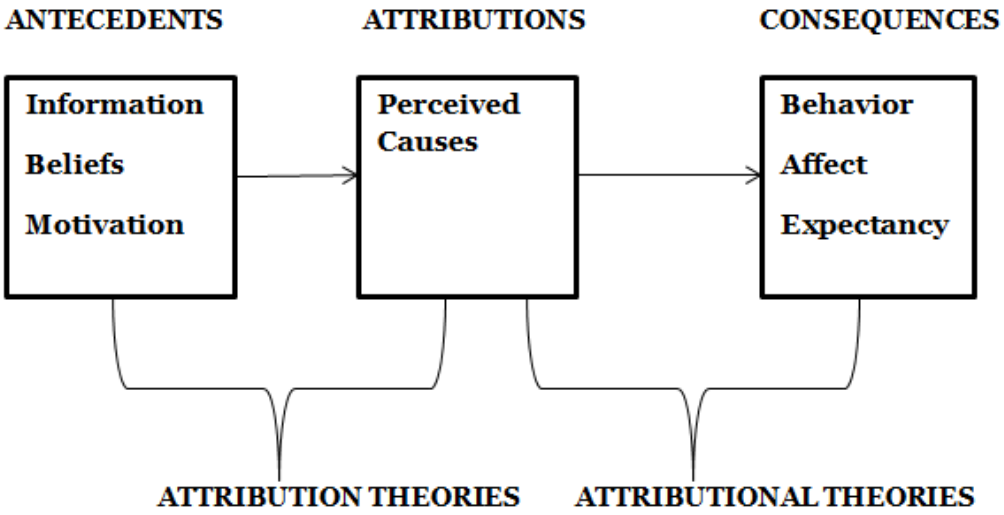

Figure 2.3: General model of attribution theory (Kelley and Michela, 1980)

It is possible for teachers to base their perceptions on the durability of cell phones on the reasons given by their acquaintances as to why cell phones last for a long period of time or for a short period of time. This can serve as a rationale for including attribution theories in this study since attribution theories aim to explain the reasons causing events.

Some of the major attribution theory models are from Heider (1958), Jones and Davies (1965), Kelly (1967), Bem (1965), Arjen (1985), Weiner (1972), Malle (1999), Shaver (1985), Gilbert and Malone (1995), and Abramson *et al.* (1978):

2.3.1 Heider's theory of "Naïve analysis of action"

Heider (1958) proposed that personal factors and environmental factors are the two types of factors that are responsible for determining the outcome (i.e., success or failure) of an event. Motivation, intention, effort and power are the main personal factors that influence the outcome of an event. However, power or ability can either be boosted or reduced by the difficulties or fortunes produced by environmental factors.

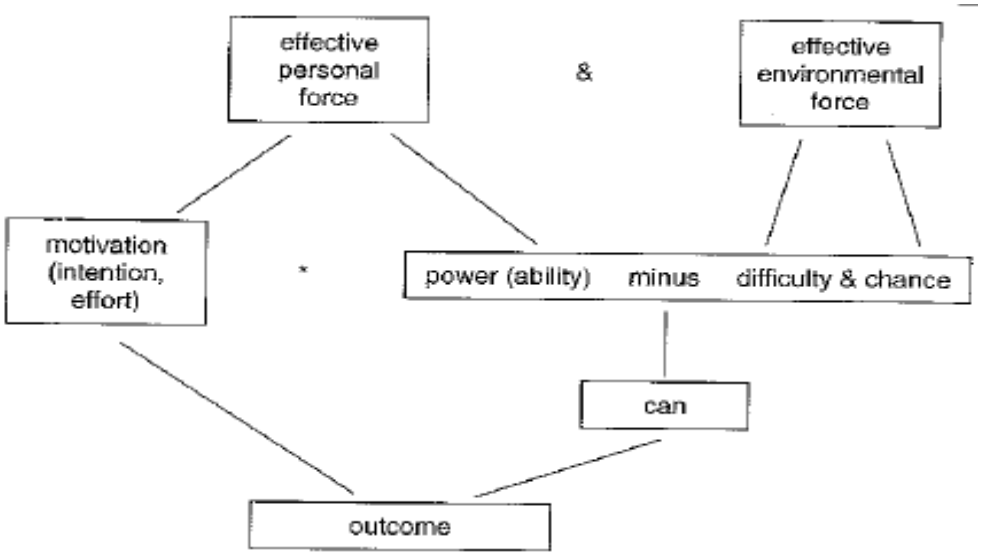

Figure 2.3.1: Heider's theory of naïve analysis of action

2.3.2 Jones and Davies theory of "Correspondent Inferences"

According to Jones and Davies (1965), the intentions of a person depend on his or her disposition or personality; and these intentions determine his or her knowledge and ability which, in turn, trigger appropriate actions with corresponding consequences or effects.

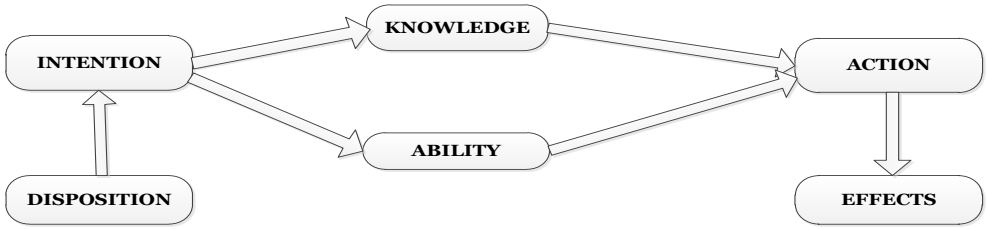

Figure 2.3.2: Jones and Davies theory of correspondent inferences

2.3.3 Kelley's theory of "Co-variation and Configuration"

Harold Kelley's theory is an attempt to establish whether a given behaviour of a person should be exclusively attributed to that person himself or herself, or to another individual or external person, or to the situation at hand. The behaviour of a person is exclusively attributed to the person himself or herself when that behaviour depends on the internal attributes of that person such as his or her feelings, thoughts,

moods, attitudes, values, traits, abilities, skills, motivations, interests, and desires. The behaviour of a person can be attributed to another individual or external person when that behaviour depends on the internal attributes of that other individual or external person such as that person's feelings, thoughts, moods, attitudes, values, traits, abilities, skills, motivations, interests, and desires. The behaviour of a person can be attributed to the situation at hand when that behaviour depends on something external to the person such as an accidental or hazardous occurrence or happening in the environment, setting, or context (Kellermann, 1984). Kelley's co-variation model, depicted by figure 2.3.3, shows that the cause of a person's behaviour can be attributed to that person himself or herself if other individuals do not (low) usually behave as that person, if the circumstances of that behaviour are not (low) unique, and if the person in question is very likely (high) to repeat that behaviour. On the other hand, the cause of a behavior affecting a person can be attributed to another person if other people always exhibit such a behavior (high), if the circumstances of that behaviour are unique (high), and if that other person is very likely (high) to repeat that behaviour. Furthermore, the cause of a behaviour affecting a person can be attributed to the prevailing circumstances if other people do not exhibit such a behaviour (low) , if the circumstances of that behaviour are unique (high), and if that person is not likely (low) to repeat that behaviour (Kelley, 1967).

	Others do as Person? Consensus is:	*Stimulus Unique? Distinctiveness is:*	*Person do again? Consistency is:*
Type of Attribution			
Person	Low	Low	High
Stimulus	High	High	High
Situation	Low	High	Low

Figure 2.3.3: Kelly's Co-variation model.

2.3.4 Theory of Planned Behaviour

The theory of planned behaviour argues that the behaviour of an individual is determined by his or her intention to carry out that behaviour. A person's intentions towards a given behaviour depend on his or her attitude towards that behaviour and

on his or her ability to control such behaviour even under the influence of social pressures or subjective norms (Arjen, 1985).

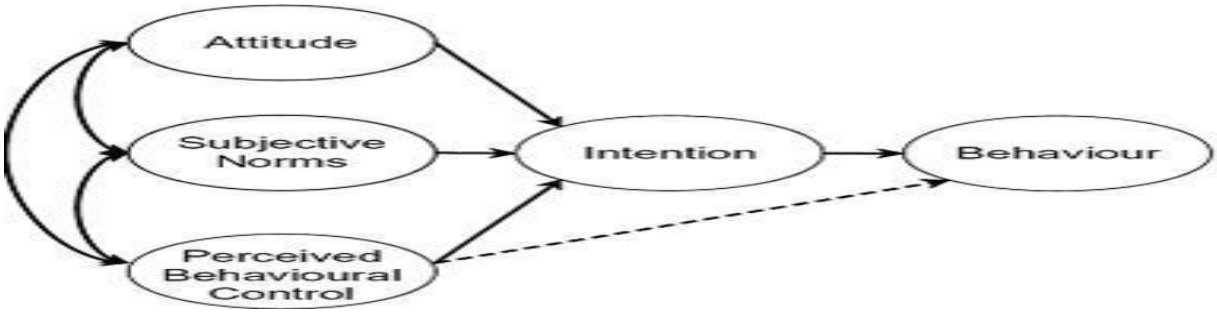

Figure 2.3.4: Theory of planned behaviour

2.3.5 Weiner's theory of "Achievement motivation and Emotion"

According to Wiener (1985), the evaluation of successful or failed outcomes for an event or task by an individual leads to emotions such as happiness, sadness or frustration. In other words, people become happy when they succeed, and they are sad or frustrated when they fail in an endeavour. These emotions then lead people to make assumptions or attributions on the reasons behind these outcomes; and these assumptions or attributions, coupled with the level of control of the situation and with its locus, give rise to emotional feelings towards the cause of these outcomes. Furthermore, the intensity of the emotional reactions to the outcome itself, and to the cause of that outcome, and the level of expectancy of success for that outcome determine the likelihood of a positive or negative action about the outcome.

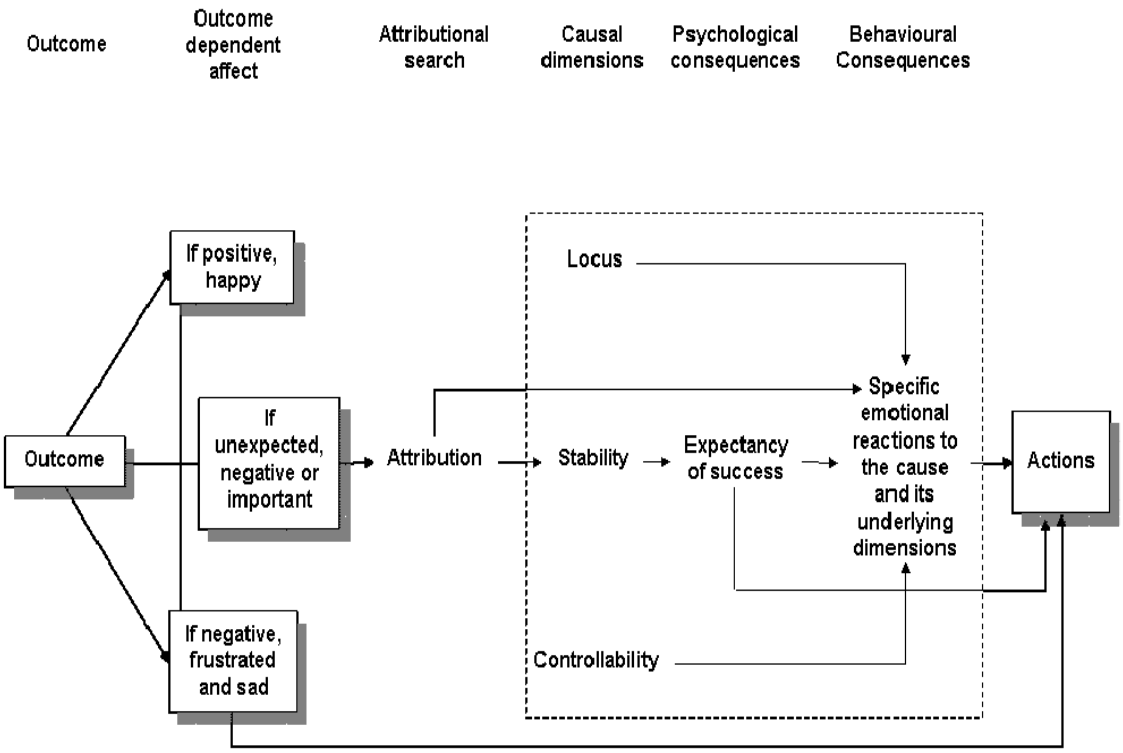

Figure 2.3.5: Weiner's theory of achievement motivation and emotion

2.3.6 Folk theory of behaviour explanation

The folk theory of behaviour explanation explains that, for an action to be judged as intentional, the outcomes of this action must be highly desired and there must be a strong belief in the success of these outcomes (Malle, 1999).

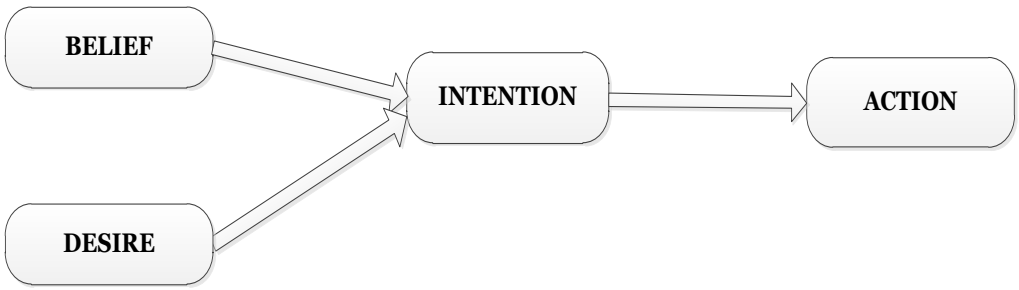

Figure 2.3.6: Folk theory of behaviour explanation

2.3.7 Shaver's Blame attribution theory

According to Shaver's blame attribution theory, a person can be blamed for behaviour if he or she is unable to offer an appropriate justification or excuse for this

behaviour depending on his or her responsibility in this behaviour. The level of responsibility of a person for a given behaviour depends on his or her level of involvement in the causes of that behaviour, and the intentions and coercion towards it (Shaver, 1985).

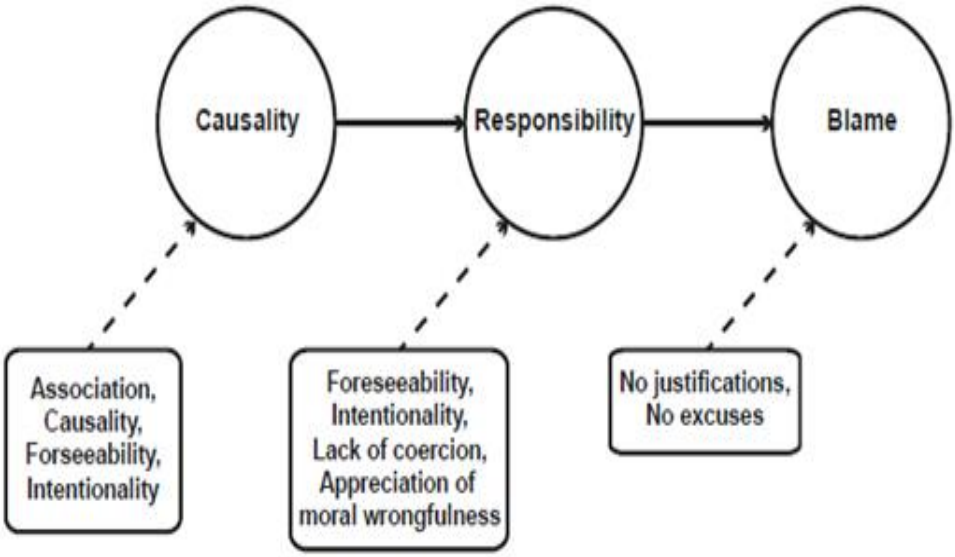

Figure 2.3.7: Shaver's blame attribution theory

2.3.8 Fundamental Attribution Error

When a person's behaviour is perceived as not being conformed to other people's standards or behavioural expectations for that behavior, such people will make dispositional inferences about this behavior by attributing such behaviour to that person instead of attributing it to the situation. However, fundamental attribution error happens when people make dispositional inferences even if there is no mismatch between the perceptions and the expectations of the observer of a behaviour, and this error leads to situational correction (Gilbert and Malone, 1995).

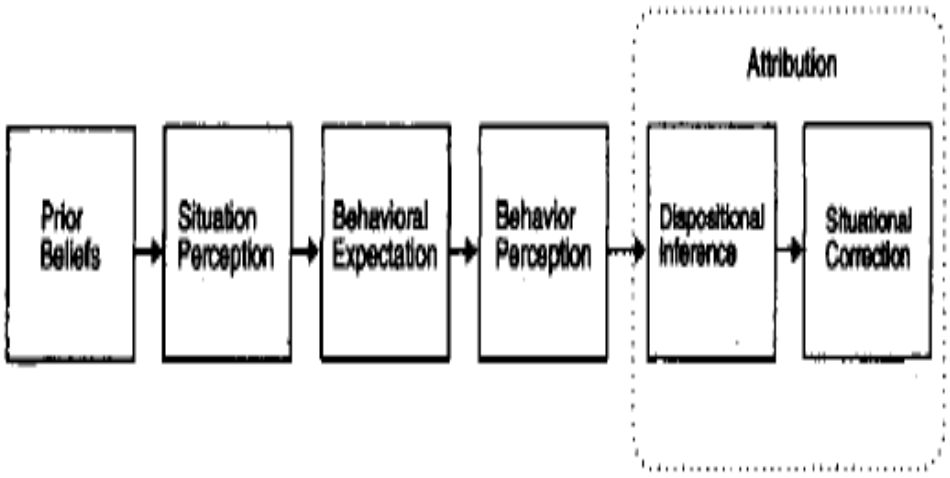

Figure 2.3.8: Fundamental Attribution Error

2.3.9 Helplessness theory of depression

This theory describes how a person arrives at the conclusion that he or she cannot salvage a given situation (i.e., helplessness) based on the absence of contingency plans or solutions for that situation. First, the person perceives or believes that all his past and present efforts or actions are futile in achieving the desired outcome, no matter how hard he tries, and this perception of effort futility then leads the person to make attributions or give reasons for why he cannot achieve the desired future outcomes. These negative expectations ultimately lead to helplessness behaviour (depression) in the person (Abramson *et al.* 1978).

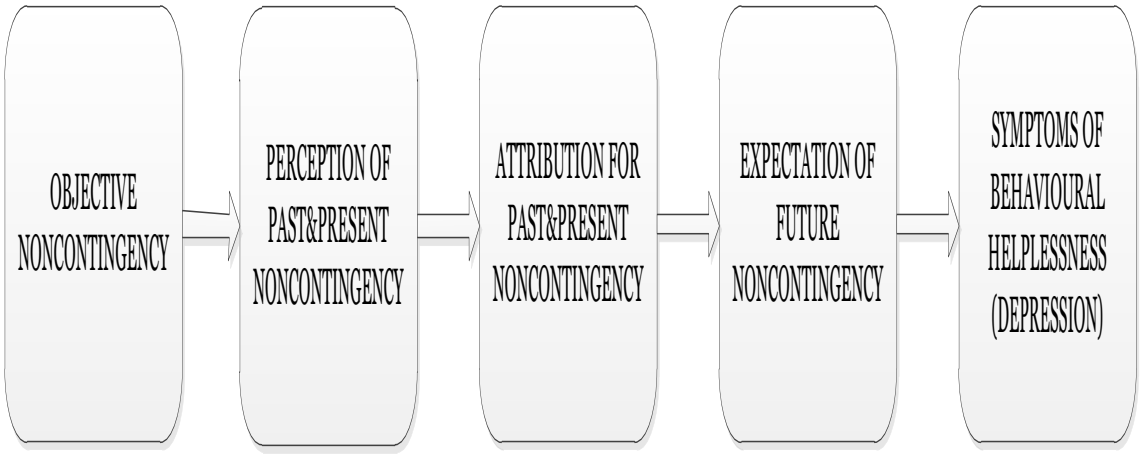

Figure 2.3.9: Helplessness theory of depression

Merits and Demerits of Models

Expectancy Disconfirmation Theory

In spite of its dominance, the Expectancy Disconfirmation theory has several drawbacks ( ). First, the use of expectations might be less meaningful for experiential services than for tangible consumer goods that are easy to evaluate prior to purchase (Hill, 1985). The EDT predicts that customers will be satisfied (dissatisfied) when their initial expectations are met (unmet); however, this may not necessarily be the case in every consumption situation. Depending on the situation, some customers may be satisfied with the service experience even when the performance falls short of their predictive expectations but above the minimum tolerable level. Second, in line with the conventional EDT, many of these studies have used predictive expectations as the comparative standard. However, there is inadequate research evidence on whether consumers use only predictive expectations in their post purchase product evaluations, whether they use other standard(s), which they bring into the consumption experience (e.g., minimum tolerable level, desires, ideals), or other standards that may emerge after the purchase (e.g., what others have received). Another limitation relates to the fact that the EDT cannot accommodate the dynamic nature of expectations. Consumers' initial expectations of a product or service might be substantially different from their expectations if measured after a service experience that involves several encounters.

Consumer Complaint behavior

Although the disconfirmation paradigm has been utilized extensively in Consumer Complaint Behaviour research, it has a number of limitations. One of such limitations is that it addresses the elements and process leading to satisfaction appraisal while the ongoing process of how consumers respond to consumption experiences is only implied. In similar vein Maute and Forrester (1993) express the opinion that the disconfirmation paradigm ignores the nature, preceding conditions and consequences of dissatisfactory consumption experiences and that dissatisfaction response studies have been largely unstructured and lack a theoretical framework (Blodgett and Granbois, 1992; Maute and Forrester,1993).

Attribution theory

Attribution theory has several limitations, for example, a major limitation of the attribution theory is the lack of psychometrically sound instruments for measuring attributions (Kent and Martinko 1995). Another limitation is terminology. If researchers provide explanatory categories to participants, this may result in forcing causal explanations to fit casual dimensions (Kent and Martinko 1995). Yet, if participants provide their own category, it may be difficult to identify the underlying causal structure (Kent and Martinko 1995). A related issue is that researchers often investigate the causal dimensions of the attribution theory without providing justification as to why those dimensions would relate to the phenomenon under study (Kent and Martinko 1995).

2.4 Conceptual Model

This research proposes a new conceptual model of the factors that can affect the perceptions of teachers on the durability of cell phones when used for teaching and learning purposes. Even though three major theories, EDT, CCB, and attribution theories are presented in this chapter for their relevance to this study, this study has chosen Jones and Davies correspondence inference model of attribution as its theoretical framework to build a new conceptual model of the factors affecting teachers' perceptions on the durability of cell phones for teaching and learning. The new conceptual model uses the constructs of intention, knowledge/ability, and action from the Jones and Davies correspondence inference model of attribution theory as possible factors that can affect the perceptions of teachers on the durability of cell phones for teaching and learning. In other words, this model hypothesizes that the perceptions of teachers on the durability of cell phones for teaching and learning depend on the demographics of these teachers. It also depend on teachers' perceptions on the intentions of learners to use cell phones, as well as on teachers' perceptions on the knowledge and ability of these learners to use cell phones. This model finally hypothesizes that the perceptions of teachers on the durability of cell phones for teaching and learning depend on the teachers' perceptions on how learners actually use cell phones.

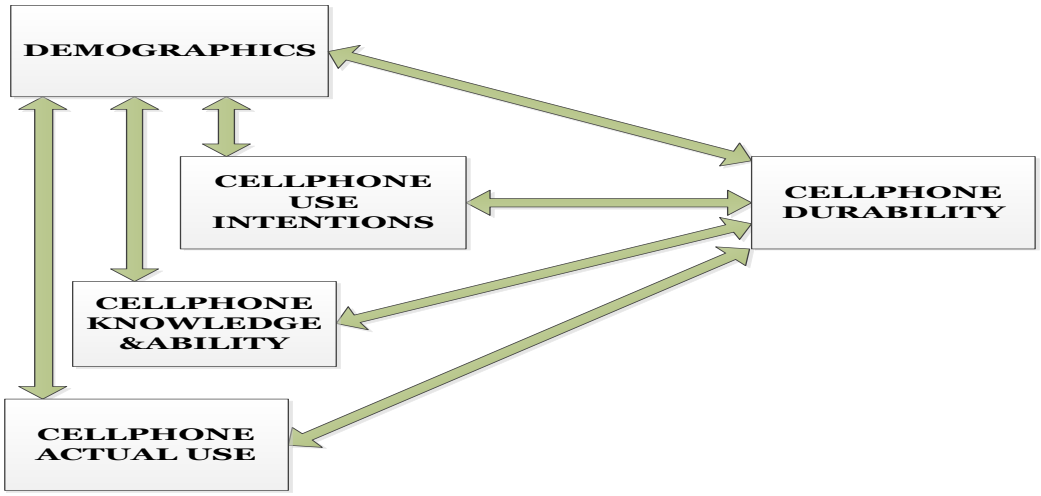

Figure 2.4: Conceptual Model

2.5 Conclusion

This chapter presented the theoretical frameworks for this study consisting of the theories and models that can be used for the examination of the perceptions of teachers on the durability of cell phones when used for teaching and learning purposes. The theories identified are the expectancy disconfirmation theory, the consumer complaint behaviour theory and the attribution theory. The expectancy disconfirmation theory (Oliver, 1980) explains how consumers arrive at decisions concerning their satisfaction or dissatisfaction with a product based on three constructs: Expectations, Performance, and Disconfirmation. The consumer complaint behaviour theory describes the consumers' behavioural and non-behavioural responses that directly convey an "expression of dissatisfaction" in order to complain about a product. Some of the models of consumer complaint behaviour include the Exit, voice and loyalty typology (Hirschman, 1970), the taxonomy of consumer complaint responses (Singh, 1988), and the taxonomy of consumer complaint behaviour (Day and Landon, 1977). The attribution theory describes the process by which individuals explain the causes of behaviours and events (Alder, 1980). The main models of attribution theory are from Heider (1958), Jones and Davies (1965), Kelly (1967), Bem (1965), Arjen (1985), Weiner (1972), Malle (1999), Shaver (1985), Gilbert and Malone (1995), and Abramson *et al.* (1978). The

last part of this chapter presented a selection of constructs from the attribution theory for their ability to explain the perceptions of teachers on the durability and of cell phones for teaching and learning. The selected constructs were then used in designing a new conceptual model of possible factors that can affect perceptions of teachers on the durability of cell phones for teaching and learning. This new conceptual model will be empirically tested in the next chapter of this study.

CHAPTER III

RESEARCH DESIGN

The previous chapter highlighted suitable theories that can be used for examining the perceived durability of cell phones, and also presented a new conceptual model of possible factors that can affect the perceptions' of teachers on the durability of cell phones for teaching and learning in line with the first and second objectives of this study. This chapter will now present a detailed description of the methodology used to achieve the third study objective on the empirical testing and validation of the proposed conceptual model of possible factors affecting cell phone durability. This proposed conceptual model was empirically tested by means of a survey of secondary school teachers from ILembe and UMgungundlovu district municipalities of the KwaZulu-Natal province of South Africa between June and July 2014. The survey population, sample size, data collection and data analysis methods are subsequently described in this chapter.

3.1 Research Population

The population (N) of this survey is made up of a total of all teachers from secondary schools in the ILembe and UMgungundlovu district municipalities in KwaZulu-Natal province of South Africa. The ILembe district municipality is located about 65km north of Durban (see figure 12), its main city is KwaDukuza, and the majority of its 560,000 inhabitants speak the isiZulu language. The UMgungundlovu district municipality is situated 145 km north-west of Durban (see figure 13); its main city is Pietermaritzburg, and the majority of its 927,000 inhabitants also speak isiZulu. At the time when this survey was conducted, between June and July 2014, there were 116 secondary schools in both the ILembe and UMgungundlovu district municipalities for a total of about 3,112 teachers (Education Management Information Systems 2013). Out of these 116 schools, only 11 schools were selected, and these teachers constituted the research population of this survey out of which a sample size was drawn. These 11 schools were selected because of the following reasons: This study was conducted at the time when another researcher was also conducting a study on the use of ICTs in hospitality studies in secondary schools, and it was decided that the two studies be conducted in the same secondary schools which were offering hospitality studies as one of their subjects. These 11 schools had a total of 236 teachers, and these 236 constitute the total population of this survey.

Figure 3.1.1: ILembe District Municipality, KwaZulu-Natal. South Africa (2)

Figure 3.1.2: UMgungundlovu District Municipality, KwaZulu-Natal, South Africa (3)

3.2 Sampling

The total sample size of this survey was calculated according to the sample size formula proposed by Naing *et al.* (2006) (see equation 3.2) for finite populations, where n= sample size, Z=confidence level, P=Estimated proportion, d=precision or acceptable margin of error, and N=Population size. The value of n was estimated using the following parameters: Z=1.96, P=0.05, d=0.044 and N= 236 teachers which give a sample size of 67 teachers. The construction of the sample of the 67 teachers surveyed by this study was done as follows: For each of the eleven schools of the two districts, the ratio of the number of teachers in that school was calculated compared to the total number of teachers in the district, and this ratio was multiplied by the sample size in order to get the number of teachers in the sample for that school. In each of the schools, the school's principal was requested to select the required number of teachers to participate in the survey.

$$n = \frac{NZ^2P(1-P)}{d^2(N-1) + Z^2P(1-P)}$$ Equation 3.1

3.3 Data Collection

The data for the survey conducted by this study was collected using a questionnaire made up of the following five variables from the conceptual model presented in the second chapter of this dissertation: teachers' demographics, their perceptions on learners' cell phone use intentions, their perceptions on learners' cell phone knowledge and ability, their perceptions on the actual use of cell phones by learners, and their perceptions on the durability of cell phones when used by learners. Apart from the demographic variable, data for all the items of the other four variables were collected using the following five point Likert-scale in order to record the level of agreement of the teachers with the item in question: strongly disagree, disagree, weakly agree, agree, and strongly agree. All the items for each of the five variables of the questionnaire of this survey are briefly presented below.

Demographics: The demographic variable consisted of 10 categorical items: Gender, School Location, Age group, grade class teaching, current class size, highest level of qualification, subject specialization, frequency of computer usage, ethnicity, and teaching experience.

- A1. Gender: This questionnaire item aimed to identify the gender of the teachers participating in the survey. These teachers could select either the male or the female gender, as applicable.
- A2. School Location: This questionnaire item aimed to identify the location of the school of the teacher. These teachers could select either the rural or urban location.
- A3. Age Group: This questionnaire item aimed to identify the age of the teachers. These teachers could select one of the following age groups that applied to them: less than 30 years, 30 to 40 years, 41 to 50 years, and above 50 years.
- A4. Grade Class teaching: This questionnaire item aimed to identify the grade or class taught by the teacher. These teachers could select one or more of the

following grades that applied to them: Grade R to 3, Grade 4 to 6, Grade 7 to 9, and Grade 10 to 12.

- A5. Current Class size: This questionnaire item aimed to identify the approximate number of students in the teachers' class. These teachers could select one of the following class sizes: 1-20, 21-40, 41-60, and above 60.
- A6. Highest level of Education: This questionnaire item aimed to identify the level of qualification of the teachers. These teachers could select one of the following qualification levels that applied to them: Diploma, Bachelors, Honours', and Masters.
- A7. Subject Specialization: This questionnaire item aimed to identify the subject(s) taught by the teachers. These teachers could select one of the following subjects that applied to them: Languages, Mathematics, Science and Technology, and Social Sciences.
- A8. Frequency of Computer Usage: This questionnaire item aimed to identify the frequency of computer or ICT usage by the teachers. These teachers could select one of the following computer usage frequencies that applied to them: none, daily, weekly, monthly.
- A9. Ethnicity: This questionnaire item aimed to identify the teachers' race or ethnic group. These teachers could select one of the following ethnicities that applied to them: African, Indian, Coloured, White, and others.
- A10. Teaching experience: This questionnaire item aimed to identify the number of years a teacher has been in the practice of teaching. These teachers could select one of the following years of teaching experience that applied to them: Below 5 years, 5 to 10 years, 10 to 15 years, 15 to 20 years, and above 20 years.

Cell Phone use intentions. The cell phone use intentions variable consisted of 7 items adapted from the scale proposed by Persaud and Sehgal (2005).

- B1. Intended lifespan of current cell phone: This questionnaire item aimed to identify teachers' perceptions on the intended length of time for which learners' plan to use their cell phones before changing it.

- B2. Intended frequency of usage of cell phones: This questionnaire item aimed to identify teachers' perceptions on how frequently learners' intend to use their cell phones.
- B3. Intended diversification of purposes of usage of cell phones: This questionnaire item aimed to identify teachers' perceptions on the multiplicity of the purposes for which learners' intend to use cell phones.
- B4. Intended diversification of places of usage of cell phones: This questionnaire item aimed to identify teachers' perceptions on the multiplicity of places in which learners intend to use their cell phones, besides their homes.
- B5. Intentions to share cell phones with others: This questionnaire item aimed to identify teachers' perceptions on the extent to which learners intend to share their cell phone with other people, in addition to their family and friends.
- B6. Intended level of care in the use of cell phones: This questionnaire item aimed to identify teachers' perceptions on learners' intentions to cautiously or carefully use their cell phones.
- B7. Intentions to repair damaged cell phone: This questionnaire item aimed to identify teachers' perceptions on learners' intentions to repair their cell phones when damaged.

Cell Phone Knowledge and Ability The cell phone knowledge and ability variable consisted of 8 items adapted from the scale proposed by Van Deursen and Van Dijk (2008).

- C1. Ability to copy or move files and folders using cell phones: This questionnaire item aimed to identify teachers' perceptions on learners' ability to use their cell phones for copying, editing, and moving files and folders.
- C2. Ability to perform basic arithmetic calculations using cell phones: This questionnaire item aimed to identify teachers' perceptions on learners' ability to perform basic arithmetic calculations on their cell phones.

- C3. Ability to copy content with cut and paste using cell phones: This questionnaire item aimed to identify teachers' perceptions on learners' ability to cut and paste content with their cell phones.
- C4. Ability to connect cell phones to other devices such as computers and sound systems: This questionnaire item aimed to identify teachers' perceptions on learners' ability to connect their cell phones to other types of electronic devices such as computers and sound systems.
- C5. Ability to send SMS, MMS, and emails using cell phones: This questionnaire item aimed to identify teachers' perceptions on learners' ability to send messages with their cell phones using messaging services such as SMS, MMS, and emails.
- C6. Ability to post messages in chat rooms, newsgroups, and online forums using cell phones: This questionnaire item aimed to identify teachers' perceptions on learners' ability to connect to social media networks with their cell phones.
- C7. Ability to share files such as music and movies with other mobile devices: This questionnaire item aimed to identify teachers' perceptions on learners' ability to use their cell phones to share multimedia contents with other devices.
- C8. Ability to find information on Internet via search engines using their cell phones: This questionnaire item aimed to identify teachers' perceptions on learners' ability to use their cell phones for finding information on the Internet through search engines.

Cell Actual Use The cell phone knowledge and ability variable consisted of 8 items adapted from the scale proposed by Persaud and Sehgal (2005).

- D1. Lifespan of cell phones: This questionnaire item aimed to identify teachers' perceptions on how long learners' use their cell phones before changing it.

- D2. Frequency of usage of cell phones: This questionnaire item aimed to identify teachers' perceptions on the how frequently learners' use their cell phones.
- D3. Intensity of usage of cell phones: This questionnaire item aimed to identify teachers' perceptions on learners' cell phone usage purposes.
- D4. Places of usage of cell phones: This questionnaire item aimed to identify teachers' perceptions on the multiplicity of places in which learners use their cell phones, besides their homes.
- D5. Sharing of cell phones with others: This questionnaire item aimed to identify teachers' perceptions on the extent to which learners usually share their cell phones with other people, in addition to their family and friends.
- D6. Level of care in the use of cell phones: This questionnaire item aimed to identify teachers' perceptions on how careful learners are when using their cell phones.
- D7. Repair of damaged cell phones: This questionnaire item aimed to identify teachers' perceptions on the extent to which learners repair their cell phones when damaged.

Cell Durability The cell phone durability variable consisted of 10 items adapted from the scale proposed by Jansen and Ayers (2007).

- E1. Expected lifespan of cell phones' screens: This questionnaire item aimed to estimate teachers' perceptions on the time duration for which the screens of the cell phones used by learners generally last without failure.
- E2. Expected lifespan of cell phones' memory cards: This questionnaire item aimed to estimate teachers' perceptions on the time duration for which the memory cards of the cell phones used by learners generally last without failure.
- E3. Expected lifespan of cell phones' speakers: This questionnaire item aimed to estimate teachers' perceptions on the time duration for which the speakers of the cell phones used by learners generally last without failure.

- E4. Expected lifespan of cell phones' keypads: This questionnaire item aimed to estimate teachers' perceptions on the time duration for which the keypads of the cell phones used by learners generally last without failure.
- E5. Expected lifespan of cell phones' voice inputs: This questionnaire item aimed to estimate teachers' perceptions on the time duration for which the voice inputs (mouthpieces) of the cell phones used by learners generally last without failure.
- E6. Expected lifespan of cell phones' network antennas: This questionnaire item aimed to estimate teachers' perceptions on the time duration for which the network antennas of the cell phones used by learners generally last without failure.
- E7. Expected lifespan of cell phones' Bluetooth/Wi-Fi connectors: This questionnaire item aimed to estimate teachers' perceptions on the time duration for which the Bluetooth/Wi-Fi connectors of the cell phones used by learners generally last without failure.
- E8. Expected lifespan of cell phones' batteries: This questionnaire item aimed to estimate teachers' perceptions on the time duration for which the batteries of the cell phones used by learners generally last without failure.
- E9. Expected lifespan of cell phones' SMS/MMS applications: This questionnaire item aimed to estimate teachers' perceptions on the time duration for which the messaging services of the cell phones used by learners generally last without failure.
- E10. Expected lifespan of cell phones' Internet applications: This questionnaire item aimed to estimate teachers' perceptions on the time duration for which the internet applications of the cell phones used by learners generally last without failure.

3.4 Data Analysis

The data collected by this survey on the perceptions of teachers on the durability of cell phones when used for teaching and learning purposes was analysed using the Statistical Package for Social Sciences (SPSS) version 21.0 (IBM-SPSS Inc. 2012).

SPSS is an application that is used to perform data entry and data analysis, and to create tables and graphs. The SPSS software is capable of handling large amounts of data and can perform many different types of data analysis. It is commonly used in the social sciences, in the business world, and in academic research (Holmes et al. 2014). Some of the functionalities of SPSS includes, Data transformations, Data Examination, Descriptive Statistics, Contingency tables, Reliability tests, Correlation, T-tests, ANOVA, MANOVA, General Linear Model (Release 7.0 and higher), Regression, Nonlinear Regression, Logistic Regression, Loglinear Regression, Discriminant Analysis, Factor Analysis, Cluster anlaysis, Multidimensional scaling, Probit analysis, Forecasting/Time Series, Survival analysis, and Nonparametric analysis (IBM-SPSS Inc. 2012). These data was first tested for reliability and validity using the Cronbach Alpha coefficient for all four Likert Scale variables of the survey: teachers' perceptions on learners' cell phone usage intentions, their perceptions on learners' cell phone knowledge and ability, and their perceptions on the durability of cell phones. Descriptive and inferential analysis was subsequently performed on the validated and reliable data. The descriptive statistics were likewise performed for the demographics of the surveyed teachers in terms of means and frequencies. Inferential analysis was performed with the aid of Pearson's correlation tests between all Likert-scale variables, and linear regression equations were calculated for the variables with positive Pearson's correlation tests. The impact of the demographics on cell phone durability was tested using ANOVA. The Analysis of variance (ANOVA) is a hypothesis testing technique that is used for testing the equality of two or more population means by examining the variances of the samples that are taken in order to determine whether there are differences between the means of several groups of variables (Heron 2009). The confidence level of 95% was set for all the tests conducted by this study with a significance p-value between 0.00 and 0.05.

3.5 Conclusion

The population of the survey conducted by this study consisted of 236 secondary school teachers from 11 secondary schools of the iLembe and uMgungundlovu

district municipalities in the KwaZulu-Natal province of South Africa. The sample size consisted of 67 teachers selected from these 236 teachers, and the number of teachers selected from each school was calculated based on the ratio of the number of teachers in each school compared to the total number of teachers in the district multiplied by the sample size. Data was collected using a questionnaire consisting of a total of 42 items for the five variables of the conceptual model presented in the second chapter of this dissertation as adapted from Persaud and Sehgal (2005), from Van Deursen and Van Dijk (2008), and from Jansen and Ayers (2007): teachers' perceptions on learners cell phone use intentions, teachers' perceptions on learners' cell phone knowledge and ability, teachers' perceptions on learners' cell phone actual use, and teachers' perceptions on the durability of cell phones for teaching and learning. These data was analysed using the SPSS version 21.0 (IBM-SPSS Inc. 2012). The results of this survey will be presented in the next chapter.

CHAPTER IV

RESULTS

The previous chapter gave a detailed description of the survey conducted by this study on teachers' perceptions on the durability of cell phones when used for teaching and learning purposes. The survey results are presented in this chapter for data validity and reliability, as well as for its descriptive and inferential statistical tests.

4.1 Data Validity and Reliability

The data collected by this questionnaire-based survey is reliable as evidenced by the fact that all Likert-scale based research variables have a Cronbach's alpha (α) greater than 0.7. (See table 4.1). Furthermore, data validity was confirmed in SPSS where it was established that the coding of all the data in the form of integer values between 1 and 5 did not present any empty field and all integer values were between 1 and 5.

TABLE 4.1: RELIABILITY TABLE FOR THE RESEARCH VARIABLES

Research Variable	No of items	Cronbach's Alpha (α)
Learners' cell phone use intentions	7	0.843
Learners' cell phone knowledge and ability	8	0.883
Learners' cell phones actual usage	7	0.891
Teachers' perception on the cell phone durability	10	0.899

4.2 Descriptive Statistics

This section presents descriptive statistics on teachers' demographics, their perceptions on learners' cell phone use intentions, their perceptions on learners' cell phone knowledge and ability, their perceptions on the actual use of cell phones by learners', and their perceptions on the durability of cell phones when used by learners.

4.2.1 Demographics

Results from Table 4.2.1, illustrated by figures 4.2.1.1 to 4.2.1.10, indicate that the demographics of the teachers that participated in the survey conducted by this study are evenly distributed across gender and school location (see figures 4.2.1.1 and 4.2.1.2). On the other hand, an overwhelming majority of the teachers are of African origins followed by a non-negligible group size of teachers of Indian origins, and most of them are aged below 40 years. Almost all of the teachers that participated in this survey are teaching Grade 10 to Grade 12 students, and it is also interesting to note that almost all the teachers reported that they have at least a first degree; have less than ten years of teaching experience, and use computers at least on a daily basis.

TABLE 4.2.1 DESCRIPTIVE STATISTICS FOR DEMOGRAPHICS

Demographics		**Percentage**
Gender:	Male	51
	Female	49
School Location:	Urban	49
	Rural	51
Age Group:	Less 30	39
	30-40	40
	41-50	7
	Above 50	14
Grade Teaching:	Grade R-3	0
	Grade 4-6	1
	Grade 7-9	12
	Grade 10-12	87
Current Class Size:	Below 20	2
	20-40	43
	41-60	37
	Above 61	18
Highest Level of Qualification:	Diploma	12
	Bachelors	67
	Honours	21
Subject Specialization:	Languages	14
	Mathematics	25

	Science & Technology	39
	Social Sciences	22
Frequency of Computer Usage:	None	9
	Daily	79
	Monthly	12
Ethnicity:	African	73
	Indian	25
	White	2
Teaching experience:	0-5Years	42
	5-10Years	40
	10-20Years	6
	Above 20Years	12

Figures 4.2.1.1 to 4.2.1.10 show the analysis of the results (in percentages) on the demographics of the teachers that participated in the survey conducted by this study.

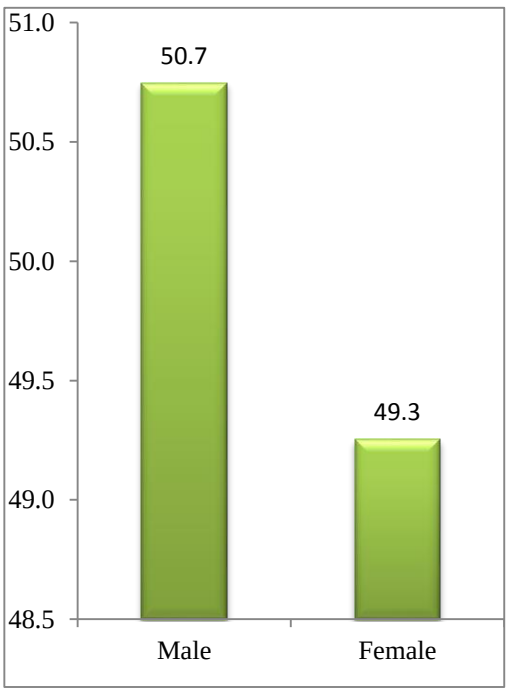

Figure 4.2.1.1: Teachers' Gender

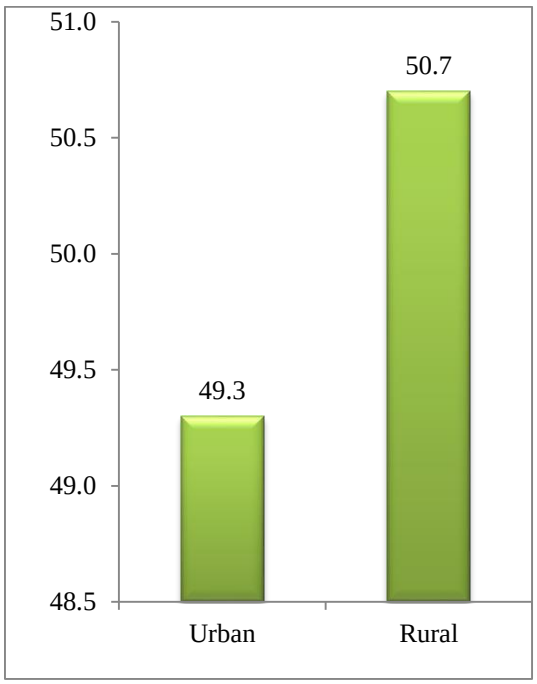

Figure 4.2.1.2: Teachers' school location

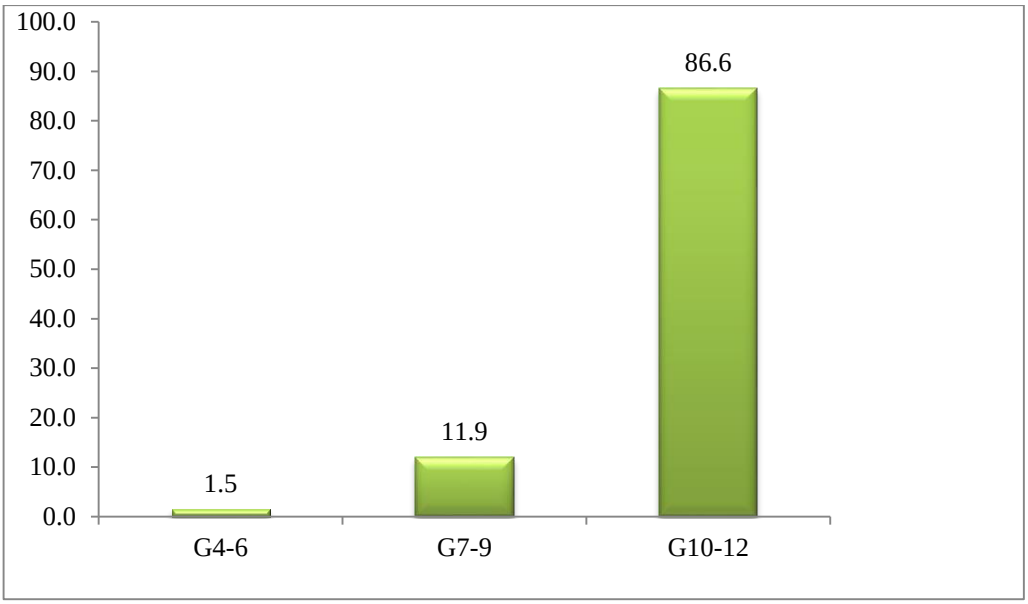

Figure 4.2.1.3: Grade teaching

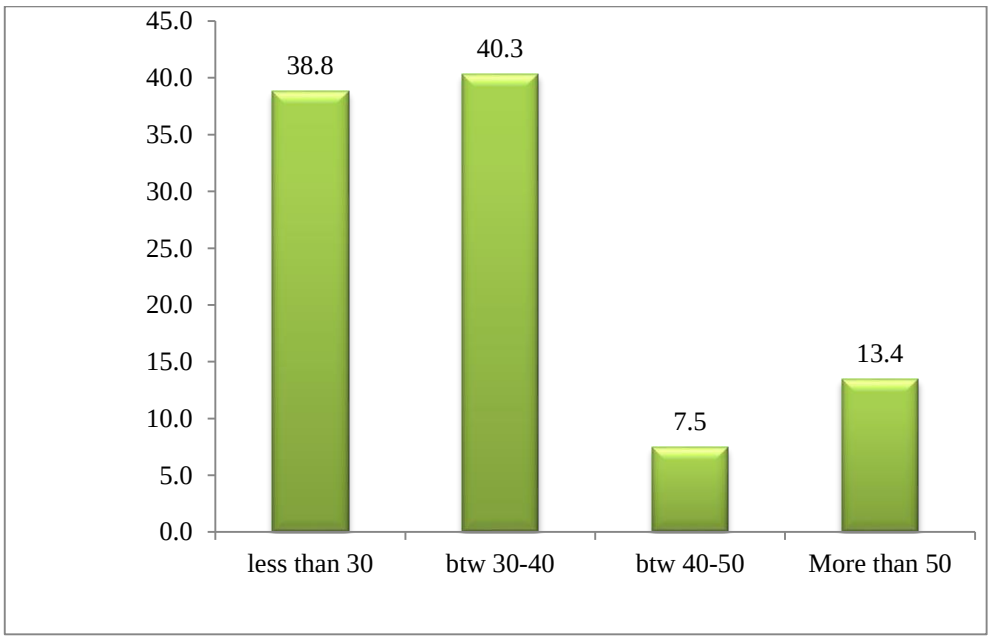

Figure 4.2.1.4: Teachers' Age Group

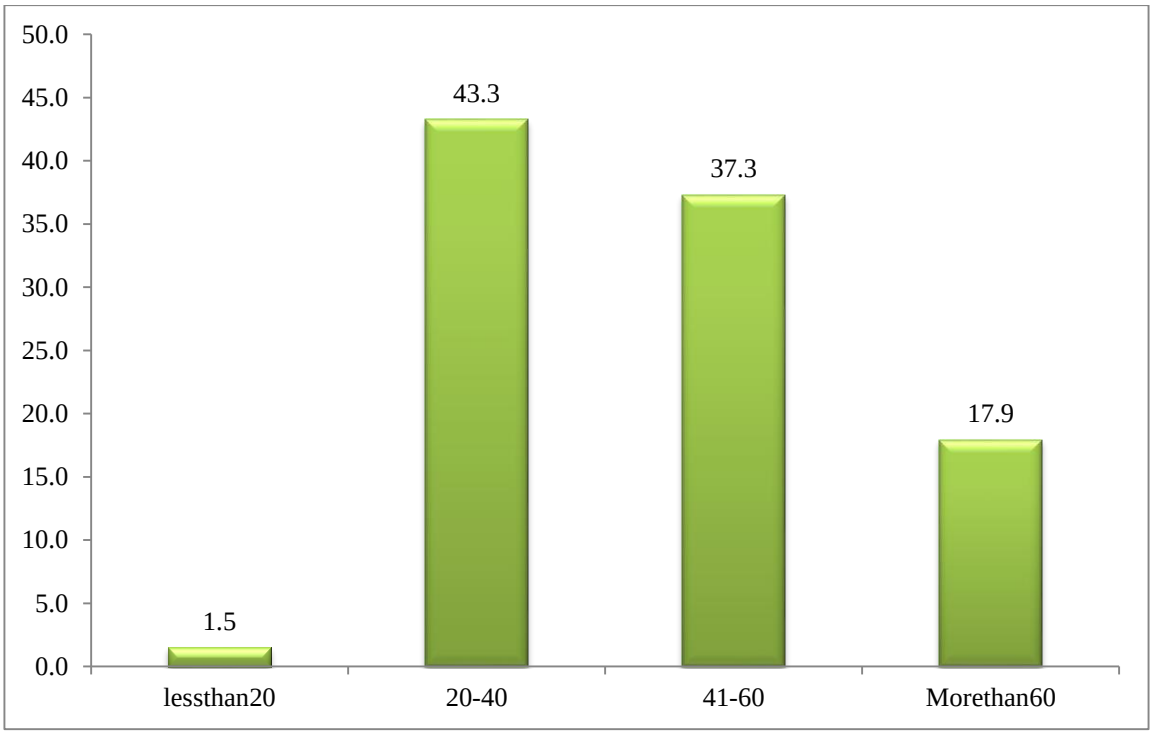

Figure 4.2.1.5: Teachers' current class size

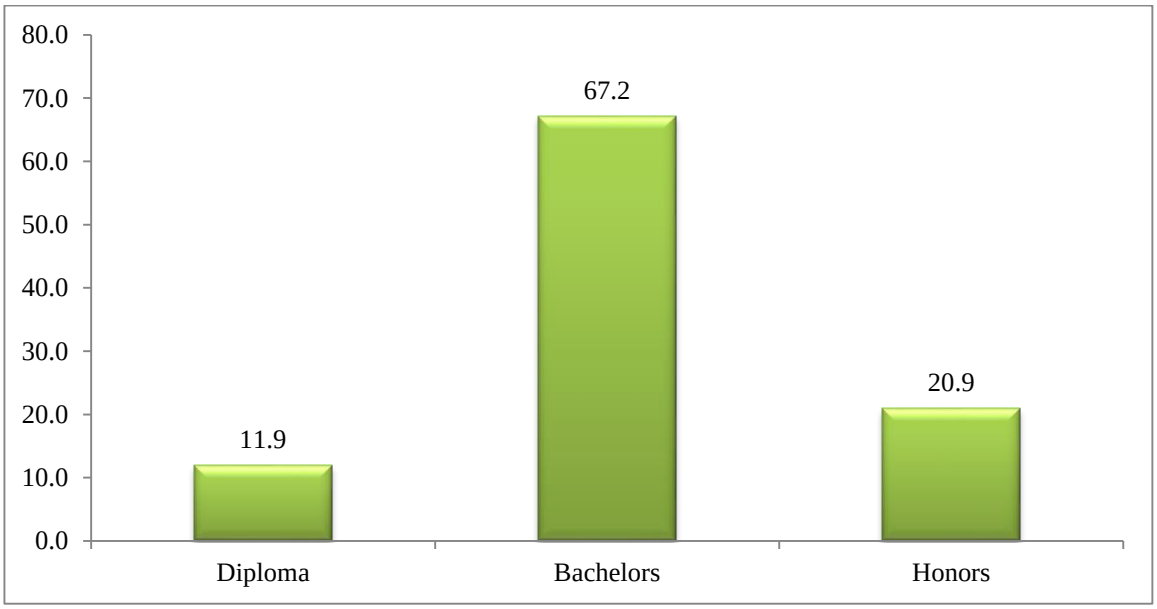

Figure 4.2.1.6: Teachers' highest level of education

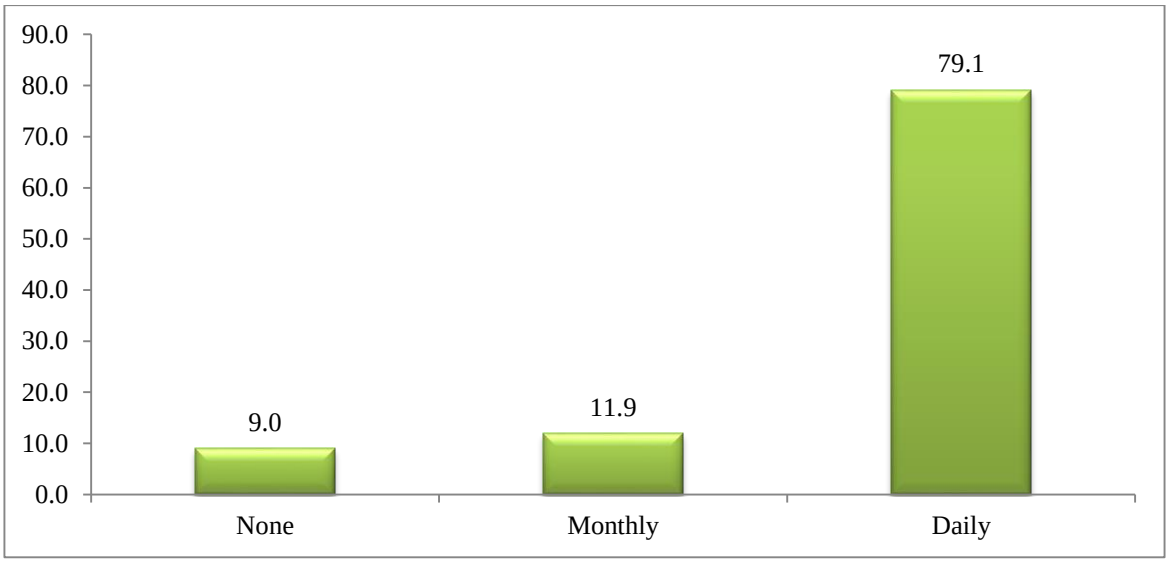

Figure 4.2.1.7: Teachers' computer usage frequency

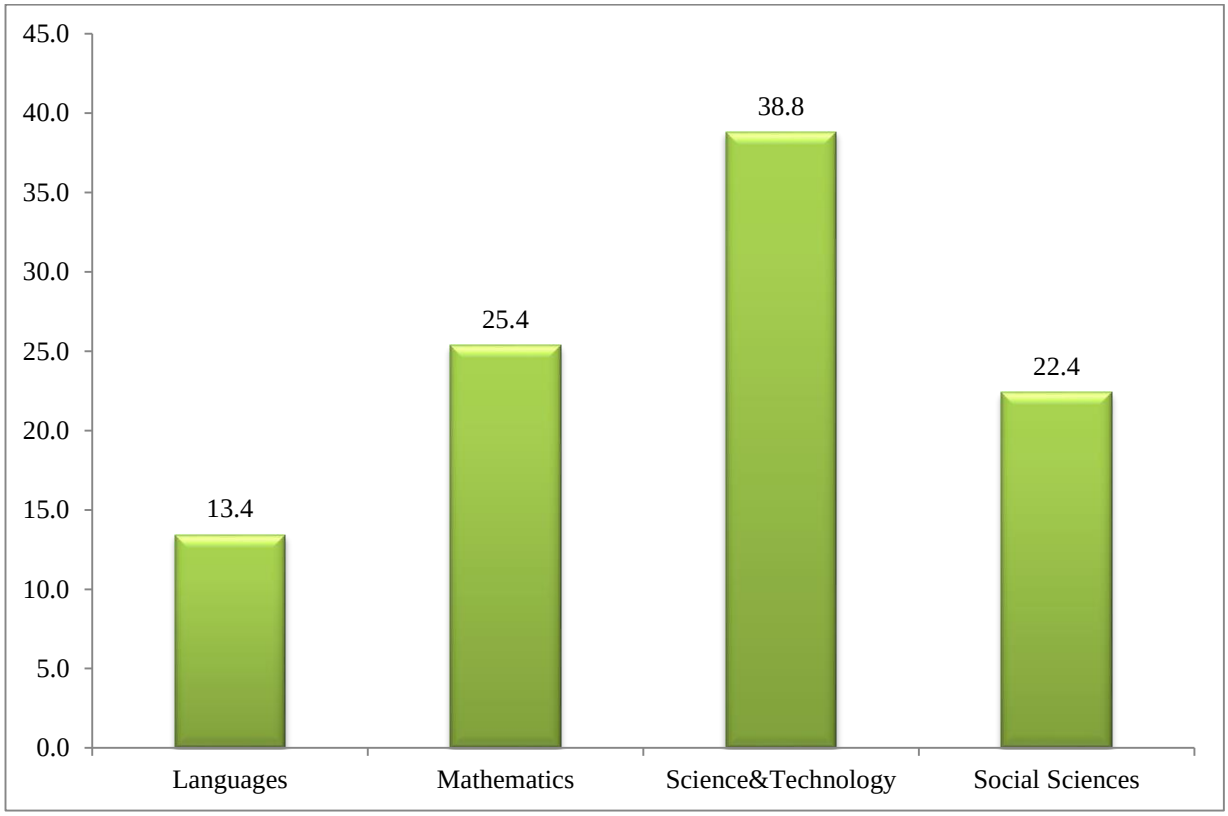

Figure 4.2.1.8: Teachers' subject specialization

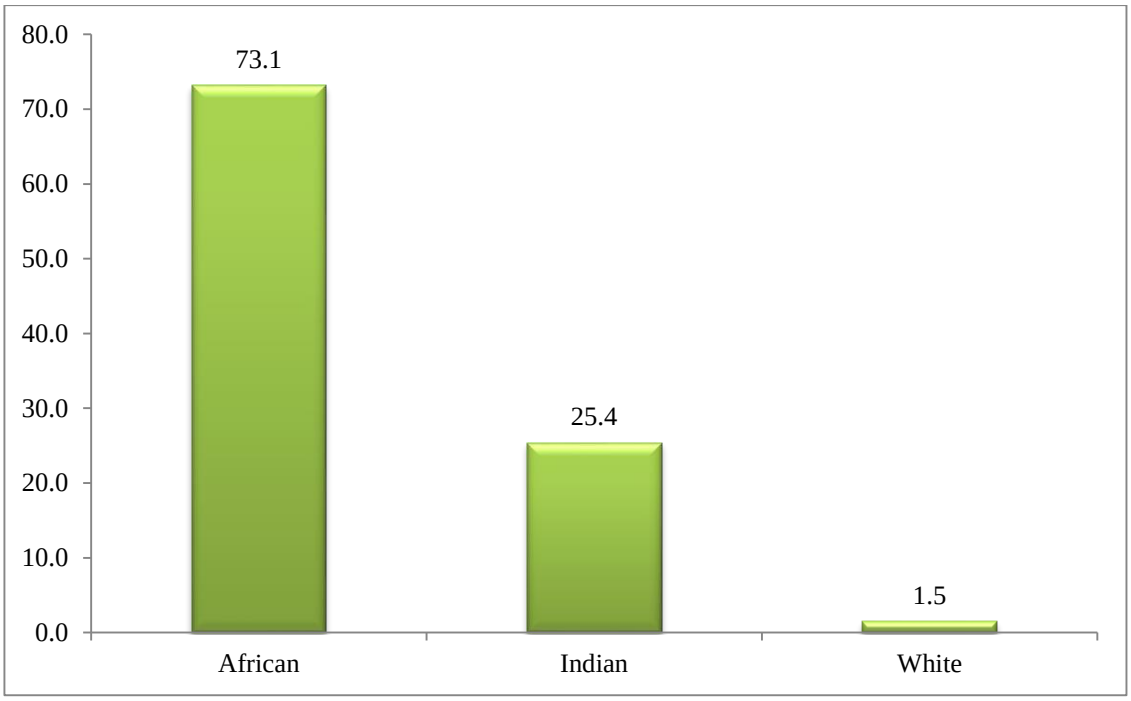

Figure 4.2.1.9: Teachers' Ethnicity

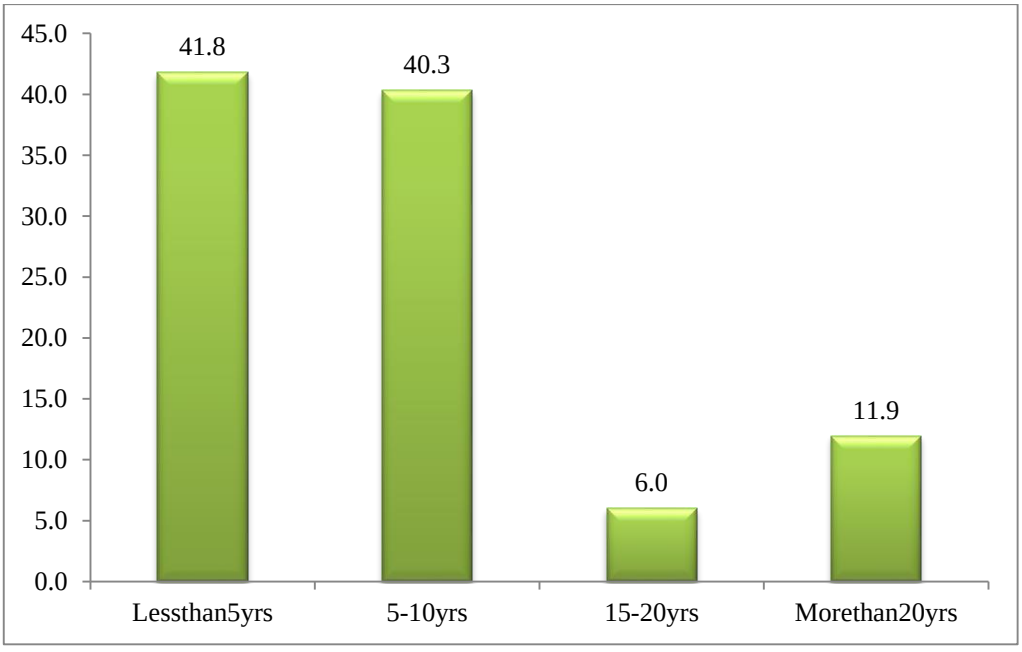

Figure 4.2.1.10: Teachers' number of years of teaching experience

4.2.2 Learners' Cell phone use intentions

The analysis of the results on learners cell phone use intentions illustrated by figure 4.2.2.1, figure 4.2.2.2 and table 4.2.2, show that only a simple majority of the teachers who participated in this study agree or strongly agree that learners intend to use their cell phones for a long period of time, intend to repair it when damaged, and intend to use it with care. However, an absolute majority of teachers agree or strongly agree that learners intend to use their cell phones for a variety of purposes, with many people, and in different places.

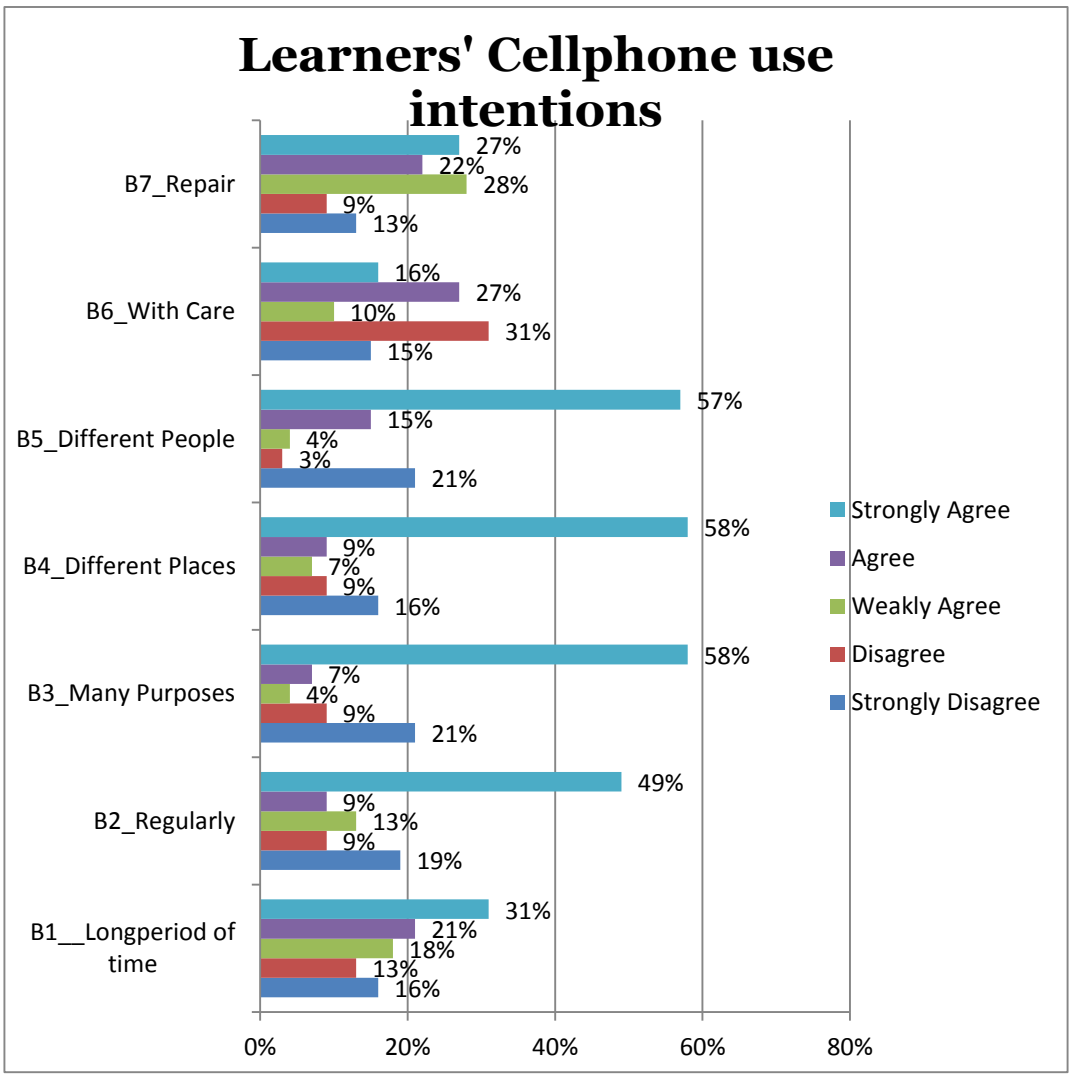

Figure 4.2.2.1: Teachers' perceptions on learners' cell phone use intentions

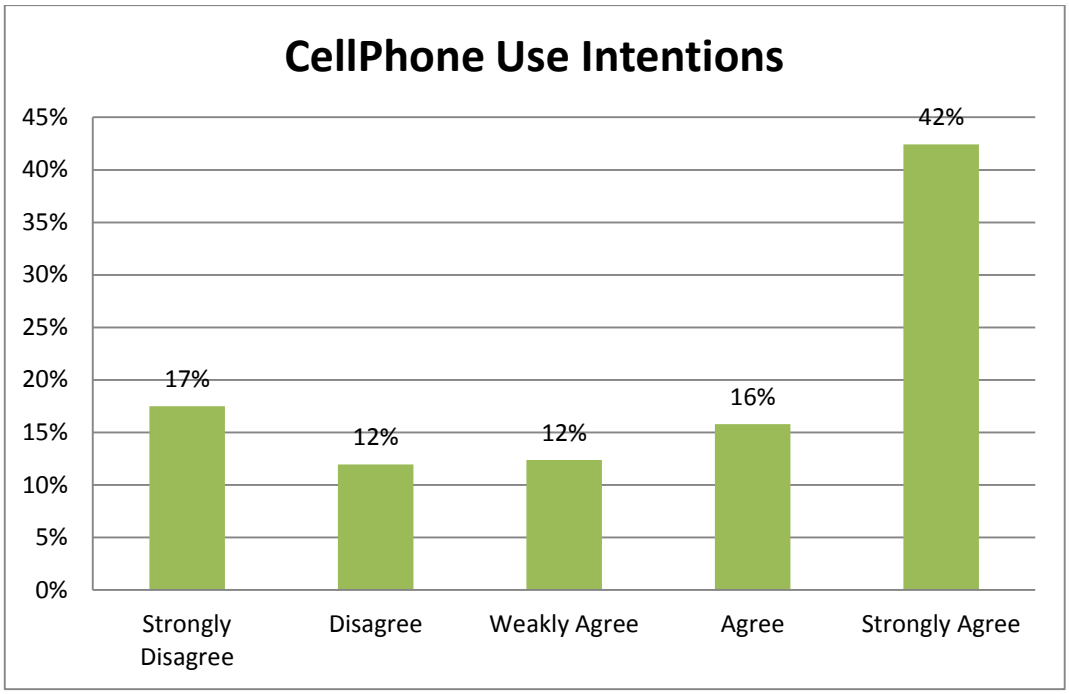

Figure 4.2.2.2: Teachers' overall perceptions on learners' cell phone use intentions

TABLE 4.2.2: DESCRIPTIVE STATISTICS ON LEARNERS' CELL PHONE USE INTENTIONS

B	SD	D	WA	A	SA	Mean	Std. Dev.
B1	16	13	18	21	31	3.37	1.465
B2	19	9	13	9	49	3.6	1.615
B3	21	9	4	7	57	3.73	1.684
B4	16	9	7	9	57	3.84	1.582
B5	21	3	4	15	56	3.84	1.62
B6	15	31	10	26	16	2.99	1.365
B7	13	9	28	22	26	3.40	1.338
Avg.	17.3	12.57	12.0	15.57	41.7	3.54	

4.2.3 Learners' Cell phone knowledge and ability

The analysis of the results on learners' cell phone knowledge and ability illustrated by figure 4.2.3.1, figure 4.2.3.2, and table 4.2.3 show that an absolute majority of the teachers that participated in this study agree or strongly agree that learners have a good knowledge and ability for the use of cell phones, in general. However, opinions

of these educators are spread as to whether learners have the ability and knowledge for the following items when using cell phones: for copying and moving files and folders, for performing basic arithmetic calculations, and for copy contents with cut and paste.

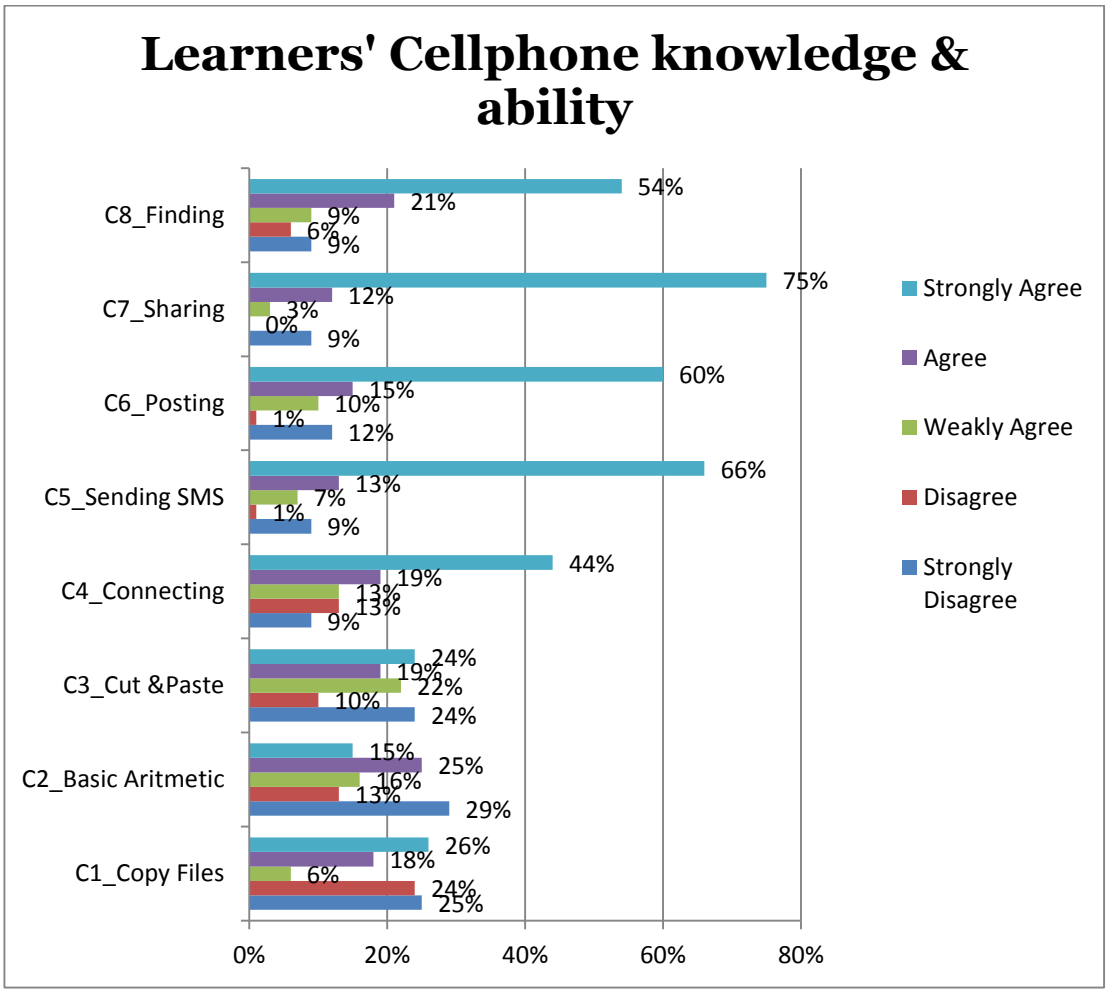

Figure 4.2.3.1: Teachers' perceptions on learners' cell phone knowledge and ability

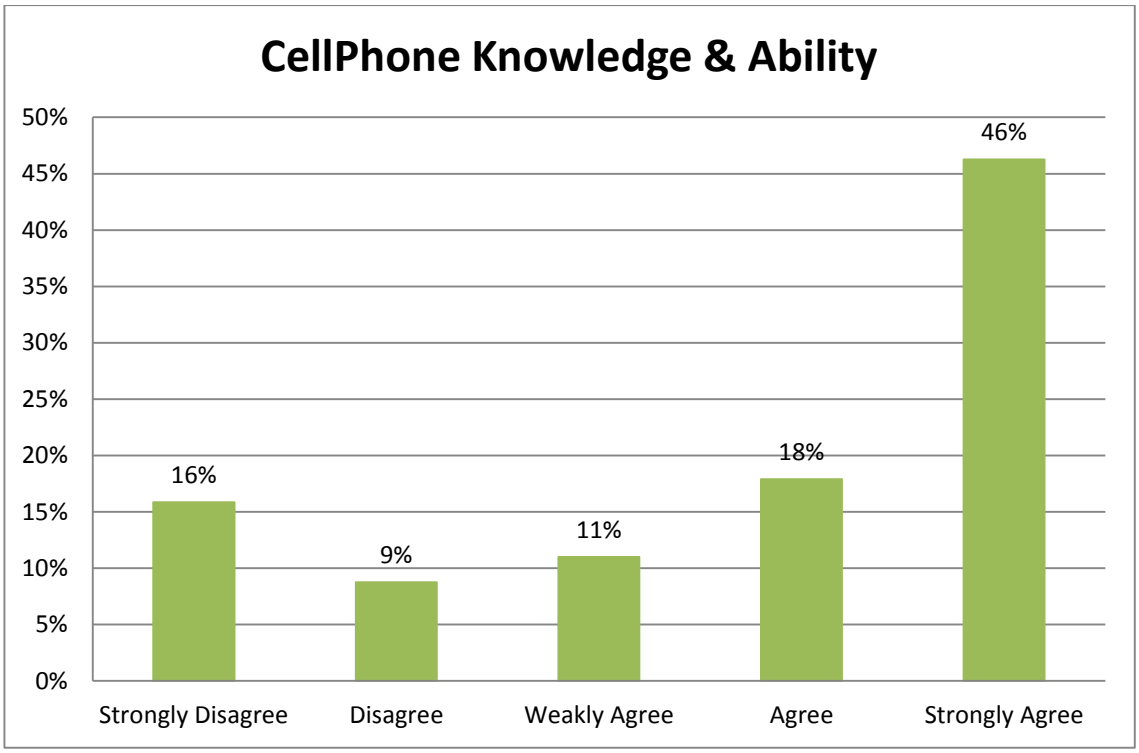

Figure 4.2.3.2: Teachers overall perceptions on learners' cell phone knowledge and ability

TABLE 4.2.3: DESCRIPTIVE STATISTICS ON LEARNERS' CELL PHONE KNOWLEDGE AND ABILITY

C	S1	S2	S3	S4	S5	Mean	SD
C1	25	24	6	18	26	2.97	1.595
C2	29	13	16	25	15	2.82	1.476
C3	24	10	22	19	24	3.09	1.495
C4	9	13	13	19	44	3.78	1.38
C5	9	1	7	13	66	4.3	1.252
C6	12	1	10	15	60	4.12	1.365
C7	9	0	3	12	76	4.46	1.185
C8	9	6	9	21	54	4.07	1.306
Avg.	15.75	8.5	10.75	17.75	45.65	3.70	

4.2.4 Learners' Cell phone actual use

The analysis of the results on learners' cell phone actual use illustrated by figure 4.2.4.1, figure 4.2.4.2, and table 4.2.4 show that only a simple majority of the

teachers, who participated in this study, believe that learners actually repair their cell phones when damaged and actually uses them with care. However, an absolute majority of teachers believe that learners actually use their cell phones for a variety of purposes, with many people, in different places, regularly, and for a long period of time without changing them.

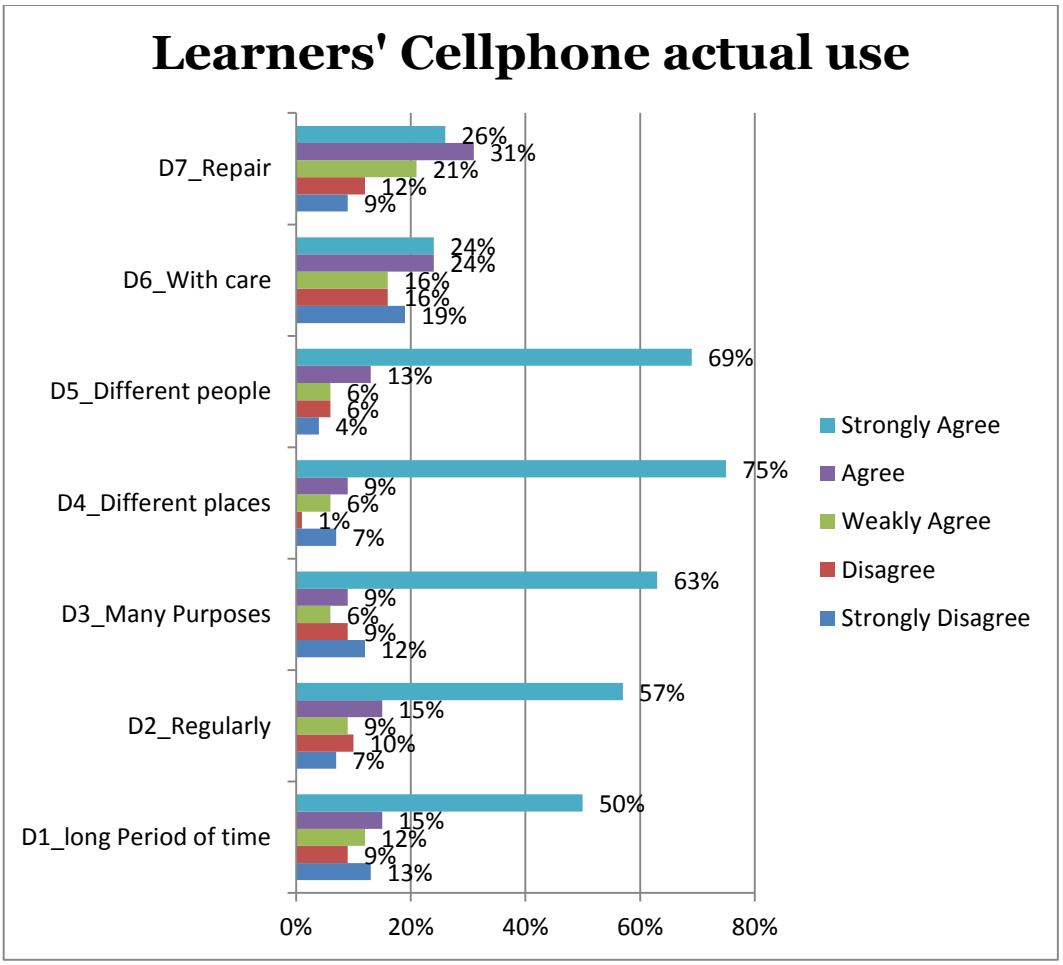

Figure 4.2.4.1: Teachers' perceptions on learners' cell phone actual use

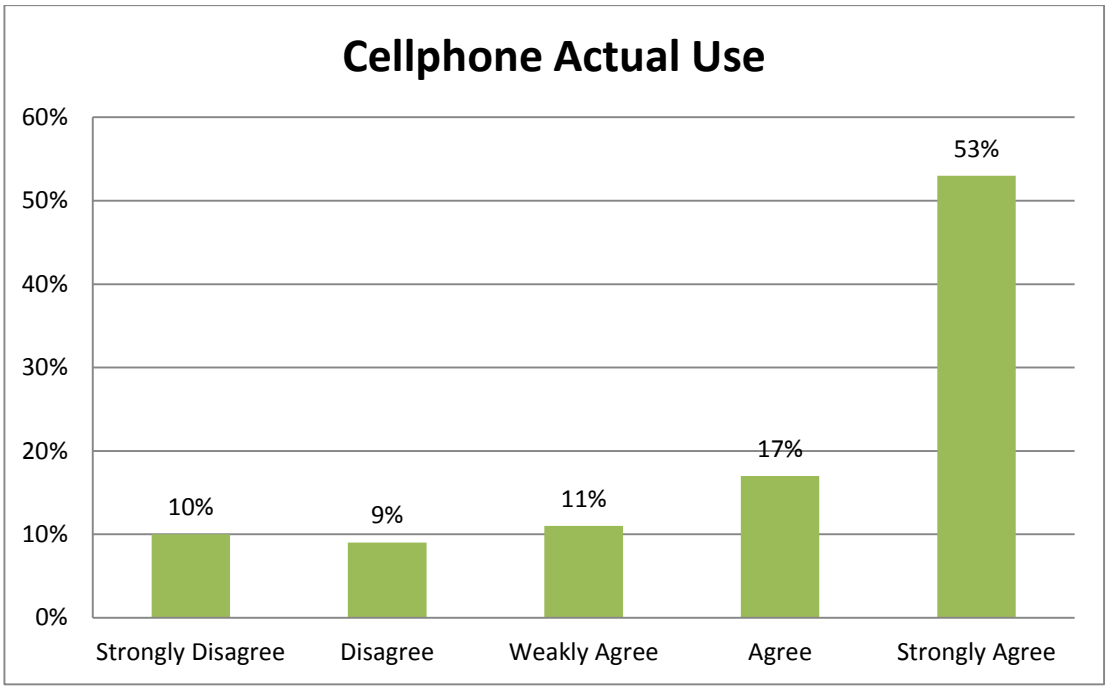

Figure 4.2.4.2: Teachers' overall perceptions on learners' cell phones actual use

TABLE 4.2.4: DESCRIPTIVE STATISTCS ON LEARNERS' CELLPHONE ACTUAL USE

D	SD	D	WA	A	SA	Mean	Std. Dev.
D1	13	9	12	15	50	3.81	1.48
D2	7	10	9	15	57	4.06	1.336
D3	12	9	6	9	63	4.04	1.471
D4	7	1	6	9	75	4.45	1.171
D5	4	6	6	13	69	4.39	1.128
D6	19	16	16	24	24	3.16	1.463
D7	9	12	21	31	26	3.55	1.259
Avg.	10.14	9.00	10.85	16.60	52.00	3.92	

4.2.5 Teachers' Perceptions on Cell phone Durability

The analysis of the results on teachers' perceptions on the durability of cell phones used by learners' illustrated by figure 4.2.5.1, figure 4.2.5.2, and table 4.2.5 show that the opinions of the teachers are spread with regard to the duration of time or number of years that cell phone components can last when used by learners. However, a simple majority (about 55%) of the teachers who participated in this

study believe that the cell phone components such as the Bluetooth, battery, network, voice input or mouthpiece, keypads, speakers, memory cards, and screen usually last for less than two years before failure. Figure 4.2.5.1 also shows that an absolute majority of the teachers believe that cell phones used by learners usually last for less than three years.

Figure 4.2.5.1: Teachers overall perceptions on cell phone durability

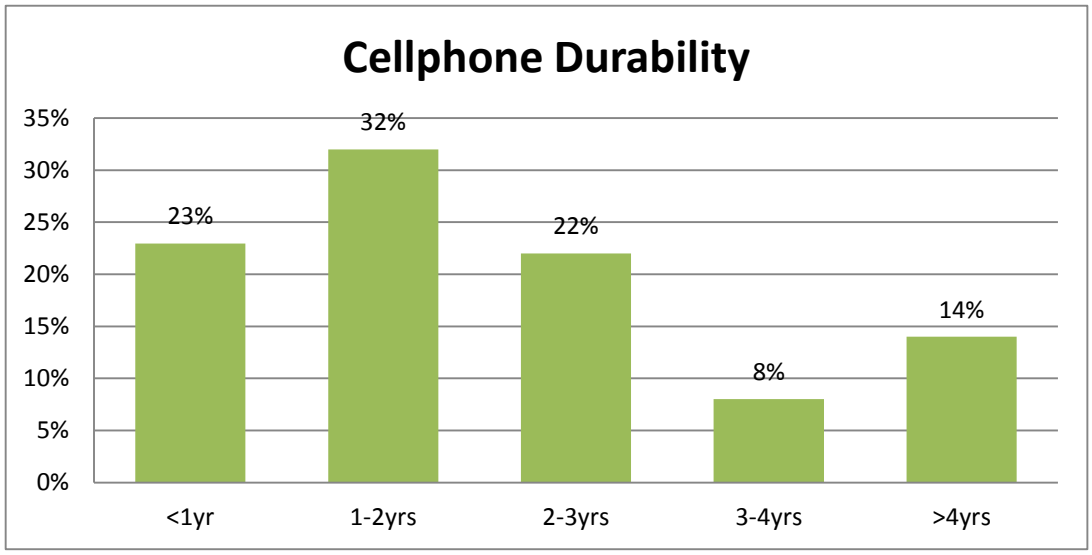

TABLE 4.2.5: DESCRIPTIVE STATISTICS ON TEACHERS' PERCEPTIONS ON CELLPHONE DURABILITY

E	Less than 1yr	1-2yrs	2-3yrs	3-4yrs	More than 4yrs	Mean	Std. Dev.
E1	25	44	16	3	10	2.28	1.191
E2	25	34	22	9	9	2.42	1.22
E3	24	34	26	6	9	2.42	1.183
E4	29	31	25	6	7	2.30	1.181
E5	13	40	24	9	13	2.69	1.221
E6	18	31	21	16	13	2.76	1.304
E7	19	29	18	9	24	2.88	1.462
E8	37	31	21	7	3	2.07	1.078
E9	16	24	24	4	31	3.10	1.489
E10	22	22	25	9	21	2.84	1.431
Avg.	22.8	32.0	22.2	7.8	14.0	2.57	

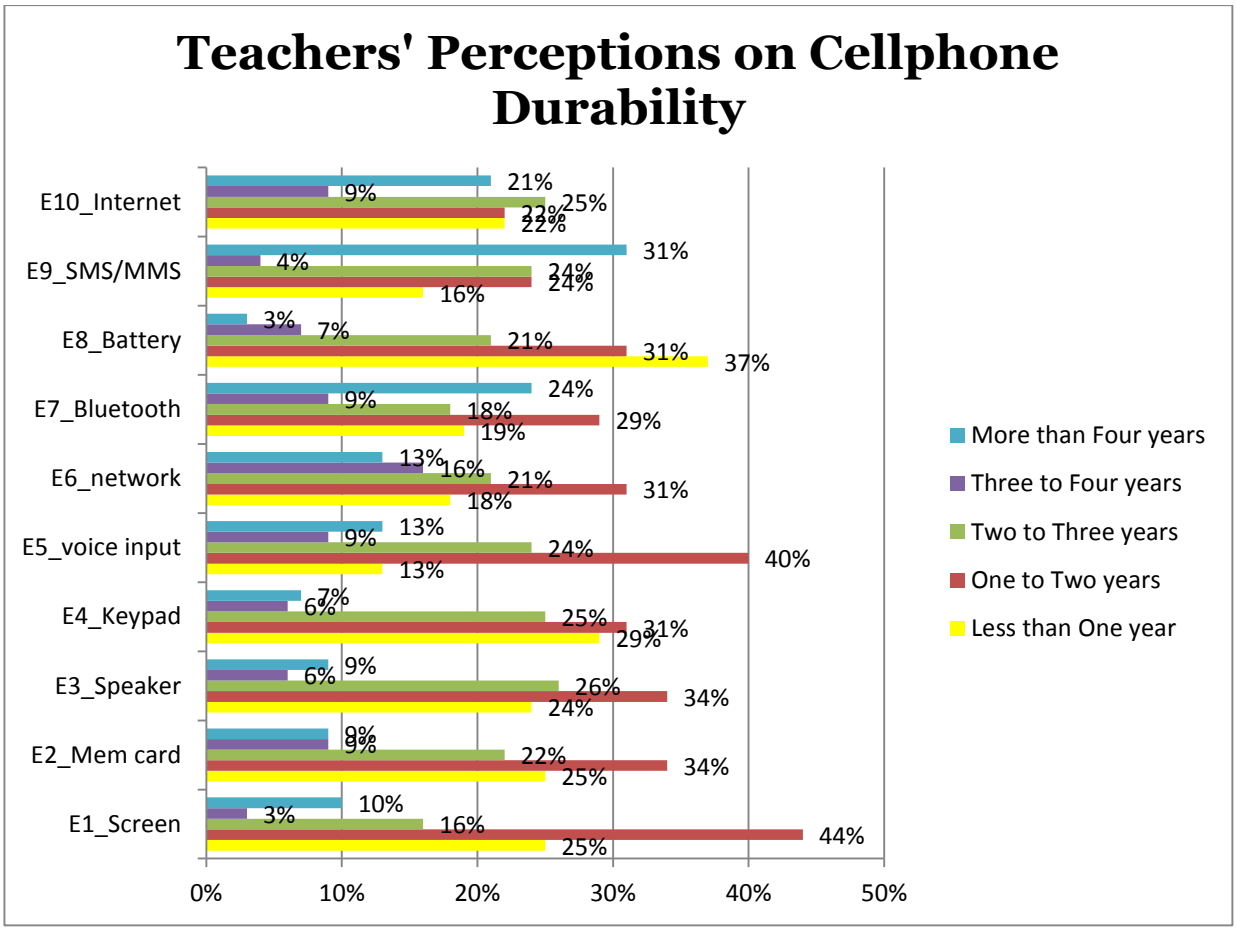

Figure 4.2.5.2: Teachers' perceptions on cell phone durability

4.3 Inferential Statistics (Correlations)

This section presents the results of the correlation tests conducted by this study starting with the results of the ANOVA tests and followed by the Pearson's correlation tests.

4.3.1 ANOVA test results

The results of the ANOVA tests conducted by this study are hereby presented (see table 4.3.1.1 to 4.3.1.10) in terms of their confirmation (sig. < 0.05) or disconfirmation (sig. > 0.05) of the hypotheses of this study.

Fa: In terms of demographics, the perceptions of teachers on the durability of cell phones when used for teaching and learning are only affected by the school location of these teachers.

Fb: In terms of demographics, the perceptions of teachers on learners' cell phone usage intentions are only affected by the teaching experience of these teachers.

Fc: Neither the teachers' perceptions on learners' cell phone knowledge and ability, nor their perceptions on the way learners actually use their cell phones, are correlated with the demographics of the teachers.

Table 4.3.1.1: **ANOVA test result (Gender)**

		Sum of Squares	**Df**	**Mean Square**	**F**	**Sig.**
Cell phone use Intentions	Between Groups	53.316	1	53.316	.902	.346
	Within Groups	3842.863	65	59.121		
	Total	3896.179	66			
Cell phone Knowledge and Ability	Between Groups	36.379	1	36.379	.533	.468
	Within Groups	4371.939	64	68.312		
	Total	4408.318	65			
Cell phone Actual Use	Between Groups	25.665	1	25.665	.481	.490
	Within Groups	3468.992	65	53.369		
	Total	3494.657	66			
Cell phone durability perceptions	Between Groups	8.429	1	8.429	.097	.757
	Within Groups	5671.750	65	87.258		
	Total	5680.179	66			

Table 4.3.1.2**: ANOVA test result (School Location)**

		Sum of Squares	**Df**	**Mean Square**	**F**	**Sig.**
Cell phone use Intentions	Between Groups	223.069	1	223.069	3.947	.051
	Within Groups	3673.110	65	56.509		
	Total	3896.179	66			
Cell phone Knowledge and Ability	Between Groups	207.409	1	207.409	3.160	.080
	Within Groups	4200.909	64	65.639		
	Total	4408.318	65			
Cell phone Actual Use	Between Groups	30.855	1	30.855	.579	.449
	Within Groups	3463.801	65	53.289		
	Total	3494.657	66			
Cell phone durability perceptions	Between Groups	482.407	1	482.407	6.033	.017
	Within Groups	5197.772	65	79.966		
	Total	5680.179	66			

Table 4.3.1.3**: ANOVA test result (Age Group)**

		Sum of Squares	Df	Mean Square	F	Sig.
Cell phone use Intentions	Between Groups	40.287	2	20.143	.334	.717
	Within Groups	3855.892	64	60.248		
	Total	3896.179	66			
Cell phone Knowledge and Ability	Between Groups	180.388	2	90.194	1.344	.268
	Within Groups	4227.930	63	67.110		
	Total	4408.318	65			
Cell phone Actual Use	Between Groups	43.553	2	21.777	.404	.669
	Within Groups	3451.103	64	53.923		
	Total	3494.657	66			
Cell phone durability perceptions	Between Groups	50.093	2	25.046	.285	.753
	Within Groups	5630.086	64	87.970		
	Total	5680.179	66			

Table 4.3.1.4**: ANOVA test result (Grade)**

		Sum of Squares	Df	Mean Square	F	Sig.
Cell phone use Intentions	Between Groups	40.287	2	20.143	.334	.717
	Within Groups	3855.892	64	60.248		
	Total	3896.179	66			
Cell phone Knowledge and Ability	Between Groups	180.388	2	90.194	1.344	.268
	Within Groups	4227.930	63	67.110		
	Total	4408.318	65			
Cell phone Actual Use	Between Groups	43.553	2	21.777	.404	.669
	Within Groups	3451.103	64	53.923		
	Total	3494.657	66			
Cell phone durability perceptions	Between Groups	50.093	2	25.046	.285	.753
	Within Groups	5630.086	64	87.970		
	Total	5680.179	66			

Table 4.3.1.5: **ANOVA test result (Current Class Size)**

		Sum of Squares	Df	Mean Square	F	Sig.
Cell phone use Intentions	Between Groups	285.502	3	95.167	1.661	.185
	Within Groups	3610.677	63	57.312		
	Total	3896.179	66			
Cell phone Knowledge and Ability	Between Groups	121.247	3	40.416	.584	.627
	Within Groups	4287.071	62	69.146		
	Total	4408.318	65			
Cell phone Actual Use	Between Groups	58.856	3	19.619	.360	.782
	Within Groups	3435.800	63	54.537		
	Total	3494.657	66			
Cell phone durability perceptions	Between Groups	369.771	3	123.257	1.462	.233
	Within Groups	5310.408	63	84.292		
	Total	5680.179	66			

Table 4.3.1.6: **ANOVA test result (Highest Level of Education)**

		Sum of Squares	Df	Mean Square	F	Sig.
Cell phone use Intentions	Between Groups	62.368	2	31.184	.521	.597
	Within Groups	3833.811	64	59.903		
	Total	3896.179	66			
Cell phone Knowledge and Ability	Between Groups	92.106	2	46.053	.672	.514
	Within Groups	4316.213	63	68.511		
	Total	4408.318	65			
Cell phone Actual Use	Between Groups	197.704	2	98.852	1.919	.155
	Within Groups	3296.953	64	51.515		
	Total	3494.657	66			
Cell phone durability perceptions	Between Groups	198.122	2	99.061	1.156	.321
	Within Groups	5482.057	64	85.657		
	Total	5680.179	66			

Table 4.3.1.7: **ANOVA test result (Subject Specialization)**

		Sum of Squares	Df	Mean Square	F	Sig.
Cell phone use Intentions	Between Groups	133.757	3	44.586	.747	.528
	Within Groups	3762.423	63	59.721		
	Total	3896.179	66			
Cell phone Knowledge and Ability	Between Groups	46.483	3	15.494	.220	.882
	Within Groups	4361.835	62	70.352		
	Total	4408.318	65			
Cell phone Actual Use	Between Groups	101.414	3	33.805	.628	.600
	Within Groups	3393.243	63	53.861		
	Total	3494.657	66			
Cell phone durability perceptions	Between Groups	180.739	3	60.246	.690	.561
	Within Groups	5499.440	63	87.293		
	Total	5680.179	66			

Table 4.3.1.8: **ANOVA test result (Computer Usage Frequency)**

		Sum of Squares	Df	Mean Square	F	Sig.
Cell phone use Intentions	Between Groups	11.311	2	5.656	.093	.911
	Within Groups	3884.868	64	60.701		
	Total	3896.179	66			
Cell phone Knowledge and Ability	Between Groups	10.552	2	5.276	.076	.927
	Within Groups	4397.766	63	69.806		
	Total	4408.318	65			
Cell phone Actual Use	Between Groups	18.470	2	9.235	.170	.844
	Within Groups	3476.186	64	54.315		
	Total	3494.657	66			
Cell phone durability perceptions	Between Groups	62.518	2	31.259	.356	.702
	Within Groups	5617.661	64	87.776		
	Total	5680.179	66			

Table 4.3.1.9: **ANOVA test result (Ethnicity A9)**

		Sum of Squares	Df	Mean Square	F	Sig.
Cell phone use Intentions	Between Groups	157.149	2	78.575	1.345	.268
	Within Groups	3739.030	64	58.422		
	Total	3896.179	66			
Cell phone Knowledge and Ability	Between Groups	78.645	2	39.322	.572	.567
	Within Groups	4329.673	63	68.725		
	Total	4408.318	65			
Cell phone Actual Use	Between Groups	184.421	2	92.211	1.783	.176
	Within Groups	3310.235	64	51.722		
	Total	3494.657	66			
Cell phone durability perception	Between Groups	263.639	2	131.819	1.558	.219
	Within Groups	5416.540	64	84.633		
	Total	5680.179	66			

Table 4.3.1.10: **ANOVA test result (Teaching Experience)**

		Sum of Squares	Df	Mean Square	F	Sig.
Cell phone use Intentions	Between Groups	583.959	3	194.653	3.702	.016
	Within Groups	3312.220	63	52.575		
	Total	3896.179	66			
Cell phone Knowledge and Ability	Between Groups	209.836	3	69.945	1.033	.384
	Within Groups	4198.482	62	67.717		
	Total	4408.318	65			
Cell phone Actual Use	Between Groups	145.067	3	48.356	.909	.442
	Within Groups	3349.589	63	53.168		
	Total	3494.657	66			
Cell phone durability perception	Between Groups	443.209	3	147.736	1.777	.161
	Within Groups	5236.970	63	83.127		
	Total	5680.179	66			

4.3.2 Differences between groups

An additional output of the inferential tests conducted by this study is presented by Table 4.3.2.2 which indicates that teachers from urban schools believe that cell phones are more durable compared to teachers from rural schools. Table 4.3.2.1and table 4.3.2 also indicates that the teachers with below 5 years of teaching experience and teachers with teaching experience between 5 to 10 years do not have the same perceptions on learners' cell phone usage intentions; whereby teachers with between five to ten years of teaching experience trust learners with regards to their cell phone usage intentions compared to teachers with less than five years' experience.

Table 4.3.2.1: Descriptive statistics table for teachers' perceptions on learners' cell phone usage intentions and teaching experience

Teaching Experience	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
< 5yrs	28	22.3929	7.28438	1.37662	19.5683	25.2174	11.00	35.00
5-10yrs	27	27.8889	5.55624	1.06930	25.6909	30.0869	10.00	35.00
15-20yrs	4	18.5000	13.30413	6.65207	-2.6698	39.6698	7.00	31.00
>20 yrs.	8	25.6250	8.83075	3.12214	18.2423	33.0077	7.00	35.00
Total	67	24.7612	7.68329	.93866	22.8871	26.6353	7.00	35.00

Table 4.3.2: Multiple comparisons on teachers' perceptions on learners' cell phone usage intentions and teaching experience

(I) Teaching experience	(J) Teaching experience	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound

Less than 5 years	Between 5 to 10 years	-5.49603*	1.95573	.033	-10.6571	-.3349
	Between 10 to 20 years	3.89286	3.87575	.747	-6.3351	14.1208
	More than 20 year	-3.23214	2.90681	.684	-10.9031	4.4388
Between 5 to 10 years	Less than 5 years	5.49603*	1.95573	.033	.3349	10.6571
	Between 15 to 20 years	9.38889	3.88471	.084	-.8627	19.6404
	More than 20 years	2.26389	2.91875	.865	-5.4385	9.9663
Between 10 to 20 years	Less than 5 years	-3.89286	3.87575	.747	-14.1208	6.3351
	Between 5 to 10 years	-9.38889	3.88471	.084	-19.6404	.8627
	More than 20 years	-7.12500	4.44022	.383	-18.8425	4.5925
More than 20 years	Less than 5 years	3.23214	2.90681	.684	-4.4388	10.9031
	Between 5 to 10 years	-2.26389	2.91875	.865	-9.9663	5.4385
	Between 10 to 20 years	7.12500	4.44022	.383	-4.5925	18.8425

*. The mean difference is significant at the 0.05 level.

Table 4.3.2.2: descriptive statistics for teachers' school location and teachers' perceptions on cell phone durability

					95% Confidence Interval for Mean			
Location	**N**	**Mean**	**Std. Deviation**	**Std. Error**	**Lower Bound**	**Upper Bound**	**Minimum**	**Maximum**
Urban	33	28.4848	9.16215	1.59493	25.2361	31.7336	10.00	46.00
Rural	34	23.1176	8.72393	1.49614	20.0737	26.1616	10.00	45.00
Total	67	25.7612	9.27703	1.13337	23.4983	28.0240	10.00	46.00

4.3.3 Pearson Correlations Results

The results of the Pearson correlation tests conducted by this study are presented by Table 4.3.3 and they can be summarized as follows in terms of their confirmation of the hypotheses of this study:

Fa: There is a direct relationship between teachers' perceptions on learners' cell phone usage intentions, and their perceptions on learners' cell phone

knowledge and ability.

Fb: There is a direct relationship between teachers' perceptions on learners' cell phone usage intentions, and their perceptions on learners' cell phone actual use.

Fc: There is a direct relationship between teachers' perceptions on learners' cell phone usage intentions, and their perceptions on cell phone durability when used by learners.

Fd: There is a direct relationship between teachers' perceptions on learners' cell phone usage intentions, and their perceptions on learners' cell phone knowledge and ability.

Fe: There is a direct relationship between teachers' perceptions on learners' cell phone knowledge and ability, and their perceptions on learners' cell phone actual usage.

Fg: There is a direct relationship between teachers' perceptions on learners' cell phone actual usage, and their perceptions on cell phone durability when used for teaching and learning purposes.

TABLE 4.3.3: CORRELATIONS BETWEEN LIKERT SCALE VARIABLES

Variables		**B**	**C**	**D**	**E**
B	Pearson Correlation	1	.456**	.475**	.271*
	Sig. (2-tailed)		0	0	0.027
	N	67	67	67	67
C	Pearson Correlation	.456**	1	.630**	0.171

	Sig. (2-tailed)	0		0	0.169
	N	67	67	67	67
D	Pearson Correlation	.475**	.630**	1	.317**
	Sig. (2-tailed)	0	0	0	0.009
	N	67	67	67	67
E	Pearson Correlation	.271*	0.171	.317*	1
	Sig. (2-tailed)	0	0.169	0.009	
	N	67	67	67	67

**. Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

From the results of the ANOVA tests, it was confirmed that there is a relationship between teachers teaching experiences and their perceptions on learners' cell phone usage intentions. The results of the person correlation tests also confirmed relationships between teachers' perceptions on the durability of cell phones for teaching and learning and the school location on one hand, and their perceptions on learners' cell phone usage intentions, and actual use on the other hand. The results also confirm that there are relationships between all the variables proposed by the initial hypotheses of this study (see figure 4.3.3).

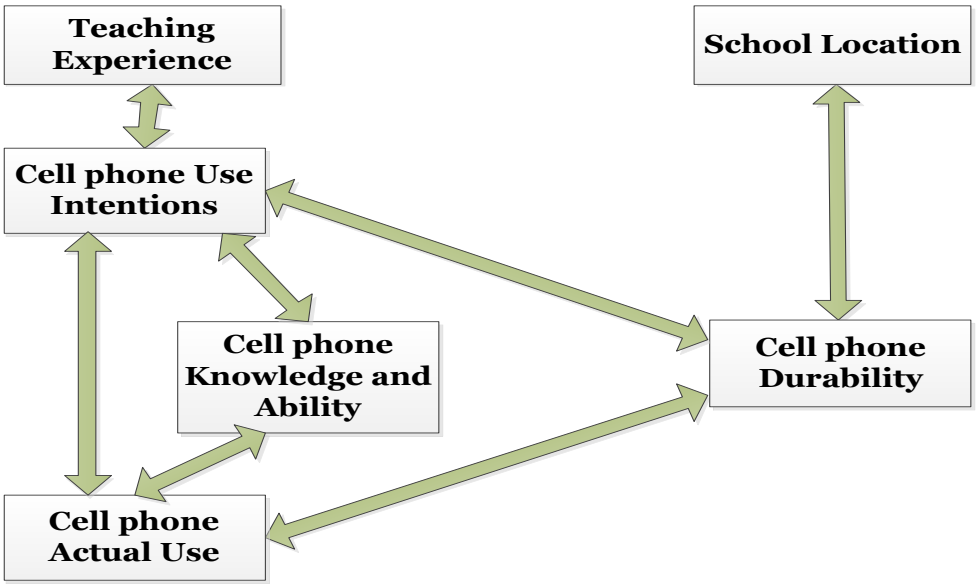

Figure 4.3.3: Validated Model

4.3.4 Linear Regression Test

Table 4.3.4 and Equation 4.3 present the results of the linear regression test between teachers' perceptions on cell phone durability on one hand, and their perceptions on learners' cell phone usage intentions and actual usage.

TABLE 4.3.4: Linear regression between variables [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	12.597	4.601		2.738	.008
	Cell phone use intentions	.188	.161	.156	1.167	.247
	Cell phone actual use	.310	.170	.243	1.824	.073

a. Dependent Variable: Cell phone durability

$$\text{CellPhone Durability} = .188\ (\text{Cellphone UseIntentions}) + .310\ (\text{Cellphone ActualUse}) + 12.597 \quad \text{(Eq. 4.3.4)}$$

4.4 Conclusion

The results of the descriptive statistics of this study indicate that the demographics of the teachers that participated in the survey conducted by this study are evenly distributed across gender and school location. Furthermore, an overwhelming majority of teachers are of African origins followed by a non-negligible group size of teachers of Indian origins, and most of them are aged below 40 years. Almost all of these teachers are teaching between Grade 10 and Grade 12, they have at least a first degree; they have less than ten years of teaching experience, and they use computers on a daily basis. Only a simple majority of the teachers who participated in this study believe that learners intend to use their cell phones for a long period of time, to repair it when damaged, and to use it with care, and only a simple majority of the teachers who participated in this study believe that learners actually repair their cell phones when damaged and they actually use them with care. However, an absolute majority of the teachers that participated in this study agree or strongly agree that learners have a good knowledge and ability for the use of cell phones in general. The results of the inferential tests performed by this study further reveal that the teachers' school location, their perceptions on learners' cell phone usage intentions and their perceptions on learners' cell phone actual usage are factors that affect their perceptions on cell phone durability when used by learners. Another interesting finding of this survey is that the perceptions of teachers on learners' cell phone usage intentions are affected by the teaching experience of these teachers and that an absolute majority of the teachers believe that cell phones used by learners usually last for less than three years. The next chapter is dedicated to the discussion of these findings in comparison with existing empirical studies on the durability or expected lifespan of cell phones.

CHAPTER V

DISCUSSION &CONCLUSION

The previous chapter presented the data validity and reliability, descriptive statistics, and inferential statistics results of the survey conducted by this study on teachers' perceived durability of cell phones when used for teaching and learning purposes. This chapter is dedicated to the discussion of these findings in comparison with existing empirical studies on the durability of cell phones. It will also present the research gaps, recommendations for improving the durability of cell phones when used by learners, and recommendations for future research in line with the fourth objective of this study.

5.1 Summary of current empirical study

Results from the survey conducted by this study presented in chapter four, indicate that the teachers that participated in the survey are high school teachers of African and Indian origins. They have at least a first degree; they have less than ten years of teaching experience, and they use computers on a daily basis. These teachers agreed that learners have good intentions in the use of their cell phones, and that learners have good knowledge and ability to use their cell phones. These teachers also agreed that learners actually use their cell phones decently, and they estimate that cell phones used by learners generally last between two to three years. The results of the inferential tests performed by this study further revealed that teachers' school location, their perceptions on learners' cell phone usage intentions, and their perceptions on learners' cell phone actual usage are factors that affect their perceptions on cell phones durability when used by learners. These inferential tests also found a mutual relationship between teachers' perceptions on learners' cell phone usage intentions, their perceptions on learners' cell phone knowledge and ability, and their perceptions on learners' cell phone actual usage. Finally, it was found that there is a relationship between teachers' teaching experience and their perceptions on learners' cell phone usage intention s.

5.2 Summary of previous empirical studies

The results of the literature review conducted by this study on the relationship between attribution theory constructs and perceived durability of mobile phones are summarized by 5.2.1.These literature review results are presented below in terms of descriptive results and in terms of inferential results according to the theoretical framework proposed by the second chapter of this study.

5.2.1 Descriptive Results

Table 5.2.1 summarises the descriptive results on the perceptions of cell phone users on the durability of cell phones. According to the results of the literature review conducted by this study (See Appendix B for paper authors), the durability or expected lifetime of cell phones is generally perceived to be under two years by most users (62.5% of the surveyed papers), only 5% of these papers reported a perceived

cell phone durability of more than three years, and 32.5% of these papers reported a perceived cell phone durability of between two and three years. Almost all these papers are focused on the durability of the device itself (94%) rather than on the durability of cell phone components (6%). The cell phone components, whose durability is mostly examined by existing literature, are the battery (13.8%), screen (3%), network (3%), and wireless connectivity (1%).

Table 5.2.1: Descriptive statistics results on cell phones durability.

Paper	**E1**	**E2**	**E3**	**E4**	**E5**	**E6**	**E7**	**E8**	**E9**	**E10**	**E**
P1-P12								L			L
P13-P23											B,L,M
P24-P30								L			L
P31											L,M
P32								L			L
P33											B
P34	L						L	L			L
P35								L			B
P36											M
P37								L			L
P38											B,L
P39											L
P40						L		L			
P41											L
P42	L										
P43											B
P44											B
P52											L
P53											M
P54											M
P55						L					
P60											B

P61											M
P62								L			
P63											L
P64								L			M
P65											L
P66											M

**L= less than two years, B= between two to three years, M= more than three years.

5.2.2 Inferential Results

According to table 5.2.2., the perceived durability of mobile phones is affected by demographic factors such as gender and age (58.3%), location (8%) (Yong and Jindi, 2005), and usage frequency or intensity (8%) (Cooper 2004).

Table 5.2.2: Effect of demographics on perceived cell phone durability

Paper	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**A10**
P10	E									
P12			E							
P19	E		E							
P31		E								
P32	E									
P45	E		E							
P46	E									
P47			E							
P48			E							
P49	E									
P29,50	E		E					E		
P51			E							
P54	E		E							
Current study		E								

5.2.3 Other factors

Obsolescence occurs when products become ‘‘out of use’’ or ‘‘out of date.’’ The results from this research project on household appliances suggest that absolute obsolescence, which arises from technical failure, is exerting less influence upon life spans than relative obsolescence. These two types of obsolescence are considered in turn below and the implications for future appliance life spans are then discussed.

The literature review conducted by this study on the factors affecting the durability of mobile devices reveals that some of these factors cannot be grouped according to the four antecedent constructs of the theoretical framework of this study: demographics, cell phone use intentions, cell phone knowledge and ability, and cell phone actual use. However, the following paragraph endeavours to present these factors according to the framework proposed by Cooper (2004) who differentiates products’ absolute obsolescence from products’ relative obsolescence (See table 5.2.3). According to Cooper (2004), a product becomes obsolete when it is out of use or out of date, but absolute obsolescence which is due to technical failure (in terms of reliability, availability and maintainability) impacts less on products lifespans compared to relative obsolescence. Relative obsolescence mainly depends on the following attributes: psychological obsolescence, economic obsolescence, and technological obsolescence. All these three types of product obsolescence can be described in terms of their forms and in terms of their sources. The form of obsolescence simply describes how that obsolescence is manifested and its source is the cause of that obsolescence.

5.2.3.1 Psychological Obsolescence

According to Cooper (2004), psychological obsolescence arises from personal or individual changes in users’ perceptions of products. Two of its main forms are expressed when a user is no longer satisfied with a product and when he or she is no more attracted to it (aesthetic, functional or symbolic value). There are four main sources of psychological obsolescence: changes in perceived need, new trends in design (style, fashion), desire for social status (emulation), and marketing. There are twenty three (23) papers in the literature review conducted by the current study that are interested in the study of products’ psychological obsolescence factors. Eleven

(11) papers are on the forms of psychological obsolescence and twelve (12) papers on the sources of psychological obsolescence. Among the papers that are on the psychological obsolescence forms, there are seven (7) papers on user satisfaction, and four (4) papers on desire or attractiveness. Among the papers on the psychological obsolescence sources, four (4) papers are on changes in users perceived needs, four (4) papers on style or fashion, two (2) papers are on desire for social status, and two (2) papers are on market factors.

5.2.3.2 Economic Obsolescence

Economic obsolescence occurs when there are financial factors that cause certain products to be considered as undesirable or useless to the owner and, hence, he or she concludes that the product has no value and is no longer worth keeping in use. The three main forms of economic obsolescence are financial outlay (income), value, and depreciation. Sources of economic obsolescence include low performance to cost ratio, reduced value, excessive repair costs in relation to replacement costs and price trends caused by market structures (Cooper, 2004). There are twenty one (21) papers in the literature review conducted by this study that are concerned with products' economic obsolescence factors. Two (2) papers are on economic obsolescence forms and nineteen (19) papers on economic obsolescence sources. Among the papers on the economic obsolescence forms, two papers (2) are on revenue or income. Among the papers on the economic obsolescence sources, fifteen (15) papers are on cost of purchase, three (3) papers are on cost of repair or replacement, one (1) paper for performance, and one (1) paper for price trends caused by market structures.

5.2.3.3 Technological obsolescence

According to Cooper (2004), technological obsolescence arises when individuals are attracted to products with new functions added or changed as a result of advances in knowledge or technology, i.e., when functional qualities of newly introduced products are superior to the existing products. There are three main forms of technological obsolescence: functional change, quality, and effectiveness; and sources of technological obsolescence include innovation through new knowledge, reduced environmental impact, and information or communications capability. There are twenty three (23) papers in the literature review conducted by this study that are

connected to products' technological obsolescence. Six (6) papers are on technological obsolescence forms and seventeen (17) papers are on technological obsolescence sources. Among the papers on technological obsolescence forms, nine (9) papers are on innovation or new technology; eight (8) papers are on environmental impact, three papers (3) are on functional change, and three (3) papers are on product quality.

Table 5.2.3 Factors affecting products' obsolescence

Paper	Factors influencing expected lifetime or durability of mobile phones
P1	Environmental factors (TS2), number of owners, and maintenance (AF4)
P2	Malfunctions (AF3), technology (TS1), cost (ES2), demographics
P3	Cost (ES2), performance (ES1), size (PF1), number of owners
P4	Demographics, personal needs (PS1), market factors (PS4, ES5), social factors (PS3)
P5	Demographics, attitude, behaviour, expectations, cost (ES2)
P8	Damage and malfunctions (AF3), technology (TS1), fashion (PS2)
P9	Cost (ES2), performance (ES1), size (PF1), number of owners
P10	Technology (TS1), Functionality (TF1), Demographics
P11	Behaviour, attitude (PF), technology (TS1), fashion (PS2), functionality (TF1), damage/malfunction (AF3)
P12	Behaviour, attitude (PF), demographics, cost (ES2), personal needs (PS1), environmental factors (TS2), functionality (TF1), malfunction/damage (AF3)
P13	Attachment/detachment (PF2), Emotions (PF2), Rationality , satisfaction (PF2), gratification (PF2)
P14	Reliability (AF2), design (PF1), cost (ES2), quality (TF2)
P15	Psychological factors (Knowledge, attitude, behaviour)-PF2, environmental awareness (TS2)
P19	Expectations, behaviour, technology (TS1), malfunctions (AF3), cost (ES2), brand
P20	Malfunctions (covariates/problems) /failure (AF3)
P21	Malfunctions and damages (AF3), technology (TS1), personal factors (PS1), cost (ES2), performance (ES1), functionality (TF1), usability (PF1), aesthetics (PF1)

P22	Malfunctions and damages (AF3), cost (ES2), personal factors (PS1), performance (ES1), technology (TS1), quality (TF2)
P23	Income (EFI), cost (ES2,ES4), billing methods (ES2)
P24	Technology (TS1), fashion (PS2), personal factors (PS1)
P29	Perceptions, expectations, attitude, behaviour/actions (PF2)
P30	Usage behaviour, demographics (PF2)
P31	Behaviour/actions, demographics (PF2)
P32	Behaviour, demographics, awareness, attitude(PF2)
P34	Usage Behaviour, malfunctions &damages (AF3)
P35	Usage behaviour, demographics, (PF2)
P36	Replacement costs (ES4)
P37	Demographics, intention, malfunctions (AF3)
P38	Demographics, Behaviour (PF2)
P40	Intention, self-efficacy, actual use, acceptance, attitude, interest, PU, PEU (PF1)
P41	Malfunction/damage (AF3), upgrade/technology (TS1)
P42	Environmental factors (temperature &humidity)-TS2, actual use (PF2)
P44	Cost (ES2, ES4)
P45	Perception, product disposal and recycling (TS2), different aspects on products ownership and use, product lifespans (AF1), product resale and reuse (EF2)
P46	Consumer or user lifestyles (PS2) and demographics, use motivations (PF2), and product attributes (durability, quality, performance)-AF1, TF2
P47	Demographics (age), reliability (AF2), technology (TS1), quality (TF2)
P50	Demographics, actual use (PF2), efficiency and sufficiency (TS2), consumption
P51	Demographics, malfunctions (AF3)
P52	Demographics, usage intention, actual use, usage intensity, frequency of use, cost (ES2), social influence (PS3)
P53	Ownership period (AF1)
P54	Demographics, behaviour, attitude, knowledge, subjective norm (PS3)
P55	Demographics, Motivation, usage patterns, attitude (PF)
P56	Expectations, attitude, behaviour (PF)
P57	Intention, usage behaviour (PF)
P58	Duration of use/usage duration (AF1, AF2)
P60	Demographics, usage behaviour, attitude, product attributes (TF2, AF1, AF2, PF1),

	satisfaction (PF2)
P61	Average lifetime estimates (AF1), e-waste assessment (TS2)
P62	Actual use, duration of use, behaviour, (PF)
P63	Cost (TS2, TS4), environmental factors (TS2)
P64	Put on the market (PS4), end of life (TS2), destination
P65	Social (PS3), economic (ES2), environmental factors (TS2), individual action (PF1)
P66	Demographics, action, awareness, knowledge (PF1)

*PS- Psychological obsolescence source, PF- Psychological obsolescence forms

*ES- Economical obsolescence sources, EF-Economical obsolescence forms

*TS- Technological obsolescence sources, TF-Technological obsolescence forms

*AF- Absolute obsolescence forms, AS- Absolute obsolescence sources

5.3 Comparing current empirical studies to existing empirical studies

This section will present the results of the descriptive and inferential results of the current study in comparison to those of existing literature on the durability or lifespan of cell phones.

5.3.1 Comparing descriptive results

Table 5.3.1: Comparing descriptive results on cell phone durability perceptions

Paper	**E1**	**E2**	**E3**	**E4**	**E5**	**E6**	**E7**	**E8**	**E9**	**E10**	**E**
P1-P12								L			L
P13-P23											B,L,M
P24-P30								L			L
P31											L,M
P32								L			L
P33											B
P34	L						L	L			L
P35								L			B
P36											M
P37								L			L

P38											B,L
P39											L
P40						L		L			
P41											L
P42	L										
P43											B
P44											B
P52											L
P53											M
P54											M
P55						L					
P60											B
P61											M
P62								L			
P63											L
P64								L			M
P65											L
P66											M
Current study	B	B	B	B	B	B	B	B	B	B	B

**L= less than two years, B= between two to three years, M= more than three years.

Table 5.3.1 summarises the results of the comparison between the current empirical study and previous studies on cell phone durability.

Only four cell phone component durability or lifespan items (screen, network, wireless, and battery) were found to have been examined by existing studies according to the literature reviewed by the current study; and all these studies reported a lifespan of less than two years for these components compared to the current study which is reporting a lifespan of between two to three years for all these cell phone components. As far as the average lifespan of cell phones is concerned, there is no unanimous agreement on the value of this average lifespan as values vary from less than two years, between two to three years and more than three years. This

non unanimity of users' opinions on cell phone lifespans might be due to the fact these studies were carried out in different countries or regions (Africa, America, Europe, Asia, and Australia) with different social, economic (level of income, cell phone prices, and value), technological (cell phone quality, and innovation), infrastructural, and environmental conditions. It may also be due to the fact that some of these surveys were carried out with different research population types such as students, teachers, and general users having different perceptions on cell phone durability.

5.3.2 Comparing inferential results

Table 5.3.2: Comparing inferential results on the effects of users' demographics on cell phone durability

Paper	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**A10**
P10	E									
P12			E							
P19	E		E							
P29	E		E							
P31		E								
P32	E									
P45	E		E							
P46	E									
P47			E							
P48			E							
P49	E									
P50	E		E					E		
P51			E							
P54	E		E							
Current study		E								

The results of the existing literature reviewed in this study show that users' gender, location, age group, and usage intensity are the demographic factors that affect cell phone durability compared to the current study the current study which reported that only the school location affects teachers perceptions' on cell phone durability (See table 5.3.2).

5.4 Research gaps and areas for future research

The analysis of the literature reviewed by this study based on the theoretical framework of the current research points to the following gaps in the state of research on the factors affecting the durability of cell phones:

- None of the reviewed studies is examining how cell phones durability is affected by users' cell phone usage intentions, by users' cell phone knowledge and ability, or by users' cell phone actual use;
- None of the reviewed studies is examining cell phone durability in the e-learning context. This might explain why none of them is examining how cell phone durability is affected by teachers' demographic variables such as grade taught, class size, level of education, subject specialization, ethnicity, and teaching experience;
- None of the reviewed studies is examining the durability or lifespans of cell phone components such as the memory cards, speakers or earpieces, keypads, and mouthpieces;
- None of the reviewed studies is based on products' technological obsolescence forms (product effectiveness), products' technological obsolescence sources (ICT capability) and products' economic obsolescence forms (product value, and depreciation);
- Only a few studies are related to products' psychological obsolescence sources such as user desire for social status (emulation), and product marketing; products' economic obsolescence forms (income, and performance); and

- Only a few studies refer to the durability or lifespans of cell phone components such as the screen, network, wireless, batteries, messaging and internet.

5.5 Recommendations

The following recommendations can be made based on the results of the current study and on the above identified research gaps.

- One of the interesting findings of the survey conducted by this study is that learners do not use and do not even intend to use their cell phones with care. Therefore, more research should be done on that aspect in order to improve the durability of cell phones when used for teaching and learning.
- Another finding of the current study is that the teachers that were surveyed by this study are of the opinion that cell phones used by learners generally last, on average, for between two to three years. Therefore, this study proposes a three-year cycle for cell phone renewals in schools' mobile learning projects in order to manage e-waste through new e-recycling projects.
- Another interesting finding of the current study is that an overwhelming majority of the teachers who participated in this survey are of African and Indian origins, and their perceived actual use of mobile devices is high. Therefore, this study proposes that these teachers be used as champions for mobile learning projects in schools.
- One of the research gaps identified by this study is that none of the reviewed studies is examining how cell phone durability is affected by users' cell phone usage intentions, by users' cell phone knowledge and ability, or by users' cell phone actual use. Therefore, it is recommended that more research be conducted on the effect of these factors on the durability of cell phones, not only in the context of e-learning, as it is the case for this study, but also for other contexts.
- Another gap identified from the literature reviewed by the current study is that there are no empirical studies examining the durability of cell phones in

the e-learning context. Therefore, more research should be done on this aspect.

- Another gap identified from the literature reviewed by the current study is that there only a few studies on products' psychological obsolescence sources such as users' desire for social status (emulation), and product marketing; products' economic obsolescence forms such as income and product performance. Therefore, more research should be done on this aspect.
- Another gap identified from the literature reviewed by the current study is that none of the reviewed studies is on the product effectiveness form of products' technological obsolescence or on the ICT capability source of products' technological obsolescence, nor on the product value and depreciation forms of products' economic obsolescence. Therefore, more research should be done on these aspects of cell phone relative obsolescence.

5.6 Conclusion

This chapter conducted an analysis of existing literature on the factors affecting cell phones durability using the framework proposed by Cooper (2004) on the factors affecting products' relative obsolescence, in addition to the conceptual framework of the current study. According to Cooper (2004), relative obsolescence is divided into three different dimensions: Psychological, Technological, and Economical. This chapter also compared the descriptive and inferential results of the survey conducted by this study against the descriptive and inferential results from previous empirical studies, and found that teachers are of the opinion that the lifespan of cell phones is between two to three years when they are used by learners. This is relatively higher than the lifespan of less than two years which is reported by existing studies. Moreover, the results of the literature reviewed by this study show that users' gender, location, age group, and usage intensity are the demographic factors that affect cell phone durability compared to the current study which found that only the school location affects teachers' perceptions on learners' cell phone durability.

Some of the major research gaps identified from the analysis of the literature reviewed by this study are: none of the reviewed studies is examining how cell phone

durability is affected by users' cell phone usage intentions, by users' cell phone knowledge and ability, or by users' cell phone actual use; none of the reviewed studies is examining cell phone durability in the e-learning context; none of the reviewed studies is examining the product effectiveness form of technological obsolescence, nor the product value and depreciation forms of products economic obsolescence. This chapter ends with some recommendations made based on the results of the current study and on the research gaps identified from the analysis of existing literature, as hereby highlighted: a three-year cycle project can be initiated for the renewal of cell phone devices in schools' mobile learning projects in order to manage e-waste through new e-recycling projects; teachers of African and Indian origins can be used as champions for mobile learning projects in schools; and there is a need for more research on how to teach learners about caring for the way they use their cell phones.

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APPENDICES

APPENDIX A: Questionnaire on examining the perceived durability of cell phones for teaching and learning.

Dear participant,

This questionnaire will only be used for research purposes and information provided by you will always remain anonymous. Please tick the box that best describes your answer for each item.

A.	**Demographics**								
A1.	Gender	Male	☐	Female	☐				
A2.	School Location	Urban	☐	Rural	☐				
A3.	Age Group	Less than 30	30 – 40		41 – 50	Above 50			
		☐	☐		☐	☐			
A4.	Grade (Class)	R – 3	4 – 6		7 – 9	10 -12			
		☐	☐		☐	☐			
A5.	Current Class size	1 -20	21 -40		41 – 60	Above 60			
		☐	☐		☐	☐			
A6.	Highest Level of Education	Diploma	Bachelors		Honours	Masters			
		☐	☐		☐	☐			
A7.	Subject Specialization	Languages	Mathematics		Science and Technology	Social Sciences			
		☐	☐		☐	☐			
A8.	Computer Usage	None	Daily		Weekly	Monthly			
		☐	☐		☐	☐			
A9.	Ethnicity	African	Indian		Coloured	White	Others		
		☐	☐		☐	☐	☐		
A10.	Teaching Experience (Years)	0 – 5	6 – 10		11 – 15	16 - 20	Above 20		
		☐	☐		☐	☐	☐		

B. Learners' cellphone use intentions I believe that the intention of **most learners** is to use their cellphones		Strongly Disagree	Fairly Disagree	Weakly Agree.	Fairly Agree	Strongly Agree
B1	For a long period of time without changing it.					
B2	Regularly.					
B3	For many purposes beyond communication.					
B4	In different places beyond their home.					
B5	With different people apart from their family and friends.					
B6	With care.					
B7	And repair it if damaged.					

C. Learners' cellphone knowledge and ability I believe that **most learners** are able to use their cellphones for		Strongly Disagree	Fairly Disagree	Weakly Agree.	Fairly Agree	Strongly Agree
C1	Copying or moving files and folders.					
C2	Performing basic arithmetic calculations.					
C3	Copying content with cut and paste.					
C4	Connecting to devices such as computers and sound systems.					
C5	Sending SMS, MMS, and emails.					
C6	Posting, chat rooms, newsgroups, and online forums messages.					
C7	Sharing files such as music and movies with other devices.					
C8	Finding information on Internet via search engines.					

D. Learners' cellphone actual use I believe that **most learners** actually use their cellphones		Strongly Disagree	Fairly Disagree	Weakly Agree.	Fairly Agree	Strongly Agree
D1	For a long period of time.					
D2	Regularly.					
D3	For many purposes beyond communication.					
D4	In different places beyond their homes.					
D5	With different people apart from their family and friends.					
D6	With care.					
D7	And repair it if damaged.					

E. Cellphone durability perceptions' I believe that the hereby listed **components of cellphones used by learners** can function well for the following time duration		Less than One year	One to Two years	Two to Three years	Three to Four years	More than Four years
E1	Screen.					
E2	Memory Card.					
E3	Speakers.					
E4	Keypad.					
E5	Voice input.					
E6	Network.					
E7	Bluetooth/Wi-Fi/Infrared.					
E8	Battery.					
E9	SMS/MMS.					
E10	Internet.					

APPENDIX B: Literature Review Table

Paper	Author(s)
P1	Polak and Drapalova (2013)
P2	Osibanjo and Nnorom (2011)
P3	Oguchi et al. (2010)
P4	Yeo (2013)
P5	Cooper (2005)
P6	Fraige et al (2012)
P7	Bergelin (2008)
P8	Bo Li et al. (2012)
P9	Murakemi et al. (2010)
P10	Jang and Kim (2010)
P11	Yin et al. (2013)
P12	Wilhelm et al. (2012)
P13	Rahmani et al. (2011)
P14	Tabakova and Shulga (2012)
P15	Kim (2003)
P16	Nokia (2009)
P19	Cox et al. (2013)
P20	Tiwari and Roy (2013)
P21	Yeo (2013)
P22	Zamfarmand et al. (2009)
P23	Entner (2011)
P24	Ferse and Breiter (2013)
P25	Bo Li et al. (2012)
P26	Gao (2013)
P27	Mu (2013)
P28	Huang (2008)
P29	Lyndhurst (2011)
P30	Hengrasmee (2007)

P31	Yong and Jindi (2005)
P32	Ongondo and Williams (2011)
P34	Jacobson and Williams (2004)
P35	Babatunde et al. (2014)
P36	NAICS (2012)
P37	Madevu (2010)
P38	Goel et al. (2000)
P39	Dalen and Tarassouk (2013)
P40	Adedoja et al (2013)
P42	Johnson (2006)
P43	Schueller (2013)
P44	Marshall and Swift (2009)
P45	Cooper and Mayers (2000)
P46	Mazzoni et al. (2007)
P47	Jainairain (2012)
P48	Jang and Kim (2010)
P49	Turnbull et al. (2000)
P50	Cooper (2004)
P51	Steinke et al (2013)
P52	GSMA (2006)
P53	Florida Department of Revenue (2000)
P54	Pietikainen (2007)
P55	Priyangani (2013)
P56	Evans and Cooper (2003)
P57	Cooper (2005)
P58	Malik et al (2012)
P59	Jeffrey and Kinshuk (2014)
P60	Owusu Prempeh (2013)
P61	Schluep et al (2009)
P62	Choochom et al (2009)

P63	Neira (2006)
P64	Cobbing (2008)
P65	US Environmental Protection Agency (2009)
P66	Kimeli (2014)