Optimization of KNEC Storage System using Electronic Identification and GSM Communication System

Kelvin Mong'are[1] and P.M. Musyimi[2]

Abstract **-** Examinations provide a standardized criterion for institutions to evaluate whether the set educational objectives are met. However, rising cases of examination cheating for the Kenya Certificate of Primary Education (KCPE) and Kenya Certificate of Secondary Education (KCSE) examinations has been a chronic problem in the country over the recent years. The major challenge faced was the nature of handling of the examination papers, whereby most of the examination papers were in the possession of candidates and other unauthorized persons before the examination commencement date. This has brought insecurities concerning the decay of morals in our various institutions which needs to be addressed with utmost urgency.

This malpractice has necessitated for innovative ways to improve the security of the examination papers. This project intends to come up with an integrated Electronic Identification and Global System for Mobile Communication (GSM) System with access given to the authorized recipient only, and in the process, minimize human contact during storage. This project entails three aspects, the design of a secure unit with anti-tampering technology, programming and design of the communication system that will be used for monitoring.

Through the use of this technology, we aim at laying up the infrastructure that will curb examination cheating incidences.

Keywords **-** Electronic Identification, Global System for Mobile Communication (GSM), Optimization

I. Introduction

The rate of examination cheating has been on the rise consequently, decreasing the quality of education offered by institutions. It has been a common statement for the Ministry of Education to point out the ever-rising cases of examination cheating in primary and secondary schools every year during the release of examination results. This malpractice has led to the overall decay of morals in the society and loss of integrity of the education system [1]. This ill-mannered behavior spreads to the future life of the candidates and it is no surprise that Kenya is among the leading nations on the corruption index. The World Bank Group (2002) define malpractice in public examinations as a deliberate act of wrongdoing contrary to official examination rules that is designed to place a candidate at an unfair advantage. The social equity of many students has been compromised and many a young people end up depressed and choked by life's frustrations. Their once valued ambitions of achieving their most sought goals quick turn to be pipe dreams. To guarantee social justice, fair evaluation and equity, the education system should be dearth of all malpractice. K.N.E.C. (Kenya National Examination Council) cartels, involving officials, and local university students steal examination papers and marking schemes. The materials are then sold to desperate candidates, subjected to local pressure to attain the highest grade. The rate of examination cheating has increased proportional to the evolving technology. As witnessed in many instances, daring candidates enter examination rooms with their mobile phones to access answers over the internet. The spread of a leaked exam is very fast and is attributed to the presence of social media platforms available to the public. Photos are shared mostly on the WhatsApp platform and university students offer a hand in solving the questions to provide answers thereof. Without overemphasizing on this, it is clear that there is a need to attend to this problem immediately. The major and consistent factor affecting cheating is the ineffectiveness of examination handling and distribution procedures. This project will incorporate recent technology to ensure effective and secure ways to package and store examination papers.

II. Literature Review

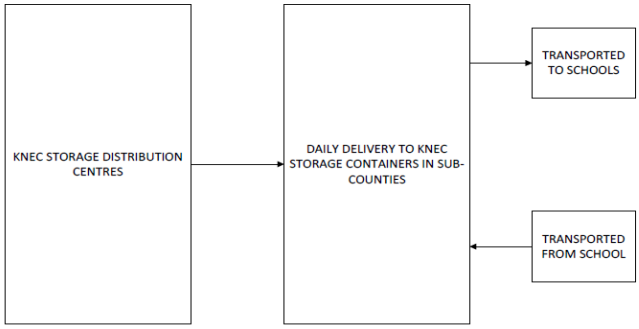


Fig. 1 Current KNEC Storage System

The current storage system comprises of a total of 346 double-lock metal containers whose keys are in the possession of education officials. The metal containers have been distributed across all sub-county offices and county commissioners are

[1] Kelvin Mong'are, Department of Electrical and Electronic Engineering, JKUAT. (Phone: +254721815638; email: mongarekelvin@gmail.com)
[2] P.M. Musyimi, Department of Electrical and Electronic Engineering, JKUAT. (Email: pclassics@yahoo.com)

tasked to ensure 24-hour security. The examination papers arrive from overseas one week to the start of examinations and are temporarily stored in protected regional distribution offices in Nairobi, Mombasa, Eldoret and Wajir. Daily dispatch to sub-county containers take place with some areas requiring airlifting. School heads collect examination papers at 5am in a daily basis from the containers, which are opened jointly by the sub-county education officials and examination official in the presence of a police officer [2]. The school heads and sub-county education officer sign against accountability documents confirming both the container and the exam papers have not been tampered with, and escorted to respective schools by senior officer. County commissioners are the overall managers at the distribution centers. All school heads are required to produce their appointment letters and identification badges for vetting and confirmation of legitimacy by the sub-county officers before receiving the examination papers. The supervisors and invigilators are limited to administration of exams only after which they handover scripts to the school heads. Spare question papers which were present in the older systems have now been removed. Each page of the question papers to be used by candidates will further have specific watermark barcodes that will help in investigations and identification of any copying. Shrink-wrapping has also been introduced on all examination cartons to discourage breakage. After the examination is ended, the examination materials are transported back to the storage facilities. Shrink wrapping is also done to cartons containing examination materials which will act as a visual detector for any tampering [3].

Fig. 2 Manning of Metal Containers

Advantages

1. Easier control on release of examination materials

2. Reduction in storage cost

Disadvantages

1. Time consuming

2. Vulnerable to human intrusion

3. Many loopholes which facilitate corruption.

4. Inefficient accountability and record-keeping.

5. System is independent on good individuals.

III. PROPOSED SYSTEM

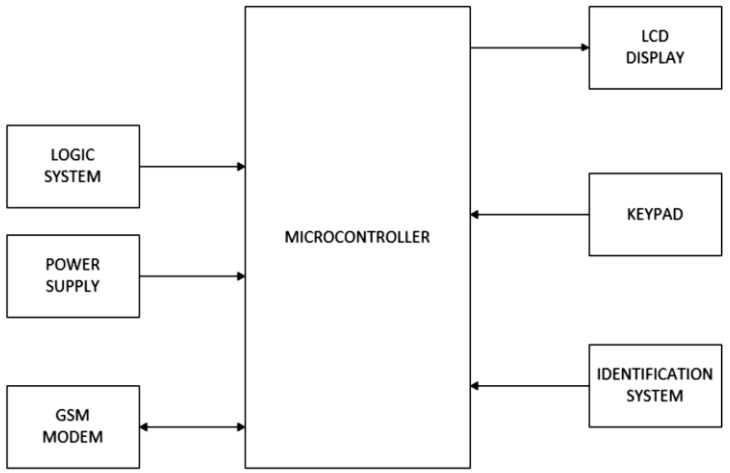


Fig. 3 Proposed System

The proposed system will comprise of the following: A **GSM (Global System for Mobile Communication) Module** which enables communication with the box. Once the box is opened, details of the user opening the box will be sent to the control centre. An implementation of GSM redundancy will enable a more effective communication in different locations. GSM module was chosen because it is readily available in the market. Two identification modules which are RFID (Radio Frequency Identification) Module and Fingerprint scanner. **RFID Module** which will enable an effective and efficient sorting of examination materials. Every school will have their designated box which will contain all the materials assigned to them. RFID form of identification is used because it has superior advantages over the barcode and manual methods of data collection. The identification module will also include a **Fingerprint Scanner** which will be used to securely access the box through user fingerprint. A **Logic System** will ensure that the boxes are only opened at intended times only. During the initial storage, the boxes are fully closed awaiting first delivery. It will also include **Electronic lock** to secure the access to the box. A **Power**

Supply will provide the power requirements to the system's circuitry.

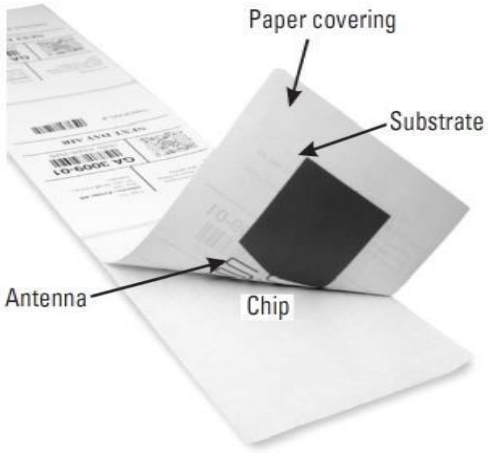
The main components of the system include the GSM Module and Identification System

IV. IDENTIFICATION SYSTEM

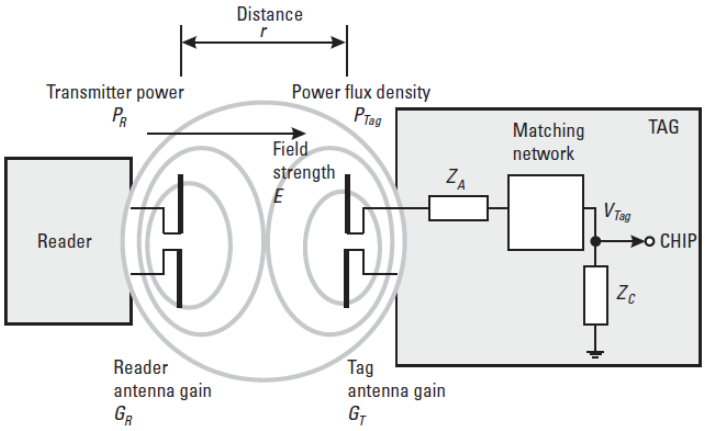
A. Radio Frequency Identification (RFID)

RFID system consists of an RFID reader, RFID tag, and information managing host computer. Radio Frequency Identification has emerged as a reliable technology that aims to improve the efficiency of data manipulation. The RFID enables data capture and enable technology which enhances ubiquitous computing and integration of systems seamlessly. Researches has been conducted concerning RFIDs and it has shown that investors using this technology can improve logistics efficiency responsiveness and cut down on labour costs. It is a widely-accepted technology owing to the fact that it is unique and contactless, making it most suitable for security features [4].

A typical RFID system consists of tags, readers, and application software. Tags have a memory embedded and a unique identify code which are either active (with batteries) or passive (without batteries). RFID readers collect data from and write data to compatible RFID tags, pass retrieved data to a server through network and enrich applications, such as inventory control real-time tracking, and business intelligence. The reader contains an RF transceiver module (transmitter and receiver), a signal processor and controller unit, a coupling element(antenna), and a serial data interface (RS232, RS485) to a host system. The tag and reader must work at the same specified working frequency and comply with specific regulations and protocols.



(a)



(b)

Fig. 4 RFID System

$$P_{Tag} = \left(\frac{E^2}{120\pi}\right)\left(\frac{\lambda^2}{4\pi}\right)G_T = \frac{{V_{Tag}}^2}{R_c} \qquad (1)$$

$$and \ \frac{E^2}{120\pi} = \frac{P_R G_R}{4\pi r^2}$$

$$P_{Tag} = \left(\frac{P_R G_R}{4\pi r^2}\right)\left(\frac{\lambda^2}{4\pi}\right)G_T = \frac{{V_{Tag}}^2}{R_c} \qquad (2)$$

where

The separation between the antennas is r, which is assumed to be large enough for the tag to be in the far field of the reader. E is the electric field strength of the reader at the tag location. The efficiency of the matching network will be taken as unity and ignored (losses in the network may also be accounted for in the value of G_T). Antenna gains G_R and G_T are expressed relative to an isotropic antenna. From considerations of power flux density at the tag, with λ as the wavelength. The typical output power of tag is 500mW. The voltage of the tag can be obtained by:

$$V_{Tag} = \left(\frac{\lambda}{4\pi r}\right)\sqrt{P_R G_R G_T R_C} \qquad (3)$$

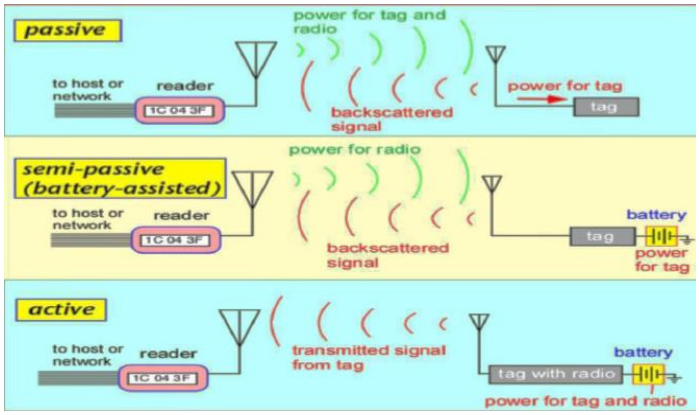


Fig. 5 Types of RFID

From the Fig. 5, the tags can be categorized as:

a. Active Tag

This type of tag contains a battery which supplies power to all functions and a transmitter.

b. Semi-passive Tag

This type of tag contains a battery which us only used to power the tag Integrated Circuit and not for communication.

c. Passive Tag

This tag has no battery integrated to it. This actually makes the tags cheaper and reliable in their use compared to the active tags. They are able to draw power from the reader. The electromagnetic wave received causes a current to be induced in the tag's antenna. The current is then used to power the tag's circuitry.

The quality and reliability of RFID system depends on: tag size, reader/writer antenna size, tag orientation, tag operating time, tag movement velocity, effect of metallic substances on operating range, multiple- tag operating characteristics, and the effect of the number of tags on operating success rate, tag overlapping.

Advantages

i. RFID tags are very easy to install/inject inside the body of animals, thus helping to keep a track on them. This is useful in animal husbandry and the poultry industry, wherein the installed tags give information about the age, vaccinations, and health of the animal.

ii. It is more secure than barcodes since it cannot be duplicated easily.

iii. Can store data up to 2KB(Kilobytes) compared to the barcode which contains 10-12 digits. This allows a better encoded identification.

iv. Making updating of stocks, during transportation and logistics of a product more effective.

v. Does not require line of sight.

vi. RFID tags are reusable

Disadvantages

i. Difficulty in reading information from tags stored in liquids and metal cases. The radio waves are reflected.

ii. Interference by neighbouring cell towers.

B. Fingerprint Scanner

Fingerprint scanning has proved to be more effective and convenient method for biometric systems. The scanners are classified as follows:

i. Optical Scanners

This is the oldest method which as the name suggests captures an image of the fingerprint and using an algorithm to detect unique patterns on the surface such as ridges or unique marks. The higher the resolution of the scanner, the higher the accuracy. However, the scanner can be bypassed by prosthetics or images of good quality.

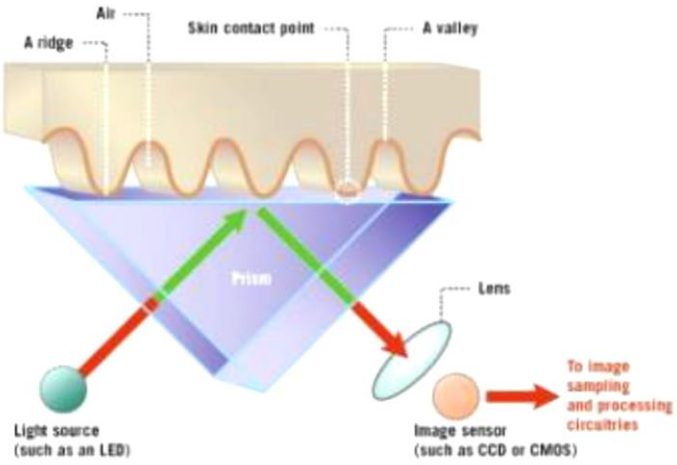


Fig. 6 Optical Scanner

ii. Capacitive Scanners

This scanner uses an array of tiny capacitor circuits to collect information about a fingerprint. A plate is connected to charge holding capacitors. When the finger's ridge is placed on the plate, the charge changes slightly while the air gap will leave the charge at the capacitor relatively unchanged. An operational amplifier is incorporated to the circuit to detect these changes and recorded by an analogue-to-digital converter. The information is then stored and distinctive patterns analysed. This method is very secure since it cannot be fooled by an

image. The only loophole is software or hardware hacking. An increase in capacitor components increases the resolution.

$$Capacitance_{Sensor} = Capacitance_{air} + Capacitance_{Oxide}$$

where; $C_x = \frac{\varepsilon_{oA}}{d}$ and $C = \frac{Q}{V}$

$$Q - charge, C - Capacitance, V - Voltage,$$

$$\varepsilon - Permitivity$$

With varying capacitance, the voltage varies and is fed to inverting amplifier.

$$V_{output} = \frac{R_{feedback}}{R_{output}} V_{input}$$

where R – Resistance and V – Voltage.

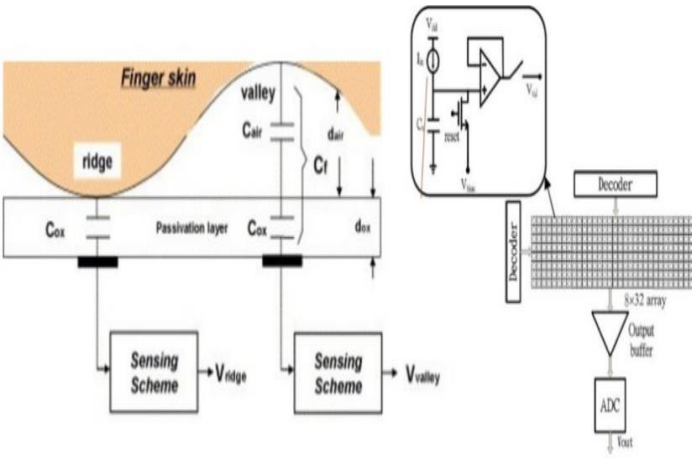


Fig. 7 Capacitive Finger scanner

iii. Ultrasonic Scanners

This is the latest scanning technology. An ultrasonic transmitter and receiver are used. During the recognition process, an ultrasonic pulse is transmitted against the finger. Some of the pulse is absorbed while others bounce back to the sensor which relies on the pattern of the finger ridge. A sensor is used to detect mechanical stress and calculates the intensity of the returning ultrasonic pulse at different points of the scanner. The longer the scanning the higher the accuracy of the information obtained. This enables the creation of a 3D reproduction making a more secure alternative to the capacitive scanners.

V. Global System for Mobile Communication (GSM)

This is a cellular technology used for transmitting mobile voice and data services. Initially known as Groupe Spėcial Mobile, it was later renamed to Global System for Mobile Communication to accommodate worldwide usage. This standard was created around 2G networks. It was first deployed in Finland in 1991. It had the following features:

- ✓ Digital, circuit-switched network optimized for full duplex voice telephony.
- ✓ Data communication first by circuit switched transport then by packet data transport through GPRS (General Packet Radio Services) and EDGE (Enhanced Data rates for GSM Evolution)

The system utilizes Time-Division Multiple Access (TDMA) to enable greater capacity. It is the most widespread method of communication in the cell technologies in use in the industry. Through the development of GPS, Short Messaging Service (SMS)was created. The radio spectrum can be shared by various users accessing the same frequency band without obstruction. GSM uses 200kHz radio frequency channels which are time-division multiplexed. Eight concurrent calls on same radio frequency are possible. Multiplexing divides the accessible bandwidth between different channels.

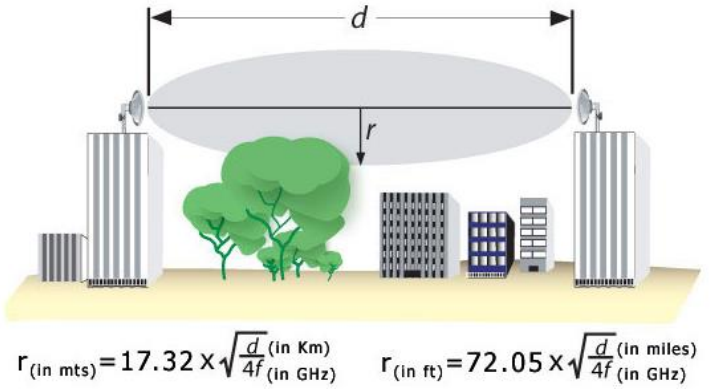


Fig. 8 GSM Coverage

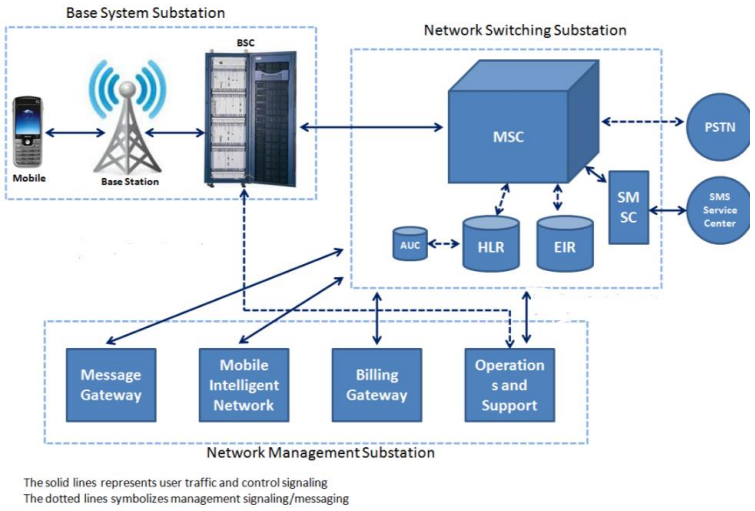


Fig. 9 Network Management

BSC: Base Station Controller

MSC: Mobile Station Controller

SMSC: Short message Service Centre

EIR: Equipment Identity Register

HLR: Home Location Register

AUC: Authentication Centre

PSTN: Public Switched Telephone Network

Network Structure

The basic GSM network is divided into:

a. Base Station Subsystem

b. Network and Switching Subsystem

c. GPRS Core Network

d. Operation Support System

GSM system is a cellular network which cell phones connect to the network by searching for cells in the immediate vicinity. The different classes of sizes are:

i. Macro – Base Station Antenna is on a mast or a building above average rooftop.

ii. Micro – Antenna height is under average rooftop and mostly used in urban centers.

iii. Pico – Has a coverage diameter of a few meters and mostly used indoors.

iv. Femto – Used in residential setups or small business to connect to service providers through broadband internet.

v. Umbrella Cells – Cover shadowed regions of smaller cells.

The cell horizontal radius depends on:

a. Antenna height

b. Antenna gain

c. Propagation Conditions (GSM = 35km)

Advantages

i. GSM technology has an extensive coverage and contains a harmonized spectrum such that even though countries operate in different frequency bands, users can transfer seamlessly between networks and keep the same number.

ii. GSM technology is supported by many devices

Disadvantages

i. When the bandwidth has enough users, the transmission encounters interference.

ii. GSM interferes with other electronic devices such as pace-makers.

VI. Comparison

TABLE I

CURRENT SYSTEM	PROPOSED SYSTEM
• Vulnerable to human intrusion	• Secure to human intrusion
• Time consuming	• Time efficient
• Many loopholes to facilitate corruption.	• Does not require human contact
• Insufficient accountability and record-keeping.	• Effective automated storage and sorting system.

VII. Conclusion

Examination cheating in Kenya has bedeviled the education system. The effects in the society are plain and a solution has to be found immediately. It has been realized that most of the theft occurs at storage points [5] [6]. From my research, it was also noted that both the examination papers and marking schemes were stolen [7] [8].The proposed system addresses this problem by monitoring and controlling access to the examination materials in real time using a computer system. This will enable fair measure of student's performance nationally without compromising on financial constraints of the economy since the components are readily available. The proposed system will also provide a foundation of digital literacy improvement program of the country as per Kenya Vision 2030. Upon full implementation of the proposed system, real-time online examinations would be a reality across the country. More research is to be done concerning examination malpractices to provide better systems.

VIII. Acknowledgement

Kelvin Mong'are would like to thank God for the strength provided to perform this work.

REFERENCES

[1] G. B. Nyamoita and K. Otieno, "Effectiveness of Kenya National Examinations Council Measure in Curbing National Examination Malpractices in Public Secondary Schools in Kisii County," *International Journal of scientific research and management (IJSRM),* vol. 4, no. 02, pp. 3882-3907, 2016.

[2] K. Odit, "Record Number of Candidates Sit the 2016 Form Four Exams," 07 November 2016. [Online]. Available: http://allafrica.com/stories/201611070093.html. [Accessed 08 November 2016].

[3] A. Oduor, "New details of how KCSE, KCPE will be conducted," 13 October 2016. [Online]. Available: http://www.standardmedia.co.ke/mobile/article/2000219525/new-details-of-how-kcse-kcpe-will-be-conducted?pageNo=2. [Accessed 28 October 2016].

[4] R. Niranjan, S. Thangapandi, M. Gladwin and G. Thadeus , "A New Approach of RFID and GSM Assisted," *International Journal of Emerging Technology in Computer Science & Electronics (IJETCSE),* vol. 8, no. 1, pp. 0976-1353, 2014.

[5] C. Nyamwange, P. Ondima and P. Onderi, "Factors Influencing Examination Cheating Among Secondary School Students: A Case of Masaba South District of Kisii County, Kenya," *Elixir International Journal,* vol. 56, no. 1, pp. 13519-13524, 2013.

[6] E. K. Njue, G. M. Muthaa and P. K. Muriungi, "Effectiveness of Examination Handling and DIstribution Procedures in Curbing Malpractices in Secondary Schools in Eastern Province, Kenya," *Creative Education,* vol. 5, no. 10, pp. 573-579, 2014.

[7] J. Angote, "A Mandera teacher made Sh1.5 million from selling leaked exam," 29 March 2016. [Online]. Available: http://www.nation.co.ke/news/Revealed-How-police-and-teachers-steal-KCSE-exams/1056-3137164-12f7qm7z/index.html. [Accessed 26 October 2016].

[8] "How KCSE exams are stolen," 14 February 2009. [Online]. Available: http://www.nation.co.ke/news/1056-530526-k7bmstz/index.html. [Accessed 26 Ocotber 2016].