



UNIVERSITY OF NAIROBI
SCHOOL OF COMPUTING AND INFORMATICS

**Integrating Item Response Theory of testing for Quality Tests by
Implementing an Online Item Development and Banking System for the
Kenya National Examinations Council**

By

CATHERINE K. MASILA

Registration No: P58/63383/2011

Supervisor

Prof. ELIJAH OMWENGA

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**A research submitted to the school of computing and informatics in the partial fulfillment of the
requirement for the award of Master of Science in Computer science of the University of Nairobi**

Declaration

This project as presented in this report is my original work and has not been presented for any other University Award.

Signed:

Date:

Masila, Catherine Koki

This report has been submitted as partial fulfillment of the requirements for the Master of Science in Computer Science of the University of Nairobi with my approval as the University supervisor.

Signed:

Date:

Prof. Elijah Omwenga

School of Computing and Informatics

University of Nairobi

Dedication

I dedicate this research work to the *Almighty God* for the gift of life and wisdom. To my beloved daughter and son, *Titian Jepchumba* and *Leo Koech Rono* 's respectively, thank you for your love, patience, encouragement and laughter that has kept me strong and focused.

To my classmates and colleagues at work whom I consulted on many occasions in relation to this project, I could not have managed without their input and understanding as this work at times called for their attention and sacrifice.

To my supervisor, *Prof. Elijah Omwenga*, I could not have made it this far without your support, am glad. To all individuals, institutions and experts in the field of testing who participated in one way or another to make this research project a success, I cannot thank you enough, God bless!

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Thank you & God Bless You All!

Abstract

The evolution of testing has gone a long way from traditional testing methods to highly computerized and professional designs using item banks. Previous work show that most of the examination bodies in Africa still use traditional item banking methods that are manual, tedious, test centered and therefore prone to errors. The process involves only a few test item writers who not only compose test items manually but also are tasked with determining each item's characteristics to ensure quality test items are generated resulting to a few items. The need to revise or create new test items with some frequency to avoid administering the same test year after year can be a very time consuming.

This research project examines the current item development and banking processes in the Kenya National Examinations Council (KNEC), establishes the gaps, defines and compares the two commonly used theories of testing. Using the research findings, an online item development and banking system integrated with Item Response Theory (IRT) of testing by implementing each subject's table of specification, content area, instructional objective measured and the skill was developed to overcome the current manual system challenges. According to available literature review, IRT subjects each developed item to rigorous process of validation and psychometric analysis unlike the currently applied Classical Test Theory (CTT) which is test centered and believed to be biased.

Structured Systems Analysis and Development Method (SSADM) methodology used was the most preferred due to its modular based approach. The research design for this study involved face to face interviews and administering structured questionnaires to individuals to collect factual information from the respondents. Results were analyzed, graphically represented and interpreted. It is suggested that the online system is sufficiently robust for it to be of value to all potential item bank users. Good quality test items which are the building blocks of examinations. To develop examination items that meet the deemed standards of validity, discrimination, fairness and integrity, there is need emphasize on modern item banking practices and therefore, the implementation of the online system by KNEC.

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Definition of terms

1. **Assessment item:** An assessment item is a complex object, consisting of a question together with its associated data such as score, feedback and either any media files required or links to those files. Items are aggregated into assessments, either in advance of the assessment or during the assessment process itself manually, automatically, or by a combination of the two.
2. **CTT:** Classical Test Theory.
3. **ICT:** Information and Communication Technology.
4. **IRT:** Item Response Theory.
5. **Item:** The terms ‘item’ and ‘question’ are often used interchangeably Individual items have limited value; normally they are delivered with other items as assessments.
6. **Item Bank:** Burghof (2001) defines an item bank as *a relatively large collection of easily accessible items stored in a database, categorized and coded by topic, year, level, item type, graphic file source, thinking skills and processes from Blooms Taxonomy and item difficulty. It summarizes the procedures used in planning, assembling, calibrating and entering items into a database that will house the items.*
7. **Item Pool:** An item pool is a collection of related items from which a subset can be drawn to create a test.
8. **KEY:** Answer also termed as Options.
9. **KNEC:** Kenya National Examination Council
10. **KCPE:** Kenya Certificate of Primary education.
11. **MCQ’s:** Multiple Choice Questions
12. **QA:** Quality Assurance
13. **Test theory:** Theory of Psychological Tests and Measurements. It provides a general collection of techniques for evaluating the development and use, in assessment, of specific psychological tests.

1. CHAPTER 1:

1.1. Introduction

Management of national examinations is a great task that calls for integrity, validity, fairness and credibility of examinations. Assessment in education is crucial in gauging the functioning of education systems, to be able to determine whether the content and objectives of education have been mastered by administering quality tests. Test items are the building blocks of all exams. They comprise more than just a question but also, instructions on presentation, response processing and feedback to the test taker.

The aim of this chapter is to provide an overview of the fundamental principles of item banking. Item banking is a means to producing better questions (or items) and question papers (or tests) through the use of up to date statistical information about how tests and items perform when sat by candidates. The use of this alternative to the conventional process of question paper item development commonly referred to hand written can also improve the efficiency of the production of examination materials; provide for the controlled re-use of questions (or items); and, lead to a reduction in the time between item development, item moderation, pre- testing, banking of quality items and finally test selection.

Item banking is used to support new models of assessment that begin to move away from offering one or two examinations per year on fixed dates. The destination of such a journey is online item development and banking which offers the ultimate in flexibility and speed. This chapter gives an overview of the background of the problem, the problem statement and the purpose of the project outlining the research outcomes and their key significance to the target audiences.

The chapter defines the research objectives, the scope, assumptions and limitations of the research. Generally, it is observed that examination bodies need to develop new and quality tests with some frequency to avoid administering the same test year after year.

1.2. The Background

Quality of education is seen as the extent to which Assessment of learning provides several means of generating and recording indications of performance and attributes in a variety of ways for various forms of evaluation; monitoring progress, diagnosing learning difficulties and for ascertaining the quality of education. It is greatly determined by effective educational policy and therefore, policy dialogue must arrive at a relevant balanced set of aims describing what learners should learn and why in reference to quality assessment and testing.

The number of test items must be adequate to cover the subject matter as outlined by the curriculum. If items are classified into subject matter categories, each category must contain a sufficient number of quality items to assess the corresponding educational objectives. Items to be included in an item bank must be obtained from a source that has been identified by the teachers, subject experts and assessment specialists as one that will create items that match the curriculum to which the item bank will be referenced. Item development and banking in high stakes examinations should therefore be streamlined to ensure an efficient, quality, reliable, secure, consistent and accurate banking process.

The Kenya National Examinations Council (KNEC), a Government agency under the ministry of education Kenya is charged with the sole responsibility of managing National and Tertiary Examinations except university examinations. KNEC has been on the frontline to quality assessment in education with the vision, *“to be a world class organization in assessment for quality education”*. The use of information and communication technologies has improved the efficiency and flexibility in various sectors of the economy. While appreciating the dynamic technological innovations, KNEC has been on the frontline in embracing technology from e- registration, E-marks capture, e- payments to contracted professionals among other online services. However, Item development and banking which is a core process in test development, banking and administration of test items as examinations is still manual.

Currently, due to the cost and challenges of managing the manual process, only a few item writers are recruited and trained during a workshop to develop test items manually (hand written). Selection of good items that meet the deemed statistical values or psychometric characteristics such as item difficulty and discrimination index is also done manually from the few developed items after they are moderated and pre- tested. With the need to develop many new tests with some frequency to

avoid administering the same items year after year, this process is therefore tedious, time consuming and prone to errors. Test development currently focuses on the students' general performance for the whole test rather than on the behavior and response to each question. Classical Test Theory (CTT) is test centered and therefore, commonly used for item analysis.

During the monitoring of examinations in various parts of the country, many teachers have been requested to be part of the item development process that will go along with training to upgrade their assessment skills too even in classroom. Available literature review has shown that CTT focus on the test hardly distinguishes item bias from true difference on trait level. However, in order to develop examination items that meet the deemed standards of validity, discrimination, fairness and integrity, Item Response Theory (IRT) of testing is said to be superior to CTT and that unlike the CTT, ensures items are subjected to rigorous process of validation through pretesting and psychometric analysis.

This research project established several challenges with the current item banking process in KNEC related to the manual processes and the mode of testing. Generally, available automated item banks operated using specially designed computer software that are made to suit the purpose for which the tests items are deposited, discovered, retrieved and compiled from the bank are common in the modern item development and banking. However, it was evident that several item banking softwares available were not only very costly and incompatible with the current automated and in house developed systems but also, not tailor made to the KNEC examination needs.

Available literature review, feasibility study, requirement analysis and recommendations formed the background idea of integrating Item response theory of testing for quality tests by implementing an online item development and banking system the Kenya National Examinations Council was born. The online system allows all potential teachers to participate in the item development process by registering to access training materials online and begin writing test items. The integration of IRT was achieved by implementing each subject's table of specification, content area, objective and the skill to be tested in the system.

1.3. Problem Statement

“Challenges facing the Kenya National Examination Council’s current manual item banking practices in the sustenance of the process of test development and banking for quality testing in high stakes examinations”

Item banking: what is it good for?

A study on the current item banking practices in the Kenya National Examinations Council is evident that the process also referred to as paper pool is very manual, time consuming and a tedious process fraught with numerous opportunities for error. The study further reveals that although many teachers (item writers) would be willing to participate in the this process, only a few item writers are recruited and trained for writing test questions (items) on paper by hand therefore generating a few items. There were obviously many opportunities for item cards or foolscaps to get lost, misplaced, or misfiled. Subject officers collect the generated test items and after scrutinizing and moderating, the manuscript secretaries type and transfer the same in soft copy. Test items are the foundation of every exam. Creating new tests manually can be very time consuming.

Item banking, a core process in assessment and administration of high stake examinations is a significant stage that involves; *item writing* also referred to as item development, *item moderation*, pretesting, analysis and banking of good items from which a test is selected. Item banking offers solutions to some of the challenges presented when providing high stakes assessments in testing candidates. When those items are well-crafted, they allow one to accurately assess the skills and knowledge that are central to their testing/assessment goals.

The use information technology to meet the regulators’ drive for efficiency and flexibility in assessment enables online training and generation of more test items by all potential item writers. The quality of submitted items is established after moderation and is also depended on the applied theory of testing. To develop new and quality tests with some frequency to avoid administering the same test year after year, computer-based testing will be no doubt proved to be a positive development in this assessment practice.

The study entailed development and implementation of an online item development and banking system using the Item Response Theory approach that has been shown to provide for specific objectivity in psychological measurement and subjects each item to rigorous process of validation and psychometric analysis. The online system was found to be very effective from the research findings represented at the end of this research in providing suitable solutions to the current manual item banking challenges.

1.4. Purpose of the project

The purpose of this project was to study and understand the current item banking system process in KNEC, establish the gaps and therefore formulate a framework for possible solutions in the management of examinations. It was also seeking to establish the level of awareness and application of the item Response Theory and the Classical Test Theory.

Finally, the study aimed at establishing the ICT literacy level for the target users of the system, security available and infrastructure in readiness to implement the online item development and banking system. With the online system, all registered teachers would therefore participate in item writing after an online induction to generate more or sufficient quality items.

1.5. Objectives

The general objective of the study was to establish the best practices in item development and banking process from available literature review in managing high stakes examinations. The study focused on the current item banking challenges in the Kenya National Examinations Council in order to come up with a proper framework for the improvement of the process based on the best item banking practices commonly referred to as modern item banking.

The main aim was to facilitate the development of many quality items for quality assessment and testing. In order to achieve the main objective, the specific objectives were as follows;

- 1) To examine the current item banking process in KNEC, challenges and establish possible solutions for implementation.
- 2) To design and develop an online item development and banking system accessible to all registered teachers for more items development anywhere, any time.

- 3) To upload item writing induction materials accessible to registered teachers for online training on how to develop quality items for the Kenya National Examinations Council.
- 4) To integrate Item response theory mode of testing in the online system by implementing each subject's table of specification, item content area, objective and the skill to be tested that MUST be followed to emphasize on quality items.

1.6. The Significance of the Research

Millman and Arter (1984) stated that an outspoken critic of educational testing, Jerold Zacharias, was once quoted by (Kohn, 1975) as saying: *"I feel emotionally towards the testing industry as I would towards any other merchant of death. I feel that way because of what they do to the kids. I am not saying they murder every child – only 20 percent of them. Testing has distorted their ambitions, distorted their careers"*. The same critic now supports testing children with questions selected from carefully developed item banks – even those created by commercial publishers (Davis & Zacharias, 1982; Zacharias, 1979).

This research project was very significant in the following areas;

1. It provided online training materials to all registered teachers and enhancing their capacity of as item writers in generating quality items for quality testing and routine assessment.
2. The study was found to be useful in the implementation and management of item banks for quality testing learning from the current item banking challenges in KNEC and recommended solutions.
3. The developed system created new areas of research in relation to the item banking for high takes examinations with the need to integrate ICT in all examination processes.

1.7. The Scope and limitations of the proposed project

The study covered only sampled teachers (item setters) and moderators' as well as the KNEC Test development, ICT, Manuscript and reprographics, Exam Research & Quality assurance departments. Officers from these departments play key roles in item development, banking, administration and analysis and shall be randomly selected.

1. **The limitation** of the study was mainly the Time constraints to collect user requirements exhaustively, design, develop and test the system since full access to the item banking data was very confidential. However, available sample data was used especially for teachers.
2. **Another limitation** of the study is that only multiple choice questions (MCQ's) were to be developed and posted online. Although assessment of essay questions is equally important, suggested implementation for this type of questions would be good for future research.
3. **Delimitation:** Choosing not to observe multiple teams of test developers, even though such comparisons might be valuable, in order to allow more depth of understanding regarding the focus group.

1.8. Assumption

The proposed study assumed that the sample selected for data collection was sufficient to represent the various categories and content of subject areas for only multiple choice Subjects (KCPE examination) in Kenya and the questionnaires to be used were valid enough to measure all that this research desires.

From various benchmarking reports, the study assumed that the current item banking process in KNEC was similar to several other national examination bodies and therefore, it would be a great innovation useful by the similar examination bodies across the region.

1.9. Project Deliverables

1. An online item development and banking system based on the Item Response Theory of testing for the Kenya National Examinations Council.
2. Online induction or training materials on quality item writing accessible to all registered teachers to guide the in developing quality test items.
3. System documentation and a user manual for the system users.

1.10. CONCEPTUAL MODEL

The conceptual framework is presented in a schematic interpretation as shown in figure 1 below. It identifies the variables that when put together explain the problem statement giving a set of broad ideas used to explain the relationship between the independent variables (factors) and the dependent variables (outcomes) as illustrated below.

Conceptual model of online item development and banking system

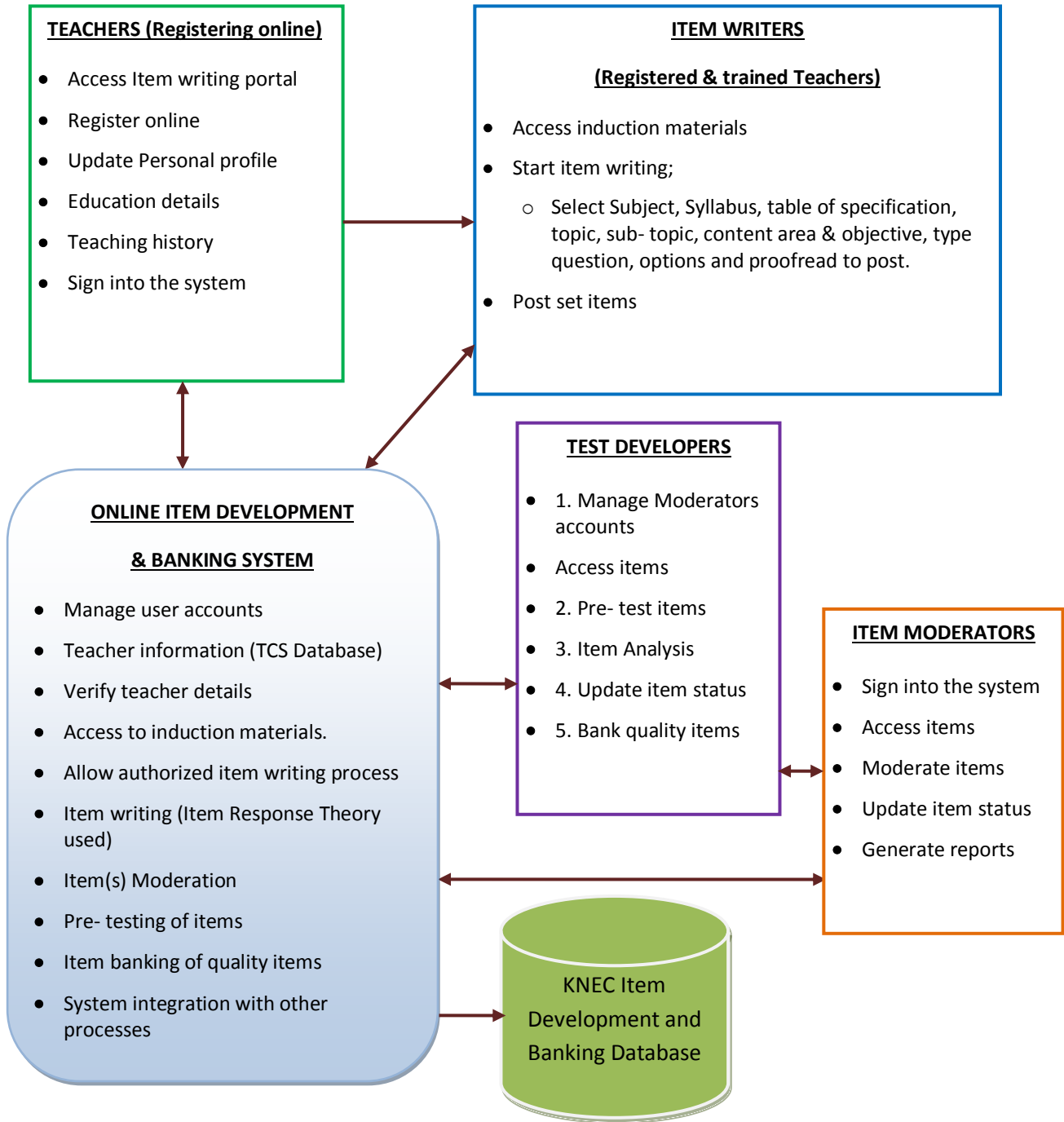


Figure 1: Item development and banking Conceptual model

In the Conceptual Model above, the following processes take place based on the actor(s)

- 1. Teachers:** - These are registered teachers by the Teachers Service Commission (TSC). By accessing the Unified Resource Allocator (URL), teachers register online for system verification and updating of the following details; Personal profile, Education and Teaching History.
- 2. Item Writers:** - These are online registered teachers within the item development and banking system. Item writers accessing the item writing portal from their comfort are able to read online or download training or induction materials, train online and therefore start generating or developing and posting quality items securely online.
- 3. Item Moderators:** - Moderators are experts and teachers selected by the specific subject officers to scrutinize and revise items developed by item writers. Using the KNEC guidelines and regulations on item development in reference to the syllabuses from Kenya Institute of Curriculum Development (KICD), moderators ensure that test items meet the desired specifications.
- 4. Test Developers:-**These are KNEC subject officers in charge of the processes of item development and test or Full paper generation. They work hand in hand with the item Moderators. Some of the activities include item pre- testing, scoring, item analysis and if need be, post moderation. The process subjects items to a rigorous validation to ensure the banking of only quality items for test selection and administration.
- 5. Theory of testing:** - Item Response Theory (IRT) of testing has been used in the online item development and banking system. This is because of it rigorous validation and focus on the qualities of a single item (Question) to ensure credibility and validity in testing unlike the Classical Test Theory (CTT) which focuses on the whole test (all questions performance).
- 6. Online Item Development & Banking System:** - This is the desired system that is used by the stakeholders to facilitate the item development process. The system is tailor made for KNEC based on the current manual item development and banking process. The system allows access all authorized stakeholders to perform authorized user roles based on user privileges.

Relationship between the syllabus, instruction and external assessment

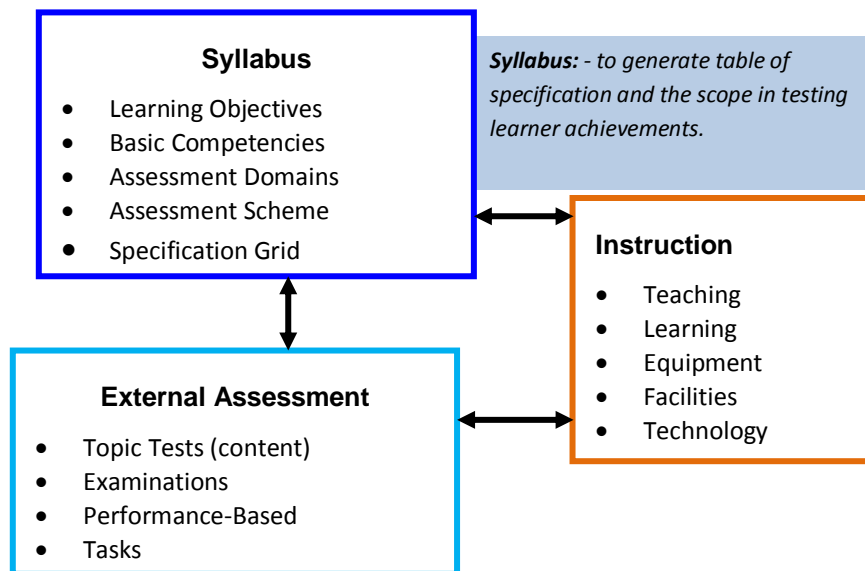


Figure 2: Syllabus, Instruction & Assessment relationship

Chapter Summary: This chapter introduces the current manual item banking process and the challenges experienced at the Kenya National Examinations Council (KNEC). To establish possible solutions to the current challenges, an online item development and banking system was developed that integrates Item Response Theory of testing (IRT) that according to available literature review most preferred to the currently used Classical Test Theory of testing (CTT).

The chapter gives the background, statement of the problem, purpose of the study and objectives. Finally, research questions, significance of the study, limitations and assumption as well as the deliverable(s) in this study are clearly outlined.

2. CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

This chapter discusses the need for measurement theory, the concepts of Classical Test Theory (CTT) and the Item Response Theory (IRT) test theories giving a brief overview of each, a comparison, limitations and therefore, the most preferred mode of testing. The chapter also introduces item banking overview, its advantages and the process involve from; item development, pretesting, banking and selection to generate a test in high-stakes examinations. It also involves the review of related literature on test theories, item development and banking through case studies; examination of relevant documents such journals, conference papers, benchmarking reports, conference training reports and books that have a bearing on this study.

Secondary data from KNEC and policy documents on item banking shall also be reviewed. The review provides the researcher with insight into what has already been done pinpointing its strength and weaknesses and proposed solutions. It is from the literature review that designing, development; testing and implementation of the proposed Item Response Theory (IRT) Management System for Item Banking in High Stake Examinations shall be based upon.

2.2. The Need for Measurement Theory

According to Lord and Novick (1968), the reasons we need theory of psychological measurement is that performance scores contain sizable errors of measurement, because the traits that we wish to study, which these scores represent, are usually not directly observable; rather they must be studied indirectly through the measurement of related quantities. We need to be able to describe the items by item parameters and the examinees by person parameter in such a way that we can predict probabilistically the response of any examinee to any item, even if similar examinee have never taken similar items before.

According to Lord (1980), this involves making predictions about things beyond the control of the psychometrician, and to be able to do this we need the guidance of a theory. The traits we wish to study are latent, so cannot be measured directly, they are hypothetical (exist in our minds and not amenable to any form of physical contact), hence we need some bases from which we can speculate or hypothesize to operationalise them in the attempt to bring them from the abstract world to the real world.

For Hambleton and Jones (1993), test theory provide a general framework linking observable variables, such as test and item score to unobservable variables, such as true score and ability scores. Furthermore, to them, test theory provide a framework for considering vexing issues and addressing technical problems in educational measurement, as well as providing a frame of reference for test design and solving other practical test problems.

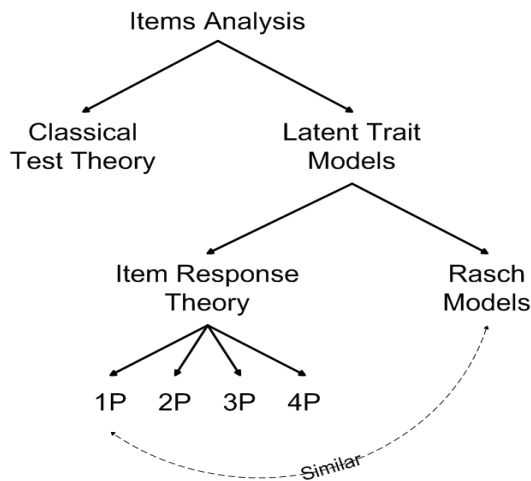


Figure 3: Theory of testing; CTT & IRT

Item Analysis: Item analysis provides a way of measuring the quality of questions - seeing how appropriate they were for the respondents and how well they measured their ability/trait.

It also provides a way of re-using items over and over again in different tests with prior knowledge of how they are going to perform; creating a population of questions with known properties

2.3. The Concept of CTT

Classical Test Theory (CTT) - analyses are the easiest and most widely used form of analyses. The statistics can be computed by readily available statistical packages (or even by hand)

2.3.1. Classical Test Theory Overview

Classical test theory or "true score" theory, as oftentimes called, holds that a score observed on a test consists of two parts. The first part is the "true" amount of whatever is being measured, e.g., mathematics ability, while the second part consists of random error of measurement. The true score is that which an examinee would make if there were no error in measurement.

The observed score is the examinee's performance on the test, and this is used as an estimate of the "true score." In Classical test theory, we assume that the error is *normally distributed, uncorrelated with true score* & has a mean of Zero. **Classical theory statistics** include the following; Difficulty (*item level statistic*), Discrimination (*item level statistic*) & Reliability (*test level statistic*)

2.3.2. Problems with CTT-based Measurement

Classical Test Theory (CTT) - analyses are the easiest and most widely used form of analyses. The statistics can be computed by readily available statistical packages (or even by hand). In Africa, it is this theory that underlies all our educational measurement efforts. According to Nenty (2004), Measurement based on CTT is infected with several serious problems that call to serious doubt the suitability of scores derived from it as that based on which quality of education could be determined. A majority of individuals involved in constructing and using tests for educational purposes are not aware of the fundamental problems inherent in measuring human behaviour and especially in using CTT-based tests to measure the extent to which learning takes place. Some of the disadvantages of CTT are highlighted as follows;

1. At the item level, the CTT model is relatively simple; CTT does not invoke a complex theoretical model to relate an examinee's ability to success on a particular item. Instead, CTT collectively considers a pool of examinees on an item. In this case, test scores are derived by adding up the number of items scored right without taking into consideration the different cognitive resistance or the difficulty of the items. A testee who answered only the five most difficult items has the same score of five as the one that answered only the five easiest items. This is commonly is referred to as item bias.
2. Secondly, any score made by a testee is dependent on the test designed to measure the same ability that he/she took. A score of 10 on one of such tests does not represent the same ability as the same score of 10 made on another of the same tests designed to measure the same ability. A score takes a meaning relative to the test he/she took, though all the tests are designed to measure the same ability. It is just like designing some metre rules to measure height, and each of them gives significantly different reading of the same height. Hence the value of the height depends on the particular ruler used in the measurement. That is, if the same individual takes more than one test designed to measure the same ability, significantly different amount of the same ability may be estimated for him/her. Hence CTT-based estimate of a testee's ability is not invariant across tests designed to measure such ability.
3. Another important handicap of CTT-based measurement is the lack of invariance in its estimate of the trait level of the item. The estimate of the difficulty or parameter of the same

item differs significantly across group of test takers. For example, the heaviness of a piece of metal is an inherent and constant property of the piece, but if the estimate of this property differs significantly when lifted by people of different weight-lifting ability, then such measurement is faulty. The piece may appear lighter to a person with high weight-lifting ability but that should not change the inherent weight of the piece. Hence the amount of trait an item needs before it could be overcome should not depend on who is taking on the item.

4. Our decision as to the quality of our education should not have relative meaning, but with CTT-based measurement, a score has relative meaning. For a given ability, the score one makes depend on the test he/she takes, and the meaning of such score depends on the group along with which one was measured. A testee's score, compared to a less able group indicates a high quality performance, whereas the same testee compared to a more able group portrays a low quality performance. According to Ross (2005) decisions based on test scores that have relative meaning are often very likely to be wrong.
5. According to Nenty (2004c) the ability of the testing process to give us valid or true information reduces the level of our error in educational decision-making. CTT-based testing has been found to be very weak at providing valid information on the ability underlying learners' performance to the different arena of decision-making. The level of confidence with which scores from test items could be used to infer the ability under measurement depends on both (i) how well the test items represent the totality of the ability and only the ability under measurement, and (ii) the extent to which it is only this ability that sustains responses to these items. "Highly representative items with good characteristics cannot give valid results if responses to them are not sustained by the ability to which inference is intended, neither could responses sustained by the desired ability but on unrepresentative items with poor measurement qualities" (Nenty, 1996, p. 66). CTT has no provisions to ensure and check any of these two conditions; hence it is difficult to secure valid scores from CTT-based test (Nenty, 2004c)

Conclusion: With these limitations, it is obvious that classical test theory deals with the individual's total score, and not their ability at the individual item level (Hambleton et al. 1991). An alternative to CTT is the Item Response Theory of testing.

2.4. Concept of Item Response Theory (IRT)

Item Response Theory models conceptualize that the probability of an examinee correctly responding to any particular test item is dependent on his/her ability. The Rasch model, which is also known as the “one-parameter logistic” (1PL) model holds that the probability of an examinee correctly responding to an item depends on the ability of the examinee and the item difficulty. The “two-parameter logistic” (2PL) model, however, assumes that the probability of an examinee answering an item correctly depends on his ability, the difficulty and the discrimination index of the item. In the same way, the “three-parameter logistic” (3PL) model assumes that an examinee’s performance is a product of his ability, difficulty of item, discrimination index and the guessing parameter or pseudo-chance value of the item.

Researchers are still on the trend to identify more parameters in a bid to clearly come out with the probability of an examinee getting a test item correctly. The concept of IRT, item calibration, estimation of ability and item parameter and item characteristic curve are discussed below.

2.4.1. Item Calibration

Essentially, item calibration involves determining item parameters for the item and ability estimates for the subjects. In calibrating the item, the IRT model to be used must be decided. That is, is it the 1PL model by Rasch, the 2PL model by Birnbaum or the 3PL model by Lord? Rasch model is viewed as most appealing of all because of its simplicity, few mathematical calculations and the fact that the performance of an individual is assumed to reflect the difficulty of the item.

2.4.2. Estimation of Ability and Item Parameter

The procedure used in estimating abilities and item parameters is iterative, repeated several times before the final estimates are determined. This procedure usually starts with some starting estimates for ability, normally derived from the number of correct scores of the individual or responses to the test item, holding these values as fixed. Treating the item parameters as known, the abilities are re-estimated. This process continues until satisfactory convergence in the estimate is obtained. Computer programs are often used in this estimation because of the complexity of the estimation process (Yen, 1986).

2.4.3. Item Characteristic Curve

IRT assumes that there is a correlation between the score gained by a candidate for an item and his/her overall ability or the latent trait which underlies test performance. The characteristics of an item are said to be independent of the abilities of the candidates who were sampled. In most educational and psychological measurement situations, there is a fundamental variable of concern. This variable is often exhibited by an individual as intelligence. It is a construct and cannot be seen physically and psychometricians often refer to it as a hidden and unobservable latent trait. It therefore cannot be measured by any known scale. The most important objective according to measurement experts in test measurement and evaluation is how to determine how much of such latent trait (ability) a person possesses.

2.4.4. Advantages of IRT over CTT

IRT provides an alternative to classical test theory as a basis for examining the relationship between item responses and the ability of the examinee being measured by the test or scale (Hambleton and Swaminathan 1985) That is, the essence of IRT is that the probability of answering an item correctly or of attaining a particular response level is modeled as a function of an individual's ability and the characteristics of the item. And a paramount goal of IRT is predicting the probability of an examinee of a given ability level responding correctly to an item of a particular difficulty. The several advantages of Item Response Theory over the commonly used Classical Test Theory are summarized as follows;

1. Sample-free item calibration
2. Test-free person measurement
3. Item banking facility
4. Computer delivery of tests
5. Test tailoring facility
6. Score reporting facility
7. Item bias detection.

2.5. Major components of item development life cycle

The years since 1985 have seen computers automate the processes of item banking, test assembly, test analysis, and test delivery. The personal computer allowed the development of new modes of test delivery – random, sequential, and adaptive – and new kinds of test items, the advent of the Internet extended test delivery to any computer that could connect to it, albeit not without some problems.

The result of this evolution of testing is a set of processes that are considerably less labor intensive, more accurate, and more efficient. The main components of the item development life cycle are as shown and described in the figure below;

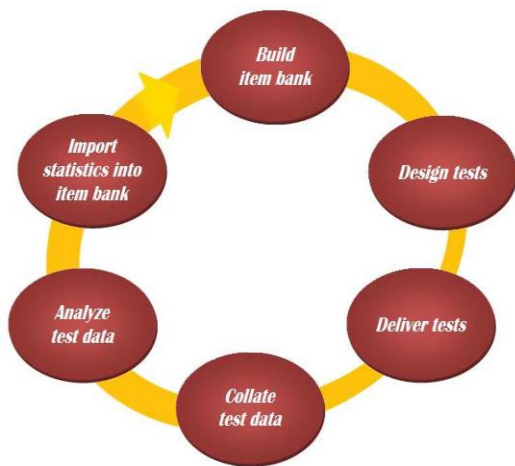


Figure 4: Major components of the item development life cycle

ITEM DEVELOPMENT COMPONENT	DESCRIPTION OF THE PROCESSES
1. Build Item Bank	Creating item banks for item storage and retrieval during test construction. Automated item banks are more preferred to manual or paper pools.
2. Design tests	Test designing involves writing quality tests better in that they more closely assess instructional objectives and assess them more accurately. Tests must be reliable, valid to ensure credibility of examinations.
3. Deliver Tests	Administering test to students.
4. Collate test data	Collecting and combining test data to organize it in a preferred order.
5. Analyze test data	Involves taking two or more sets of test scores on the same test and comparing the means of pre and post data. Used for decision making.
6. Import statistics into item bank	The process involves transferring analyzed data into the item bank. This data can be used for reporting and future analysis as well as for research purposes.

2.5.1. Item Development Process

This process is also referred to as the **Item writing process**. It is the process of generating test items according to the rules and guidelines of the item writing processes. Various processes and steps involved during test development especially for objective test items include;

2.5.1.1. Preparing Specifications

A specification determines the number of questions to be set to test each syllabus topic and each ability in any one paper. Each subject officer generates a table of specification for their specific subjects. The specification should be drafted well in advance of the first examination or pre-test' preferably when the syllabus itself is being drafted. The attempt to draft a specification may reveal unexpected deficiencies in the syllabus itself, such as undue emphasis on factual recall. Once prepared, the specification should, if possible, remain unchanged for a number of years, preferably for the life of the syllabus.

2.5.1.2. Training Question Writers and Editors:

1. Currently, the manual item writing process involves;

- (a) Inviting teachers or professionals of particular subjects to:
 - (i) *write tables of specification,*
 - (ii) *write questions,*
 - (iii) *administer the questions to candidates,*
- (b) Determining which of the teachers or professionals can write good questions and using them to come up with the bank. A paper bank in this case (test).

2. In the future (the new online system):

- (a) Using the online item development and banking system based on the concept of IRT, this activity involves all potential item writers (teachers) since they are able to access, register, train and begin developing test items online.
- (b) Induction materials are uploaded in the online system accessible to registered and verified teachers willing to set items and submit them online.
- (c) Security controls especially on authorized access, roles and user privileges are well implemented in the new system. *System users shall therefore proceed to set test items according to the system access and login requirements and the area of specialization (subject area)*

2.5.1.3. Allocating questions to writers

After the writers are selected and trained, they are invited to write as many questions as they can. Before embarking on the writing, the writers are provided with a composite blue print, which gives the behavioral objective (skills), and the content areas to be tested.

2.5.1.4. Writing of the questions:

The invited writers or examiners are given time to prepare the questions and submit them to the examining board or body.

2.5.1.5. Editing of the questions:

This is done by the panel of experts. The draft questions are edited to try and ensure their validity, the panel should check that the questions are all within the syllabus and specification are relevant and are of the right level of difficulty. This is necessary because writers may disagree on the interpretation of the syllabus.

2.5.2. Item Selection Process

Item selection is the process of deciding which actual items form a particular set of items as a test paper. It is done after trial-testing, analysis of the items and calibration. In most examination bodies in Africa, item selection process is carried out by the use of classical approach. Classical selection approach mostly involves manual operations and therefore may not be completely objective and scientific. It is either done by a single person who is seen as experienced and knowledgeable or by a group as a selection panel. Other scientific approaches that involve the use of computers include *item Sequential Selection & Successive Item Replacement Algorithm*

The following procedures must be followed in item selection despite the method that is applied;

- | | |
|---|--------------------------------|
| (i) <i>Determination of the purpose of the test</i> | (vi) <i>Trial-testing</i> |
| (ii) <i>Syllabus development</i> | (vii) <i>Item analysis</i> |
| (iii) <i>Test blueprint development</i> | (viii) <i>Item calibration</i> |
| (iv) <i>Items construction</i> | (ix) <i>Item banking</i> |
| (v) <i>Item validation</i> | (x) <i>Item selection.</i> |

2.6. Item Banking

There are several definitions on item bank. However, in this project, the following definition is used; Burghof (2001) defines an item bank as *a relatively large collection of easily accessible items stored in a database, categorized and coded by topic, year, level, item type, graphic file source, thinking skills and processes from Blooms Taxonomy and item difficulty. It summarizes the procedures used in planning, assembling, calibrating and entering items into a database that will house the items.*

Once the sources for obtaining the item bank have been identified and the formats defined, the items obtained need to be edited and revised. Whatever the sources of the items are, the revision process is an integral element in item banking. Items should be reviewed at many points during their development. In this section, the process of reviewing items until the best items are ready to be included in the bank is discussed. The items should be reviewed for satisfying item-writing rules, regency, relevance, accuracy, importance, item-objective and taxonomy congruence, bias, offensiveness, and stereotyping.

Finally the items be tried out and the responses from the try out analyzed for selection of the best statistically functioning items to be incorporated into the bank. Pretested items that meet these standards can then be securely saved or banked manually (paper pool) or electronically for use in assembling examination papers depending on the method adopted for banking.

The literature available on item banking (e.g. Brzezinski, 1984, Millman & Arter, 1984) cites several advantages of item banking in that;

- (a) it guarantees that poor items do not appear in the actual examination papers;*
- (b) Items from the bank can be recycled if they are collected from the candidates at the end of the examination. Recycling reduces the cost of setting new items every time a test has to be administered;*
- (c) Since the statistical properties of the items are known, it is possible to construct papers of comparable degree of difficulty from year to year. This increases the reliability of examinations;*
- (d) in case of need to construct a paper within a short time (e.g. due to leakage), readily available questions can be used;*
- (e) Since practicing teachers are used to write items, item-writing skills may contribute to improvement in pedagogy.*
- (f) It removes from test constructor the burden of constructing new items for each test.*
- (g) It upgrades the quality of testing the best items available to all users.*

Since test items are the center of discussion in item banking it crucial to explore the characteristics of items, which are needed for an item bank. Item banking emphasize on Care taken to see that all items are initially of high quality and when the items are easily retrievable

for editing *literature* (Annie W. Ward is President of The Techn'e Group, Inc 2800 North Atlantic Avenue, Suite 1408, Daytona Beach)

E-item banking allows searching, based on parameters, and tracking item characteristics over multiple administrations. Item banks may have one or both test theories that include Classical Test Theory or Item Response Theory.

2.6.1. Item banking some of the existing item banking software includes.

- *FastTEST*,
- *C-Quest*,
- *Bilog*,
- *Multilog*,
- *X-Caliber 4*,
- *Faim Software*
- *PARAM-3PL- LOGIS Etc.*

2.6.1.1. FastTEST

FastTEST 2 is a 32-bit Windows item banker and test assembly system for creating and managing tests, surveys, and questionnaires to be delivered by paper-and-pencil or by third-party testing centers. Designed with user-friendliness in mind, FastTEST 2 is nevertheless the world's most advanced item banking and test development system. It also serves as the item banker and test development system for the FastTEST Professional Testing System, which delivers electronic tests, surveys, and questionnaires including computerized adaptive tests (CATs) using items response theory (IRT).

2.6.1.2. BILOG-MG

This is a software program for IRT analysis of dichotomous (correct/incorrect) data, including fit and differential item functioning. BILOG – MG is capable of large scale production analysis, and handling of multiple groups. This software Performs item analysis and scoring of any number of subtests or subscales.

2.6.1.3. MULTILOG

MULTILOG is an extension of BILOG to data with polytomous (multiple) responses. It provides versatile multiple-category IRT analysis for polytomous IRT models with command code interface. MULTILOG has been replaced by Xcalibre 4, which is much more user-friendly and provides superior output.

2.6.1.4. X-Caliber 4

XCalibre is a commercial program that performs marginal maximum likelihood estimation of both dichotomous (1PL-Rasch, 2PL, 3PL) and all major polytomous IRT models. The interface is point-and-click; no command code required. Its output includes both spreadsheets and a detailed, narrated report document with embedded tables and figures, which can be printed and delivered to subject matter experts for item review. X-Caliber 4 is only available from Assessment Systems Corporation. The Joint Admissions and Matriculation Board (JAMB) -Nigeria Examination has made tremendous progress in implementing this software.

2.6.2. Online Item development software

2.6.2.1. Castle's test development software

Castle's test development is backed by the organization's exclusive ADE platform.

Designed and built by Castle's own professionals in the test development and delivery industry, our Agile Design Environment (ADE) provides an online, powerful platform for reliable, thoroughly documented, and legally defensible item and test development processes. This tool and the delivery system form a single integrated entity, so managing tests throughout development, delivery, and updates is a seamless process. This online system reduces travel expenses and alleviates the scheduling headaches of long in-person meetings by allowing a large pool of subject matter experts to write and review test items from anywhere with Internet access.

Once test items are developed, we bank and assemble exams per the test design, update content as needed, and manage multiple versions and multiple languages. Currently, ADE supports development of multiple-choice, multi-select, scenario or content sets, hot spot, and drag and drop question types. The development team continually evaluates item types for addition to the system.

ADE is:

- **User friendly:** ADE allows both experienced and new users to perform tasks in a timely manner with minimal training. ADE provides valuable dashboards and reports for project management staff.
- **Secure:** ADE applies role-based access technology, which allows Castle to specify the functions and test content that are accessible to each user. ADE is a secure, permission-based environment.
- **Configurable:** ADE is designed to meet a wide range of test development processes and needs. Castle configures several areas of ADE to meet our client's needs in development and maintenance.
- **Available 24/7:** ADE delivers its services online so users can access it as needed.
- **Flexible:** ADE offers many configurable business rules and workflows to provide flexibility, data and project management capabilities, and assurance that all items follow all steps of a defined process.
- **Engaging:** ADE employs sophisticated design and superior usability to engage users, increase their satisfaction, increase user adherence, and improve the overall quality of client programs.

2.7. High Stake Examinations

A high-stakes examination is an examination which has important consequences for the examinees, parents, guardians, the schools, communities, societies, etc. Such examinations could be for selection, placement, certification etc. If the examinees pass the examination(s), then the examinees may receive significant benefits, such as a high school diploma, a scholarship, admission to a higher institution, etc. If the examinees fail the examination(s), then they may receive significant disadvantages, such as being forced to take remedial classes until the examination can be passed, or not being admitted into a higher institution. The key features of a high-stakes examination are:

- (i) A single defined assessment
- (ii) A clear line drawn between those who pass and those who fail
- (iii) A direct consequence for passing or failing (something “at stake”)

2.8. Related work

2.8.1. Item banking at United Kingdom

Item banks are not yet widely used in the UK, though their benefits are clear. Building items across a subject area or sector can create economies of scale in the development process with less duplication of effort in different colleges and universities. When this is coordinated centrally items are more likely to be peer reviewed, validated properly and adhere to technical, interoperability and accessibility standards. Quality can also be enhanced by delivering the items to larger numbers of candidates, leading to improvements following analysis of item usage data. Because items should therefore be of higher quality, properly backed up, interoperable, and with issues such as copyright tackled from the outset, they are likely to be preserved for longer. Conversely, with proper security procedures in place, the exposure of items can be controlled and items removed when they become over-exposed.

Item Bank Infrastructure Study (IBIS) has brought together individuals and institutions in the UK with key expertise in areas relating to item banks. Funded by JISC under the Exchange for Learning (x4L) Programme in the first half of 2004 and with financial contributions from three of the exam boards involved – Edexcel, the Scottish Qualifications Authority (SQA) and the University of Cambridge Local Examination Syndicate (UCLES) the IBIS team aimed to study the processes involved in developing large scale item banks and managing an item bank service. It also puts forward a proposal for a distributed item bank system suitable for use in UK further and higher education.

2.8.2. Item banking in Thailand

In the case of Thailand, the concept of item banking apparently emerged in 1957 and was widely known in 1982-1984 when Thailand was assigned by her neighboring ASEAN countries to initiate a testing program for the entire ASEAN education region, but its use in any Asian country is still very limited, probably because of the large cost involved in development (Boonprasert, 1988). Since then, the Thai Ministry of Education has been very slowly developing item banking with a view to eventually expanding it to the regional and local levels (Department of Academics, 1991, p.5).

In Thai university campuses, there has been some limited research of item banking such as the Online Test Bank at Sura Nari University of Technology (Chansilp, 2006). The test items in this university were standardized on the basis of Traditional Measurement Theory which can only produce non-linear scores and so it is difficult to see how this item bank project can be useful and it would have been better if the researchers had used Item Response Measurement Theory to create linear measures. Other item bank projects in Thai universities have used Item Response Measurement, but they have used the now discredited so-called 2-parameter model (actually involving three parameters, item difficulty, item discrimination and one parameter of person ability) or the so-called 3-parameter model (actually involving four parameters, item difficulty, item discrimination, a guessing parameter and one parameter of person ability) (see Wright, 1999a for a discussion and discrediting of these models).

2.8.3. Item Banking in the Netherlands

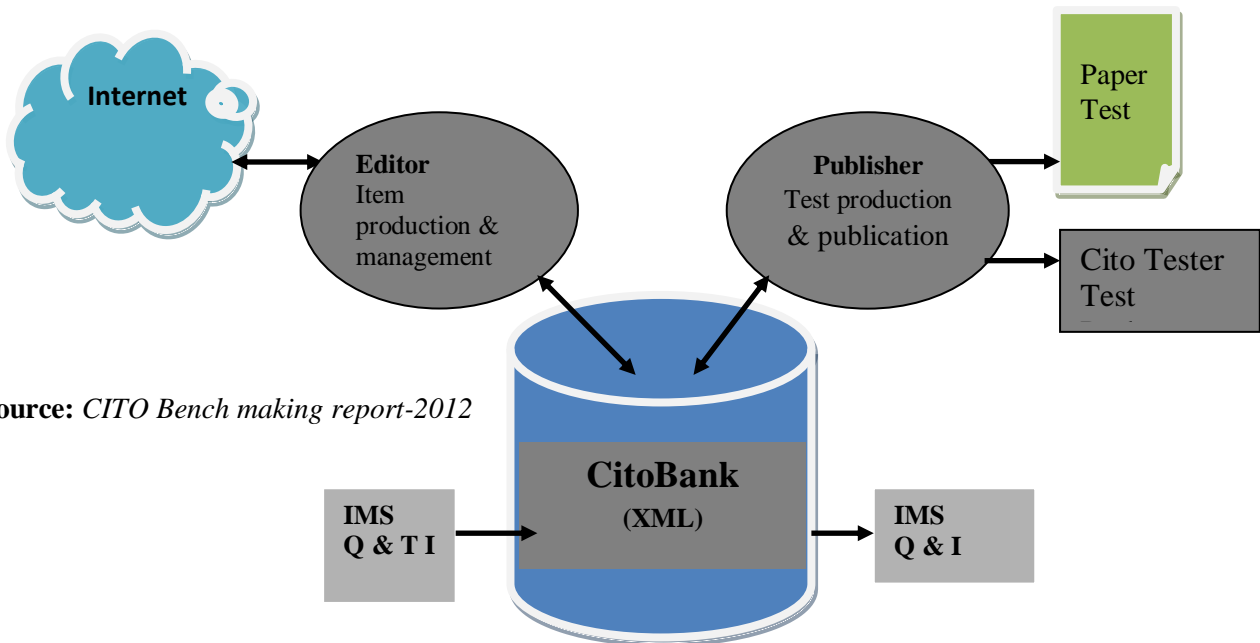
The Dutch National Institute for Educational Measurement (CITO) was commissioned by the Dutch Government to develop examinations for the secondary education. Approximately 200,000 candidates take these examinations. CITO develops examinations for nearly all the subjects taken at that level and examinations are taken twice a year. Marking is done by teacher who then send random sample of the candidates' scores to CITO for item analysis. For the final examinations, CITO produces both paper and pencil tests and computer tests and delivers the computer tests in a wide variety of equipment and computer skills to schools.

To be able to simplify the tedious process, CITO came up with a hybrid system by combining online production with test delivery and collection of test results via internet. CITO has also other related systems, a bank for managing, processing and compiling items and tests and a system for test administration. *The two form the CITO Examination System.* CITO contracts teacher to develop test items under the chairmanship of CITO experts. This guarantees that the examinations are in line with educational reality and are in accordance with test-related requirements. CITO bank is an item bank system for storage, management and re-use of large quantities of test questions. The bank is able to support various types of questions including

multi-media item types for digital tests. CITO Bank arranges the series of tests assignments in test banks. Each bank contains its own characteristics, assignments and tests. The system bank manager determines the structure of the item bank. Users with different authorization receive personalized access entitlements. Medium-neutral storage enables test materials to be exported in the IMS Question and Test Interoperability format (Q&TI version 1.2) and therefore transmitted to third party administration system and e-learning systems.

CITO Bank is based on Microsoft’s NET development tool. The web application runs on a web server with operating system Microsoft Windows Server. Storage takes place in a Microsoft SQL Server relational database management system. Metadata is stored in relational tables and content is stored in binary objects and as XML objects in the database.

Originally designed to meet the challenges of large scale electronic publishing, XML is also playing an increasingly important role in the exchange of a wide variety of data on the Web and elsewhere. The content of assignments is then exchanged in accordance with the IMS-Q&TI specifications. The Process is as shown in the diagram below.



Source: CITO Bench making report-2012

Figure 5: CITO Question and Test Interoperability System

2.8.4. The Joint Admission and Matriculation Board (JAMB)

The Joint Admission and Matriculation Board (JAMB) recently introduced Computer Based Testing (CBT) for the Unified Tertiary Matriculation Examination. The introduction of the CBT marked a new examination regime aimed at revolutionizing the education sector with the best item banking and test development practices. According to information Nigeria online new on education dated, Wednesday, 9 July 2014, it said that Jonathan called for partnership between CITO and Nigerian examination bodies in the conduct of e-testing and other forms of electronic innovations in Nigeria. The statement said that the president promised to ensure that the board was adequately financed to establish centres to conduct the CBT during the forthcoming UTME. Prof.

Dibu Ojerinde, Registrar of JAMB, at the forum, said that the collaboration with CITO would help the board to administer the test. Ojerinde said that there were some challenges experienced in the conduct of the last UTME, using the CBT. He, however, said that the body was determined to resolve the challenges. The registrar said that 100,000 candidates in 55 centres took the 2013 UTME, using CBT. “Based on the success of the test last year, more of the UTME candidates have indicated interest in the CBT. “This year, the examination will be taking place in 153 centres with 600,000 candidates across the nation,” the statement quotes Ojerinde as saying. Ojerinde explained that the CBT was introduced to curb examination malpractice, result black-out and other challenges undermining the paper pencil test. [NAN]

From available literature and benchmarking report, these test items have been developed and banked electronically and therefore, it was possible to offer the CBT test online successfully.

3. CHAPTER 3: Methodology

This chapter gives a detailed explanation of the research methodology adopted and how this project has been implemented. Methodology provides the various steps that are generally adopted in studying the research problem along with the logic behind them (Kothari, 2008).

3.1. Research Design and System Design Methodology

3.1.1. Research Design

The research design this study was a survey. The survey research design focused on opinions or factual information depending on its purpose of the study. Many surveys involve administering questionnaires to individuals to collect factual information from the respondents through questionnaires. This was very successful since the target population was conversant with the proposed research area.

3.1.2. System Design Methodology

The online item development and banking management system has several modules for different users. For instance, there are the item writers, the subject officers, moderators, system administrators and the system technical support team among others. The methodology adopted was the Structured Analysis and Development Method (SSADM).

3.1.2.1. Why SSADM?

Like the online item development and banking system, SSADM divides an application development project into modules, stages, steps, and tasks, and provides a framework for describing projects in a fashion suited to managing the project. SSADM's objectives are to:

- 1.** Improve project management & control
- 2.** Make more effective use of experienced and inexperienced development staff
- 3.** Develop better quality systems and make projects resilient to the loss of staff
- 4.** Enable projects to be supported by computer-based tools such as computer-aided software engineering systems
- 5.** Establish a framework for good communications between participants in a project

This methodology found to be the most favorable due to the step by step development of the different item banking modules. This Methodology adopts a sequential design process which is

often used in software development processes. Like a waterfall, the progress in this model flows steadily downwards through the phases as shown in the figure below. However, it concentrates on the analysis and design phase of the Waterfall Model of the Systems Development lifecycle as shown below.

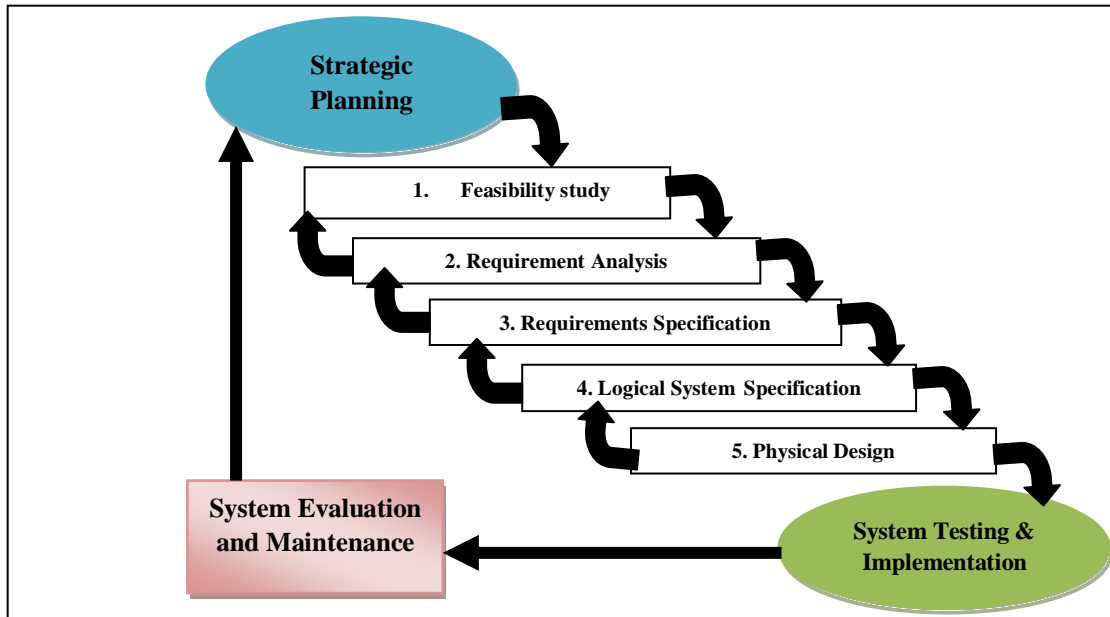


Figure 6: Structured Analysis and Development Method (SSADM) Model

3.1.2.2. SSADM's Modular approach

SSADM application development projects are divided into the above five modules that are further broken down into a hierarchy of stages, steps and tasks as shown below:

1. **Feasibility Study** -- the business area is analyzed to determine whether a system can cost effectively support the business requirements.
2. **Requirements Analysis** -- the requirements of the system to be developed are identified and the current business environment is modeled in terms of the processes carried out and the data structures involved.
3. **Requirements Specification** -- detailed functional and non-functional requirements are identified and new techniques are introduced to define the required processing and data structures.
4. **Logical System Specification** -- technical systems options are produced and the logical design of update and enquiry processing and system dialogues.

5. **Physical Design** -- a physical database design and a set of program specifications are created using the logical system specification and technical system specification.

3.1.2.3. SSADM Model stages, steps and tasks overview

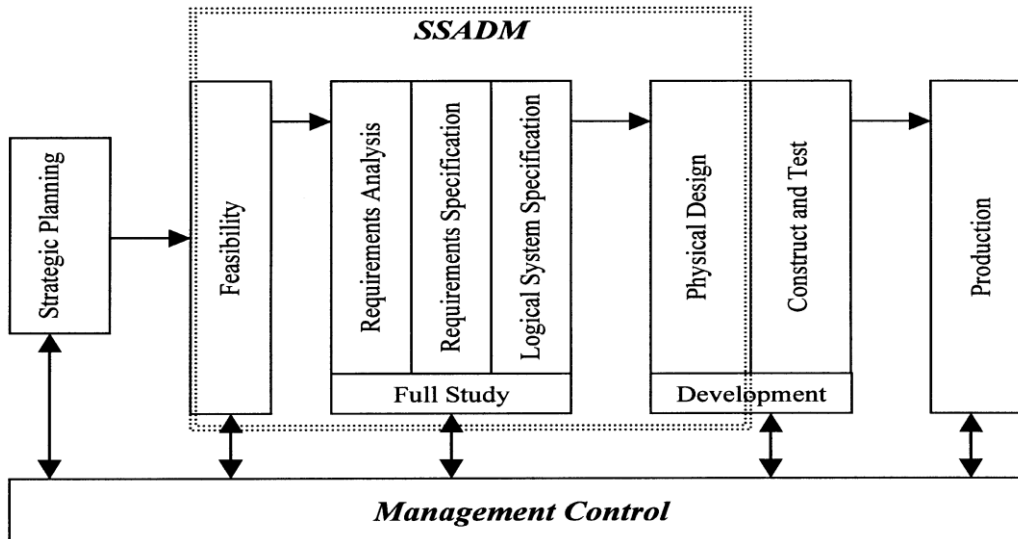


Figure 7: SSADM stages, steps and tasks representation

SSADM's main stages are further grouped and divided into the following steps and actions.

1. **Strategic Planning.**
2. **Feasibility study.**
3. **Full system study:** Requirements Analysis, specification & Logical system specification.
4. **System development:** Physical Design, Construct (coding) and System testing.
5. **Production:** System delivery based on user requirements.

3.2. SSADM methodology limitation:

Although this methodology is rigid, it is inevitable that the requirements for the system will change at some point during development. This was experienced during the study and a review of the project plan was done to meet the new user requirements.

3.3. Sources of data or information for the study

To gather available information on current and modern item banking practices, the following documentations, reports and processes were used as well as available case studies, journals and online information. An overview of available item development and banking softwares was also examined to gather any relevant and important information that could be included in the development of the target system. Some of the documentations include;

1. A cross- sectional survey of assessment tools in KNEC examinations have been used as the methodology.
2. Study of existing methods of item development and banking in KNEC
3. Study of available policy documents in KNEC
4. Study of item writing, banking and other materials used in the currently used in KNEC.
5. Trainings and conference reports.
6. Benchmarking reports and case studies on item response theory.

3.4. Data collection tools

The process of data collection is very critical in designing systems as well as reporting in the cases of pure research. It is due to this fact that to gather actual information on the area of research and project development that the following tools were found favorable and therefore used to collect data for the study. They include;

3.4.1. Case Studies

A case study is usually an in-depth description of a process, experience, or structure at a single institution. In relation to this study, case studies used were based on the research topic and project development. The main focus was on item development and banking for quality assessment and testing in education.

3.4.2. Observation

Through Descriptive observations, a lot of information on was collected by simply writing down the observation on the item writing and banking processes. Observation was also used to examine the sampled item banking softwares using trial versions. A good example is the fairm software and the FastTest web.

3.4.3. Surveys or Questionnaires

A set of standardized questions that explored on the research and system development topic were used to collect information about demographics and opinions of the respondents under different themes.

3.4.4. Interviews

During the system testing, a one on one interview was conducted to establish the opinions of the system users. The feedback was recorded and analyzed to establish the final results for reporting, recommendations and possible implementations.

3.5. Aspects and procedures of data collection and evaluation

The following aspects of data collection and evaluation were considered to ensure proper information was gathered for quality evaluation and reporting.

3.5.1. Population of Study

The population of the study was a sample of registered teachers from the Teachers Service Commission (TSC) and staff members of the Kenya National Examinations Council whose duties are in line with the theme or objective of the study. These include the officers from Test development, ICT, Research & QA, Examination Administration and Manuscript departments. This was in regard to the processes of test item development, test item analysis, item selection and banking, system support and management.

3.5.2. Sampling Technique and Sample Size

Purposive and stratified sampling procedures were adopted for the study.

Stratified sampling: The entire target population was varying and therefore the need to divide them into different subgroups. The KNEC population was grouped according to various departments as follows; ICT, Test Development, Research, Exam administration, manuscript and reprographics.

Purposive sampling (non-probability sampling approach) in selection of KNEC respondents was employed because only a small team of officers conversant with the process of item development, banking and test theory were targeted. During system testing, practicing teachers and some subject officers were sampled having been teachers before.

Variables: The sampling Variables were advised by the design process of the system and its eventual implementation. This included the variables in item writing and development processes identified in the conceptual model.

Below was the proposed distribution of the respondents from each department.

Table 1: Questionnaire Respondents Distribution

Department	No of Respondents on ICT, CTT & IRT				
	Proposed No.	Proposed (%)	Respondents Female	Respondents Male	Total Respondents (%)
ICT	7 of 10	70	3= (30%)	4= (40%)	70%
Test Development (KCPE)	10 of 12	83	6= (50%)	4= (33%)	83%
Manuscript	6 of 6	100	6= (100%)	-	100%
Exam Administration KCPE Senior officers	3 of 5	60	1= (20%)	2= (40%)	60%
Research & QA School Exams	5 of 7	72	3= (43%)	2= (29%)	72%
Total	31 of 38	82%	19 (50%)	12= (32%)	82%

3.6. Instrument Development and Pre- testing

Three parts questionnaire were administered for data collection in the study. The first Part was based on ICT literacy level and available infrastructure. The second part was based on the knowledge and application of the two test theories Classical Test Theory (CTT) and the preferred Item Response Theory (IRT). The third part of the questionnaire was on the proposed system testing, suitability, implementation and evaluation. All the questionnaires were successfully administered with an 82% feedback. **System testing feedback:** This was a general interaction with the system by sample teachers to give feedback on the online item writing training, item development and posting.

3.7. Data Collection Procedure

This was done through observation and by structured interviewing and questionnaire administration to the target population of as follows;

3.7.1. Questionnaire administration

PART I: *To acquire BIO data and establish general information. (Filing personal details)*

- Age bracket
- Gender
- Other relevant personal details

PART II: *Establish gaps in the current Item banking system and processes under these themes.*

- Item Banking process
- Security of item banking
- Integration of ICT in item banking management.
- Level of literacy in item banking and Item selection
- Level of Classical Test Theory literacy
- Level of Item Response Theory literacy

PART III: *Investigate the readiness for the proposed item banking system looking at the following critical areas;*

- Level of ICT literacy.
- Accessibility to ICT infrastructure.
- Attitude towards the proposed system.
- Duration of various activities in relation to item banking & ICT's
- Attitude towards quality assessment.

3.7.2. Structured interviewing

Structure interviewing was done based on the following system testing goals to establish the system acceptability.

System testing was done to establish mainly, the following properties based on the feedback from the target system users mainly teachers and the specific subject officers. This was done randomly during the system testing exercise.

Feedback was recorded as shown in APPENDIX B.

Their system testing goals were as follows;

1. Establishing the user friendliness of the system
2. Establishing gaps in the current Item banking system and processes.
3. Investigating the readiness for the proposed item banking system and ICT infrastructure.
4. Finding out whether the system is generally suitable for item writing and development.
5. Finding out whether the system was preferred to the current item banking system by KNEC.

3.8. Data Analysis Procedure

After administering, questionnaires were collated, scored and keyed-in for analysis. This was done using MS spreadsheets (Excel) for the quantifiable data. Results were presented using graphs and charts. *(See analysis results in this document)*

Why Excel? Excel is quite a powerful instrument that can do a lot of simple statistics. If no advanced statistics is needed in data analysis. It is okay to use it as a statistics tool. It does contain some basic statistical analysis and could serve for simple inferences.

Limitation of using Excel: If data analysis requires more advanced statistics, other statistical packages like SAS, SPSS, STATA &etc may be more accurate and professional. For instance, according to available literature, excel cannot handle missing data, analyze subsets and has limited output on the analysis.

How the limitation of methodology was overcome: During the data analysis, some data field was lost and this was overcome by inputting the data again since it was in the questionnaires.

3.8.1. Data analysis Results;

The results were analyzed and evaluated according to the themes of the questionnaire. This was presented for decision making under the system implementation and results evaluation.

4. CHAPTER 4: System Analysis and Design

The principal objective of the systems-analysis phase is the specification of what the system needs to do to meet the requirements of end users. In the systems-design phase such specifications are converted to a hierarchy of charts that define the data required and the processes to be carried out on the data so that they can be expressed as instructions of a computer program.

During the systems analysis and design, to understand the item development and banking process, it was very important to collect information on how the current or existing system works as well as the target system. The process involved evaluation of the item development and banking process to identify the system's desired objectives and determining procedures that when applied would efficiently assist in attaining the end user requirements.

4.1. Systems Analysis

Analysis phase involved conducting the survey and planning of the system and project, studying and analysis of the existing item development and banking system, and finally, defining of end user and system requirements and priorities for target system as shown in the diagram below.

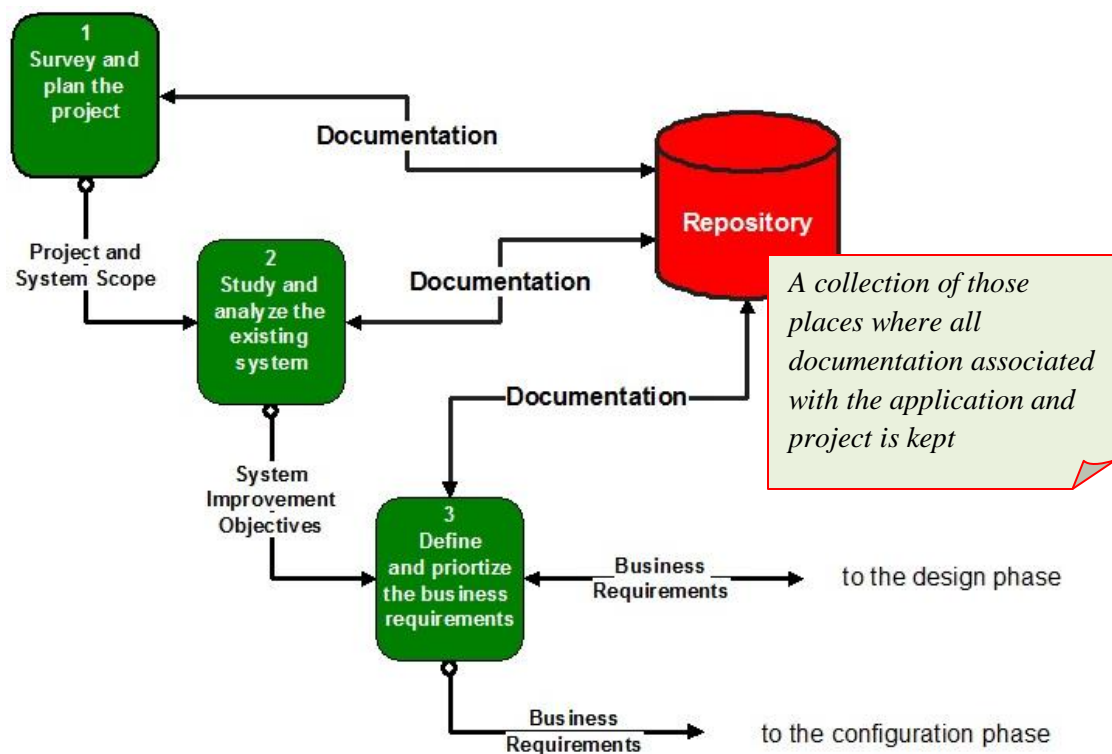


Figure 8: The Systems Analysis Phases of the Project

The systems analysis process was driven by system users concerns with the aim of establishing and implementing the best practices. The current item banking system in KNEC was cross examined to identify the target system goals, purposes and procedures that would achieve the development and implementation of new system efficiently. Item development and banking inputs, outputs, processes and goals were identified. Recording this information was very important to ensure a step by step guided system development based on user requirements.

A series of process models called *data flow diagrams* that depict the essential processes of a system along with inputs, outputs, and files have been used in the study. Data flow diagrams used to give a clear understanding of the existing and the target system process executions. *Logical models / design* for the system have also been used to guide and give the logical approach representing the physical system(s).

The Goal diagram below represents the system goal *analyses* – Goals are the objectives which the target system should achieve through cooperation of actors in the intended software and in the environment.

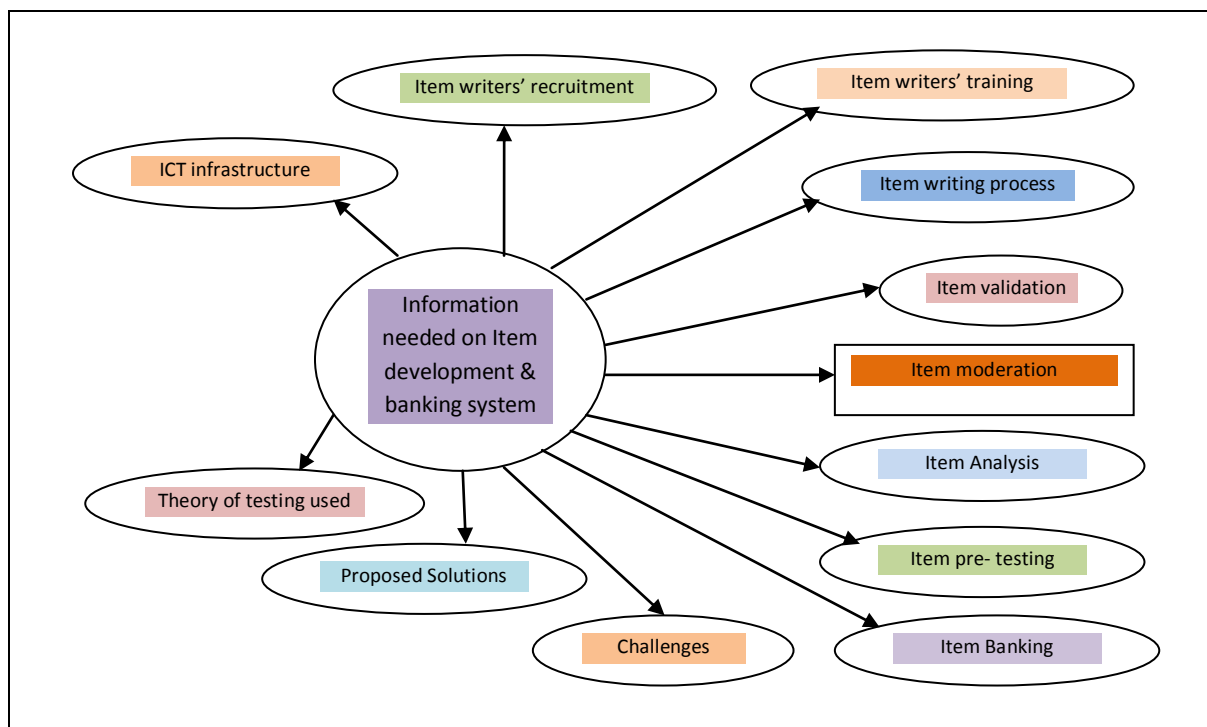


Figure 9: Goal diagram

4.1.1. Description of the Current KNEC Item Development and Banking System

The current item development and banking system at the Kenya national Examinations council is a manual system with the following processes;

1. Recruiting item writers from a sample population commonly referred to as head search.
2. Preparing an item writing training and development workshop.
3. Inviting identified item writers to be trained to generate test items during the workshop.
4. Subject officers collecting and consolidating hand written test items from the trainees
5. Subject officers establishing the quality of generated items with the help of item moderators.
6. Moderated items deemed of quality submitted to KNEC Manuscript secretaries for typing to be stored as a soft copy.
7. Proofreading of items and test selection for pre- testing.
8. Test scoring and Analysis
9. Paper banking.
10. Generation of test papers banked for future testing.

4.1.2. Level 1 Data flow Diagram for the KNEC current system.

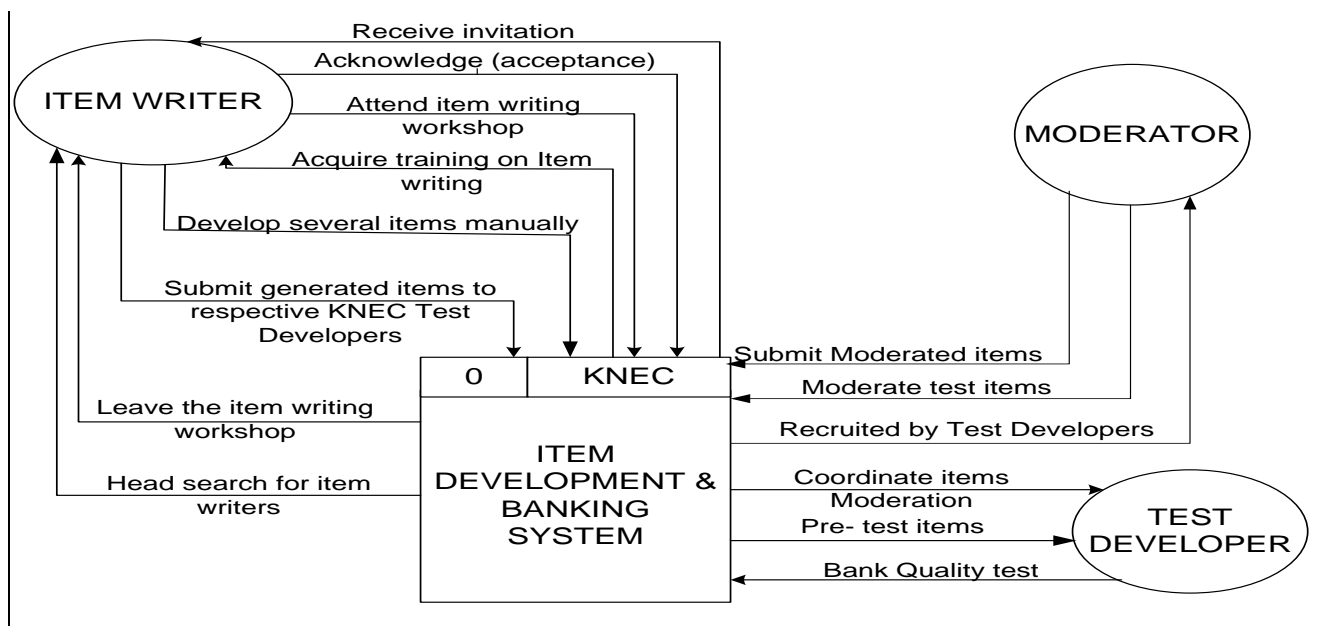


Figure 10: KNEC Current System level 1 data flow diagram

4.1.3. Target system requirements identification process

This process involved doing a feasibility study on the current system to identify problems that users are facing currently. Identifying user and information requirements provided a platform to gather necessary requirements through questionnaires, interviews and observation to assist in the development of the online item development and banking Management system. The process was guided by the available literature review, benchmarking reports and related conferences on best practices in item banking to overcome the current challenges turning the challenges into the following opportunities as recommendations for the target system.

Recommendations made by users during feasibility study as requirements;

- 1. Focus on all teachers registered by the Teachers Service Commission in the country access the system to willingly register and participate in this noble activity.*
- 2. Ensure online induction for all online registered item writers within the system.*
- 3. Gather important details from the teachers to enable segregation of duties and privileges within the system in reference to the different roles by each user. E.g.; item writers, Moderators, setters and subject officers.*
- 4. Ensure system verification for users' details as provided and allow authorized updating of records. This is because most of the teacher details are not up to date.*
- 5. Application of item response theory (IRT). Provide the table of specification, item content area and objectives that assist in establishing the items statistical values.*
- 6. A well structured electronic item bank to securely store and retrieval of items easily.*
- 7. Manage user accounts and assign each user unique roles and privileges accordingly.*
- 8. Ensure system security; System logs, audit trails and encryption techniques deemed necessary to safeguard the item generation, storage, retrieval, pretesting and banking.*
- 9. System documentation; user manuals, moderation process and training modules.etc.*
- 10. Emphasize on a closed process to ensure items generated are tailor made.*
- 11. Emphasize on item banking best practices for quality test items development & banking.*
- 12. The focus is Multiple Choice Questions (MCQ's) for the time being while in the future, there is need to focus on essay questions too.*

4.1.4. Project planning process

The planning process involved gathering and putting in place all what would be required for the system design. Platforms, modules, variables and features identified were used to implement the online item development and banking management system. The following hardware and software requirements were also identified for better planning and budgeting effectively.

4.1.4.1. System requirements: Hardware and Software

Hardware:

1. Disk space of at least 500MB. 10 GB would be most preferred for storing documents.
2. Offsite back up:- Available in KNEC
3. Memory: - at least 2GB

Suggested for full implementation

4. SQL server 2008 R2 (Enterprise Edition): Has an Audit trail and Database level encryption.

Software:

1. Operating System – Windows XP and above. Preferably Windows server 2008 R2
2. Development tools
3. Web server: IIS.
4. A database: SQL Server
5. SSL Certificates and Antivirus solution
6. Microsoft Visio 2007 , Microsoft word, spreadsheet etc

Non Functional requirements:

1. System Security: User name and passwords based on user roles and privileges.
2. User Friendliness of the system ensures users interact with the system easily.
3. System availability and reliability:

4.1.5. Online item development and banking system

In the figure below, the following logical system specification was established using the feasibility study, requirement analysis and specification.

4.1.6. Proposed/ Target system logical DFD

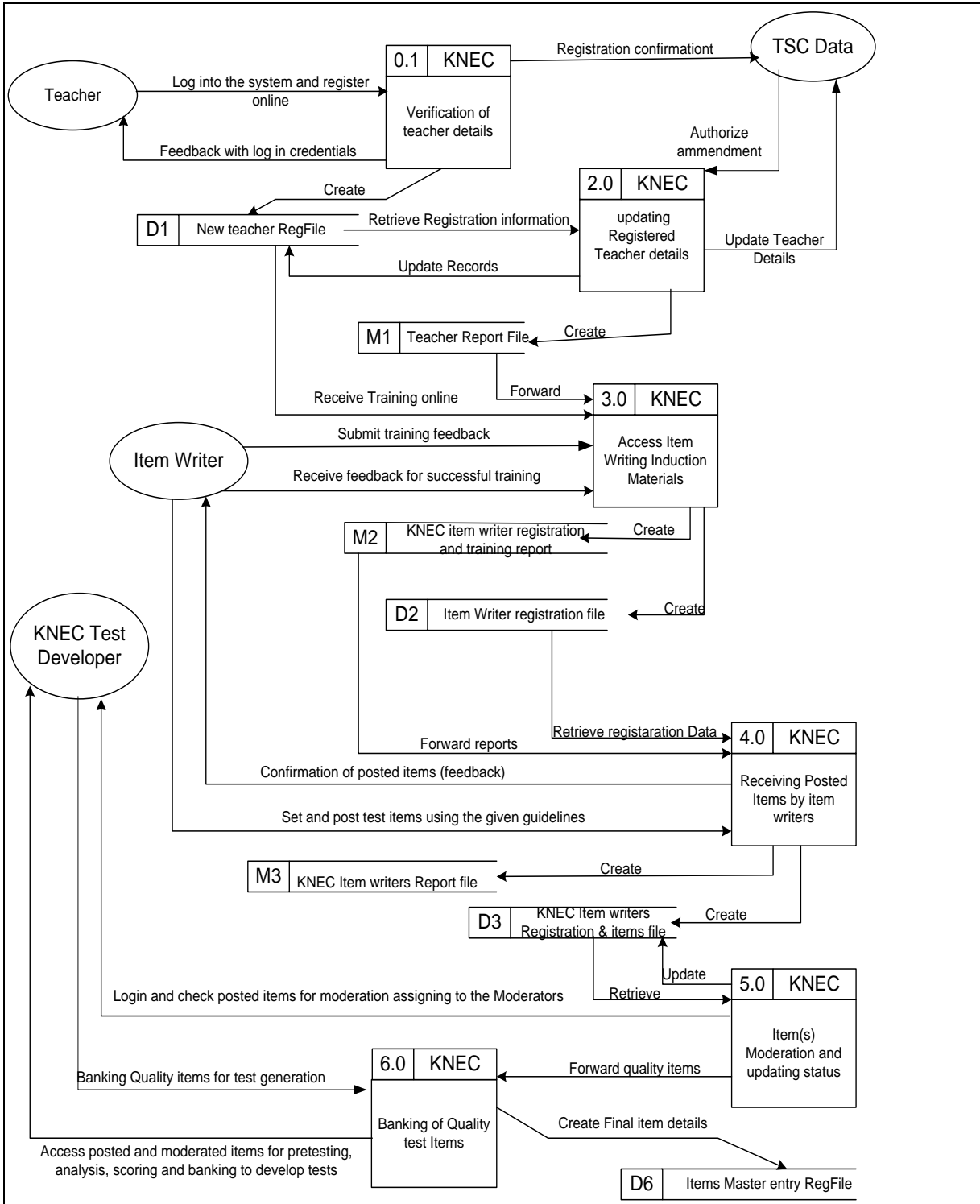


Figure 11: Proposed Logical Data Flow Diagram

4.1.7. Conceptual Entity Relational model (ERM)

This is the Members relationship and other Field(s) just within the System

4.1.7.1. Entity relational model

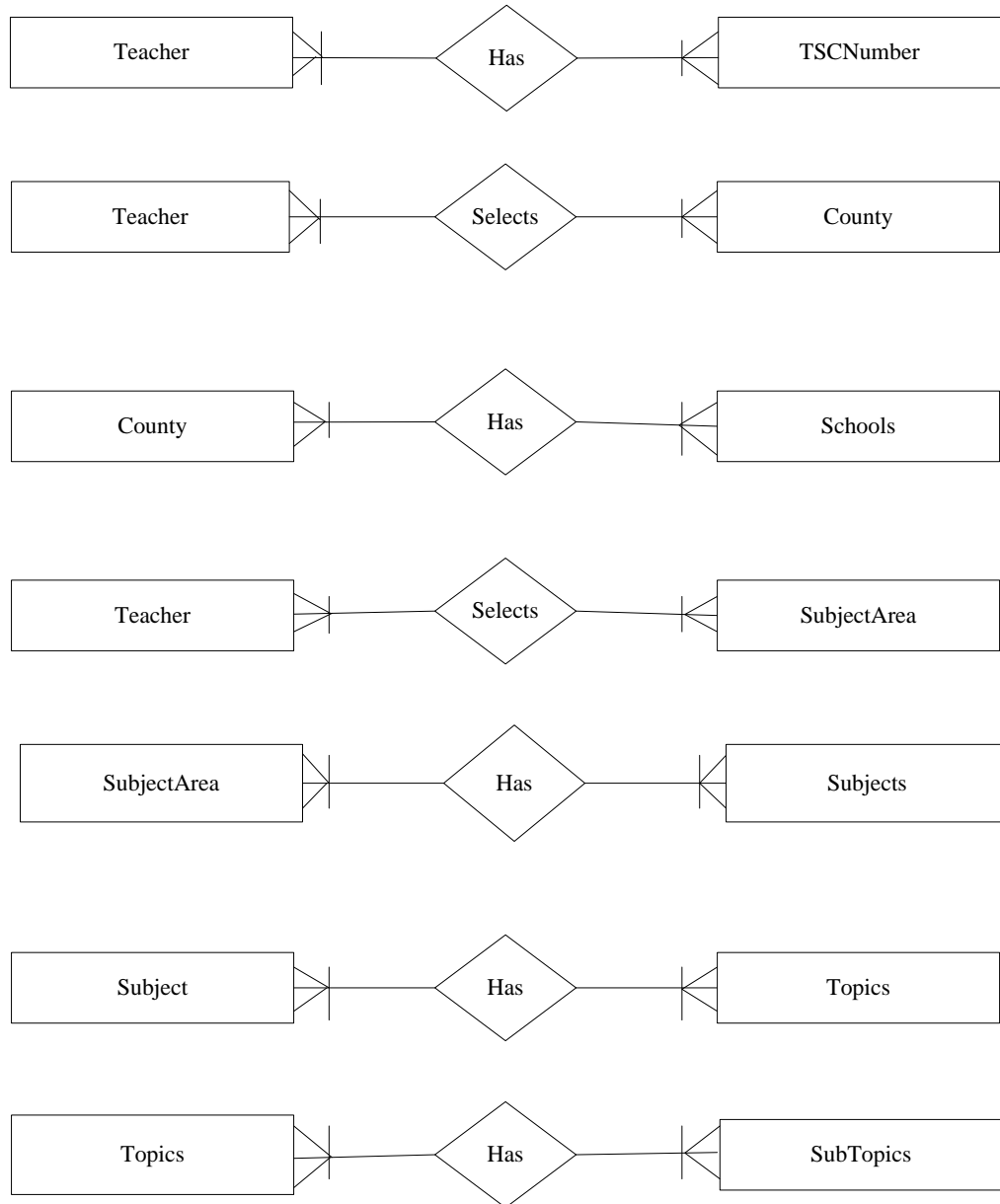


Figure 12: Entity Relational Models

4.1.7.2. Many to Many relationships

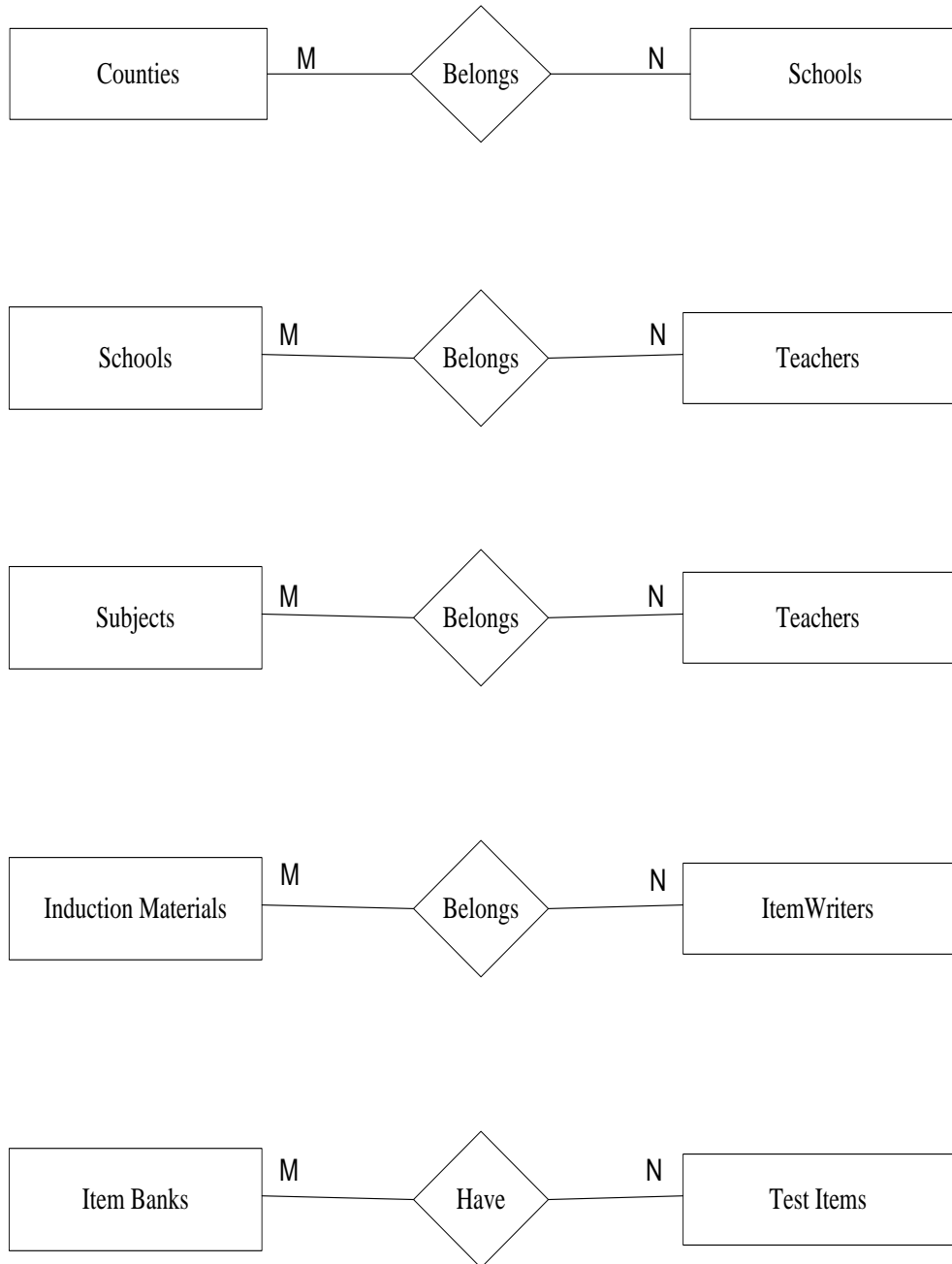


Figure 13: Many to Many Relations

4.1.8. Translation of Logical data model

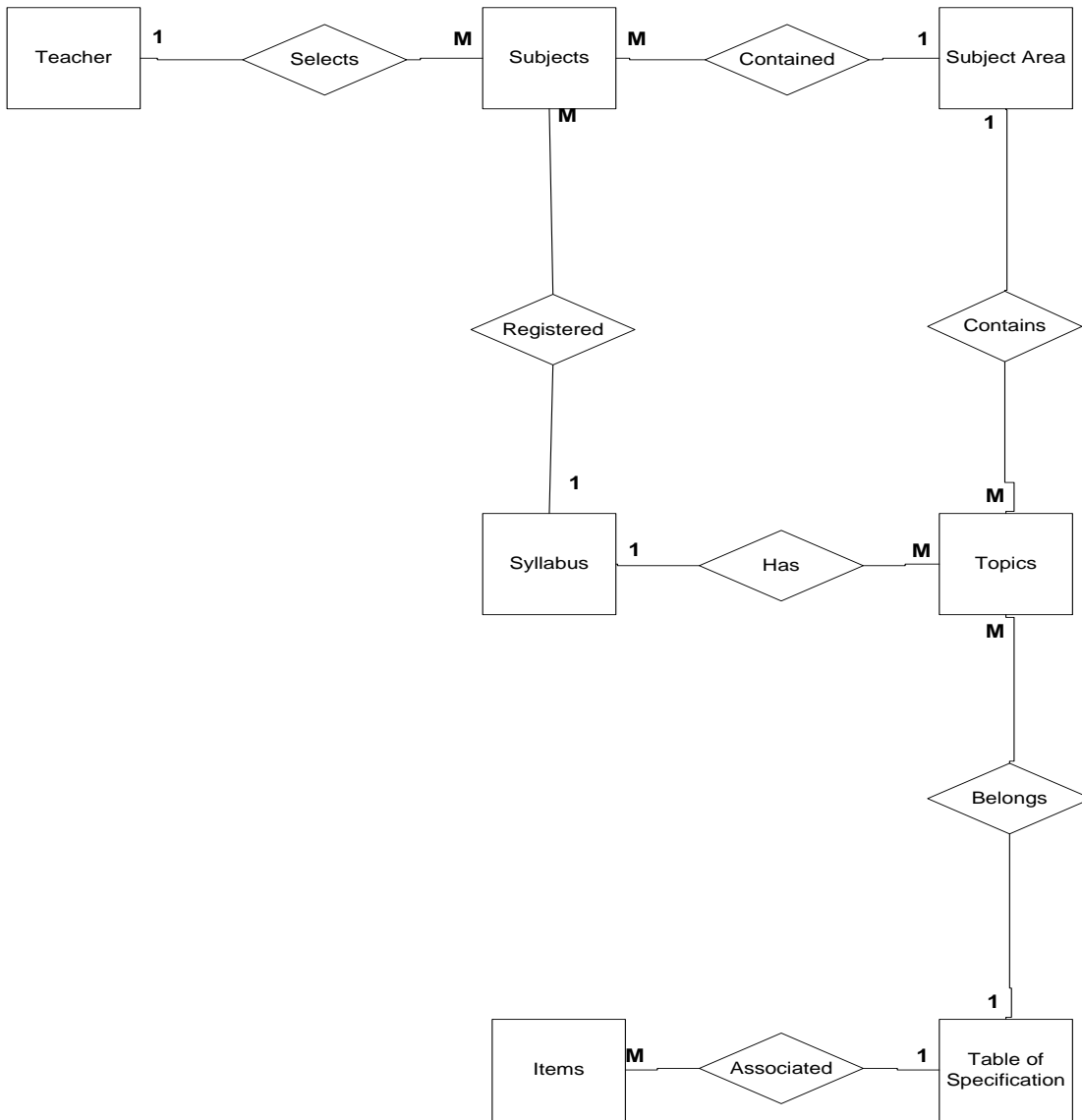


Figure 14: Logical Data Model (LDM)

4.1.9. System analysis conclusion and recommendations:

Although most of the information acquired during system analysis took long seeking approvals to access information, the process was successful. This outcome was a great achievement since the study objectives and goals were realized to proceed with the designing of the target system.

4.2. System Design

The main objective of system design phase is to design the solution. Several development activities took place during the design structured design phase as represented in the architectural logical diagram below.

4.2.1. Architectural logical design presentation of the proposed system

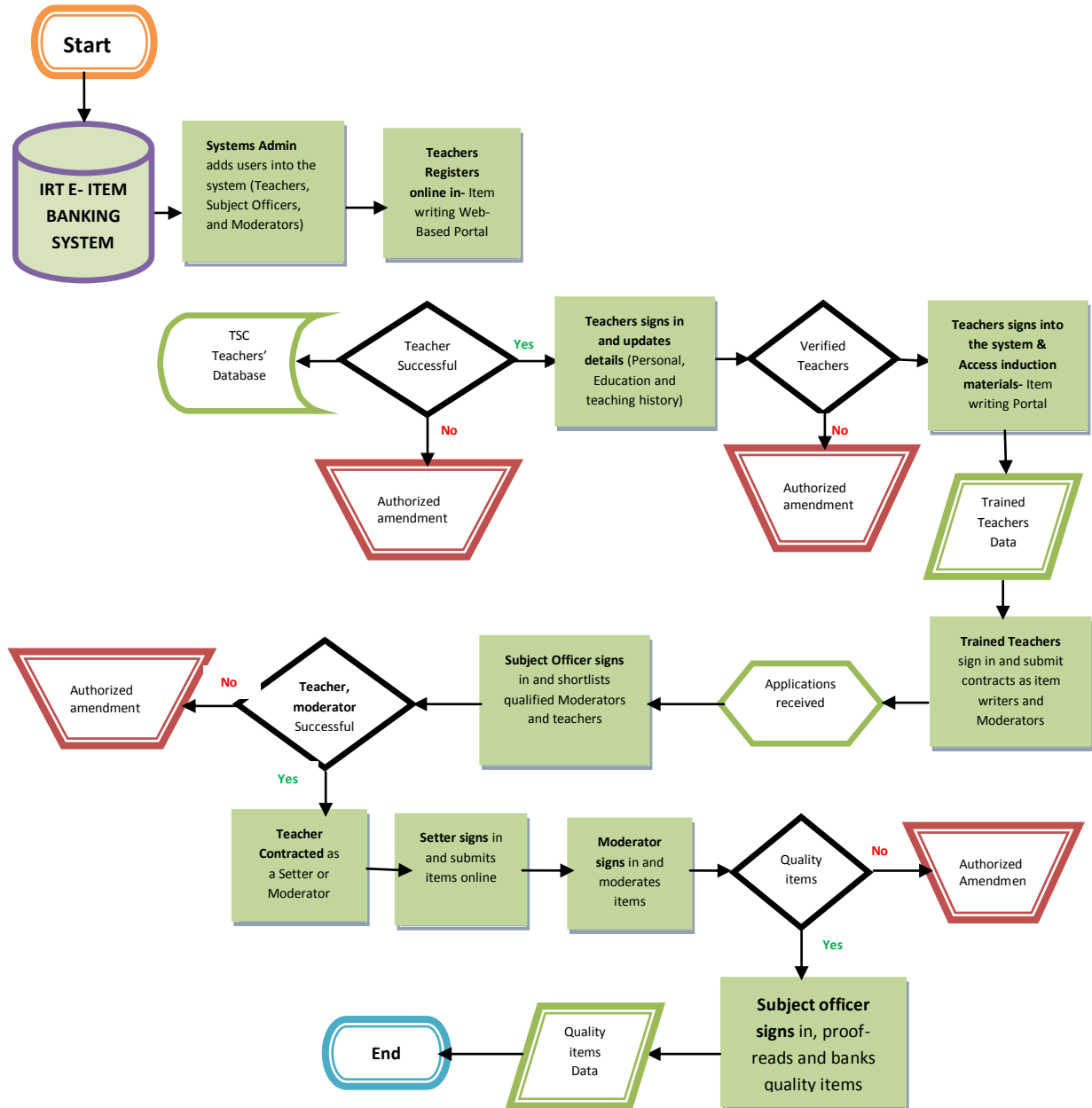


Figure 15: IRT e-item banking management system logical presentation

INFORMATION FLOW:

1. The Systems Administrator adds users into the IRT e-item banking System. The users added are teacher using the TSC data, KNEC Subject Officers and Printers and are assigned access rights to the system accordingly. Moderators are approved by subject officers.
2. Teachers register to seek approval and after system verification, they sign in to update their details. After verification again, they are given the rights to sign into the system and access induction material online. ONLY authorized amendments are made into the archive data.
3. Inducted teachers sign contractual agreement with KNEC to begin the item writing and posting.
4. Subject officer access submitted items for moderation, pretesting, banking and test selection according to the item development and paper or test generation rules.

4.2.2. Database design

This activity involved designing of the physical database. The step by step process began with database planning, system definition, requirements collection and analysis and finally, coming up with the database design.

During database planning, standards that govern data collection process, the format and design in reference to the system users, roles and privileges were observed.

The database design was based on a Centralized Approach to Managing Multiple User Views since the online item development and banking system had several users with different user roles and privileges.

Different system users have been presented in the conceptual framework with some of the user roles and activities listed. For instance, the following viewers perform authorized activities in the system. They include; teachers, item writers, subject officers and system administrators who manage the user accounts. In addition, different users access individual information that is only authorized to the like the bio data and the personal details.

Some of the shared data include the induction or training materials and the institutions archive like the schools and colleges. However, this data is centralized but only available to authorized

user after verification for viewing, updating or gathering information. This is demonstrated in the figure below.

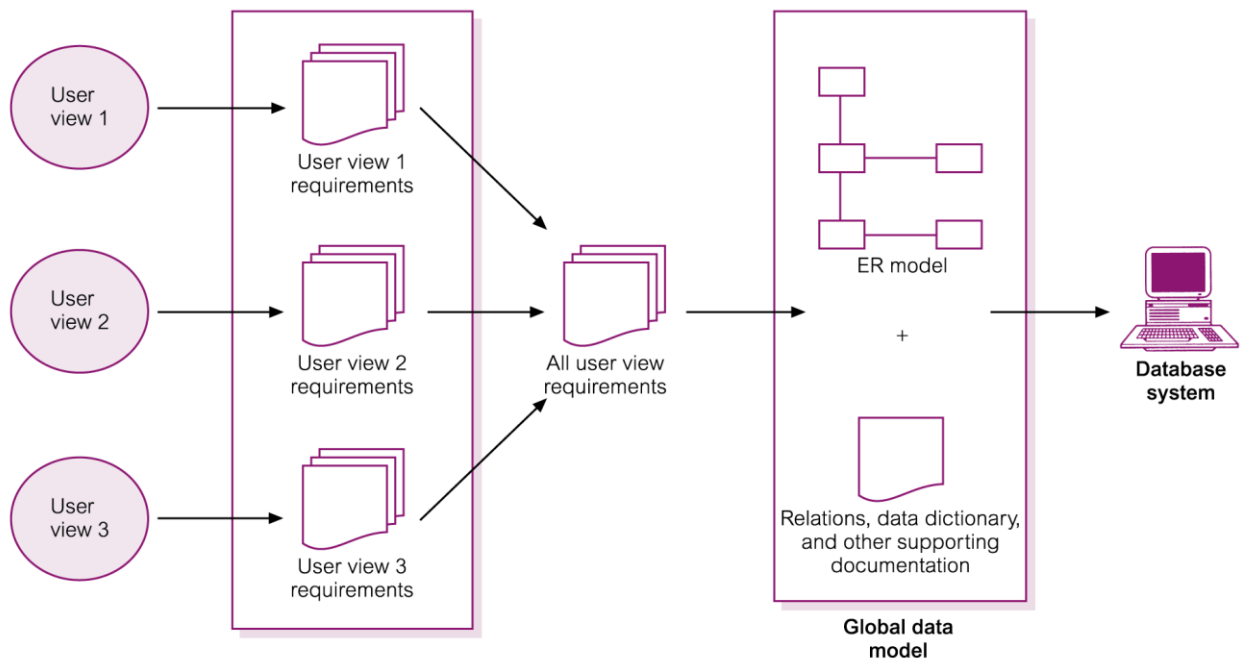


Figure 16: Centralized Approach to Managing Multiple User Views

The following database features were implemented during the database design phase. This is evident in the database schema diagram.

Data definition	Physical definition
Primary key enforcement	File structures available
Foreign key specification	File structure maintenance
Data types available	Ease of reorganization
Data type extensibility	Indexing
Domain specification	Variable length fields/records
Ease of restructuring	Data compression
Integrity controls	Encryption routines
View mechanism	Memory requirements
Data dictionary	Storage requirements
Data independence	
Underlying data model	
Schema evolution	

4.2.3. Database schema

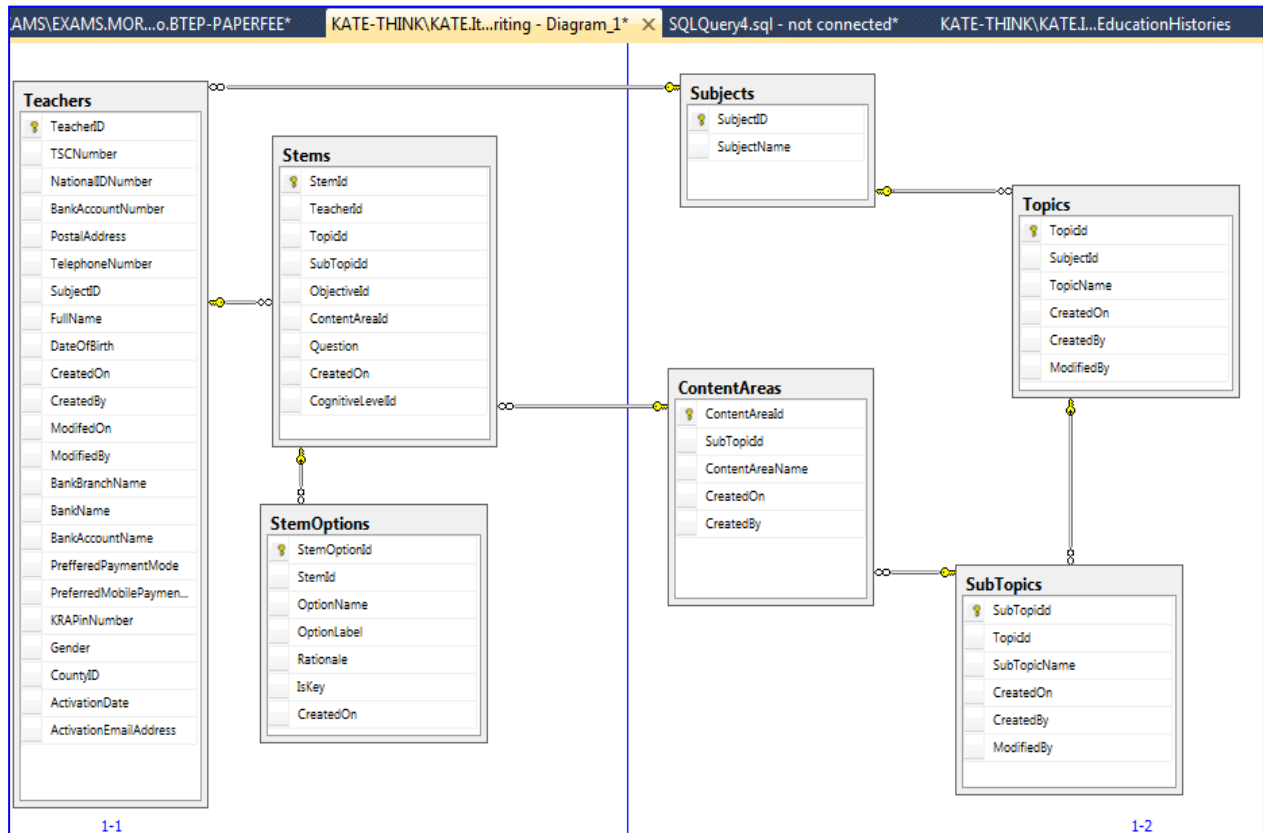


Figure 17: IRT- Item development and Banking System Database schema

4.2.4. Programs description designs

A modular process based approach was incorporated to suite different users according to their user roles and privileges. Using the user requirements and recommendations gathered, the results were analyzed and used to come up with different user interfaces for the expected system as shown below.

Process descriptions were used to design user interfaces for different process. This was very useful to establish and implement constraints and system controls during the system design process. Some of the key process procedures to perform authorized activities by different users are shown in the figures below.

4.2.5. Process Description

4.2.5.1. Teacher: Registering online to access induction materials.

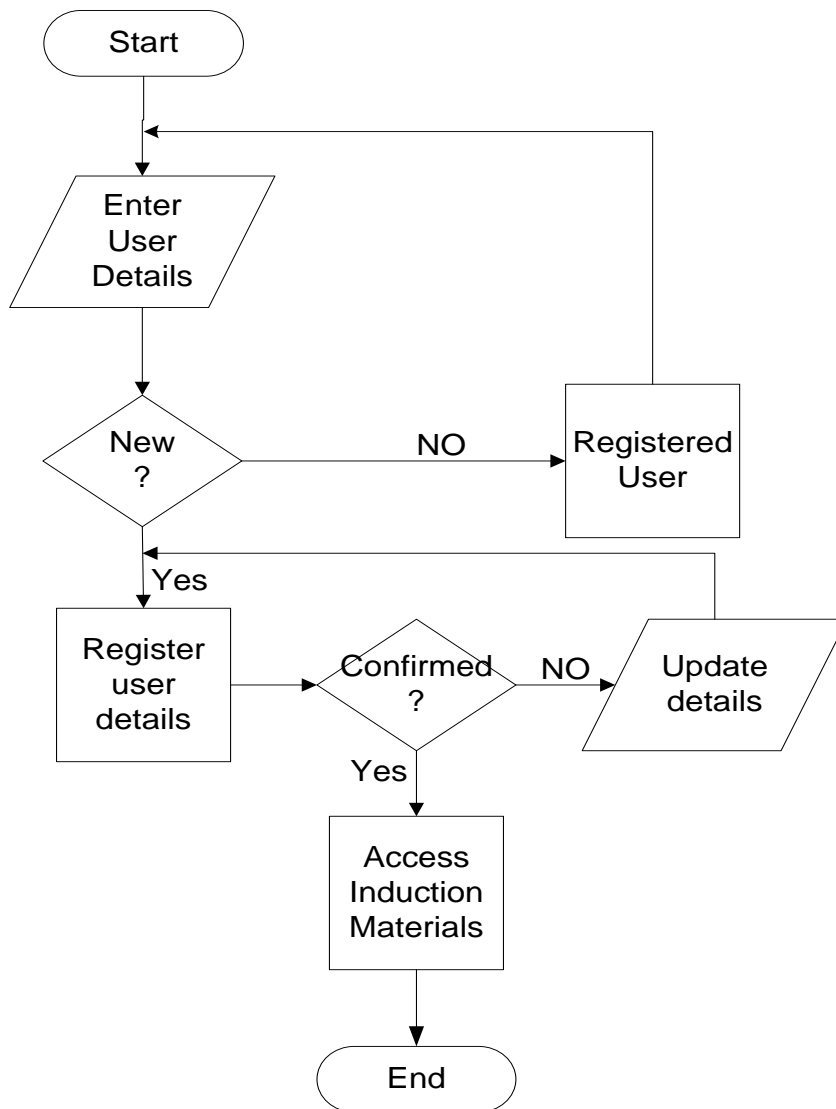


Figure 18: Teacher Registration Process

Process description:

In the figure above, the teacher logs into the system initially to register for item writing using the TSC Number. After a successful registration process, the details provided are verified by the system allowing only authorized update of information. Successfully verified teachers are able to access induction material online before starting to develop items.

4.2.5.1. Item Writer: Developing items.

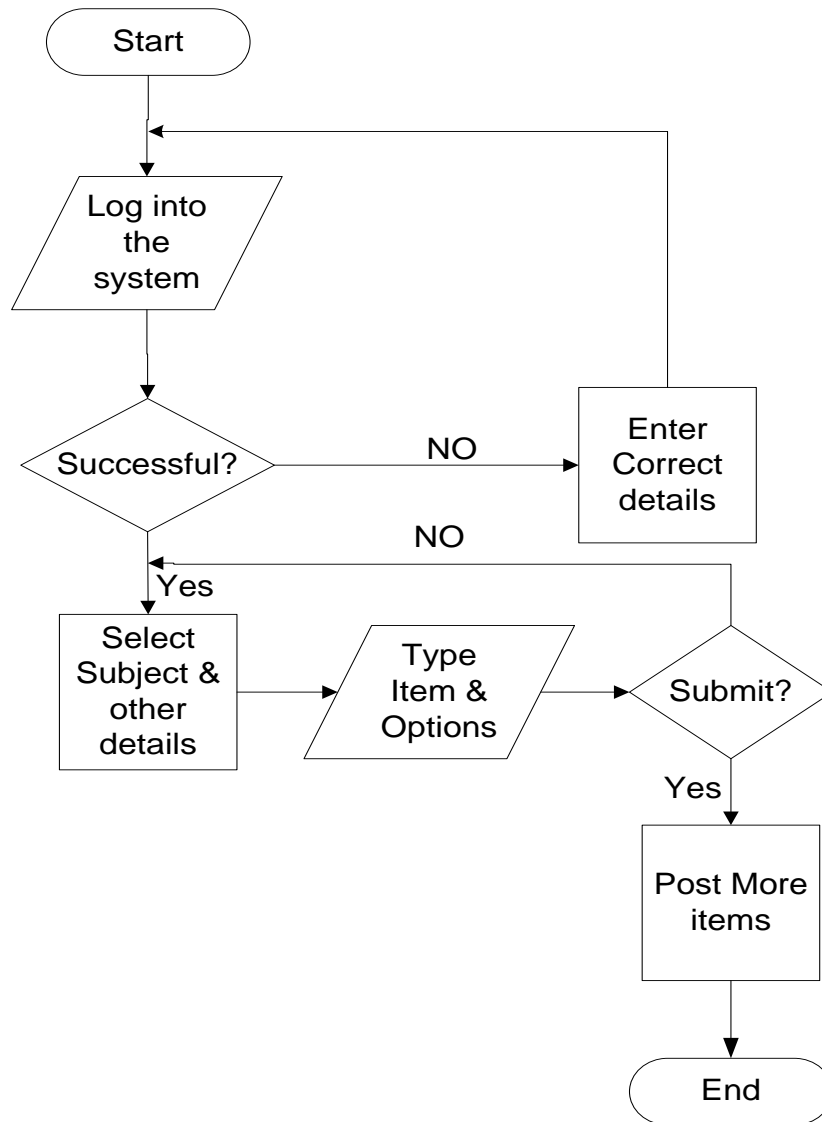


Figure 19: Item development Process

Process description:

In the figure above, the item writer **MUST** have been registered and verified as a registered teacher. They **MUST** have trained online by accessing the induction materials in the system. To develop an item, the item writer selects the subject and other details include the following; Topic, Sub topic, Objective, Content area and finally Cognitive or Skill level.

4.2.1. User Interface designs

4.2.1.1 Item Development user interfaces designs

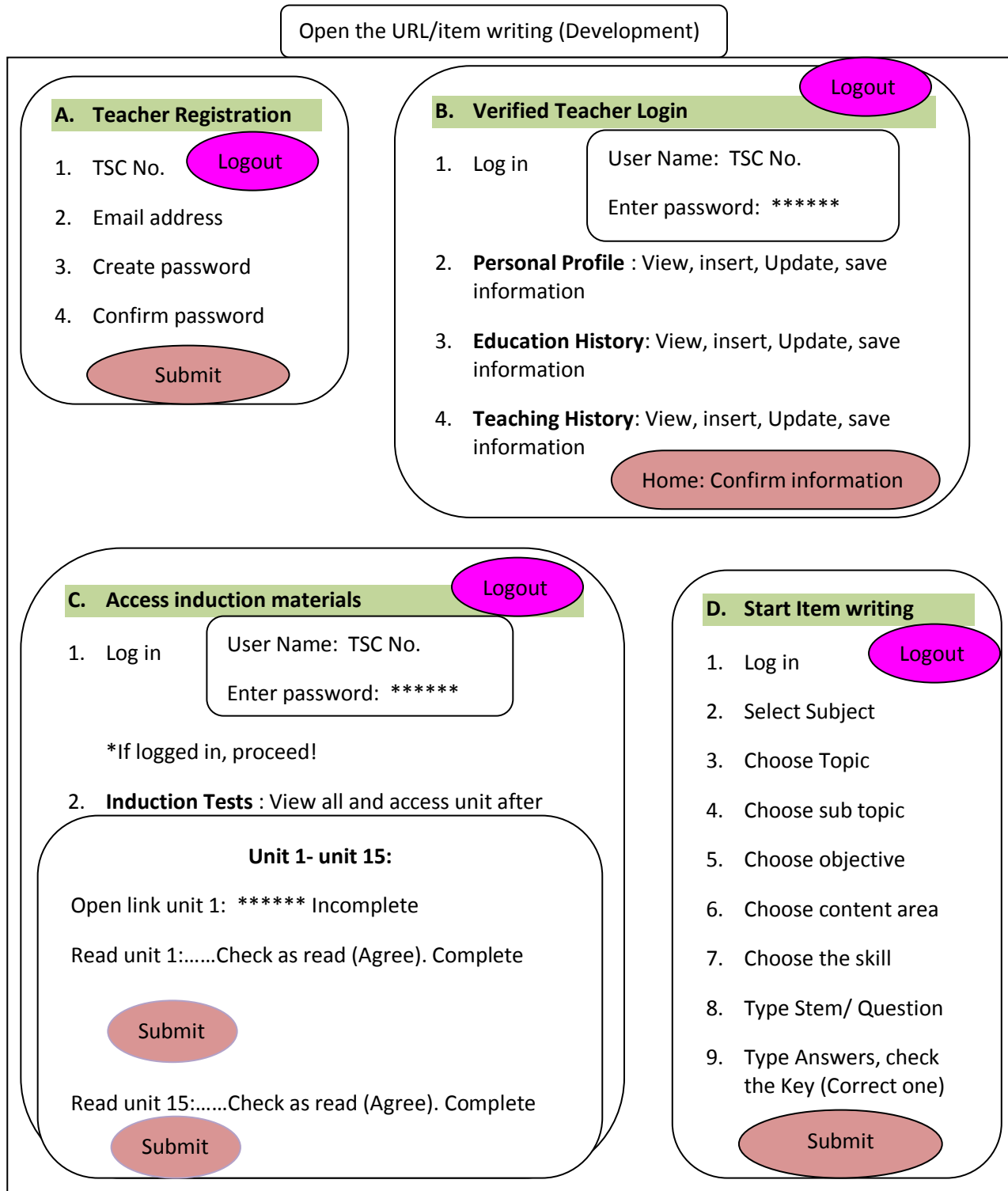


Figure 20: Item development (writing) user design interfaces

4.2.2. Input Screen designs

4.2.2.1. Accessing the item development and banking system

An access link is provided for the teachers to access the item writing system. The following home page is generated for new teachers to register into the system while existing teachers can log in using their credentials as shown below. TSC Number is used in this case as the user name for verification of users.

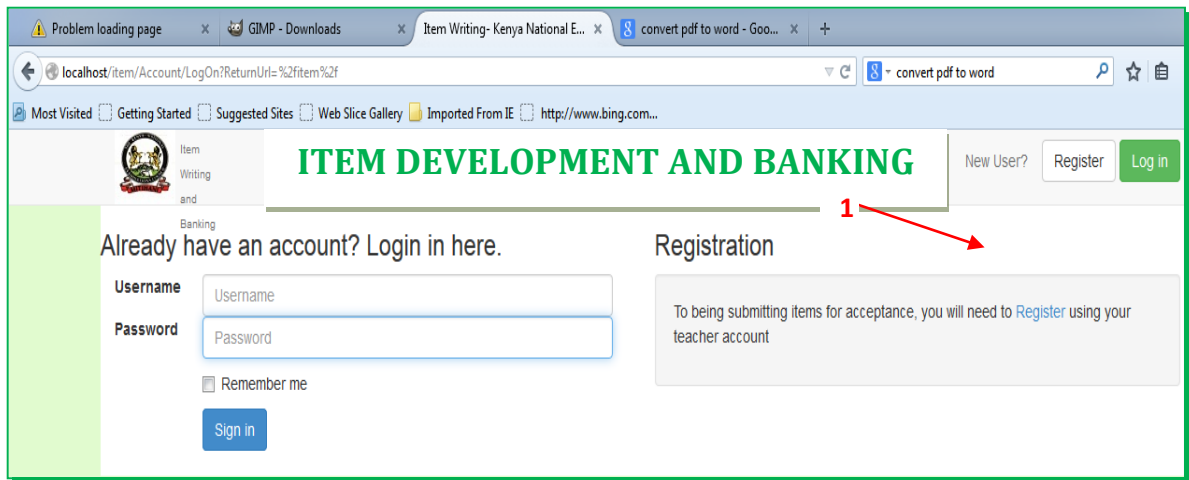


Figure 21: Item writers' registration interface

4.2.2.2. Teacher Online Registration and Log in Process

The register button in (1) above links the registering teacher to the online registration interface as shown below. Details to be provided are specified in the registration field.

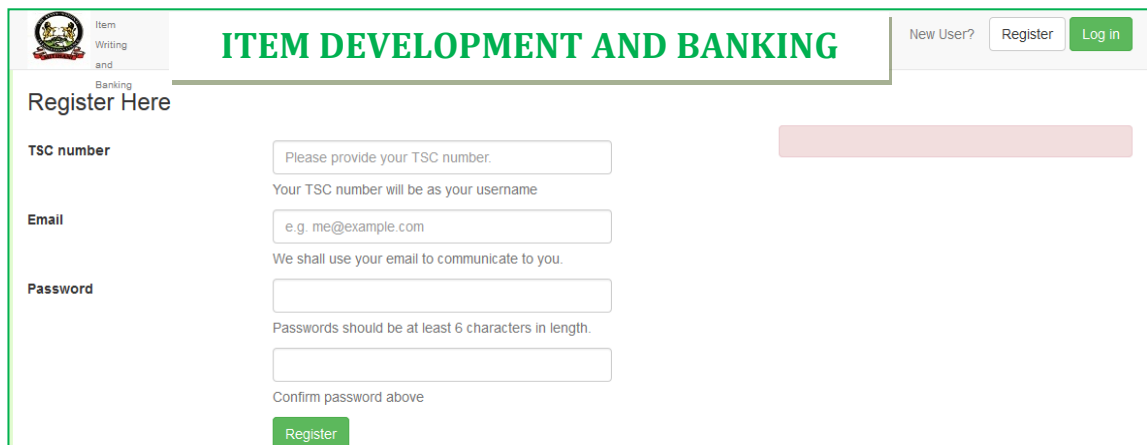


Figure 22: Teacher online registration process

4.2.2.3. Teacher successful registration

The image shows two side-by-side screenshots of a web application. The left screenshot is titled 'Register Here' and contains a registration form with the following fields: 'TSC number' (388696), 'Email' (caterono@yahoo.com), and 'Password' (masked with dots). Below the password field is a 'Confirm password above' field. A green 'Register' button is at the bottom. The right screenshot is titled 'Already have an account? Login in here.' and contains a login form with 'Username' (388696) and 'Password' (masked with dots). A 'Remember me' checkbox and a blue 'Sign in' button are also present.

Figure 23: Registered Teacher login process

4.2.2.4. Entering Teacher Details

Successfully registered teachers are required to input details accordingly as follows;

- 1) **Personal profile:** This profile involves creating the teacher Bio data by entering the specified details within the corresponding fields in the system.
- 2) **Education details:** These are details on the academic status where the user provides information on their achievement in education. They include, certificate courses, Diploma, degree etc.
- 3) **Employment Details:** Under the employment details interface, the user shall give their employment history from the original appointment and station to the current.
- 4) **Induction Tests:** Teachers access and download training materials on item writing online with the required content a unit after another.

The screenshot shows a dashboard for a registered teacher. The top navigation bar includes 'Dashboard', 'My Items', and 'Welcome, 388696'. The main content area is divided into three sections, each with a colored border and a step number:

- Personal Profile (STEP - 1):** A green-bordered box containing 'Personal Profile', 'You have provided all of your personal information.', 'Update Personal Information', 'Education History', 'You have provided 1 references of your education history', and 'Teaching History', 'You have provided 1 references of your teaching history'.
- Induction Tests (STEP - 2):** A red-bordered box containing 'Induction Tests', 'You have completed the induction tests', and a list of three completed items: 'RELATIONSHIP BETWEEN THE SYLLABUS, INSTRUCTION AND EXAMINATIONS - Complete'.
- Start Item Writing (STEP - 3):** A blue-bordered box containing 'Start Item Writing', 'Congratulations, you can now start submitting items for moderation', and 'Start Writing Items'.

A green arrow points from the 'Induction Tests' section to a text box on the right that reads: 'The following steps shall be followed from step 1-3 based on instructions populated by the click of each link.'

Figure 24: Teacher details interface

5. CHAPTER 4: Implementation and Testing

5.1. Description of Development Environment / tools

The item writing portal development platform was based on the ASP.NET MVC, a framework for building web applications that applies the general Model View Controller pattern to the ASP.NET framework. Model-View-Controller (MVC) has been an important architectural pattern in computer science for many years. Some modules incorporated Visual Basic programming language.

5.2. Description of the main system functionalities

The item development and banking system implementation involved incorporation of the different modules from teacher registration, approval, training, item writing and development.

5.2.1. Teacher Registration Module

The screenshot displays the 'Registration' page of the system. At the top right, there are links for 'New User?', 'Register', and 'Log in'. The main heading is 'Registration', followed by a message: 'To being submitting items for acceptance, you will need to Register using your teacher account'. Below this is the 'Register Here' form, which includes fields for 'TSC number', 'Email', and 'Password'. The 'TSC number' field has a placeholder 'Please provide your TSC number.' and a note 'Your TSC number will be as your username'. The 'Email' field has a placeholder 'e.g. me@example.com' and a note 'We shall use your email to communicate to you.'. The 'Password' field has a note 'Passwords should be at least 6 characters in length.' and a 'Confirm password above' field. A 'Register' button is at the bottom of the form. Below the registration form is the user profile dashboard, which includes a 'Personal Profile' section with 'Update Personal Information', 'Education History' with '1 references', 'Teaching History' with '1 references', and 'Induction Tests' with two completed items: 'RELATIONSHIP BETWEEN THE SYLLABUS, INSTRUCTION AND EXAMINATIONS - Complete'. On the right side of the dashboard, there is a 'Start Item Writing' section with a message 'Congratulations, you can now start submitting items for moderation' and a 'Start Writing Items' link. The top navigation bar includes 'Item Writing and Banking', 'Dashboard', 'My Items', and 'Welcome, 388696'.

Figure 25: Process of Teacher Registration

Process description: Teachers accessing the online item development portal register for verification. Successful teachers get log in credentials to sign into the system and update their personal, education and teaching history accordingly.

Some of the details provided are verified by the system too to proceed to the next process of accessing induction materials and training online. Authorized amendments are made into the archive data from the teachers' service commission (TSC).

5.2.2. Induction materials online access Module

The following induction materials are accessible online. They are downloadable a unit after another as shown below.

Click the check box to agree that you have read and understood content and submit

Figure 26: Accessing induction materials online

5.2.3. Item writing process Module

The process of item writing involves generating questions (stems) and options (answers) for specific subjects with the guidance of the specific table of specification (TOS). Registered teachers must read and follow the online induction test to generate quality items. Developed items are later moderated to ensure they have the deemed content and statistical value.

This is a rigorous process that involves moderators and subject officers with different panels constituted to establish and approve quality items. Below is a screen short of the process of item writing using mathematics as the subject from label 1-7.

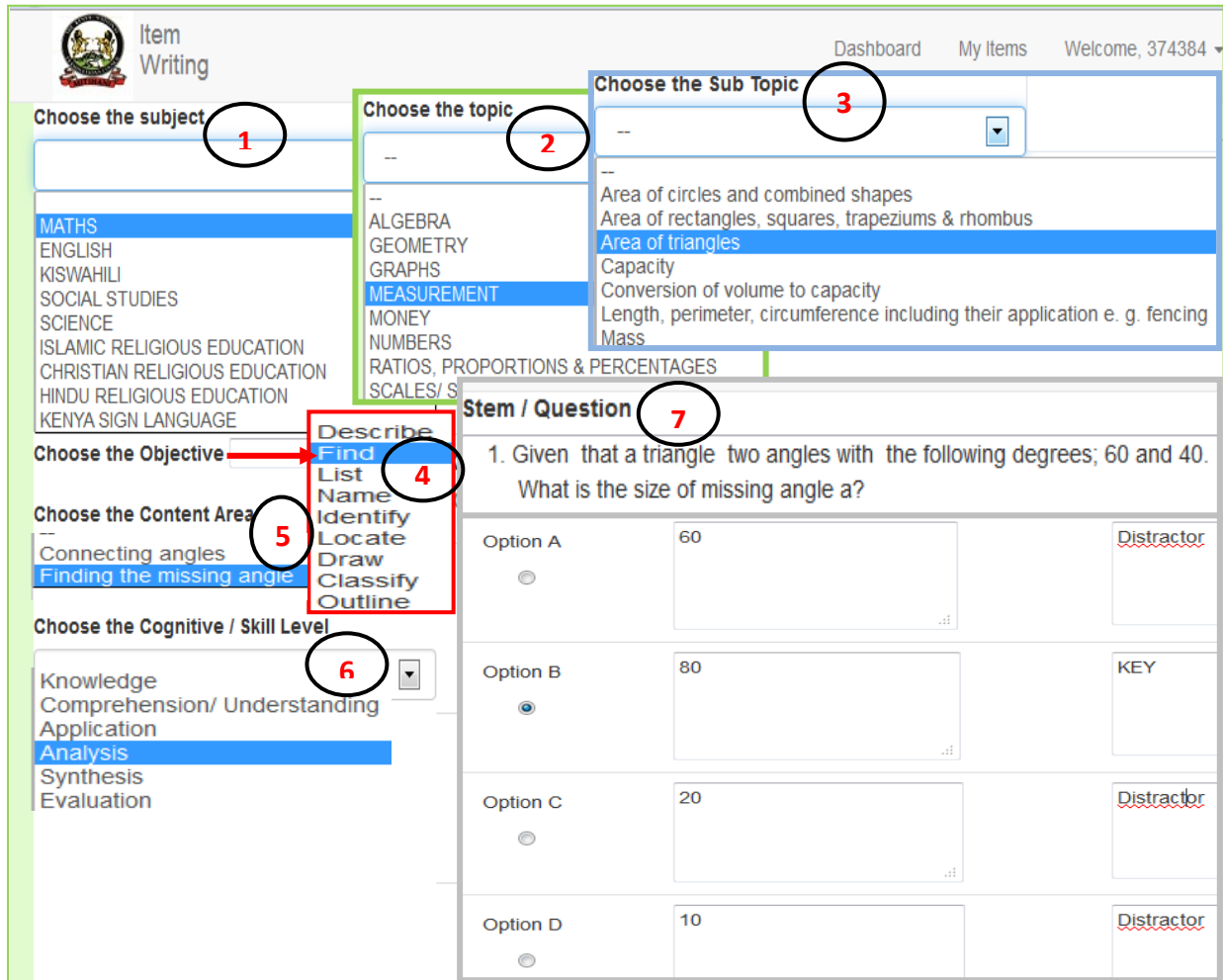


Figure 27: Item writing interface

Generated items from the above figure are only accessible to the subject officer who is a KNEC test development officer under the specific subject. Working with a team of Moderators, an item after another is moderated and stored according to the statistical value with good items being banked for pretesting and item selection in the future.

5.2.4. Item banking Modules

The following item banking modules were implemented demonstrating the system functionalities in relation to banking the developed items. The integration of item response

theory was evident since the focus on each item indicated the item characteristics as shown in the figures below.

1. Item writing implementation module

The process of item development was implemented and tested as shown in this figure. The rigorous validation shows the success of integrating Item Response theory based on the items characteristic and properties during development.

Choose the subject	Stem / Question	Key	Option	Rationale
CHRISTIAN RELIGIOUS EDUCATION	1. Explain how God cares for his creation giving two examples	(Choose One)	Option A	key
Choose the topic			Option B	DISTRUCTOR
Choose the Sub Topic				
Choose the Objective				
Choose the Content Area				
Choose the Cognitive / Skill Level				

Item Writing					Log In
fdssfgsdfs	MATHS	MEASUREMENT	Knowledge	Describe	More..
ee	MATHS	MEASUREMENT	Knowledge	Describe	More..
rrr	MATHS	MEASUREMENT	Knowledge	Describe	More..
qeqweqe	MATHS	GEOMETRY	Comprehension/ Understanding	Describe	More..
qewwqeqw	MATHS	MEASUREMENT	Comprehension/ Understanding	Find	More..
hjhjkdjghjhfjvbn	MATHS	MEASUREMENT	Comprehension/ Understanding	Identify	More..
uuu	MATHS	MEASUREMENT	Knowledge	Find	More..
1. Explain how God cares for his creation giving two examples	CHRISTIAN RELIGIOUS EDUCATION	CREATION	Knowledge	Outline	More..
STEM	MATHS	MEASUREMENT	Comprehension/ Understanding	Find	More..
STEM	MATHS	MEASUREMENT	Comprehension/ Understanding	Find	More..
sdfsdf sdfsdf	MATHS	MEASUREMENT	Knowledge	Identify	More..
testing	MATHS	MEASUREMENT	Comprehension/ Understanding	Find	More..
sdsdf	MATHS	MEASUREMENT	Knowledge	Describe	More..
sdfgsdfgdsfg	MATHS	MEASUREMENT	Knowledge	Describe	More..
dsdfsdgfsdg	MATHS	MEASUREMENT	Knowledge	Describe	More..

Figure 28: Developed sample items

2. Sample item implementation presentation

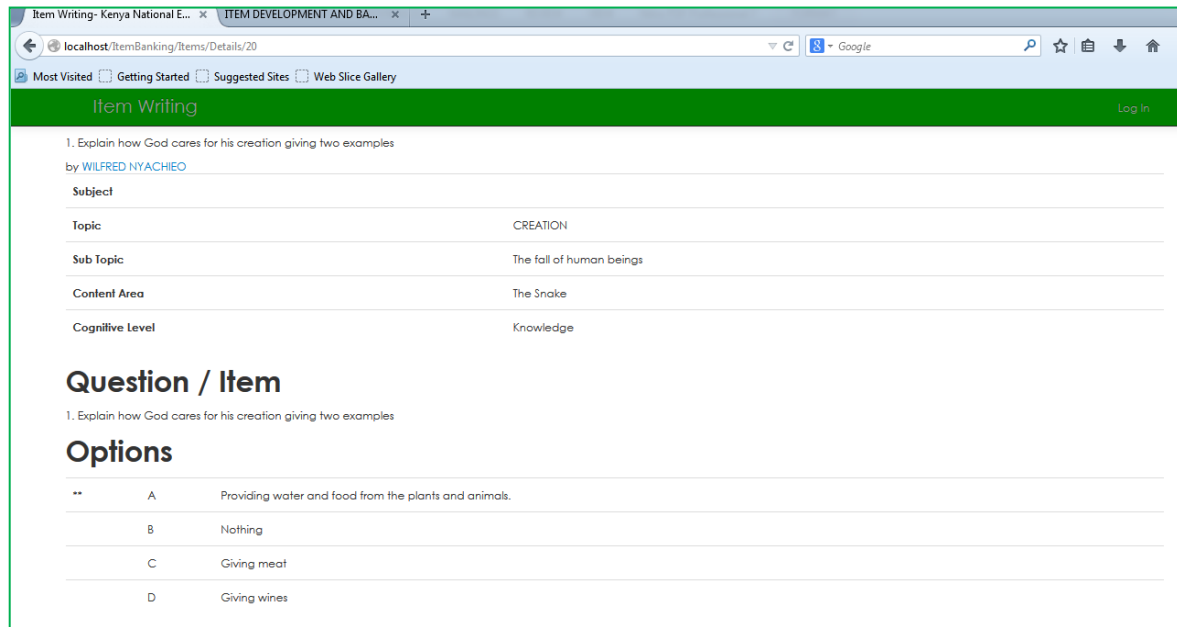


Figure 29: Sample item as viewed by KNEC subject officer

The system allow the authorized KNEC subject officer to view developed items as shown in figure 30 and also, to single out an item for analysis. The current system allows the subject to either bank the item if it is good or discard. However, a recommendation for moderating the item that has properties of being converted into a good item is recommended.

5.2.5. Implementation process

After successfully designing the core modules of the system, integration of the processes was done by putting into place all the proposed designs at the implementation phase.

5.3. System Testing

During this stage, users were identified to interact with the system to ensure the implemented system is usable as recommended by the users. This process was carried out at the Kenya national Examinations council where the following users interacted with the system.

5.3.1. System testing sampled personnel

3. ICT Officers
4. Test Development (KCPE)
5. Manuscript Secretaries
6. Exam Administration KCPE Senior officers
7. Research & QA School Exams
8. Sampled teachers as item writers

5.3.2. System testing goals

6. The user friendliness of the system
7. Establish gaps in the current Item banking system and processes.
8. Investigate the readiness for the proposed item banking system and ICT infrastructure.
9. Whether the system is generally suitable for item writing and development.
10. Whether the system was preferred to the current item banking system by KNEC.

5.3.3. The following were the key or leading questions during the testing exercise.

1. Is the current item development process manual or automated?
2. What is the level of knowledge and application of test theories?
3. What is the level of knowledge and application of ICT in readiness to item banking?
4. Security and availability of system infrastructure?
5. What is the preparedness of teachers to be inducted online, develop and post quality items?

Once the participants were done with the testing, they were issued with questionnaires that had the questions leading to the above objectives to establish the suitability of the system, readiness and system security and availability.

5.3.4. System Testing Feedback

A. Kenya National Examinations Council officers' feedback

The following responses as represented in the system evaluation report and results were obtained from the sampled participants during the testing process.

1. The current item banking process was found to be very manual with the users emphasizing on the need to automate or re- engineer the process.
2. The level of ICT knowledge and available infrastructure was good although a more appropriate infrastructure and ICT resources was suggested in the need to fully implement the system.
3. The current item banking had many challenges and it was evident that the online item development and banking system had solved most of the challenges and therefore, its implementation was very much supported.
4. The system was found to be very user friendly since most of the information was already loaded for users to select.
5. Most people have the knowledge of the theories of testing.
6. The Item Response Theory (IRT) was found to be very effective as compared to the current classical test theory since IRT focuses an on item rigorously to ensure it has the desired objective and statistical values.
7. The test development officers appreciated the new innovation expecting to gather more quality items from the online posting saving on time and cost.

B. Sampled teachers/ item writers feedback

Testing for teachers' ability to access the online item writing portal, register online and access induction materials was done from a sample population of teachers. They interacted with the system to register online, access induction materials, generate and post test items although this were only for testing and may not have been quality items.

1. The Item writing platform enabled all teachers the opportunity to participate in the item development activity.
2. Teachers were very happy with the system adding that accessing induction materials online would allow them to train online and sharpen their skills even on the usual assessments for students.
3. Teachers embraced the closed questions assessment and inclusion of the syllabus in the system as well as the table of specification.
4. It was noted that teachers have basic ICT skills but they needed to train more on this skills.

6. CHAPTER 6: Evaluation of the system, results and conclusion

6.1. System Evaluation and Results

The IRT e- Item banking management system was evaluated and established that it had satisfied and met the proposed objectives. The general objective was to implement the system to be used by KNEC. Below are the results and the discussion as recorded and tabulated from the participants' responses during the system development and testing.

A. SAMPLE POPULATION (KNEC OFFICERS)

Participant's tabulation:

Department	RESPONDENTS		
	Female	Male	Total
Information Communication Technology (ICT)	30%	40%	70%
Test Development KCPE (TD)	50%	33%	83%
Manuscript (MS)	100%		100%
Examination Administration KCPE officers (EA)	20%	40%	60%
Research & QA School examinations (R&QA)	43%	29%	72%
Total	50%	32%	82%

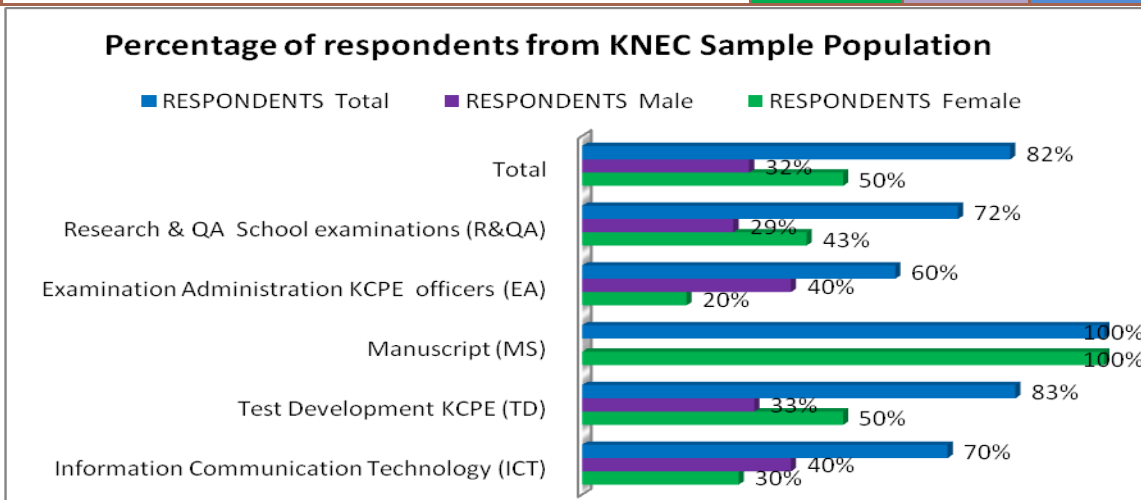


Figure 30: Record of participants for system development and testing

Response from the target personnel was at 82% which was very successful. More women answered the questionnaires but in the case of the manuscript department, there are only ladies hence the 100% outcome.

This results show the willingness of the participants to be part of the success of the developed system by providing feedback to the themes in the questionnaires. The choice of the participants was based on the research area to gather accurate information on the problem statement.

B. CURRENT ITEM BANKING STATUS AT KNEC

Participant’s Responses on the current status of item development and banking processes in KNEC.

Departments	Q1		Q2		Q3		Q4		Q5		Q6		Q7		Q8		Q9		Q10		Q11		Total	
	TD	MS	TD	MS	TD	MS	TD	MS	TD	MS	TD	MS	TD	MS	TD	MS	TD	MS	TD	MS	TD	MS	No.	%
Manual	9	5	10	5	7	4	8	4	7	3	7	4	10	6	9	5	8	6	6	4	7	4	138	78.4
Automated	1	1	0	1	3	2	2	2	3	3	3	2	0	0	1	1	2	0	4	2	3	2	38	21.6
Total	10	6	10	6	10	6	10	6	10	6	10	6	10	6	10	6	10	6	10	6	10	6	276	100

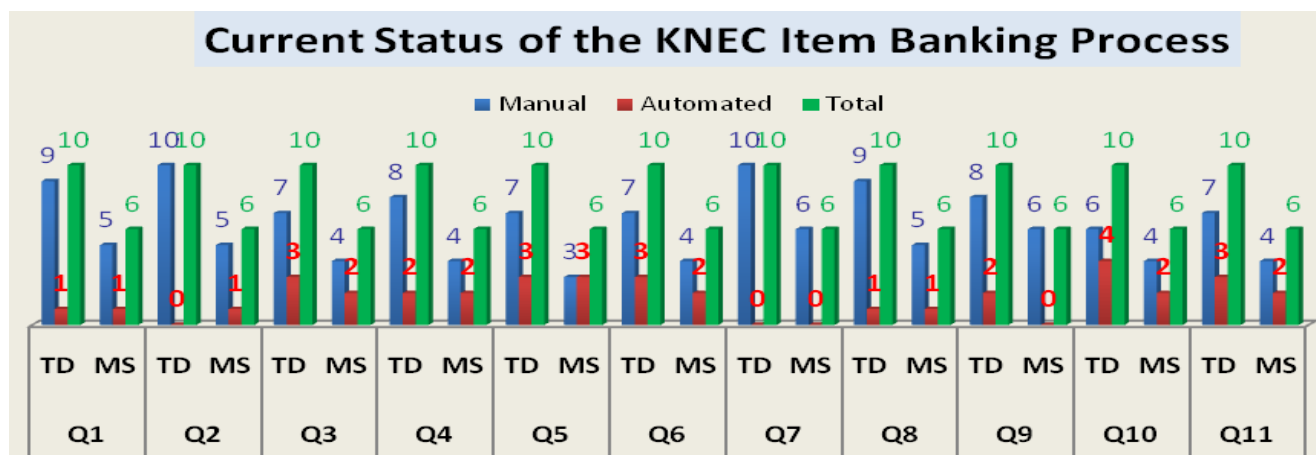
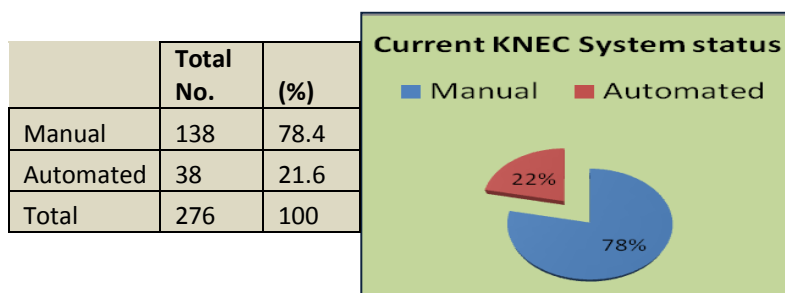


Figure 31: Participant responses on the current item development and banking process in KNEC



The feedback above show the status of the current item banking process at KNEC. From the results, it is clear that the process 78% of the current item writing and banking is manual with a small percentage of 22 automated. This is evident that the current system is very manual and in reference to the challenges that were highlighted, automation of the system was a great success to provide the end user requirements and quality testing.

C. KNOWLEDGE OF TEST THEORIES

Participant’s Responses on the level of Knowledge and application of the test theories (CTT & IRT).

TEST THEORIES (CTT&IRT)	Q12		Q13		Q14		Q15		Q16		Q17		Q18		TOTAL	
	T D	M S	T D	M S	T D	M S	T D	M S	T D	M S	T D	M S	T D	M S	%TENS	%
Above Average-IRT	3	2	2	2	1	1	3	2	2	1	3	2	6	3	3	29.5
Average-IRT & CTT	5	3	5	3	6	3	5	3	5	3	6	3	3	2	5	49.1
Below Average-NONE	2	1	3	1	3	2	2	1	3	2	1	1	1	1	2	21.4
Total	10	6	10	6	10	6	10	6	10	6	10	6	10	6	10	100%

TEST THEORIES (CTT&IRT)	Q12		Q13		Q14		Q15		Q16		Q17		Q18		Total (%)
	TD	MS	TD	MS	TD	MS	TD	MS	TD	MS	TD	MS	TD	MS	
Above Average-IRT (%)	30	33	20	33	10	17	30	33	20	17	30	33	60	50	29.5
Average-IRT & CTT (%)	50	50	50	50	60	50	50	50	50	50	60	50	30	33	49.1
Below Average (%)	20	17	30	17	30	33	20	17	30	33	10	17	10	17	21.4
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100%

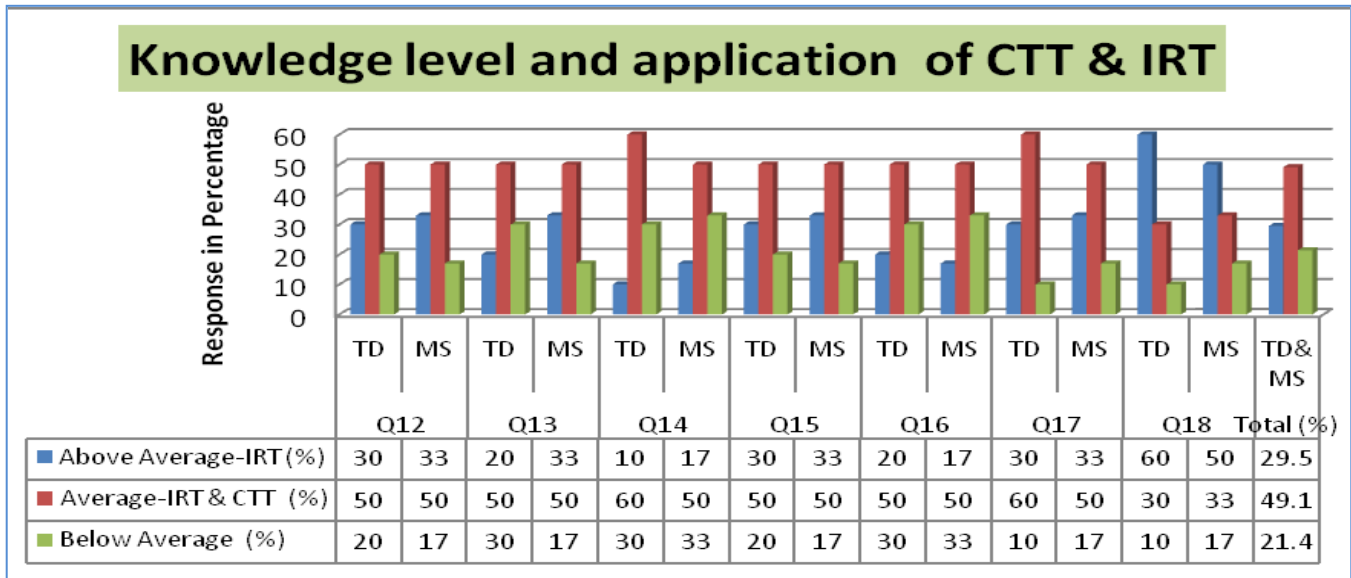


Figure 32: Knowledge level and application of CTT & IRT

Above are the results on how participants responded to the questionnaire on the Knowledge level of test theories and the application of these theories. From the results as presented, 49% of the officers sampled have average knowledge on the item response theory (IRT) and the classical test theory of testing (CTT). Some of the questions were purely on the knowledge of IRT and the feedback was good

from the results since 29% of the officers were above average. The resulting 21.4% of below average response was mainly due to the fact that most of the officers are not directly involved in test development especially the Manuscript secretaries.

These results indicate that the implementation of item response theory was a great idea since most of the people have adequate knowledge to apply the test theory during item development and even analysis of pre- tested data.

D. ICT INFRASTRUCTURE AND SECURITY

Participant’s Responses on the level availability of ICT infrastructure and security.

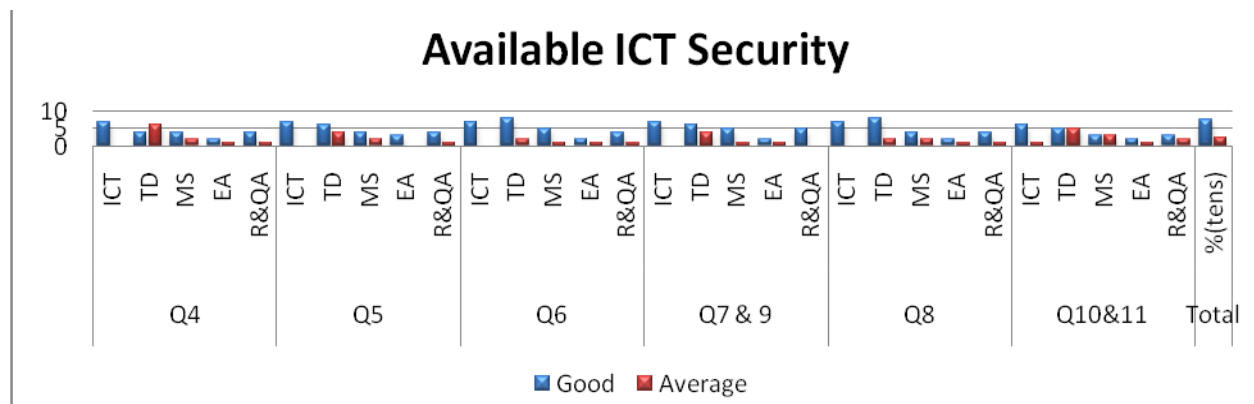


Figure 33: Level availability of ICT infrastructure and security

The ICT infrastructure and security are good from the evaluation of the results. This is important since the success of the project implementation depends on the good infrastructure.

6.2. Structured interview feedback and recommendation:

1. The system is user friendly
2. System users who are mainly teachers are ready to use the system
3. The available ICT security and infrastructure is good enough to begin the system implementation.
4. The system is generally suitable for item writing and development.
5. The system is the most preferred to the current item banking system by KNEC.

The system should be implemented by the Kenya National examinations council to allow all teachers to participate in the item development activity.

7. DISCUSSION AND CONCLUSION

An Item Bank is a key component for organizations that are authoring and maintaining their own test items. The item bank database stores all of the statistical attributes of the item, as well as its performance within tests, and the history of its development. With the results from system testing and evaluation, the need to implement the online item development and banking system was evidence. The item bank is integration with the test delivery tool then it can also be used to dynamically produce Web based tests.

Tests include too many questions measuring only knowledge of facts. One of the most common complaints from students is that the test content did not reflect the material discussed in class or what the professor seemed to indicate was most important. This may happen because knowledge questions are the easiest to write. This system provides an Item Response Theory approach that rigorously establishes the validity, reliability, credibility and the statistical value of a single test item by implementing a detailed item development process to ensure the desired content and quality. Unlike other available item banking systems or software, this system was tailor made for the Kenya National Examinations Council and could easily be integrated with other existing examination processes systems and therefore, enhancing technological integration in all processes.

The system allows all teachers from all counties to participate in this process of item writing and this will go along improving the quality of testing even in schools, generate enough items and hence ensure repeat of questions is not done.

System Maintenance: The system successful testing was a great achievement for implementation to the intended users. Like any other system, during the period that the system shall be in use, constant maintenance shall be required to ensure that it remains relevant. It is during this period that upgrading and modifications can be done after evaluation from time to time.

7.1. Further recommendations

The security management module: An emphasis on implementing more security feature and other modules for subject officer processes would be a great achievement. The online item development and banking system can be modified to include online testing which could reduce exam malpractices as well as examination processing time.

Testing item writers after induction test: Although the induction material is sufficient to the teachers who are willing to undertake the training online, a simple test after every unit would be of great help to emphasize and ensure they acquire these skills.

Item Moderators module: The developed system has only achieved the scope of the research study. However, the development of other related modules especially the item moderation module should be fully accomplished.

Item writer's restriction to view their items after submitting: It is important to note that after submission of developed items, viewing these items may subject them to unauthorized individuals or encourage the item writers to authorize revision before they are tested. Although testing such items takes a long period to be administered as tests, they may be abused.

7.2. Limitations of the research:

This research was limited to only multiple choice questions. Secondly, the application of the item response theory of testing should be implemented during analysis of the pre- test scores to establish the item difficulty and discrimination index for further item validation.

Only sample data was used due to the confidentiality of the research area and therefore, there is need to acquire the accurate information especially the teachers' archive data.

7.3. Recommendations for the research and practice

This research has been carried out well by acquiring all necessary information from previous findings. From the available analysed results, this is a real research problem that needs to be addressed and therefore, these research findings should be implemented to enable practise and application by the various stakeholders.

Related work shows that the practice has been welcomed with tremendous advantages and with the need to embrace the 21st century skills, this research findings and online development and banking system should be implemented.

According to Nenty (1998), though the CTT has sustained educational measurement for almost a century now, Item Response Theory has arrived on time to take us to the next century of educational measurement with bright hopes and an exciting future. IRT does not hold for data from any test, but for data on items constructed to meet its stringent assumptions.

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9. APPENDICES

9.1. APPENDIX A- Interview transcription

KNEC CURRENT ITEM BANKING SYSTEM THREE PARTS INTERVIEW GUIDE

Part I: *Bio Data (General Information)*

Part II: *Establish gaps in the current Item banking system and processes.*

Part III: *Investigate the readiness for the proposed item banking system and ICT infrastructure.*

BIO DATA -Please tick as appropriately.

- 1) Please specify your gender
- | | |
|--------|-----|
| Male | [] |
| Female | [] |
- 2) Please specify your age?
- | | |
|----------------|-----|
| a. 20-30 years | [] |
| b. 31-40 years | [] |
| c. 41-50 years | [] |
| d. 51-60 years | [] |
- 3) What is your highest level of education?
- | | |
|----------------------------|-----|
| a. Certificate | [] |
| b. Diploma | [] |
| c. Undergraduate | [] |
| d. Masters | [] |
| e. Others (Please Specify) | [] |
- 4) Under which department are you in the organization?
- | | | |
|---|-----|-----------------------------------|
| a. Test Development | [] | } Answer Part II & III |
| b. Manuscript | [] | |
| c. Research | [] | } Answer Part III ONLY |
| d. Information and Communication Technology | [] | |
| e. Examination Administration | [] | |

PART II: FOR SUBJECT OFFICERS AND MANUSCRIPT SECRETARIES ONLY

2.1. Specific Objective: *Current item development process manual or automated?*

1. *How are item writers (setters) and moderators recruited for item writing workshops?*

- Online application (website)
- Public announcement (Newspaper Advertisement/ Television)
- Circulars to schools requesting the heads
- Head hunting

2. *How are items generated?*

- Manually
- Using a computer
- Using an item banking system
- All of the above methods

3. *How are the items generated stored?*

- In a bank
- As a paper pool
- In a computer
- In a server.
- Online

4. How do you store test papers with their grids?

- Test papers alone
- Test Papers with keys
- Test papers with item characteristics
- Test papers with a marking guide

5. Do you have an item banking software and if yes, is it used?

.....

6. In what format are your items stored and retrieved in the item bank/ item pool?

- Content areas
- Individual Items
- Complete sets of test
- None

7. How do you determine the candidates for pretest?

- By estimation
- By sampling
- Other (Specify.....)

8. Which type of test items are trail – tested in KNEC?

- Essay
- Multiple choice (MCQ's)
- Structured essay
- None of the above

9. *What do you do with bad items?*

- Discard them
- Moderate (Revise) them
- Store them in item pool

10. *What software do you use to analyze items?*

.....

11. *Give a brief on challenges faced during; item writing, moderation, pretesting, scoring, analyzing, banking and selection process. Suggest possible solutions.*

Challenges;.....

Suggested solutions.....

2.2. Specific Objective: knowledge and application of test theories
--

12. *Which of the following theories of testing are you aware of?*

- Classical Test Theory (CTT)
- Item Response Theory (IRT)
- Not aware of any

13. *What is the medium of application of CTT and IRT in KNEC?*

- Software
- Manual

14. *Which of the following theory (ies) do you apply for item selection and item banking?*

- Classical Test Theory (CTT)
- Item Response Theory (IRT)
- Not aware of any

15. At what level do you use Classical Test Theory and/ Item Response Theory? In Item....

	Writing	Moderation	Analysis	None
a) Classical Test Theory (CTT)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b) Item Response Theory (IRT)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

16. How do you ensure that test items are not biased?

.....

17. How do you ensure that test items measure a particular objective and skill in each subject?

.....

18. In coming up with an Item banking system for managing the test items, what features would you like to see included

.....

PART III: FOR ALL RESPONDENTS

3.1. Specific Objective: knowledge and application of ICT in readiness to item banking

1. What is your computer competence level?

High

Moderate

Low

Nil

2. Which of the following computer applications softwares are you familiar with?

Word Processing;

Microsoft Word

WordPerfect

OpenOffice Writer

WordPad

Corel

Other Specify.....

Spreadsheet;

- Microsoft Excel
- LibreOffice Calc
- Lotus
- Ability Office
- PlanMaker
- Gnumeric
- Other Specify.....

Database management systems;

- MS- Access
- Database Management Library
- FileMaker Pro
- Microsoft Access
- Microsoft SQL Server
- Oracle
- Other Specify.....
- MS -Publisher
- Adobe InDesign
- Adobe PageMaker
- Adobe HomePublisher
- Corel Ventura
- Microsoft Office Publisher
- OpenOffice.org / LibreOffice
- Other Specify.....

3. Do you have an email address? If YES, how often do you access it?

- Daily
- Twice a week
- Monthly
- Not at all

3.2. Specific Objective: Security and availability of system infrastructure

4. How do you prevent unauthorized access to your computer resources?

- Password
- Firewalls
- Physical security
- Data encryption
- All the above

5. What type of computer network exists in your organization?

- Local Area Network (LAN)
- Wide Area Network (WAN)
- Metropolitan Area Network (MAN)
- None of the above

6. What is your perception or suggestion on the need for a reliable power supply?

- An alternative source of power
- Requirement for uninterruptible power supply (UPS)
- All of the above
- Other, Specify.....

7. How often do you receive training on ICT to be able to keep a breast with the new technologies?

- Yearly
- Monthly
- When need arises
- Not at all

8. *Do you back up your data? If YES, how do you back up your data?*

Using External hard disk

On the server

On my computer

All of the above.

I do not back up data.

9. On average, how can you rate your contracted professionals' ability to use internet?

Excellent

Good

Average

poor

10. *What challenges do you encounter while using the current available online systems in KNEC?*

11. *Suggest possible solutions or measures for the highlighted online systems challenges above.*

END

9.2. APPENDIX B- Structured Interviewing- System testing goals



The Kenya National Examinations Council

Online item Development and Banking acceptance testing feedback

Sample teachers were able to interact with the developed system and had the following general observation about the online item development module of the system guided by the following system goals;

9.2.1. System testing goals and feedback

1. The user friendliness of the system:

- i. The Online system is available anywhere, any time for all teachers to register and proceed with item development after successful verification.
- ii. The log in process is user friendly with tailor made interfaces that the teachers are able to interact and input the required information accurately.
- iii. The system is very user friendly since most of the information about the teachers is readily available and only require updating accordingly.
- iv. The induction materials are easily available with all the required information and teachers will not only use the training for item writing to the Kenya National Examination Council but also for their day to day assessment enhancing their skills for quality assessment.
- v. The Table of specification is inbuilt in the system making the item development process very accurate, efficient and well guided to develop quality test items. The focus is on each item and therefore, a rigorous validation will end up with very good items acceptable even after moderation for banking.

2. Establish gaps in the current Item banking system and processes.

- i. The current item banking system has been very manual and allowed only a few teachers identified by test developers to participate in the item development activity.
- ii. The current system offered training to a few in a workshop environment and therefore, it was not sufficient to gather all the required skills from the training.
- iii. The current system was test based and therefore, prone to item bias since there was a generalized observation of the developed items especially after pre testing and analyzing the testing results. This is why the classical test theory (CTT) was the preferred mode of testing but with the focus on each single item developed, the most accurate mode of testing also referred to as the superior to CTT, Item response theory is applicable resulting to more quality testing and assessment.

3. Investigate the readiness for the proposed item banking system and ICT infrastructure.

- i. It was evident that most of the teachers were willing to use the system with some saying that it was long overdue.
- ii. Some teachers lacked basic computer skills and although the system is very user friendly, they proposed to be taught on computer basics within the institutions and online.
- iii. The available infrastructure was good to implement the system with suggested improvements especially acquiring computer resources and network connection in most of the institutions. Although many would do the item development and training in their houses and cyber, they would prefer doing it in staffrooms during break or free times.
- iv. More training and teacher capacity building was suggested adding that the already trained teachers sampled would be trainers of trainers in their institutions and regions.

4. Whether the system is generally suitable for item writing and development.

- i. The Online system is was preferred and suitable for online item development since this would lead to more items developed and as well, more quality items banked after pre- testing.
- ii. It was suggested that a module for online test item selection to generate examination papers would be a good idea in the future.

5. Whether the system was preferred to the current item banking system by KNEC.

- i. The Online system was more preferred from the results compared to the current item banking system in the Kenya National Examinations Council.
- ii. The system was therefore voted for implementation as soon as possible and be used for online item development and banking.
- iii. It was suggested that creating awareness to all teachers through all kinds of medium would be a great idea to do another pilot before full implementation.

9.3. APPENDIX C- System manual



Online item Development and Banking User manual

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1.0. Item Writing HOME Page

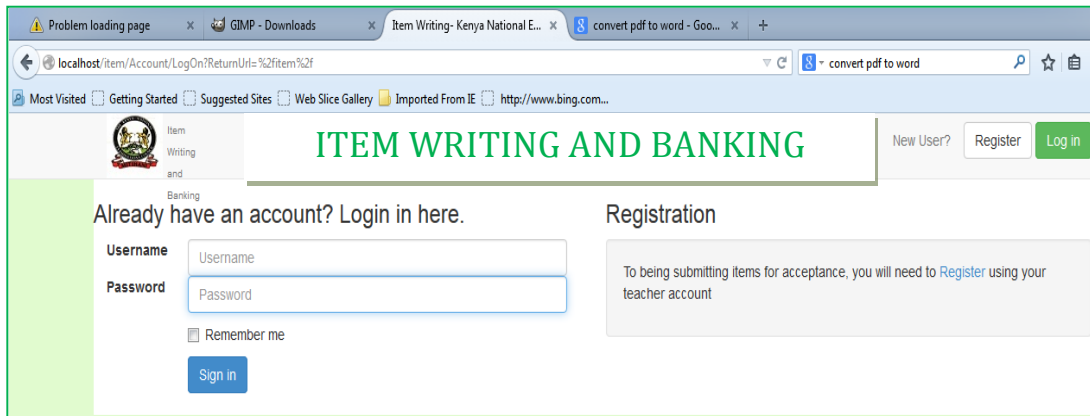


Figure 1

1.1. Login into the System:

1. Registered Teachers can log into the item development and banking system while those who have not registered, to register online by providing the required details
2. The system verifies submitted details especially the TSC Numbers and employment history.

1.2. Teacher Registration process

1. The following interface shall be visible for the teachers to register into the item writing portal by providing the required details.
 - a. Enter Email address
 - b. Enter TSC Number
 - c. Enter preferred password
 - d. Enter the password again to confirm
 - e. Click the register button to register.
2. The details provided shall be verified by the system using the TSC data on registered teachers.
3. Feedback shall be send through the email provided by the user on the status of the registration.

4. It is after successful registration that the teacher proceeds to provide more information on bio data and employment history.

New User? Register Log in

Registration

To being submitting items for acceptance, you will need to Register using your teacher account

Banking

Register Here

TSC number
Your TSC number will be as your username

Email
We shall use your email to communicate to you.

Password
Passwords should be at least 6 characters in length.

Confirm password above

Register

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Figure 2

5. Login using the TSC number and the password created to proceed with the registration.

1.3. Online registered teacher log in page

Teachers who have registered successfully online will be able to log into the system by entering the acquired credentials; user name and password. This is send as feedback through the email provided by the teacher during registration.

Item Writing and Banking

New User? Register Log in

Already have an account? Login in here.

Username

Password

Remember me

Sign in

Registration

To being submitting items for acceptance, you will need to Register using your teacher account

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Figure 3

1.4. Updating teacher records

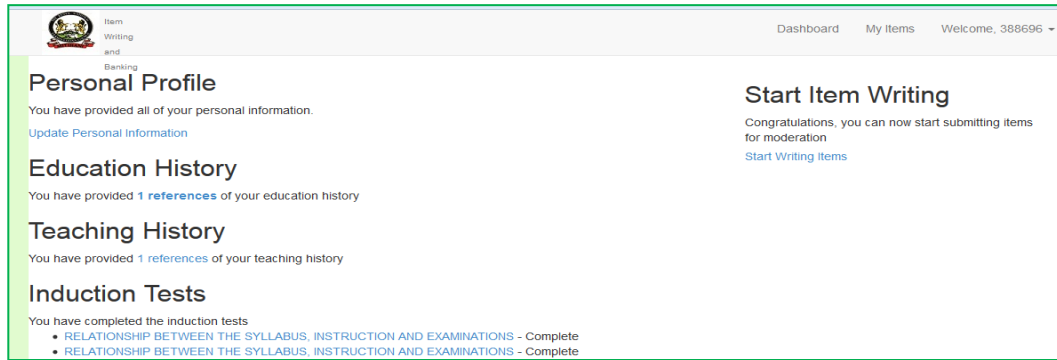


Figure 4

Process:

1. Update personal details that include; Personal Profile, Education History and teaching history accordingly. Existing details or wrong entry can be edited as it will be shown at different levels.
2. Details entered will be verified with existing records for the users to proceed with the next step. Correct details **MUST** be entered therefore.
3. Log into the system and access induction materials online.
4. Start item writing after signing and submitting a contract with KNEC.

1.4.1. Updating Personal details:

Click the update personal information link to generate the following page. Enter the missing details to update the information. Update will be done after correcting and clicking update Bio data button.

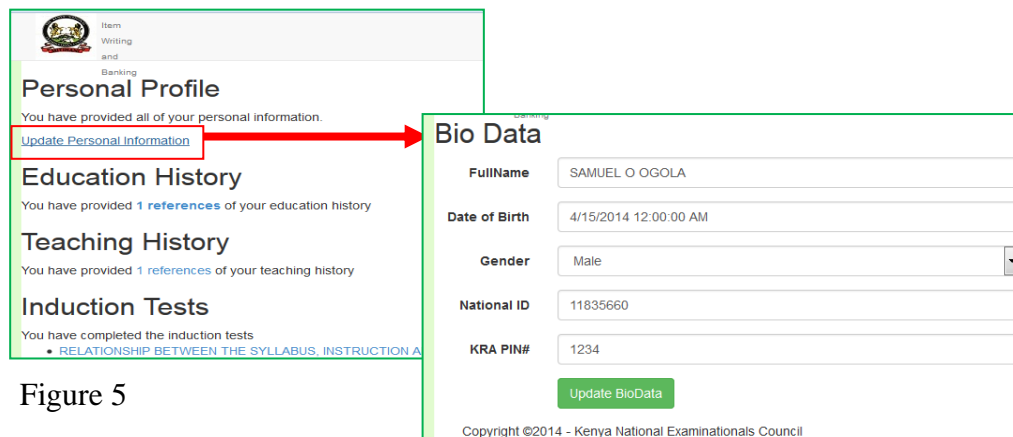


Figure 5

1.4.2. Updating Education details:

This are details on the academic status where the user provides information on their acheivement in education. They include, certificate courses, Diploma, degree, Undergraduate, Masters, PHD and other relevant professional courses.

The system allows the user to select and where selecting information is not available, the Other Button is used to enable input of information.

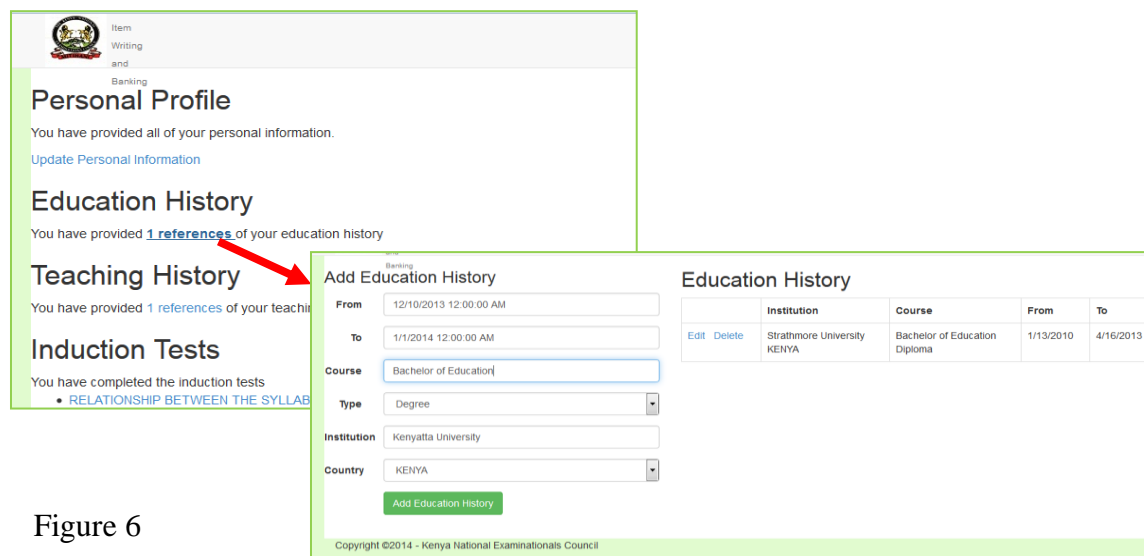


Figure 6

Under the teaching details interface, the user will give their employment history from the original appointment and station to the current posting. Other details include information on county, school name, responsibilities and subjects the user has been teaching.

Under responsibilities, the user gives details on any kind of contractual relationship with KNEC that include; setters, moderators, supervisor, examiner and many more. This is very important to enable segregation of duties in enhancing security and integrity. Selecting the county filters only the schools under that county. This enables validation of schools with similar mames which is common in different counties. *See the figure below*

Item Writing and

Teaching History

	SCHOOL	RESPONSIBILITY	SUBJECT AREA	DATE FROM	DATE TO
Edit Delete	SACHO BOYS BARINGO	HOD	LANGUAGES	1/1/0001	1/1/0001

Add Teaching Experience

CountyId: MACHAKOS SchoolName: Machakos Boys

Responsibility: Head Teacher

Responsibilities

SubjectAreas HUMANITIES AND SOCIAL STUDIES
 LANGUAGES
 MATHS AND SCIENCES
 TECHNICAL

FromDate: 1/1/2008 12:00:00 AM ToDate: 1/1/2009 12:00:00 AM

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Figure 7

Process:

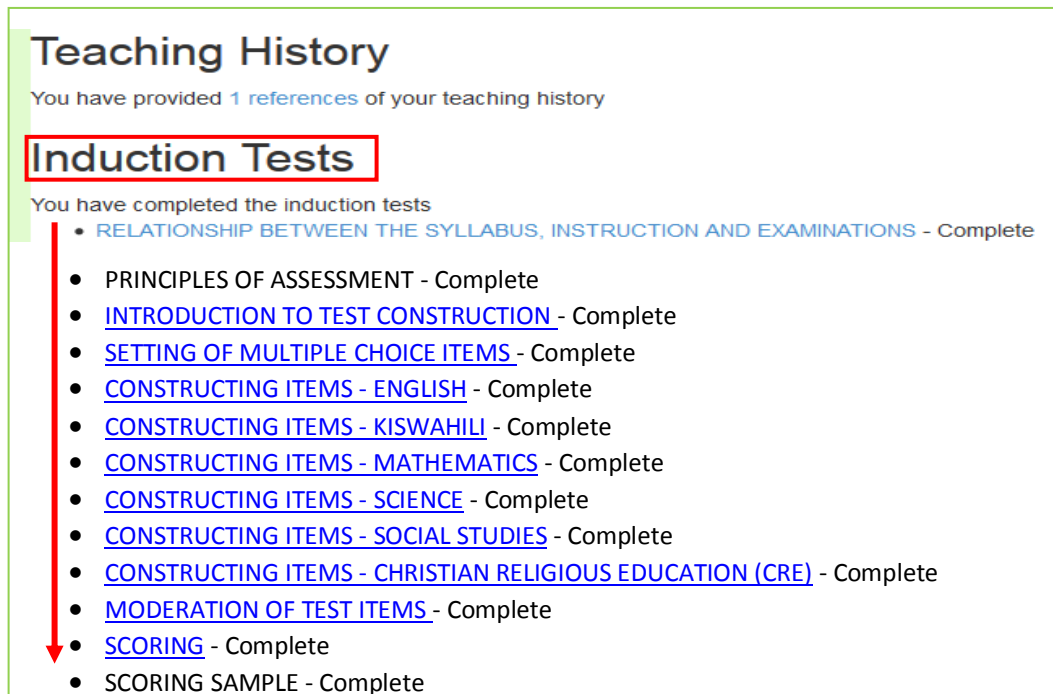
1. Select the County within where the institution is located.
2. Select the school or institution.
3. Enter teacher responsibility or assigned duty in the institution.
4. Select the subject area (This is grouped to represent several subjects)
5. Enter the period of time worked in each selected institution.
6. Keep selecting more institutions and saving to capture them all.

2.0. Accessing induction materials online

Induction materials are accessible online to the teachers who have registered online. This materials are accessible and downloadable sequentially, a unit after another.

After successful training, the user MUST accept by checking the available checkbox that they have successfully completed the unit and submit the same to proceed with the next unit.

2.1. Induction materials available



The screenshot shows a user interface for 'Teaching History'. At the top, it says 'You have provided 1 references of your teaching history'. Below this, the 'Induction Tests' section is highlighted with a red box. It states 'You have completed the induction tests' and lists 14 units, each followed by '- Complete'. A red arrow points to the 'SCORING' unit in the list.

Teaching History
You have provided 1 references of your teaching history

Induction Tests
You have completed the induction tests

- [RELATIONSHIP BETWEEN THE SYLLABUS, INSTRUCTION AND EXAMINATIONS](#) - Complete
- PRINCIPLES OF ASSESSMENT - Complete
- [INTRODUCTION TO TEST CONSTRUCTION](#) - Complete
- [SETTING OF MULTIPLE CHOICE ITEMS](#) - Complete
- [CONSTRUCTING ITEMS - ENGLISH](#) - Complete
- [CONSTRUCTING ITEMS - KISWAHILI](#) - Complete
- [CONSTRUCTING ITEMS - MATHEMATICS](#) - Complete
- [CONSTRUCTING ITEMS - SCIENCE](#) - Complete
- [CONSTRUCTING ITEMS - SOCIAL STUDIES](#) - Complete
- [CONSTRUCTING ITEMS - CHRISTIAN RELIGIOUS EDUCATION \(CRE\)](#) - Complete
- [MODERATION OF TEST ITEMS](#) - Complete
- [SCORING](#) - Complete
- SCORING SAMPLE - Complete

Figure 8

Process:

1. Click induction material under the Induction Tests Button
2. Select the units sequentially.
3. Accept and submit that you have finished and understood a unit after the other.
This is done by clicking on the check box for all the units.

3.0. Writing items

The process of item writing involves generating questions (stems) and options (answers) for specific subjects with the guidance of the specific table of specification (TOS). To generate quality items, registered teachers must read and follow the online induction test accordingly. The items set are therefore moderated to ensure they have the deemed content and statistical value.

This is a rigorous process that involves moderators and subject officers with different panels constituted to establish and approve quality items. Below is a screen short of the process of item writing using mathematics as the subject from label 1-7.

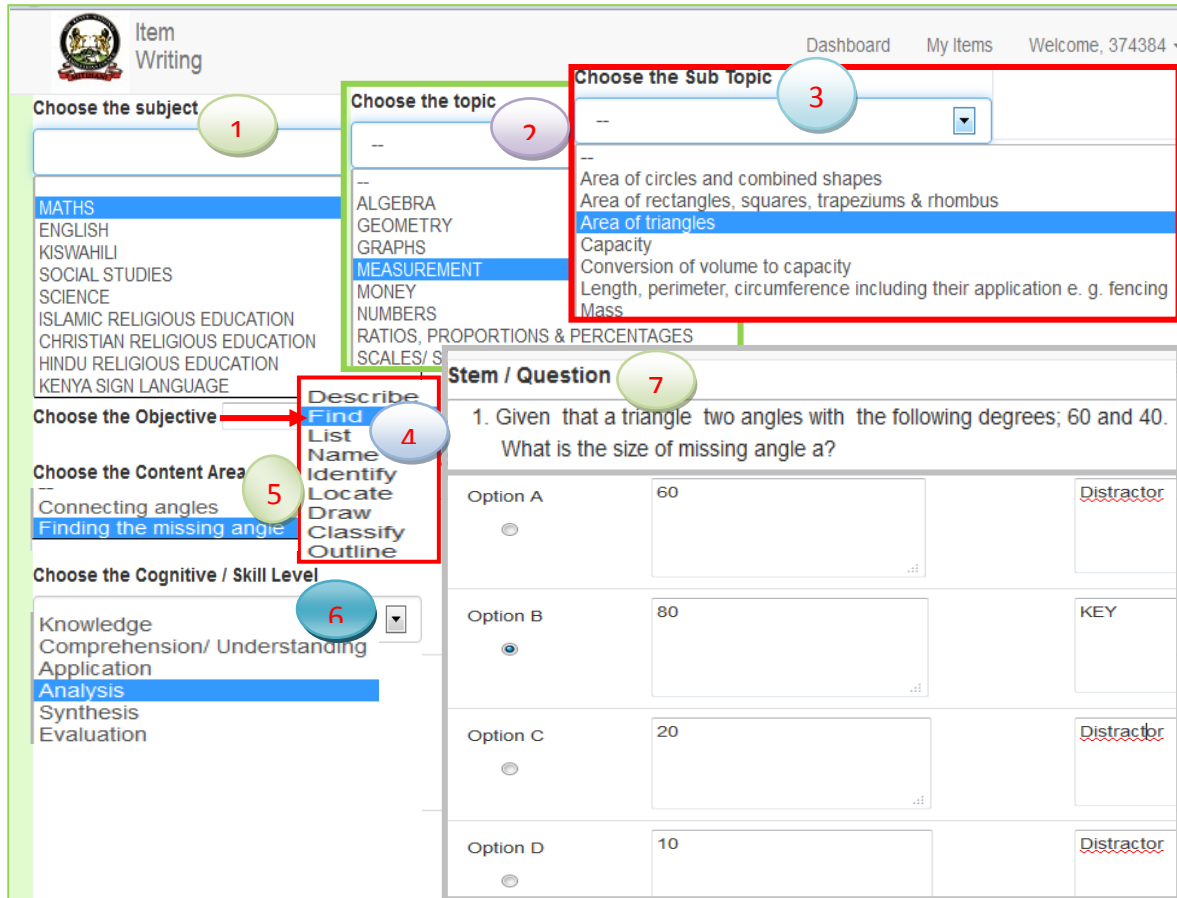


Figure 9

Process:

1. Select the subject
2. Choose the topic
3. Choose the subtopic
4. Select the objective
5. Choose the content area
6. Choose the Taxonomy, cognitive or skill level
7. Start writing the item stem (question) followed by the options (choices)
8. Select the correct answer by clicking the radio button.
9. Post or submit the developed test items.

END