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Creating a Database for Test Items in National Examinations *(pp. 162-178)*

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Abstract
This paper looks at how to generate questions for national and local examinations without putting such questions (Items) at risk of leakage; reduce cost and time taken for such activities like time consuming items analysis and moderation; and improve on the poor selection which often characterized manually generated questions. These problems raise doubt on the credibility of examinations and the innocent students who use such certificates are at the receiving end. The fundamental focus in this piece, is on how to use Database Management System (DBMS) to store questions produced during 'Items Generation' for easy selection of questions, good discrimination index, high security provision, good item-difficulty stratification, easy item analysis, a good retrieval system, specification for hardware requirement and software acquisition options.

Introduction

Database Management Systems (DBMS):

Database systems are designed to manage large bodies of information in an organization. According to SilberSchatz (2002) "Management of data as a process involved both defining the structure for storage of information and provided mechanism for manipulating the information".

Information is very important to the success of any organization and it is an asset which must be protected. Data management techniques such as read-only status, password protected database, data encryption and decryption, data warehousing, routine data backup, Secure Socket Layer (SSL) site

certification, firewall protected data, data redundancy and consistency checks and integrity checks are methods developed to protect the reliability and integrity of data in database management systems. Database systems must therefore ensure the safety of information stored, despite system failure, attempt at unauthorized access and other human frailty. The data in the database systems are primarily for the purpose of sharing among the several contending users, therefore, unauthorized update or arbitrary change in the data or the structures that hold the data must be prevented.

Historical Antecedents:
Prior to using database management systems, computer data processing was basically file processing system. The technique was supported by conventional operating systems but was fraught with a lot of problems. Some of these problems are:

Data Redundancy and Inconsistency: The activity of creating files was vested on computer programmers and the labour turnover of programming staff was usually very high. The implication of this is a situation where different programmers create files and application programs over a long period. The various files are likely to have different formats and the programs may be written in different programming languages. This duplicity of efforts creates confusion in file management. Further, the process creates redundancy of data and unilaterally increase storage requirement for data. In addition, various copies of the same data may no longer agree, such data inconsistency are not tolerated for critical activities like examination items coding, generation and recording of raw scores.

Access Problems: Accessing data in file processing system can be very difficult. The design is very rigid and may not allow a different view of the data because the design does not envisage that usage. Therefore, the design does not allow needed data to be retrieved in a convenient and efficient manner.

Data Isolation: The data are scattered in various files which may have different formats. Hence, writing a computer program to retrieve the appropriate data is difficult.

Integrity problems: The data values stored in the database must satisfy certain types of consistency constraints. In file processing method, these

constraints are enforced through programming. When new constraints are required due to changes in specification, such changes are difficult to enforce.

Atomicity problems: It is very crucial that if a failure occurs, that data should be restored to the consistent state that existed prior to the failure. It is difficult to ensure atomicity in the file processing system.

Concurrency problems: Database system allows multiple access and update of data simultaneously without degrading the performance of the system. Conventional file processing may result in inconsistent data.

Security problems: Data security is very important in test items storage. Since subject officers are concerned with their respective subjects which imply that not every user of the database system should be able to access all the data. File system will find it difficult to enforce these security constraints since application programs are added in ad hoc manner. These listed shortcomings of file processing method make it unsuitable for items banking.

Analysis of the Current Situation:

The common method of items selection and banking is manual which is laden with a lot of difficulties and security problems. In the course of this paper, the writer conducted interviews with staffers of West African Examination Council (WAEC), National Examinations Council (NECO), National Business and Technical Examinations Board (NABTEB) and Joint Admission and Matriculation Board (JAMB), all from Nigeria and the respondents' views are summarized below:

I. Examination bodies spent a lot of money during item generation. The process which involves collation of questions from examiners and test officers; testing of items; and selection of items. Honorariums are paid to these categories of people and officials from the examination bodies. Costs are also incurred for stationeries, hotel accommodation, logistics and other sundry activities.

II. Selection of test items is done manually and lacking in precision. It is difficult because the items pass through the process of stratification by difficulty level, discrimination index for multiple choice items, year the item was developed, topic section, and test

validity. In addition an item is not expected to be repeated in two consecutive examinations.

III. The process of doing the activities manually poses a lot of security risks. Human interaction with these items (live questions) raises doubt on the absolute confidentiality of the document. One of the respondents went further to state a case of an official who was caught in the act of selling the questions. The official concerned may have been dismissed from service but the dent on the examination body remains.

IV. The collation of questions or items is usually by typesetting from the item cards. This process has been found to be vulnerable, unreliable and irregularity prone. With advancement in Information and Communications Technologies (ICT), it is a possibility for fraud minded official to store items in mobile phone with memory cards or Personal Digital Assistant (PDA) which could be transmitted through mobile Small Message Service (SMS), email or email briefcase to outside typesetting hall. Any PDA with Universal Serial Bus (USB) and wireless fidelity (wifi) facilities can facilitate data transmission to outside world.

V. The study also revealed some practices that fell short of data management standard expected of such sensitive data. Items were kept in cartons in some of the organizations. These cartons tend to degenerate over time, rodents and cockroaches turn them to their natural habitats. These views expressed by the respondents are weighty and requiring urgent attention of the stakeholders in educational system.

Methodology

In the research work carried out jointly by Ruslan Mitkov and Le An Ha( ) of School of Humanities, Languages and Social Sciences University of Wolverhampton, it was concluded on multiple choice questions by saying that "the construction of multiple-choice test items with the help of computer program is much more effective than purely manual construction. We believe that this is the main advantage of the proposed methodology. As an illustration, the development of a test databank of considerable size consisting of 1000 items would require 30 hours of human input when using computer program, and 115 hours if done manually. This has direct financial implications as the time and cost in developing test items would be dramatically cut. This writer was highly influenced by the result of the above

research. As an insider in a national examination body, I feel touched and eager to find a lasting solution to the perennial problems of examination administration in Nigeria in particular and how best this can help local and national examination bodies in Africa in general. This led to this paper.

Item Analysis

A given item may be considered as acceptable if it meets some standard widely acknowledge in test development. These are difficulty level and discriminatory index. These indices can be obtained during trial testing in different locations from stratified population of very good, good and poor schools. When the items are established as suitable for the examination then, appropriate coding can be done to be included in the item database.

Analysis of Distractors:

The distractors in multiple choice tests should be as semantically close to the correct answer as possible to ascertain the level of understanding of the examinees on the question. Semantically close distractors are more plausible and therefore better at distinguishing good, confident students from poor and uncertain ones. A good distractor should attract more students from the lower group than the upper group. A poor distractor attracts more students from the upper than from the lower group. A distractor is not useful if they are selected by no student.

In theory or essay questions, alternative methods of solving problems are explored and provided as alternative answers. This holds except where a given method is specified in the question. For example a solution to a quadratic equation in mathematics may use formula method or completing the square or factorization method. A good marking scheme will award marks based on methodology used, bonus mark for mental answer and accuracy mark for precise answer. The accuracy mark is generally not awarded where the methodology is not established. Methodology often carries over 80% of the total score for a given question and can be awarded without any recourse to the accuracy of the final answer. The alternative method specification is very important in test items banking.

Item Selection

Items considered suitable and acceptable are stored in the database ready for use in any examination. Extraction of the items to be used can be done easily and can be passed on for typesetting in readiness for printing. Collation of items by many people as the case with manual method is eliminated. Incidence of paper leakage is reduced or eliminated at this stage.

Test items for selection are evaluated. They are either considered as worthy or unworthy of inclusion in the item bank. The items considered worthy are either accepted for direct use without any revision or for further post editing before being put into use. Item can be considered as unworthy and discarded. Unworthy items are those that do not focus on the central concept or requiring too much revision and considered rejected. The items for further post editing may require minor, fair or major revision. The revision is minor if action needed is insertion of articles, correction of spellings and punctuation. It is fair if it requires re-ordering, removal of words and replacement of one distractor at most. The revision is a major one if it involves more substantial grammatical revision and replacement of two or more of the distractors.

Development of Computer Based Test Items.

In this section, the paper considers requirement analysis and software specification for computer-based item banking. The discussion will be centred on Database Management Systems (DBMS). According to Silberschatz (2002), he defined DBMS as "a collection of inter-related data and a set of programs to access those data. The primary goal of a database management system is to provide a way to store and retrieve database information in a convenient and efficient manner".

Database Management System (DBMS)

The design of a database involves defining structure for storage of information, providing mechanisms for the manipulation of information and the security of information stored in the computer. Information stored in the database will allow for easy deletion of items that are no longer required, addition of new records and diverse users can also share information.

DBMS encourage centrally controlled data; therefore it gives the advantage of reducing data redundancy, avoiding data inconsistency, applying security restrictions, maintaining the integrity of data in the database and balancing conflicts in user requirements. The components of a database system may include file, records, data view, data structure, tables, forms and queries. (See Figure 1)

Common Terms in Database Management

File: A collection of similar records kept on secondary computer storage devices such as Diskettes, Tapes, Hard disk, DVD, Flash disk, Zip disk etc.

A subject table containing names of subject, topic, section, subject code and others may constitute a file. Therefore the data storage for a database is accomplished by the use of one or more files.

Record: A Collection of related fields containing elemental items like subject code, subject name, date developed, difficulty level, discrimination index may form a set of records.

Field: It is an elemental item of a record e.g. subject code.

Key Field: A field that provides a reference, that is unique for a given record, often used for searching or locating a record or records from the database. A defective key field makes mapping of a question to an answer in a Test Generation Database difficulty.

A database: A collection of mutually related data, Computer hardware that is used to store it and the computer programs used to manipulate it. The data are logically related.

Database Management Systems controls access to the data. Database Management System provides the following functionalities:

1. Concurrent access to data, which means more than one user, can have access to the data simultaneously. This is defined at the external schema level which describes the views of different user groups.
2. Access to records is conducted through a unique key that identifies the record.
3. Recovery from hardware and software errors are carried out through backup and recovery mechanism which are embedded in Data Manipulation Language (DML) at the conceptual schema level.
4. Physical storage management is incorporated into the internal schema of the database. Secure access to data is also provided at this level.

The Database Management System is the software layer between application and stored data.

Characteristics of a Good Database

A good database design should provide for the needs of the user, which implies user's specifications must be met. In addition, the database should be shareable, re-useable, flexible and do not constrain business opportunities for expansion, a new technology and the need for integration. A good database design should have the following attributes:

Flexibility: Changes to the data structure due to changing information requirements should be made with the least amount of effort.

Effectiveness: Easy access to data with minimum efforts.

Efficiency: The Database performs what it was designed to do at the lowest cost. It should require minimum effort to operate.

Reliability: The database should give precision on correctness and integrity of the data by applying relevant integrity rules such as a well tested backup and recovery procedures to guard against accidental data loss.

Shareability: A major advantage of database system is its ability to share data among contending users. It should be able to provide different views to difference users according to their needs and requirement.

Database Management System encourages centrally controlled data, which also has advantages of reducing redundancy of data; avoiding data inconsistency; data sharing by diverse users; applying security restrictions; maintaining the integrity of data in the database and balancing conflicting user requirements.

The goal of achieving high performance at the same time make the database flexible could be quite difficult to achieve. A good optimum performance and a reasonable level of flexibility may be attained.

Test Items Data Structure:
Database is synonymous with a computer based record keeping system, whose overall purpose is to record and maintain information about the subject. A database on items generation and analysis may include such data as Item code, test validity, subject name, facility value, topic section, author, discrimination index, item difficulty index, year of development, item response pattern and item analysis. These are summarized in tables 1&2.

Discussion and Recommendation
Software Selection Options
Test items generation is a specialized area, therefore for a Computer programmer to design and develop software that will automate the process of test items banking; skills in test development, test moderation, item analysis with a good programming practice are desirable. In this section, this paper is putting forward three major options to consider when an institution is confronted with the decision to bank test items electronically.

1. In-house Development: It involves the organization bringing together experts in the above disciplines for the purpose of designing and developing software for item generation and banking. This method can be very cost effective if the skills required for it are available in the organisation. Management support is also very important because the project will demands time and efforts on the part of the software developer. Management will need to commit fund for purchasing programming language software, hardware and other sundry expenses.

2. Commercial off-the-shelf (COTS) Package: There are software houses, which specialize on software development for educational and examination purposes. This option requires the user to have the first hand information on the facilities available in the software before procuring it. Much attention should be paid to the need of the organization; requirement analysis must be carried out to ascertain whether the software meets the needs of the organization. If the software is flexible enough, customization should be carried out to suite the new environment and in line with the examination syllabi. The software company is not under contractual obligation for the use of the software outside those stated in the general software agreement. Therefore, the maintenance of the software and training of personnel to use the software may be arranged locally. Any subsequent update or newer version of the software may be ordered from the company if required. This method may be cheaper because software development team, procurement of language software and other administrative expenses are not required. Some third-party software companies also entertain feedback from users to enrich the contents of their packages. Such new requests could be incorporated into the next version of the product, if the software company has a well managed configuration management policy. The disadvantage here is the rigidity of a third-party software which may not allow for a modification or usage in a different environment for which it is designed. It is also very important that this option should be thoroughly evaluated before recommending it for an organization's critical activity. The stability of the software company must be analyzed to ascertain her continuity and further support for the product.

3. Commissioning an External Consultant: An external consultant in collaboration with key departments can be commissioned to design and

develop software to carry out test item generation and banking. The implementation of this option depends on the contract terms and conditions. The software is usually tailored to specific needs of the organization. In the contract term, adequate provisions should be made for maintenance and training of in-house staff on the technical details of the software. In the case of the consulting firm going under or the project team being disbanded, the software will continue to exist and maintained.

This option involves an organization going through due process of project tender, establishing tender price, tender evaluation, selection for the award of contract, mobilization, project monitoring and commissioning. A good project management practice that will ensure optimum resource management and guarantee that these resources deliver all the work required to complete the project within the scope, quality, time and cost constraints. A project manager is required from the user or client organization, who will determine and implement the exact needs of the organization, based on his knowledge of the organization. The ability of this officer to adapt to the various internal procedures of the contracting party, and to foster close links with the nominating representatives is essential in ensuring that key issues of cost, time, quality and user satisfaction are realized.

Choosing an appropriate option is a function of many variables such as: financial commitment to the project, duration of the project, requisite skills available in the organisation, management commitment and the readiness or willingness of the user department to support the option. Selecting an option in this case depends strongly on the administrative structure on ground in each organization because what works for organization A may not work for organization B.

Computer-Based Item Banking

The items have to be developed by Test Officers, Chief Examiners, and specialists in various subjects. Each of the accepted items are grouped or stratified and coded as specified in the Examination Syllabus. The items are classified into level of difficulty obtained during "tests" for example, Economics could be coded 03 and population can be given code 08. Therefore, to store a test item on population it will attract 0308 additional information such as the date the item was developed, the author and the date it was used can be put into database.

The advantage this method has over the manual is that large volume of items can be generated over a period of time without recourse to when they will be used. The developer does not know when it will be used. The items continue to grow over the years without having exact repetition of items in an examination. The solutions to the items are put in a parallel database with cross-reference when solutions are required. Items so selected are extracted for typesetting which may involve simple copy/move and paste operation of word processing or desktop publishing. The reduction in human intervention in processing provides adequate security for test items.

Storage of Test Items

Storage media for Item Banking depend largely on the volume of data to be stored. Development in storage media in recent time has made this not to be considered a problem. In capacity of most media currently run in hundreds of gigabytes and data compression technology has also made large volume of data to be compressed into a small space. These storage media include.

(a) Hard disk of 120GB or more
(b) Zip disk 100MB, 250 MB
(c) Magnetic tape for sequential storage of data
(d) Compact Disk (CD)
(e) Flash Disk
(f) Floppy Disk etc

Test Security Issue

Security of test items and the computer Hardware in which they reside must be kept securely from deliberate attack. The rules, conventions and procedures governing computer access and user identification provide system security. Other forms of security problem and breaches may come in form of:

i. Criminal activity of leaking questions to candidates by the people entrusted with the responsibilities of generating test items, computer personnel responsible for entering the document into computer.
ii. Malicious damage to computer facilities to cause confusion, settle scores, etc.
iii. Theft of items for material gains by personnel responsible for the administration of tests.

iv. Natural disaster such as earthquake, fire outbreak, thunder storm, lightening etc. may cause security breaches.

A way out of this is a good contingency plan for disaster management and recovery. Copies of the data or items can be kept in vaults or backup to be kept in other ecological zones with different political leanings. The backup should be in a politically stable environment; not prone to political violence and a zone that is not likely to be affected by the same natural hazard like earthquake, flood, hurricane and rainstorm are advised to serve as off-site backup locations.

Protection of Items Databank

Physical access control to item databank should be enforced and restricted to only authorized personnel. The location of the computer may be protected by gates, close circuit television, security personnel and other surveillance measures to prevent intruders from gaining access to the data room. Monitoring of the movement of people around the computer room should be intensified by signing of a log book.

The most dangerous and difficult situation is a scenario where an employee with criminal intent is a computer staff or test officer. In a situation like this, a very senior officer should be assigned to monitor allocation of passwords to users and constantly changing the password. Strict adherence to procedures and rules is important and must be enforced. Data encryption should be encouraged. Third party security software which complies with Secure Socket Layer (SSL) protocol should be acquired to provide a strong firewall on the computer systems.

To prevent loss of data by accident, backup and recovery strategy be put in place on regular basis. When data are lost, recovery routines must be available in the software to restore data from the backups or other mechanisms of the software.

Legislation on Computer Crimes:

An important issue that has not been addressed by most African legislative houses is that of computer crime. A decree or an act of parliament bills on computer crime is overdue in the developing economies. As more data are stored electronically especially those mission critical applications, it is very important to protect the data from computer criminals, who for financial

gains compromise the security and confidentiality of organizations' data. It is often difficult to differentiate genuine computer error or annoying behaviour from criminal intents. The question that comes to mind is what actually constitutes a criminal behaviour?

In 1983, the Organization for Economic cooperation and Development (OECD) defined computer crime and computer related crime as 'any illegal and unethical, or unauthorized behaviour involving automatic data processing and processing and/or transmission of data. In addition to the list of computer crimes proposed by OECD, the select committee of experts on computer related crime of the council of Europe (COE) and the European committee on crimes and problems also came up with a list of computer crimes suitable for international use in 1989. This list was more comprehensive and also overcame some of the deficiencies of the earlier list. Here this paper is proposing an adaptation of this to African environment.

A clear deduction from the above is the definition of a computer fraud as any input alteration, erasure or suppression of computer data or computer programs or other interference with the course of data processing that influences the result of data processing, thereby causing economic or possessor loss of property of another person with the intent of procuring an unlawful economic gain for himself or for another person.

Therefore an organization will need to protect itself from any criminal intent of a bad employee. The criminal neglect of an enabling law on what constitute computer crime makes data processing units a haven of computer crimes.

It is also disheartening to discover that examination bodies shy away from this reality. Usually, any culprit gets his or her appointment terminated hastily to avoid negative publicity or prevent litigation that may drag on for a long time. This leaves a big hole in the exit process that is not transparent. The result of such hasty decision is litigation for wrong termination of appointment which often results in reinstatement of the employee on legal technical ground.

For every adversity there is a lesson to be learnt but this is generally prevented because of the hasty dismissal of the affected employee. The lessons to be learnt may come from the answers to the following questions:

i. What is the cause of the incident?
ii. What is the educational level of the employee?
iii. Any other insider collaborators?
iv. Any previous training on security, safety and document management?
v. Any previous complaint on financial mismanagement by the employee?
vi. What is the recruitment history of the employee?
vii. What is the level of competence on the job?
viii. How are the internal controls of the ICT department organized?
ix. How effective is supervision in the department?
x. What was the employee's reference report at entry point?

These questions will lead to preventing the reoccurrence of such incident in the future.

Conclusion

To survive in a competitive environment as ours, a total overhaul of the structures and processes becomes necessary. The engine that drives such a change is a cutting edge technology. We start looking at how best we can radically change our processes that are not adding values to our stakeholders and customers' needs. Chief executives will be doing a great favour to our examination if the following issues are addressed. These are: malpractice-free examination; reduction in examination irregularities; adequate information on the examinations' time-table; subjects available for examination conspicuously displayed during registration; locations of examination centres readily available; and timely release of results.

Computer will continue to make processes simpler, less cumbersome and make time bound operations more attainable than ever before. There are more to be done in the computerization of Test Items, most especially Item generation and banking. Using manual method exposes these important documents to hazards like paper leakage, poor selection of items, restricted item generation, unavailability of trial testing, and inadequate records for test parameters such as difficulty and discrimination indices. All these make for a good test development, which are lacking in most examination processing bodies in Africa.

This paper has been put together to give a direction on how to develop a database of test items, expatiate common database concepts, states the

qualities of a good database and precaution to safeguard the security of test items. Further, the paper listed software selection options to intimate decision makers on available opportunities for acquiring test items banking software. A word of caution was also put across to avoid the pitfall of hasty decision on employee's dismissal for suspected malpractice and irregularities.

References

Apanainen, P. and Järvinen, T. (1997) "A nonprojective dependency parser". Proceedings of the 5th Conference of Applied Natural Language Processing (ANLP-5), 64-71.

Codd, E. F. (1970). "A Relational Model of Data for Large Shared Data Banks Comm." *ACM 13*, 6, 377-387.

Date, C.J. (1992). *An Introduction to Database System*, Addison-Wesbey.

Dunn, T.F. and Goldstein, L.G. (1959). 'Test Difficulty, Validity and Reliability as Functions of Selective Multiple Choice Item Construction Principle' *Educational and Psychological Measurement, vol.19.*

Fairon, C. (1999). "A Web-based System for Automatic Language Skill Assessment: EVALING".Proceedings of Computer Mediated Language Assessment and Evaluation in Natural Language Processing Workshop.

Fishman D. Etal (1987) "IRIS: An object- oriented Database system." *ACM-TOOLS*, January 1987.

Gronlund, N. (1982) Constructing achievement tests. New York: Prentice-Hall Inc.

Justeson, J. S. and S. L. Katz (1996) "Technical terminology: some linguistic properties and an algorithm for identification in text". Natural Language Engineering, 3, (2), 259-289.

Kies, D. (2003) Modern English Grammar. Online textbook. http://www.papyr.com/hypertextbooks/engl_126/book126.htm

McBulre, S, (August 1997), 'Object Database vs Object Relational Database', *IDC Bulletin* # 14821E.

Silberschatz, Abraham(2002) Database Concepts, 4th ed. McGram Hill, New York.

Wiederhold, Gio (1981). *Database Design*. McGraw Hill.

Figure 1: Database Management System (DBMS)

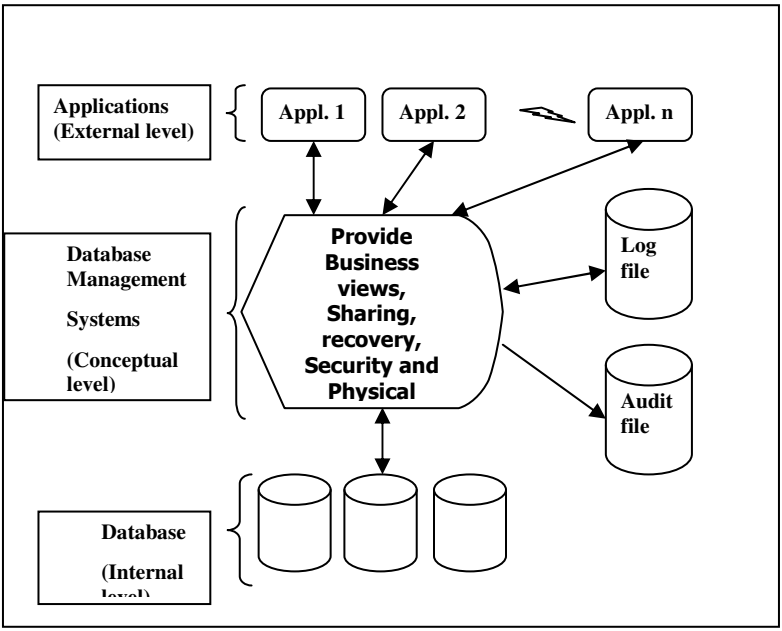

Table 1: Master table

Name	Data type	Field size	Caption	Default value	Required	Indexed
V1	Auto-number	7	Serial number		Y	Y
V2	Number	2	Subject code		Y	Y
V3	Number	2	Section code		Y	Y
V4	Number	1	Item rating 1-v.good; 2-good; 3-fair; 4-poor	2	Y	N
V5	Number	1	Discrimination index rating: 1- v. high; 2-high; 3-low	2	Y	N
V6	Number	1	Difficulty index: - v. high; 2-high; 3-low	2	Y	N
V7	Date	10	Date of item banking	Date captured	Y	Y
V8	Number	1	Item response pattern(during trial testing)- v. high; 2-high; 3-low	2	N	N
V9	Number	1	Moderation tag: 1-yes; 2-no	1	Y	N
V10	Number	1	Test validity tag: 1-yes; 2-no	1	Y	N
V11	Number	1	Test facility value		N	N
V12	Number	1	Usage tag: number of times item was used	0	Y	N
V13	Number	1	Type of question: 1-multiple choice; 2-essay; 3-matching etc		Y	N
V14	Number	1	Item type: 1-question 2-answer		Y	N
V15	Character	30	Name of the author of the item		N	N
V16	Number	1	Status of item: 1-accepted; 2-review; 3-rejected		Y	N

Table 2: Subject reference table.

Name	Data type	Field size	Caption	Default value	Required	Indexed
S1	Number	3	Subject code		Y	Y
S2	Character	30	Subject name		Y	N
S3	Number	3	Subject section code		Y	Y
S4	Character	30	Subject section name		Y	N
S5	Number	3	Subject sub-section code		Y	Y
S6	Character	30	Subject sub-section name		Y	N