

IBANK

Cesar B. Bermundo, Ph.D. PME
Ateneo de Naga University

Alex B. Bermundo, Ph.D. PME
Bicol State College of Applied Sciences and Technology

Rex C. Ballester
Ateneo de Naga University

Abstract

iBank is a project that utilizes a software to create an item Bank that store quality questions, generate test and print exam. The items are from analyze teacher-constructed test questions that provides the basis for discussing test results, by determining why a test item is or not discriminating between the better and poorer students, and by identifying alternative responses that are or are not functioning appropriately, thus, providing a basis for item improvements. More importantly, it determines where additional instruction or remedial work with individual students or the class is necessary by helping teachers determine if they have met instructional objectives in specific content areas and by providing them a check against the table of specifications for balanced objectivity and specificity of a test. The software is user-friendly and compatible with Windows-based software.

The z-test and t-test for the efficiency of the software were both found to be highly significant. The efficiency in terms of time saved for using the software over traditional method of checking and analyzing the items is 90%.

Introduction

Quality education, being a vital link towards the economic progress of the country, is a major thrust of our government. Since it is the educational system that supplies and sustains our country's work force, there is a need to upgrade the quality of education of the professionals and workers to meet the ever-increasing demands of a growing economy that has to be globally competitive.

In view of this goal to deliver quality education in the country, various school districts use standardized tests as a way to measure scholastic achievement. Usually, these districts need to revise tests with some frequency to avoid administering the same test year after year. Unfortunately, creating new tests can be a very time consuming endeavour; not only do test writers/teachers need to compose the test items, they also must determine the Item Analysis of each item in the test, a task that seems monumental to the already burdened teachers, considering the many roles, tasks and responsibilities they need to perform. Constructing a good test for a class, for example, would normally take teachers a lot of time, effort, and energy; a very demanding "input" which many teachers or lecturers cannot afford. As a result, high quality tests cannot be constructed and validated. These tests and items could have been stored and used repeatedly if they had an item bank and if they knew the concepts of item banking and computerized adaptive testing.

Statement of the Problem

The need to create an Item Bank to facilitate formulating test questions that will simplify doing statistical analysis has often been ignored because of the difficulty and complexity of the process. This project is a response to this need, for it has developed software for item bank that will store reliable and validated examination questions accurately and efficiently, and thus, eliminate the difficulty or complexity of the task which burdens most teachers. More specifically, this project attempted to achieve these objectives:

1. To create an ITEM BANK for standard quality items from the Test Questions.
 - a. Entry for single question with simple text
 - b. Entry for single question with figure/s
 - c. Entry for question with group/sub items
 - d. Entry for question with random range values
2. To generate TEST PAPER from ITEM BANK.
 - a. Selecting item/s from search/specific conditions
 - b. Generating test items using Table of Specification
 - c. Saving/Loading Test Questions
 - d. Printing different Sets of Examinations for the same items
3. To use COMPUTER for TEST/EVALUATION.
 - a. Single On-line prepared testing
 - b. Group On-line different Sets of Examination with the same Items
 - c. Random search condition testing
 - d. Review search condition testing
4. To generate ITEM ANALYSIS REPORT.
 - a. Generate item difficulty and item discrimination.
 - b. Analyze distractors.
 - c. Determine the reliability and validity.
 - d. Show the Item Response Theory.
5. To generate STUDENT PERFORMANCE REPORT.
 - a. Determine the student performance level.
 - b. Generate standard scores.
 - c. Indicate Equivalence.
 - d. Show Test Reliability.
6. To Evaluate TEACHERS' PERFORMANCE.
 - a. Determine Class Item Difficulty.
 - b. Determine Class Mean Performance Level.
 - c. Generate Division/School Performance Level per Subject.
 - d. Correlate class performance against the Over All Performance.
7. To generate COMPETENCY REPORT.
 - a. Checking the skills from the Table of Specification.
 - b. Comparing Classes Competency.
 - c. Evaluating Individual Student Competency.
 - d. Generating Sub group and Over All Competency

Importance of the Project

An item bank is a large collection of test questions organized and catalogued like the books in a library. Since normally one would think in terms of item banks with several thousand items, the number of possible tests which could be composed from such a bank is astronomical. It can be a useful way for educational systems to monitor educational achievement. As Rudner (1998) points out, item

banking has major advantages in terms of test development. It is a very time-consuming endeavour for schools to be creating new tests each year.

The idea is that the test user can select test items as required to make up a particular test, either by paper-pencil test or online testing. The great advantage of this system is its flexibility. Tests can be long or short, hard or difficult as well.

Item banking provides substantial savings of time and energy over conventional test development. An item bank is essentially a collection of items stored and used to create new assessments at a later date (Anzaldua, 2002; Bloom, Hastings, and Madaus, 1971; Leclercq, 1980; Nakamura, 2001; Rudner, 1998; Smetherham, 1979; Thorndike, 1971). Item banks have been long used in education.

Test Formulator from Item Banking can create a process that can generate test papers of various suitable test items that are "coded by subject area, instructional level or competency, instructional objective measured, and various pertinent item characteristics (e.g., item difficulty and discriminating power)" (Gronlund, 1998, p. 130).

Simulating new subtests and tests with predictable characteristics is possible with the Item Banking. On-line or computerized exam for individual examinees or groups even on a walk-in basis can be administered simultaneously by drawing items from the bank. One can also use the Item Bank to review on a particular subject/topic. In any case the examinees can be given as much time as they need to finish a given test because no human proctor needs to wait around for them to finish the test.

Nowadays, powerful microcomputers have affected the design of the structure and content of school and university curricula and the entire process of instruction and learning. They also have an impact on the types of tests created and used to assess learning outcomes. In fact, computer-based testing is increasingly viewed as a practical alternative to paper-and-pencil testing (Kingsbury and Houser, 1993). [With the use of this Item Bank and] given the advantages of individual, time-independent language testing, computer-based testing will no doubt prove to be a positive development in assessment practice (Brown, 1997).

This Item Bank, when utilized in tests to assess proficiency, can be used to assist managers in making selection decisions for appointment and for placement in training programs, identifying training and development needs, and counseling for career transitions.

Most importantly, this Item Bank only consists of questions that meet the requirements for questions in standardized and validated tests. Questions contained herein are clear, concise, and complete and are suited to the level and ability of the students. In addition they meet the objectives of the lesson and are formulated by teachers (not copied from textbooks or reference books). The questions are also challenging and do not suggest nor contain the answer.

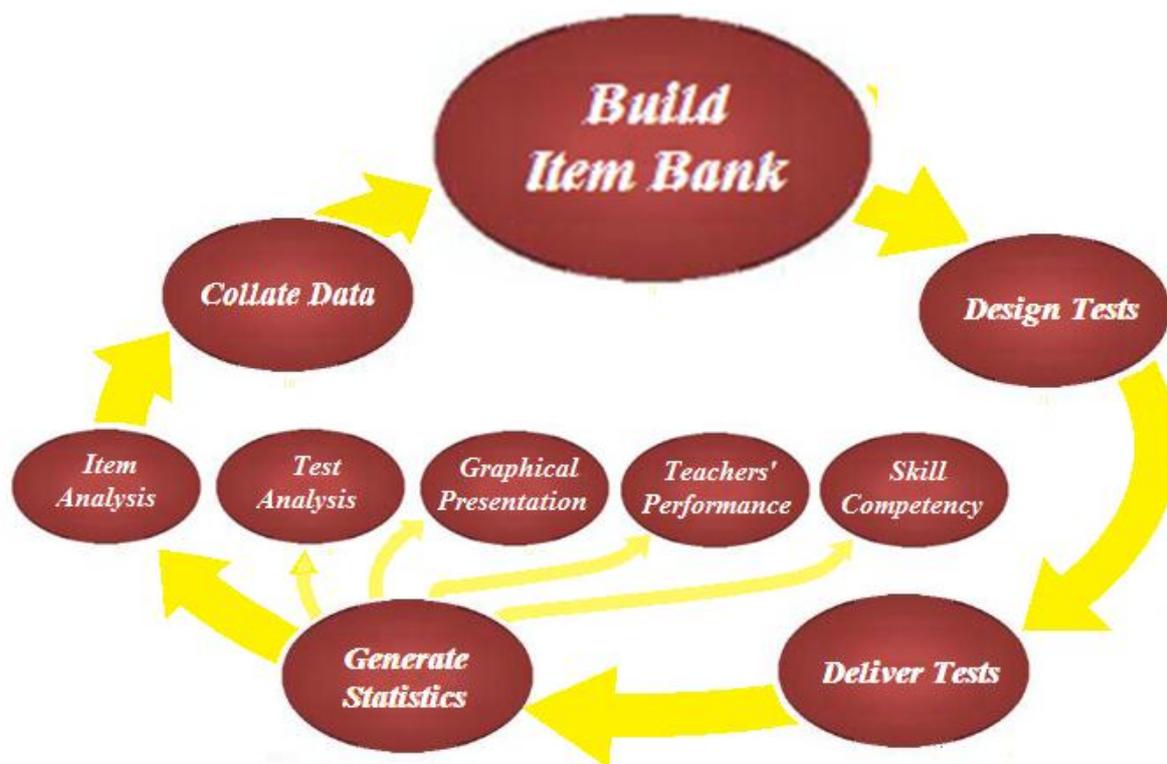
The conceptual paradigm shows the flow and the relationship of the various steps in developing the Item Bank as well as the types of statistical data generated from this development.

The first step is Test Design (when test items are formulated for certain tests) followed by Deliver Tests, the part when the tests are administered. This is followed by Generate Statistics using the various component programs in the software like Test Checker and Item Analyzer. This step enables the collection, organization, analysis, and interpretation of data. It will answer the following National Educational Goals:

1. To measure the effectiveness of the Teaching Learning Progress.
2. To measure students' present level of achievements
3. To measure one student's progress against others
4. To provide information for streamlining purposes
5. To evaluate the relevance of the curriculum

6. To measure the student's progress towards accomplishment of national educational goals.

Conceptual Framework of the Study



The following data are generated in this third step Generate Statistics:

Item Analysis. This can be a powerful technique available to instructors for the guidance and improvement of instruction. For this to be so, the items to be analyzed must be valid measures of instructional objectives. Furthermore, the items must be diagnostic; that is, knowledge of which incorrect options students select must be a clue to the nature of the misunderstanding, and thus prescriptive of appropriate remediation.

Test Analysis and Scoring. The primary purpose of any assessment is to determine what the students know and what they can do. It also provides information about the success of one's teaching and/or skill in creating assessments. However, one needs to know how to analyze tests in order to measure the effectiveness of instruction. (D.C. Howell, 1997; Runyon & Haber, 1991; West, 1991);

Graphical Presentation. A graph or a chart or drawing that shows the relationship between the various variables such as scores, comparison of scores, reliability of the items, etc. is shown by the software. It makes the data presented easier to understand even by the uninitiated.

Skill / Competency Level. The purpose is to assess an individual's/group/division/region general cognitive ability-the ability to use reasoning skills to solve problems. It measures reasoning skills required for administrative support positions and for certain operational positions.

Teachers Performance. Since a departmental test is given at the same time to the students they are teaching, the result of these can determine the performance of a teacher.

The flowchart of data generation for the data bank of test items is illustrated below.

Once the test is formulated it is delivered to examinees then scoring will come in. This score has no meaning unless it is converted into a standard form. This will help to determine the outcome from the objectives and table of specification which is related to its competency.

Other statistical output can be generated from the performance of the teachers teaching the same subject and having the same departmental examination.

Review of Related Literature

Since Item Banking is the subject of this project, it is most fitting to discuss the studies and literatures that hold significance to it.

Item banks are potentially very helpful for teachers and test developers and they make test-taking easier, faster and more efficient. In the United States, for example, the concept of item banking has been associated with the movements to both individualized instruction and behavioural objectives in the 1960s (Hambleton, 1986; Umar, 1999). Van der Linden (1986, cited in Umar, 1999) viewed item banking as a new practice in test development, as a product of the introduction of Rasch measurement (Rasch, 1960/1980) and the extensive use of computers in modern society.

Questions with low information value about the examinee's proficiency are normally avoided that tests like this are sometimes called a tailored test. The result of this approach is higher precision across a wider range of ability levels (Carson, 1994). Computer-based testing is increasingly viewed as a practical alternative to paper-and-pencil testing (Kingsbury and Houser, 1993). A computerized content-based adaptive test is another variation of computer assisted test. This type of test emphasizes mainly on installing, retrieving and administering test items in particular small "domains of knowledge" for domain-referenced testing purposes. The test is made possible by a computer program called "Computerized Content-based Adaptive Program (CCAT Pro) (Sukamolson, 1996). This program works successfully in connection with ITB Pro basing on the concepts of a constant step size pyramidal model (Weiss, 1974; Hambleton and Swaminathan, 1985).

The most difficult and demanding aspect of preparing good classroom tests is writing the test questions. The choice of item type should be made on the basis of the objective or process to be appraised by the item. If possible, the questions and items for the test should be prepared well in advance of time for testing, and reviewed and edited before they are used in the test. According to Jacob and Chase (1993), after instructors have written a set of test items, following the rules, they do not know if the items will show which students have mastered the topic of instruction and which have not. The items must be tried out on the students before the instructor can determine how well each item works.

Hopkins and Antes (1990) wrote that information gathered about item difficulty, discrimination power of items, balance, specificity and objectivity could be used to improve future tests. Effective items can be developed and good testing practices can be determined from what has been successfully developed in the past. Since the individual test items determine the nature of the test and the extent that the instrument measures what the teacher intends to measure, successful testing rests, first of all, with a set of effective items. Improvement of test quality rests in using appraisal information to strengthen test item through appropriate revision to reduce technical defects and the factors causing them.

Analyzing Test Questions. Thorndike and Hagen (1991) comment that after a test has been tried out and scored, the result may be analyzed in two ways. One is from the standpoint of what the results reveal about the pupils' learning or how successful instruction has been. Another type of the analysis has for its purpose the evaluation of the test as a measuring instrument.

Related Studies

An item bank is essentially a collection of items stored and used to create new assessments at a later date (Anzaldúa, 2002; Bloom, Hastings, and Madaus, 1971; Leclercq, 1980; Nakamura, 2001; Rudner, 1998; Smetherham, 1979; Thorndike, 1971). Item banks have been long used in education. Some of the earliest item banks consisted of collections of individual items that were written on cards and subsequently indexed and catalogued (Anzaldúa, 2002; Bloom et al., 1971; Leclercq, 1980). A paper-based item banking system can be straightforward to implement but clearly faces limitations in its practical size, scope, and complexity. In the recent past, a great deal of effort was required to generate a test from an item bank. Today, the processing power of modern computers makes this task more practical (Anzaldúa, 2002; Leclercq, 1980; Thorndike, 1971).

The most difficult and demanding aspect of preparing good classroom tests is writing the test questions. The choice of item type should be made on the basis of the objective or process to be appraised by the item. If possible, the questions and items for the test should be prepared well in advance of time for testing, and reviewed and edited before they are used in the test. According to Jacob and Chase (1993), after instructors have written a set of test items, following the rules, they do not know if the items will show which students have mastered the topic of instruction and which have not. The items must be tried out on the students before the instructor can determine how well each item works.

Hopkins and Antes (1990) wrote that information gathered about item difficulty, discrimination power of items, balance, specificity and objectivity could be used to improve future tests. Effective items can be developed and good testing practices can be determined from what has been successfully developed in the past.

Analyzing Test Questions. Thorndike and Hagen (1991) comment that after a test has been tried out and scored, the result may be analyzed in two ways. One is from the standpoint of what the results reveal about the pupils' learning or how successful instruction has been. Another type of the analysis has for its purpose the evaluation of the test as a measuring instrument.

Insuring Validity and Reliability of the Test. Hopkins and Antes (1990) discusses more on forming criterion groups such as 25%, 27%, 30% and 33% of the respondents for the high and low groups. Oosterwolf (1994) touches on the Item Response Theory (IRT) that is being used quite extensively in educational measurement, particularly with standardized test. Ebel and Prisdie (1986) discuss the item revision process on the basis of item analysis data. Brown (1981) agrees on the percentage of the distracters, which are attractive, perhaps even more attractive than the correct response.

Frederick B. Davis, in his "Item Analysis in Relation to Educational and Psychological Testing," *Psychological Bulletin*, volume 49, series 1952, pages 97-121, stated that the construction of solid and reliable tests must consider the quantitative information on the difficulty and discriminating power of each test exercise, or item proposed for use.

Result and Discussions

iBank is the software that stores quality test questions formulated by teachers in different fields of education. These are the test items accepted in the Item Analysis. It segregates the different subjects, sub subject and competencies which correspond to the different behaviors such as cognitive, affective and psychomotor. It also stores problems and selections containing figures, graphs and tables.

The software is run by the usual procedure using Windows by clicking the icon item bank twice. The user can start developing a volume of test items and manipulating the data by selecting information in the menu bar.

The item entry is composed of three selections.

The Item Bank Entry is used to store data of quality items that pass the item analysis. Image Grabber is used to store captured pictures for further use. The Subject Competency is used to View, Edit, and Delete Item in the iBank.

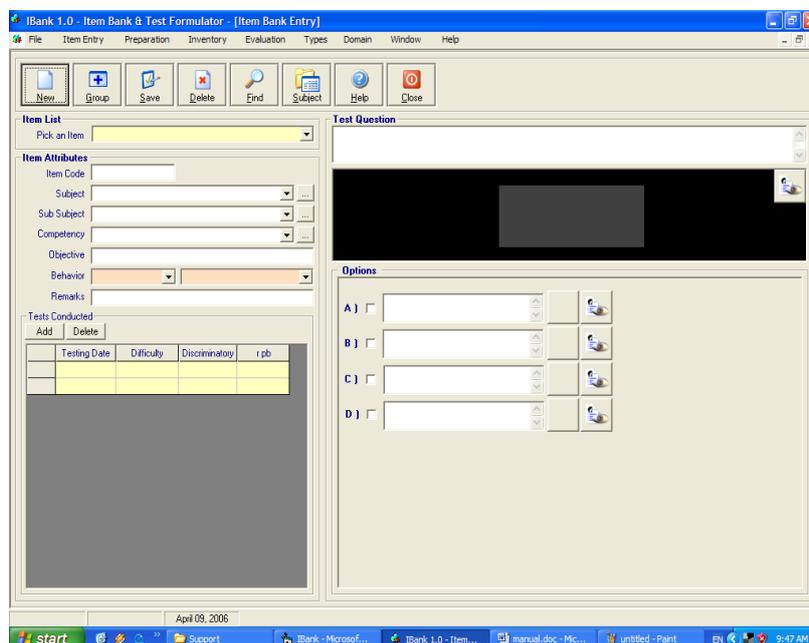


Figure 1. *Item attribute entry*

In this window, the user can fill out the form starting from Item Attributes, Test conducted, Test Questions, the Key to Correction and the four options to the problem. The user can also insert figures under the area as shown.

In the Item Attributes, the user can specify the item code of the problem, its subject, the skills addressed by the problem, its objective, the learning domains it belongs to, and any remarks. The drop-down buttons allow the user to choose from data previously entered.

The Group button allows the user to enter paragraphs and figures that can be used for a series of questions in the process. The user should fill up the group code then press Hide to fill up the rest of the item attributes then Save. S/He should press the Group button then the Next button for the next series entry. After all sub questions are entered the user should press the Close button.

The Image button in this window allows the user to capture images. By clicking this button a capture window will appear. The capture window works like the Print Screen function. The window print screens the image bordered by the window. The window can be moved and resized to accommodate larger images. Closing the window will prompt the user to either capture the image or to cancel. The captured image will be saved in the image databank.

The Variable Range Entry is used for data with a random range value such as from 20m/s to 30m/s. This is used so that students will answer questions with same statements but different given and results. Different option formula situation can also be simulated in the entry for validation. These options formulas are based from the studies on how the students' wrong answers were obtained.

The Table of Specification is used to determine easily the distribution of test items according to competencies across the cognitive skills that are based from the agreement of academic committee.

The user will enter the No. of test items and No. of Competencies and press the Enter Key, then place the time of contact per competency and Percentage or proportion per cognitive level, and then press the Calculate button. If ever the calculated items exceed the desired items, the user should manually retype specific items and press the Adjust button. The user can Export the data in a word software for printing.

The Formulate option searches for specific competencies view and selects specific items for finalization then prints the test questions.

The Statistics Form. The user will first load the saved file. The Table of specification shows the actual item distribution. Difficulty, Discrimination and IRD (Item Response Distribution) show the frequency graphs. Correlation shows the table which is based from the point biserial correlation index. Cross plot shows the placement of items across difficulty and discrimination table. Index can be changed by the user depending on the agreement of the academic committee.

The query window will allow the user to select the necessary Attributes for editing or viewing. After pressing the Search button the computer will display all the items that conform to the attributes and these items can be displayed one at a time using the Up or Down arrow key under the Item Bank Entry. The user has the option to select the sorting type and/or the order sequence.

The Finalize Test option manipulates further the saved and loaded files, renumbers them and prints the test questions. The user can renumber the items by clicking the second column as shown. The user can go back using the Browse button to add items in the list. Save and reload and determine the statistical analysis of the test.

The Generate Form is similar to the Table of Specification. The additional function is that the user can start from the subject, sub subject then competency. This time, the computer will generate the test paper by random, based from the table of specification and the actual bank inventory.

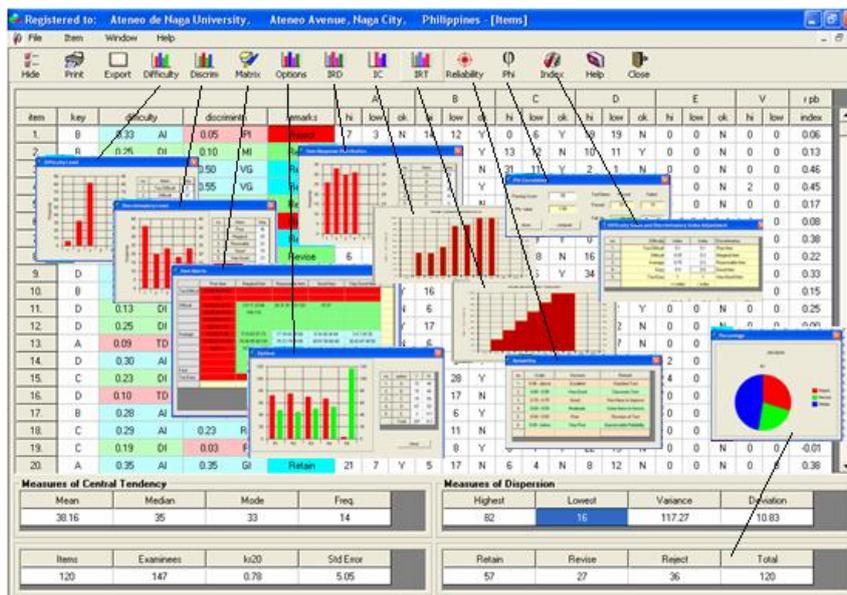


Figure 2. *The Item Analysis*

The Item Analysis is used to show the analysis of each item, such as key to correction, difficulty level, discriminatory power, remarks if the item is retained, revised or rejected. It also shows the frequency or the number of respondents that selected each option between the high scoring and low scoring respondents, the desirability of each option if accepted or not, and the point biserial correlation.

The result also shows the measures of central tendency; the measure of dispersions; reliability and standard error of measures of the test, the different graph distributions such as Item characteristics and Item response theory, Item response distributions and correlations. The user can also change the indices of difficulty and discrimination and see the analysis of each item in table.

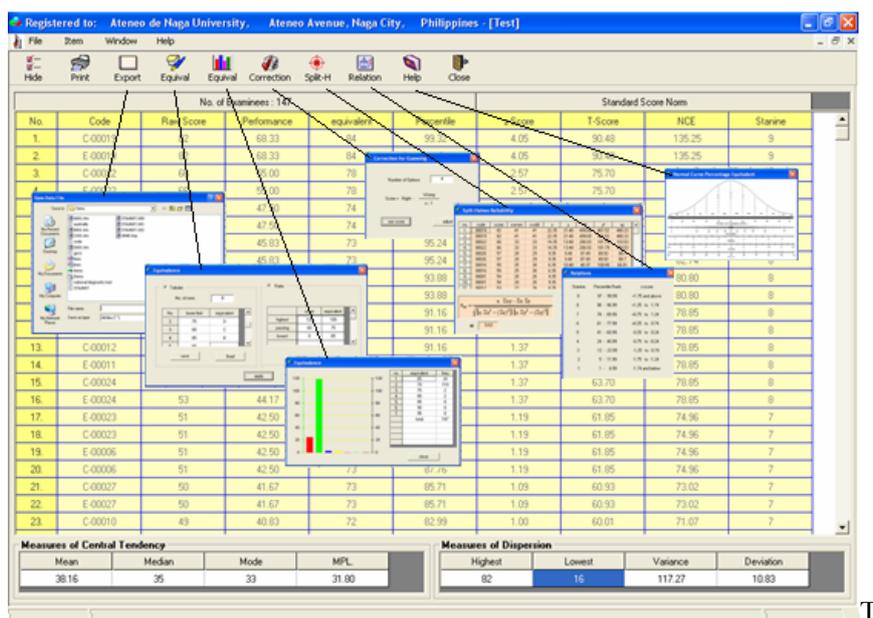


Figure 3. *The Test Analysis*

The Test Analysis shows the number of examinees, their examination code, raw score which is arranged from highest to lowest, percentile rank, standard score norm like z-score, T-score, Normal Curve Equivalent (NCE) and the stanine of each examinee. These data can be directed to a printer or a file. It shows also the score equivalent, correlation, split halves reliability, frequency distribution of score brackets and mean performance level (MPL) of the class.

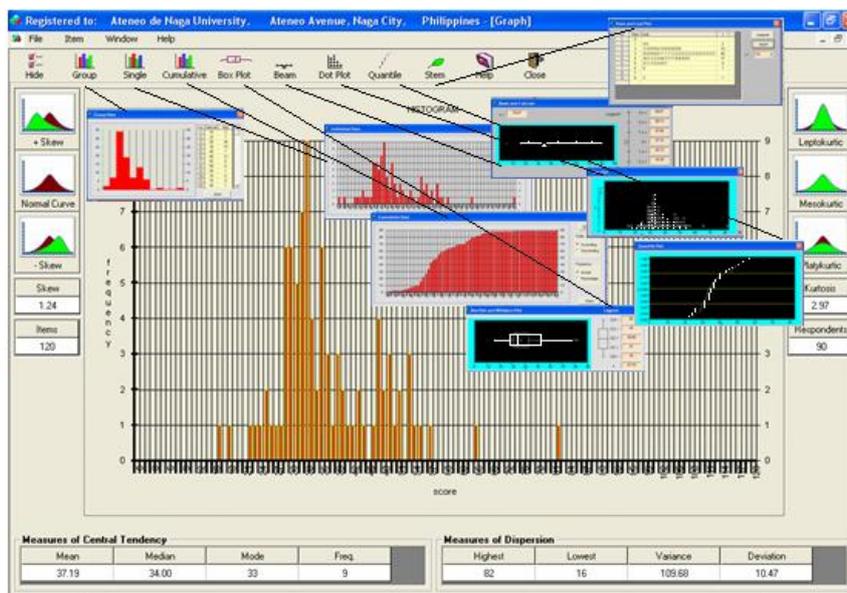


Figure 4. *The Graphical Presentations*

The graph presentation shows the frequency distributions of scores, the normality of the curve, if positive skew or negative skew; and the kurtosis of the curve if Leptokurtic, Mesokurtic, or Platykurtic, the normal curve as compared to the normal curve shown below. It also shows the group frequency distribution, individual frequency distribution, accumulative frequency distribution, "box and whiskers plot, dot plot, "beam and balance plot", "stem and leap plot" and quantile plot.

The screenshot shows a software window titled 'Registered to: - [Summary]'. The interface includes a menu bar (File, Item, Window, Help) and a toolbar with icons for Hide, Export, Correlation, r index, Mastery, Enhance, Individual, help, and Close. The main area displays a table with 20 rows of items and 7 columns of performance data. The bottom of the table shows summary statistics for Competency and Correlation.

Item	Key	Class A	Class B	Class C	Overall	Individual
1.	A	60	30	80	58	C
2.	A	25	20	90	40	D
3.	B	95	40	90	80	B
4.	C	30	20	80	40	D
5.	D	45	20	70	45	D
6.	B	65	60	90	70	B
7.	B	50	20	80	50	B
8.	A	10	30	70	30	B
9.	B	85	40	50	65	B
10.	D	30	20	90	43	D
11.	D	40	10	90	45	D
12.	D	45	20	90	50	B
13.	C	30	30	60	38	D
14.	B	60	10	80	53	B
15.	B	35	50	90	53	B
16.	C	60	40	100	65	A
17.	C	55	20	90	55	D
18.	C	55	50	100	65	C
19.	A	60	40	90	63	A
20.	B	65	50	90	68	B
%	Competency	50.00%	31.00%	83.50%	53.63%	60.00%
	Correlation	0.92	0.65	0.34	vs overall	

Figure 5. *Comparative Teachers' Performance*

The data matrix shows the key to correction and actual respondents of the examinees. Below is the frequency result per option per item to include the void answers and the no answer items. The summary shows the class performance per item in comparison with other classes and the over all performance. It shows the correlation per two groups and with respect to the over all performance. It

also shows the mean performance (skill) of each class and over all performance of the school or division.

A user who may be a department head, principal or head of the office can easily identify class performance by class, group, school, etc. including the competency level of each class or mean performance level of each class. These data can then help him/her determine which class performs better and which performs poorly thru the performance of the teacher.

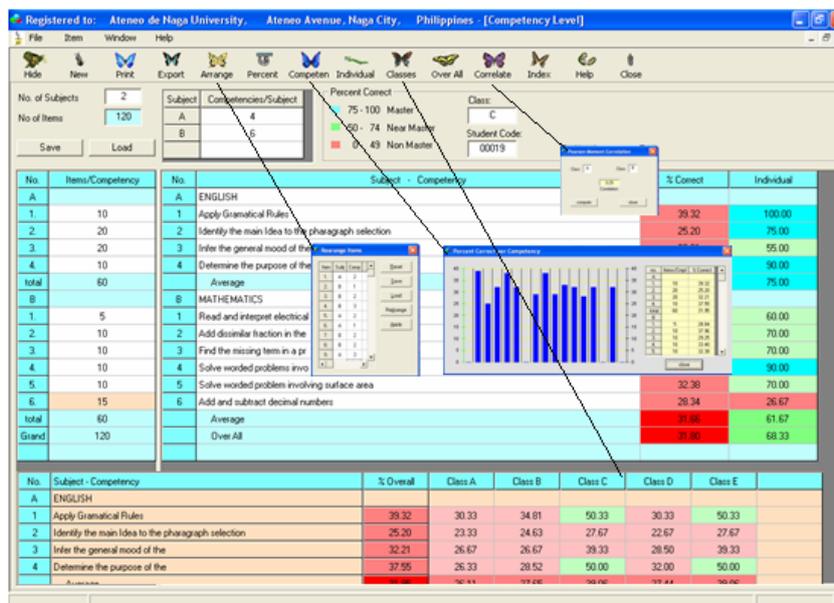


Figure 6. *The Competency Level*

The competency level shows the comparative skills per sub subject, per subject of individual, class and school. The user can also rearrange the item number per skill, correlate skills, and can change the index for percent correct. This can be done by entering first the number of subjects, pressing the Enter key, then the number of sub subject per subject; press the Enter key then the number of items per skill or sub subject.

Implication and Recommendations

In view of the foregoing findings, the researchers recommend:

a) mature technologies for dissemination

Since the Item Bank et al. has been found to be efficient and effective, it is recommended that a seminar be conducted in each division in every region of the country to orient teachers and administrators on the use of the software. This can be done by the Project Team with the cooperation of the DepEd, the CHED, the TESDA, and the DOST.

b) research and development breakthrough

This project is the first of its kind in the country, and most probably, in the whole world. The government is therefore expected to support the development of this project that will certainly put the Philippines in the map specifically in the field of inventions that are vital to national development.

c) result that can be formulated/solution to a specific problem

With Item Bank et al., teachers who used to neglect and abandon item analysis in favor of other teacher-related tasks, can now be helped. Using the data gathered from item analysis and test norms on the reliability and validity of the test questions, teachers can now formulate questions that will challenge the critical thinking of their students. Since teachers should not settle for mediocrity in their schoolwork, and should instead strive for excellence, their tasks can be facilitated if they recommend to the school the acquisition of the Item Bank et.al.

d) result for policy, planning, formulation and implementation

Since the DepEd, TESDA, DOST, and the CHED all desire to have quality education in the country, it is recommended that, as a matter of policy, these agencies require educational institutions, most specially the schools considered as centers of excellence, to acquire the Item Bank et al. to help facilitate the task of item analysis, and thus alleviate the workload of their teachers. The DepEd must, in fact, set the example by acquiring one for the National Educational Testing Center. Likewise, it is further recommended that every school under the supervision of the DepEd, the CHED, DOST, and the TESDA, be enjoined to develop a data bank of questions by disciplines, consisting of the questions accepted by the system.

In relation to school networking, it would be useful for members of the network (teachers from many different schools) to access the item banks available through Computerized Adaptive Testing. The school network could develop a bank containing tests for different subject areas or different banks for different subject areas. This can be done by establishing one school as the item bank, equipped with a central computer, while other member schools in the network can access the bank through the networking computers in their schools. This can save time and school resources in preparing tests and conducting examinations whenever it is needed. Regarding the development of the test items, teachers in every school network could cooperate to construct, try out, analyse, and select qualified items to store in the item bank. If this process is continuously done, the item bank will become large with thousands of well-calibrated items by difficulty equated on the same scale. The pooling of resources between different schools might be launched by provincial administrators. The provincial administrators could run in-service courses on Computerized Adaptive Testing (CAT) and item banks, with items appropriate to many school subjects. Moreover, CAT is a new approach for learning assessment and evaluation which is likely to be the future of assessment. There is a large monetary cost to implement this, but it would be well worth it, and probably necessary in the future.

Literature Cited

- Anastasi, Anne, C1988, "Psychological Testing", Macmilan lane. United State of America, 6th edition, 117 p
- Brown, Frederick G., "Measuring Classroom Achievement", Halt Richard and Winston, U.S.A.", c1981, pp. 101-110, 224p
- Carlson, R. (1994). Computer-adaptive testing: A shift in the evaluation paradigm. *Journal of Educational Technology System*, 22.
- Ebel, Robert L. and Prisbie, David A., "Essentials of Educational Management", Printice Hall Inc. N.J., 4th Edition, c1986, pp 226-240
- Hambleton, R.K. and Swaminathan, H. (1985). *Item response theory: Principles and applications*. Boston: Kluwer Nighoff Publishing.
- Hopkins, Charles D. and Antes, Richard L., "Classroom Management and Evaluation", F.E. Pencil Publishing, Inc. U.S.A., 3rd Edition, c 1990, pp 537-554, 273 p
- Hopkins, Kenneth D. / Stanley, Julian C, "Educational and Psychological Measurement and Evaluation", Prantice Hall, lee. N.J., 6th Edition, c1981,pp 269-288, 217 p.
- Howell, D.C. (1997), *Statistical Method for Psychology* (4th ed.), Pacific Grove, CA; Wadsworth.
- Jacob, Lucy C. & Chase, Clinton I., C1993, "Development and Using Tests Effectively", San Francisco, Jersey Publishing
- Kingsbury, G. and Hourser, R. (1993). Assessing the utility of item response models:Computer adaptive testing. *Journal of Educational Measurement*, 12.
- Linn, Robert L. and Gronlund, Norman E., "Measurement and Assesment in Teaching", Macmillan Publishing Co, U.S.A., 7th Edition, c1995, pp 318-320. 360 D
- Noll Victor H., "Introduction to Educational Measurement"¹¹, Cambridge, Massachusetts, Printed in U.S.A., c 1957, pp. 148
- Oosterwolf, Albert, "Classromm Application of Educaional Management", Macmillan Publishing Co. N.Y., 2nd Edition, c 1994, pp 196-208, 474 p
- Rasch, G. (1980/1960). Probabilistic Model for Some Intelligence and Attainment tests, The University of Chicago, Chicago, IL (original work published in 1960)
- Runyon & Haber, (1991), *Fundamental of Behavioral Statistics* (7th ed.), New York; McGraw Hill.
- Sax, G., "Principle of Educational and Psychological Measurement and Evaluation", c1989, 3rd edition, pp 227-253 Belmont, CA,
- Sukamolson, S. (1996). *Computerized item banking and computerized adaptive testing*.
- Van der Linden & C. A. W. Glass (Eds.), *Computerized adaptive testing: Theory and practice* (pp. 1-25), Kluwer Academic, Dordrecht, the Netherlands
- Wadsworth Thorndike, Robert L & Hagen, Elizabeth, "Measurement and Evaluation in Phychology and Education", 5rd Edition, c1991 New York. pp. 124-128 554 p
- West R., (1991), *Computing for Psychologists; Statistical Analysis using SPSS and Minitab*.(L.S. Aiken,1990; Anastasi, 1991; Lambert, 1991; S.T. Mejer, 1993)