ISSN 2278-3091
Volume 9, No.3, May - June 2020
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse206932020.pdf
https://doi.org/10.30534/ijatcse/2020/206932020

Computer Adaptive Testing using Iterative Algorithm

Lemuel C. Sanchez[1], Benchie L. Maribao, DIT[2]
[1]College of Computing, Studies in Information and Communication Technology, Isabela State University, Echague, Isabela, Philippines, sanchez.lemuelclemente@gmail.com
[2]College of Computing, Studies in Information and Communication Technology, Isabela State University – Main Campus, Echague, Isabela, Philippines, blmaribao@gmail.com

ABSTRACT

The study was conducted to understand how the computer adaptive testing (CAT) would greatly enhance the testing experience of students taking the admission test. It provides the idea of integrating iterative algorithm to computer adaptive testing to have a tailoring method on administering questions to the test-takers and have an ability to estimate each question that has been submitted. It also included additional features which are online pre-registration and the decision support system. The processes of creating a computer adaptive testing was also discussed in this research and how the iterative algorithm would be integrated in the system. The administering of question and managing of test and the system's function were tested using real data from the respondents. The developed system was evaluated using the ISO 25010 quality criteria to acquire the best characteristics and functions of the system. The result of the overall evaluation was 4.81 which revealed that the testers gave favor for the features and functions of the developed system.

Key words : Adaptive Testing, Admission, Decision Support, Iterative Algorithm, Online Pre-Registration.

1. INTRODUCTION

Computer adaptive testing (CAT) has been utilized in the United States since 1994. It is for assessing high-stakes test in which final examination is administered to evaluate the knowledge of a certain person mostly in licensing examination to identify if the person is qualified in a certain field of specialization. Admission test serves as a way by academic institutions to identify each student with their chosen field or designed to understand students' abilities and help institutions to evaluate how ready students are for college-level work from the large set of students. Meanwhile, in the province of Nueva Vizcaya, one of the biggest tertiary schools and the sole state-run university is the Nueva Vizcaya State University (NVSU).

Currently, the Nueva Vizcaya State University does not have a computer-based testing for its admission. Only a paper and pencil admission test is administered to incoming freshman students. Students enroll every semester coming from various places, and the Office of the Testing Center would not be certain of the number of students that would take the examination; this results in overcrowding.

It is in this context that the proponent developed a system for admission through Computer Adaptive Testing (CAT) using Iterative Algorithm that could help not only the institution with the flock of students during enrollment but also with the testing through low-stake examination or admission through electronic means. The adaptive testing is a psychological test that an individual takes to identify certain cognitive functioning. The psychological test is incorporated in the admission testing through computer-based system, that will allow the client to utilize technology to administer the examination with efficiency and ease-of-use. The system will have an online pre-registration of students for reservation of examination slots.

The iterative algorithm would be integrated with the system to provide a different approach to administering the examination. The algorithm could be used to determine the difficulty of the item that will be presented to the examinee depending on their answers. It will attempt to solve a problem which finds successive approximations for solution, starting from an initial guess. The system will determine the ability of the students that will take the exam through its adaptive capability or iteration. If an examinee answers the item properly, the next item will be more difficult. In contrast, if the examinee answers the item wrongly, the next item will less difficult. The idea for this algorithm is that it gives more precision and accuracy to the questions and results. The system will have a decision support capability functions that will calculate the results in which the scores will be calculated using averaging. Also, the developed system will lessen the papers that will be used and also lost files due to some inevitable factors.

1.1 Objectives of the Study

The primary objective is to design, develop, and implement a faster way of calculating and measuring the ability or aptitude of a student utilizing technology for admission through Computer Adaptive Testing using the Iterative Algorithm. Specifically, it aims to:

1. Design and develop Computer Adaptive Testing by integrating the Iterative Algorithm.
2. Test the system functionalities using real data taken from the respondents for the following processes:
   a) Administration of Questions
   b) Management of tests
   c) Decision Support System
3. Evaluate the System External/Internal Quality in use using ISO25010 in terms of:
   a) Functionality
   b) Usability
   c) Security
   d) Reliability

2. LITERATURE REVIEW

Computers are introduced in the academic fields to broaden and make information ready for all. To give a better instructional experience to the students, computers are widely used by practitioners or instructors to deliver their lessons with ease and effectiveness. Many students have knowledge with computer and internet and have prior knowledge of using this technology [1]. Computer-based learning environments (CBLEs) have become extra prevalent inside the classroom, empirical research has validated that a few students have trouble mastering with those environments [2].

On providing security for the test question and test answers so the institution will not purchase questions for admission. The Iterative algorithm can be utilized for the questions security by the iteration for each questions presented. This algorithm is for setting the adaptive strategy for the system [3]. Using the iterative algorithm for evaluating numerical simulations has proved the effectiveness of the proposed method in presenting iterations [4]. Iterative version of the process to incrementally increase the policies of agents leading to greater quality results in some settings. [5] Testing via computer simulation implies that the iterative algorithm is reliable [6].

Online registration creates an avenue for institutions and businesses to determine the number of individual that they will cater to have a pre-determined course of action and to minimize the possible problem of overcrowding. Using pre online-registration, individuals can sign up in their academic courses easier without issues about location [7]. Information system has a vital role in every institution through this technology, it could efficiently maximize a company's performance. [8]

Decision Support system is used for businesses and institution to come up with the final solution or to come up with a comprehensive information to solve problems. Statistics plays an important role in assessment and evaluation of performance in academic environments [9]. For effective decisions to come up with, a decision support system allows collaborative participation from scientists and decision-makers, and display the locations, magnitudes, and sources of uncertainty in the results [10]. Models of analytical and normative have assisted decision makers to utilize large bulks of information in deliberate evaluation using decision support system [11].

3. CONCEPTUAL FRAMEWORK

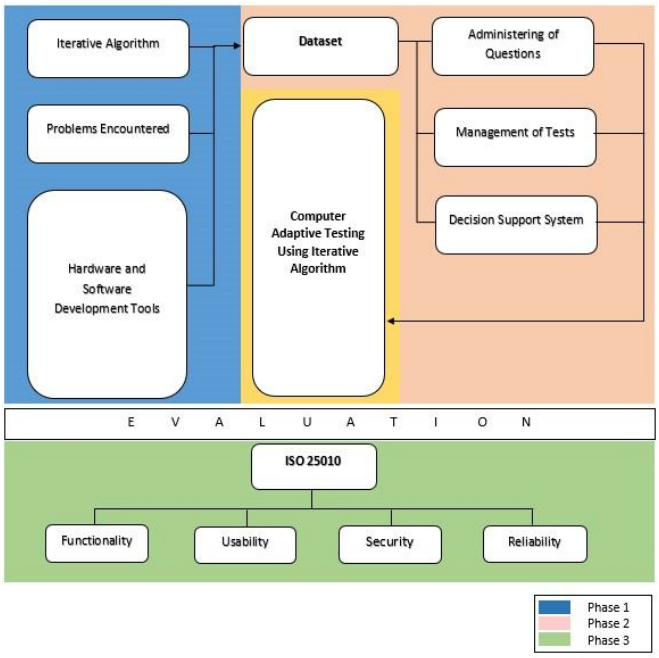

Figure 1: Conceptual Framework of the Project

The manual system of delivering the admission test to students through the paper-and-pencil method is time-consuming and takes a lot of effort from the examiner. The proponent devised a plan to make the admission testing for incoming freshmen more efficient and the ability estimation can be easily calculated. The figures above show that in the first phase of the conceptual framework through the problems encountered by the client, the proponent identified the possible solutions. Hardware and software development tools are identified for the process of developing the system. Also, the identification of a possible algorithm was taken into consideration. Through the insertion of the algorithm, a series of iteration in questions will come from the item pool based on the examinee's ability to answer the test.

Phase 2 is the creation of the dataset; the first part of building the data set is the creation of the item pool that consists of the achievement test in which all questions are pre-calibrated and are leveled on the examinee's knowledge about a certain topic. Identification of the design of online pre-registration for scheduled slots for admission testing and how the system will be presented for better management of the testing are on these phase. The questions will be presented to the test-takers then after sending the answers, they are now sent to database which makes the management of test more easy. When all the questions are answered in all categories, the examination terminates, then through the decision support system, the results will be calculated and the system displays the report of the examinee's ability through tables and graphs. Phase 1 and 2 consist of how will be the Computer Adaptive Testing using iterative algorithm will be developed and designed.

Then, Phase 3 is the evaluation of the system through ISO 25010 quality criteria to improve in the system through the evaluation of its Functionality, Reliability, Usability, and Security. Also, this will prove if the system meets the client's expectations and needs.

4. METHODOLOGY

In the identification for solution to the problems encountered by the proponent, there should be a systematic sequence that should be followed to arrive in concrete solution. In this section, the proponent explains those processes to come up with the objectives of the study in each phase of the methodology.

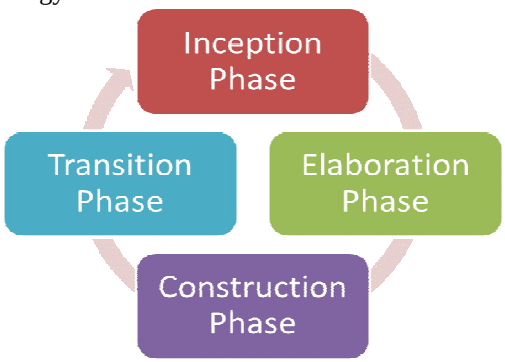

Figure 2: Iterative and Incremental Method

The researcher used Iterative and incremental method which is illustrated on Figure 2 for the system development which consists of four (4) phases. The Inception phase which is the identification of the scope of the project and acquisition of important details about the system; Elaboration phase establishes the ability to design and build the new system given the functions needed by the client; Construction phase builds a system capable of functioning in the beta customer environment to fully evaluate the system and analyze all the functions and capabilities, and the Transition phase in which the proponent focuses on detecting defects and correcting the previously identified problems.

A. Inception Phase

The researcher conducted an interview to identify the issues that the client has encountered during the manual system. From the observation and survey conducted from the client, the possible solutions have been identified. The Ishikawa diagram is one of the tools that the proponent used to measure the main problems while using the manual system.

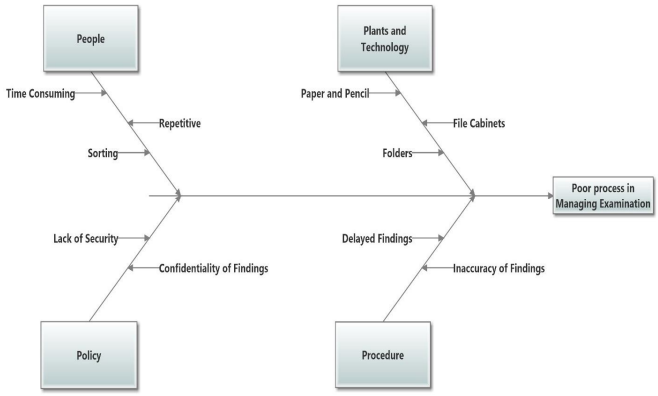

Figure 3: Ishikawa Diagram

Figure 3 tells how the proponent came up with the issues regarding the current manual system. By observing every aspect of the system and everyone involved in the process, the problems were identified. The manual system is administered by only one employee who is the Director of the Testing Center and student assistants who assist in the testing. With the number of students enrolled every year, the number of proctors is not proportioned to the takers who leads in the slow and time-consuming process. Repetition of data is also a problem with filling out forms due to rescheduling of the students who flock at the testing center. Sorting of data becomes complicated due to the lack of employees and also with the students who do not take their test on the specified schedule. The administering of the test uses a paper-and-pencil method which causes the lack of resources or loss of files due to the utilization of file cabinets for storing and filing of registration and test sheets. Anyone can enter or exit the office anytime and the files or examination is exposed to some, which can be a major problem to the administration of the test in the future. Exposure of test questions can degrade the quality of tests due to some students can give out the question and answer to future test takers and can be a factor in measuring the ability of a student or help in the career guidance.

Different schedules and the lack of employees leads to the delay of findings and results of the examination. The problem affects the students who want to enroll in their desired courses or want to know their possible career path. The test results are

calculated manually that's why errors occur and problems with the evaluation of answers can affect the possible outcome of the test. The problems encountered have resulted in the poor process in managing the examination.

B. Elaboration Phase

The gathered inputs from the client has been manipulated to fit all necessary data in the software. Through the specification given by the client the design of the system was created using a wireframe. After identifying key features, the system was developed to meet the functions needed by the client on how the adaptive testing will be administered electronically.

- **Wireframes** – For the menu and interface the researcher used wireframe for the of the proposed system's interface. This process is focused on how the respondents accepts the user to process information on the system.

The hardware specifications used to develop the system's interface are Intel Core i5-6200 @ 2.50GHz processor, 4GB DDR4 Memory, 1TB HDD, NVDIA GeForce 820MX 2GB for the GPU, 1920 x 1080 resolution and Windows 10 operating system. Software development tools used are as follows:

- **Visual Studio (VS) Code** - The proponent used this in coding in creating interface of the system, connection between the database to system and the server.
- **Hypertext Markup Language (HTML5**) – The proponent used HTML5 as the building blocks in creating the interface of the system. It is used to define and describe the content of the system.
- **Hypertext Preprocessor (PHP 7)-** The proponent used PHP programming language to develop the system especially its major functionalities.
- **Cascading Style Sheets (CSS3)** – The proponents used this to add design flexibility and interactivity to the system and also to have greater control over the layout to make precise section-wise changes.
- **Bootstrap 4** – A CSS framework is used to design and enhance the front-end of the system.
- **CodeIgniter (CI) 3.1** – The proponent used this PHP framework to develop the project faster than writing it from scratch.
- **Cross-Platform Apache MySQL PHP Perl (XAMPP 3.2.2)** – The proponent used XAMPP to interpret scripts written in the PHP file and managed database.
- **MariaDB 5.5** – The proponent used MariaDB for creating and managing database and connects them to the system because of its quick processing, proven reliability, ease and flexibility of use.
- **Adobe Photoshop CS6** – The proponent used Adobe Photoshop to create and modify images used in graphics and interface design of the system.
- **Google Charts** – The proponent used this JS Library to display the blood pressure and TPR data and to simplify the report of entries.

C. Construction Phase

In this phase, after developing the system with its key component the proponent tested the functionalities of some key feature of the system using real data which are the administration of question, management of test and the decision support system. The following functions are what the adaptive testing will provide for the client for the admission testing.

In the testing of functionality in administering of questions the low-stakes test is inserted in the system. An item pool is created with standardized questions that are equal with the knowledge of test-takers for better analyzation of ability. The questions are presented with a timer for the whole duration of examination to test the test-takers ability under pressure. The questions are given in a multiple choice type of test with four choices. Multiple choice is an objective response form of assessment that is typically used for testing and are designed to test an individual in their confidence and skill in thinking. From the question that had been answered and submitted, a proper way to check the results given is the how will the test be managed. One of the functions that will be tested with system is how can it manage the test. When the test is done or the timer has expired, the questions are submitted and inserted in the database. The result of the answers is displayed by the system in percentage and real number in how many items are answered correctly. The management of test functions as preview for all the test-takers result to identify who are how many have excelled in the admission testing.

The last function that will be tested is the decision support system. The overall result and qualitative description is displayed in the report of the system. All the results are tested by displaying the total score of test-takers and how they have been proficient in each category. The DSS assembles all need data needed in a single page or report to be interpreted and gives the examiner the idea of how a test-taker have answered the admission test to determine their possible career path in college.

D. Transition Phase

During Transition, the proponent conducted an evaluation of the system to assure that the client is satisfied with the developed system. The system was continually tested by some users or IT experts and even the developer, to check if some bugs or errors needed to be fixed. The proponent identified some issues with a thorough analysis of every part of the

system. A series of questionnaires is given to the test takers to identify what additional functionalities will be included in the system. It is to identify the possible and common bugs in the future, also to fix the errors that will be encountered. The quality model gives feedback to the proponent to give solutions in terms of the reliability of the system to administer the test to the clients and other purposes.

For the evaluation of the system the proponent used ISO 25010 standard as stated in objective 3 of this research which would reveal criteria on system's functionality, reliability, usability and security. To interpret the data efficiently, the five point Likert-Scale has been used for scaling responses from the survey research for the system. The proponent used the five-point Likert-scale to allow a degree of opinion from the respondents, therefore quantitative data can be obtained [12].

5. RESULTS AND DISCUSSION

In this part, the proponent presents the design of the system and the different data gathered for this project. To better understand what will be the flow of data from the input going to the output process. The presentation of data is the result of the objectives of the proponent.

Figure 4: Screenshot of Computer Adaptive Testing using Iterative Algorithm Main page

Figure 4 shows the dashboard of the main page's interface. (1) Provides the connection link between the different pages of the module such as the registration of students and admin; management of examination and result; reports and settings (2) Overview shows the active categories that is included in the examination and total number of item of per category; (3) Analytical figure that shows the number of students that have pre-registered; and (4) actual total of users categorized: active and inactive; male and female; and administrators to determine the registered users.

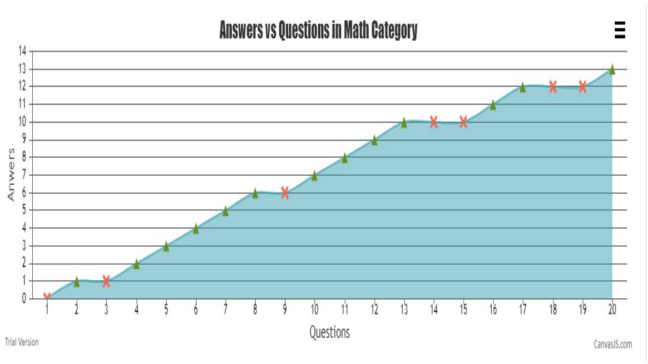

Figure 5: Integration of Iterative Algorithm to Computer Adaptive Testing

Figure 5 shows iterative algorithm adjust the level of difficulty—based on the responses provided—to match the knowledge and ability of a test taker. The algorithm represents an attempt to measure the abilities of individual students more precisely, while avoiding some of the issues often associated with the "one-size-fits-all" nature of standardized tests. Iterative algorithm offers a shorter testing session with a smaller number of questions since only those questions considered appropriate for the student are offered.

Since iterative algorithm select questions that are intended to be appropriately challenging for each student, most students will get about half the questions right and half wrong, so a score based on the total number or percentage of correct responses will be meaningless. Therefore, iterative algorithm when incorporated with computer adaptive testing the scoring is based on both the number of correct answers provided and the difficulty of the items completed this answers the objective 1 of this research.

The processes for the iterative algorithm to which the tailoring takes place in the system is as follows:

1. Initial guess for the solution vector x0. (This is usually a vector of zeros unless you specify a better guess.)
2. Compute the residual norm res = norm(b-A*x0).
3. Compare the residual against the specified tolerance. If res <= tol, end the computation and return the computed answer for x0.
4. Update the magnitude and direction of the vector x0 based on the value of the residual and other calculated quantities.
5. Repeat Steps 2 through 4 until the value of x0 is good enough to satisfy the tolerance.

The iterative methods differ in how they update the magnitude and direction of x0 in Step 4, and some have slightly different convergence criteria in Steps 2 and 3, but this captures the basic process that all iterative solvers follow. This process presents the difficulty of the questions depending on the answers of the test-takers through the system. The initial question has no difficulty meaning that it is in neutral, after answering the first question the system decides the difficulty of the question. If an answer is correct, the question becomes hard then if an answer is incorrect the question will

be easy until all question are answer will the system terminate. There is an iteration in every step until all the questions is presented and administered to the test-taker.

5.1 Modules

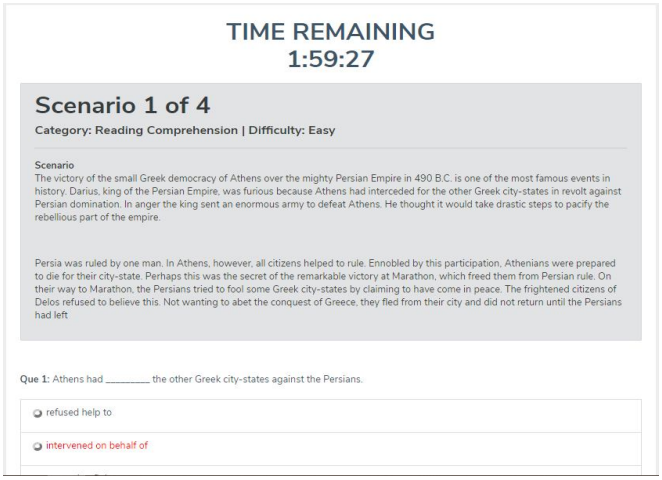

Figure 6: Screenshot of Student Examination View

Figure 6 shows the examination view of the test-taker; the question is presented with a limited time and a multiple choice type of questions. The examiner can manage a lot of examinations through computer-based testing and can administer to a specific number of examinees taking the test.

The functionality of the system which can administer the questions with ease through via network can lessen the use of paper and other materials used for admission. It increases the capabilities of the testing center to administer a lot of test to a huge number of students who registered for the admission.

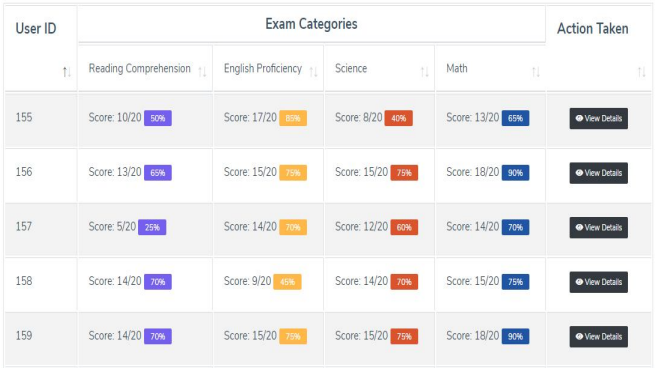

Figure 7: Screenshot of Examination Results

Figure 7 shows the list of the result of the examination for each examinee. After the examinee submits the test, the score is automatically generated in the database and can be accessed by the administrator. This function of the system gives the testing center the advantage of determining some students who excelled with the admission and also with some who did not. The management of test helps the administrator in monitoring the scores of the examination through the submitted scores. It easily identifies each test-taker for their progress in each category in the examination. Each category is presented with its score; the total result will be printed in the report page.

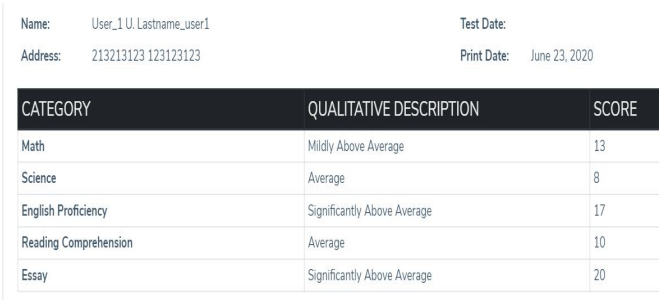

Figure 8: Screenshot of the Decision Support-System

Figure 8 shows the result of the examination of an examinee. Each category is rated through the qualitative description that is the equivalent of scores per category. There is a bracket between scores to show the qualitative description. This function of the system gives a detailed result of the admission test of a test-taker. Through this the data from the user can be automatically compiled and analyze through this function. The printed output will be given by the administrator to the examinee after all students have taken the test.

5.2 Evaluation

The proponents conducted a user acceptance testing (UAT) to the client through the developed Computer Adaptive Testing system. The testing had a total of 30 end users including the director of the Testing Center, faculty and staffs on Nueva Vizcaya State University, and IT Experts. As presented in Table 1, the respondents rated 4.81 which has an equivalent qualitative rating of strongly agree under the functionality criterion which implies that the system can do the phases of administration of test, managing of questions and the decision support system. For the usability criteria the respondents rated 4.75 which has an equivalent rating strongly agree which means that the system design suits its functionality. For the security criteria the respondents rated 4.86 which has an equivalent rating strongly agree which means that the system has a strong security that keeps the data safe from attackers/intruders and unauthorized users. For the reliability criteria the respondents rated 4.83 which has an equivalent rating strongly agree which means that the system have few failures, reacts appropriately when failure occurs and the system is capable of recovering data in case of failure.

Table 1: Evaluation Summary

Criteria	**Mean Value**	**Qualitative Rating**
Functionality	4.81	Strongly Agree
Usability	4.75	Strongly Agree
Security	4.86	Strongly Agree
Reliability	4.83	Strongly Agree
Grand Mean	4.81	**Strongly Agree**

Table 1 shows the evaluation summary obtained using the ISO 25010 standard of the system is *Strongly Agree* with the Grand
Mean of 4.81. The result means that the system is effectively functional, reliable, secured and usable for the user in charge of the admission testing.

6. CONCLUSION

Based on the results of this study conducted at Nueva Vizcaya State University – Testing Center the following conclusion were made:
1. The proponent developed a Computer Adaptive Testing by integrating the Iterative Algorithm in the system which gives it the adaptive function in the admission testing.
2. The CAT using Iterative Algorithm featured functions would improve the testing experience of the test-takers and efficiently displays the questions of administering of questions. The individual results are managed with ease and would provide user-friendly access of test. The reports are easily calculated and compiled with systematic and arranged format and can be easily understood by the administrator through the decision support system function of the system.
From the testing conducted with the respondents, the datasets fit with the functions of the system. Each dataset increases its capabilities for viewing and compilation with the incorporation with the featured functions.
3. Based on the result of the system's evaluation the highest standards for the overall task and service of the system to the end-users which had a grand mean of 4.81 that had an equivalent of Strongly Agree which meant that the system was effective in terms of functionality, reliability, usability, and security.

ACKNOWLEDGMENT

The researchers would like to express their gratitude to everyone who helped conduct this study. To the informants for their patience, cooperation and support for this project.

Special thanks to Dean Ricardo Q. Camungao, DIT for his patience and guidance all throughout this research.

REFERENCES

1. A. Chegenizadeh, M. Keramatikerman, and H. Nikraz. **Application of Innovative Technologies and Computer Aided Approach in a Resilient Teaching Practice for Engineering Students.** *International Journal of Advanced Trends in Computer Science and Engineering,* Volume 9 No. 2, 2020. https://doi.org/10.30534/ijatcse/2020/151922020
2. D. C. Moos and R. Azevedo. **Learning with Computer-Based Learning Environments: A Literature Review of Computer Self-Efficacy**. *Review of Educational Research*, 79(2), 576–600. https://doi.org/10.3102/ 0034654308326083, 2009.
3. D. Lee, J. Kim, H. Lee, and K. Jung. **Reliable multiple-choice iterative algorithm for crowdsourcing systems**. *ACM SIGMETRICS Performance Evaluation Revie*w, 43(1), 205-216, 2015, https://doi.org/10.1145/2796314.2745871
4. L. Yu, and L. Cai. **Iterative algorithm with a constraint condition for numerical reconstruction of a three-dimensional object from its hologram**. *JOSA A*, 18(5), 1033-1045, 2001.
5. A. Beynier and A. I. Mouaddib. **An iterative algorithm for solving constrained decentralized** Markov decision processes. In *AAAI,* Vol. 6, pp. 1089-1094, 2006.
6. Y. J. Liu, P. P. Zhu, B. Chen, J. Y. Wang, Q. X. Yuan, W. X. Huang, X., and H. Ming. **A new iterative algorithm to reconstruct the index.** Physics in Medicine & Biology, 52(12), L5, 2007. https://doi.org/10.1088/0031-9155/52/12/L01
7. A. Baale, A. Oluwatobi and A. Adeola. **Design and Implementation of a Mobile Students' Course Registration Platform.** *International Journal of Advanced Technology and Engineering Exploration*, 3, 2394-5443, 2015.
8. J. F. Andry, H. Tannady, and F. E. Gunawan. **Purchase Order Information System using Feature Driven Development Methodology.** *International Journal of Advanced Trends in Computer Science and Engineering*, Volume 9 No. 2, 2020. https://doi.org/10.30534/ijatcse/2020/32922020
9. D. Z. Deniz, and I. Ersan. **An academic decision support system based on academic performance evaluation for student and program assessment.** *International Journal of Engineering Education,* 2002, 18(2), 236-244.
10. D. C. Cliburn, J. J. Feddema, J. R. Miller, and T. A. Slocum). **Design and evaluation of a decision support system in a water balance application.** Computers & Graphics, 2002, 26(6), 931-949.
11. M. Tavana and S. Banerjee. **Strategic assessment model (SAM): a multiple criteria decision support system for evaluation of strategic alternatives.** Decision Sciences, 26(1), 119-143., 1995.
12. S. A McLeod. **Likert scale**. Simply psychology: https://www.simplypsychology.org/likert-scale.html, 2019.