Research Article

Intelligent Automated Exam System with Adaptive Question Bank and multi-Bloom Taxonomy Assessment

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ARTICLE INFO	ABSTRACT
	Most universities use manual examination systems, whereby the lecturer spends many hours to write exam sets for number of subjects, depends on how many subjects the lecturer has, beside preparing exam questions, the lecture must prepare answer scheme for each exam paper, this process is time consuming. After that, the lecturer must verify with a verifier which makes the process longer and still has no guarantee to minimize errors. Lecturers spend long hours marking these answer scripts. This process compromises the quality and talents of lecturers which could be used for better purposes such as research and modules improvements. The development of the proposed system utilizes a cumulative question bank that aggregates questions from question bank associated to it and updates continuously. The multi bloom level selection feature enables the system to categorize questions based on bloom's taxonomy and allow proper evaluation of student's cognitive skills. This system aims to improve effectiveness, efficiency and fairness of the examination process. The methodology applied for this research was survey and experiment methods. The survey consisted of two phases. The first phase was to get feedback of lectures of using the current examination system, the second phase was after implementing the system to get feedback of lectures after applying the new system to get the successful rate of the proposed system. **Keywords:** Big Data, Smart Education, Smart Examination System, Quality Education.

INTRODUCTION

The concept of an intelligent examination management system represent significant advancement in education technology. This system aims to enhance the examination process by integrating intelligent algorithms and adaptive learning techniques to create more personalized and effective assessment experience. By utilizing deep learning natural language processing and graph-based models, the system can generate and manage diverse range of questions tailored to different cognitive levels as defined by bloom's taxonomy. This approach not only streamlines the exam creation process but also ensures that assessments are aligned with students' learning abilities and educational goals. The following sections discuss the key components and benefits of the smart examination system

Intelligent Question:

intelligent question meant to utilize deep learning and NLP to automate the creation of exam questions ensuring efficiency and security in the process, the creation of the questions is based on customized rules set by the teacher, the rules are based on the institutional quality rules. The system then applies specific algorithms to design questions based on the subject, enhancing the relevance and quality of the assessments.

Adaptive Question Bank:

The system uses graph-based approach to develop a concept map for question storage allowing for intelligenet selection based on criteria such as difficulty, bloom's taxonomy. The system sotring as well the amount of times one question has been used during the academic year to prevent repeating the same question more than once one academic year. The system allows rephrasing of the question to change the difficulty level of it. The system generates balanced question sets that adapt to the parameters set by the teachers and the institution to ensure comprehensive coverage of the curriculum[1].

Multi-Bloom Taxonomy Assessment:

The system integrates blooms' taxonomy with item response theory to assess students' abilities across various cognitive levels, providing a nuanced understanding of student performance. The system adapts assessment content to individual student needs, identifying learning gaps and enabling targeted instructional strategies to improve student's performance and understanding of the selected subject. The system will use selected algorithms to analyze individual and overall performance of the subject to identify the gaps and where is the lacking points[2].

Personalized Learning and Assessment:

The system's adaptive characteristics allow the teacher to personalize the assessment based on the student's needs and skills and understanding and the expected outcomes of the assessment[3].

As the technology advances, user requirements also advance and change. With the advancement of technology smart cities, smart transportation, smart agriculture have changed user's lives. Smart education is part of the advancement to enhance living. Students' learning methods and strategies have changed as the generations evolve in thinking and skills. This research aims to propose smart examination system that contributes to the quality of education and enhance student learning journey. This research contributes to enhance the quality of education by providing a smart system that manages examination process using automation algorithms that meant to save the teachers time, and effort, enhances learning process, save paperwork and utilizes the institution facilities. This paper in presenting the problem statement where there is discussion about the current issues faced by teachers, students and institutions towards current methods of examination. Then presents the research objectives and questions and significance. After that, there will be discussions about the research methodology and data collection process. Parts of the system will be illustrated at the end of the paper to present the output.

PROBLEM DISCUSSION

The regular examination system in educational institutions, especially those that depend on paper-based procedures, are loaded with several ineffectiveness and obstacles. Lecturers are loaded with the repetitive and heavy responsibility of creating examination questions, which frequently results in the reutilization of previous questions due to time limitations. In addition, the traditional marking method provides struggles and most of the time leads errors and poor quality of results, inaccurate grading and misplacement of examination papers. Tradition system utilizes huge space to keep files and more than frequent these files will end up damaged.

Traditional examination method has encountered many issues and limitations that have led to inaccurate assessments_ and poor_ quality of education and students' performance. This method have exhausted the lectures energy, skills and time[1].

The traditional examination systems requires huge amount of paper which will be used for_ documenting, archiving, answer scripts, several of exam papers, several sets of marking scheme papers, huge number envelops, and files, it requires many stationaries as presented in fig1.

Figure1. Traditional Exam output

One of the primary limitations of the paper-based examination system is limited and over repeated questions. The reason for over repeating exam questions is that lectures do not have the sufficient time to create new questions for the students for the same subject more than once a year[2].

The exam is designed to test what_ the students have stored of information temporarily not_ based on their long-term skills. Due to the huge_ number_ of students and limited time for marking, lecturers tend to make mistakes such as wrong marking, forgetting scripts, losing_ scripts. Universities will always_ run out of storage and archive rooms, so they need to shred most of the papers to make room for new waste. Students' efforts and hard work will end up in trash_ despite_ how valuable their work is, this research_ proposes smart examination system that does not require involvement of humans as much as the traditional system[3].

RESEARCH OBJECTIVES

1. To design and develop a smart examination web-based system for post-secondary institutions and associated with computerized making feature.

2. To propose and select AI algorithms for question bank selection.

3. To validate reliability and validity of the questions in the question bank

4. To benchmark the proposed system against the existing solution in terms of effectiveness and usability.

RESEARCH QUESTIONS

1. How can the current examination system be enhanced with the use of ai embedded selection features and multi bloom level question pool?

2. What are the most suitable AI algorithms for question pool selection?

3. What are the measurements used to validate reliability and validity of the questions in the question bank ?

4. How effective and usable is the proposed system as compared with the current examination system?

SIGNIFICANCE OF RESEARCH

1. Staff and lecturers: The time of preparing several sets of exam_ questions and marking schemes and marking will be reduced to 50% of the original time. Lecturers will utilize the time to use their_ talents in research and modules

developments. The time of managing and preparing reports will be reduced as the system provides all sorts of reports as customized. Human Mistakes will be reduced as the system manages the exams and marking and reporting[4].

2. Students: the exam management system focuses of students skills rather than temporary memorizing information. Students wont need to use stationary as they will do the exam digitally. Having this system will minimize the number of mis-conduct as the students will be seated randomly. The automative system creates positive learning environment and enhance learning experience[5].

3. Management: The smart system helps to reduce costs of paper work such as storage rooms, electricity, paper, stationeries[6].

OVERVIEW OF EXAMINATION MANAGEMENT SYSTEMS

The examination systems in higher education institutions have evolved significantly over the years, with a demand on mixed assessment methods that comply to different types of learning styles and academic goals. The examination started from a traditional to digital examination systems, following points_ present the evolution of examination systems:

Traditional Writing Exam: to assess student's understanding of the course through fixed timed and location written answers. This approach includes essay questions, short questions, true or false questions and multiple-choice questions. This is a manual paperwork approach[7].

Open Book and Take-Home Exam System: this approach evaluates the ability to apply knowledge in a more flexible setting, where students are allowed to use textbooks[8]. This_ exam takes several hours to several days depending on the complexity of the exam. This approach includes paperwork system[9].

Continues Assessment Exam System: this system assess students via written exam and assignments. Each component takes fixed time allocation. This system evaluates the student's knowledge and understanding of the course. This approach includes paperwork system and consume long hours[10].

Computer Based Examination System: this system utilizes technology and uses digital methods to conduct the examination, it consist only of multiple choices. This system also has specific time for the student to conduct the examination. There is no other types of questions included in this system[11].

Blended and Hybrid Assessment Examination System: this system combines two different methods of exam approach to provide a more comprehensive evaluation of student's abilities. The online approach where the student can be anywhere and conduct the exam. In the same time students can do physically the same exam questions. This approach started during covid 19 as a method to improve education quality[12]. Table 1. Presents these challenges of these systems.

Table1. Challenges of Current Examination Systems

Examination system	Challenges
Traditional Writing Exam	**Paperwork:** Uses massive amounts of paper and require big storage rooms, electricity, printers, stationery from lecturers and students. **Exam approach:** paper base exam where students tend to keep the information temporarily until exam time. **Skills:** Students are tested based on what they know and understand, not based on their skills. **Marking:** lecturer utilize long hours for marking depending on the number of students, lecturer is given fixed time and deadline to submit results and reports despite the mistakes that occurred during marking. **Location:** in several exam rooms. **Supervision:** students will have invigilators to prevent misconduct.

Examination system	Challenges
Open Book and Take-Home Exam System	**Paperwork:** students must submit their written report for the exam. **Exam approach:** paper base exam where students write from other resources. **Skills:** students are tested based on the knowledge they find from other resources, the knowledge they gain is temporary until the exam time is passed. **Marking:** lecturer utilize longer hours for marking depending on the number of students. The time for marking is longer due to bigger answers. **Location:** open area. **Supervision:** students do not need invigilators as they have the exam any location[13][14].
Computer Based Examination System	**Paperwork:** there is no paperwork required for this type of system. **Exam approach:** students conduct the exam using mobile devices such as computers[15]. **Skills:** students are tested based on the knowledge which they have gained from the course. Once they have taken the exam, they tend to forget the information they have gained during the course. They learned to study only for the exam. **Marking:** lecturer must mark digitally on the computer. **Location:** specific room aligned to the computer exam[16].
Blended and Hybrid Assessment Examination System	**Paperwork:** students have the option to do the exam online from different location or physically in the exam unit. **Exam approach:** student conduct the exam on paper or on the computer from different location[17]. **Skills:** students are tested based on what they have learned in the class. **Marking:** lecturer utilize long hours for marking depending on the number of students, lecturer is given fixed time and deadline to submit results and reports despite the mistakes that occurred during marking. **Location:** exam unit on online from different location[18].

RESEARCH METHODOLOGY

This project aims to propose a smart examination system to generate different types of questions and provide instant marking and create reports for each exam. SOWT analysis have been employed to analyze the key factors of the selected project as presented in table 2.

Table 2. SWOT analysis

Strengths	
Completed Questions Bank	The question bank ensures a huge and diverse questions, which reduce the possibility of repetition and increase the system's reliability. This factor ensures to increases the education quality.
Multi-Bloom level selections	The system selects questions according to the multiple blook levels. 1. Knowledge 2. Comprehension 3. Application 4. Analysis 5. Synthesis 6. Evaluation.
Automated grading	The system automates the marking process, alleviating teachers' workload, minimizing human errors, and enhancing accuracy.

Strengths	
Personalized feedback	System provides instant feedback to lecturers and admins and allows them to customize the type of feedback and what the student can see.
Scalability	The system is easily scaled to accommodate large number of students and marking.
Weakness	
Technical dependence	The system might face technical issues such as server down or software bug. Due to this weakness, there will be plan B where the system will be running from different server to make sure quality is still ensured.
Security concerns	The system could face security breaches or issues depending on how strong the attack is; however, recovery time does not take long and there is the backed-up server ready for emergency.
Opportunities	
Expansion to new market	The scalability and adaptability make the system attractive in the market and increase the selling value.
Data Analytics	The system provides great in-depth analytical reports about the student's performance by using the analysis algorithms associated with it. These reports help the lecturer and admin to make perfect decisions about the students' performance and module enhancements.
Threats	
Cybersecurity	The system contains a huge amount of data and algorithms which make it in the face of cyber stack.
Technology changes	As technology keep on improving and enhancing, there will be a time where all sorts of exams are no longer applicable, where students will be tested based on projects not exams.

This is Preliminary research and requires certain steps to achieve the objectives, the steps are presented in fig 2. This research have applied two methodologies, survey and experiment, to collect sufficient data. The strategy of each methodology is in the following section.
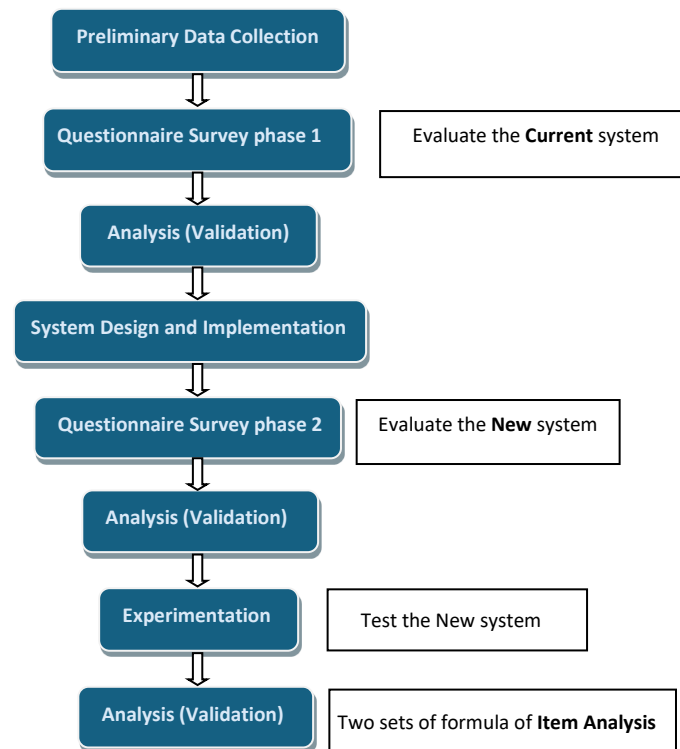

Figure 2. Preliminary Research steps

Survey:

The survey was conducted among the lecturers, and it has two phases, the first phase is to get feedback about the old system and its process. The purpose of this phase is to know duration and steps taken to perform the exam, and mistakes and issues occurred during the process. Phase two is after implementing the system. The lecturers will conduct the exam using the new system, then answer the survey. The results of both surveys will be used and compared to get proof of the success and effectiveness of the proposed system.

Based on the first phase of survey, around 40 lecturers have answered the survey about the process of old manual system they are using to create and mark exam questions. According to their answers. Lecturers spend a long-time preparing exam paper and their answer schemes; after creating these sets of exams and answers, the paper must go through two levels of verification. The process takes for one subject approximately one week for the paper to be confirmed for examination.

Fig 3. Illustrates the results of the amount of time spent by the lecturer to prepare one exam paper for one subject.
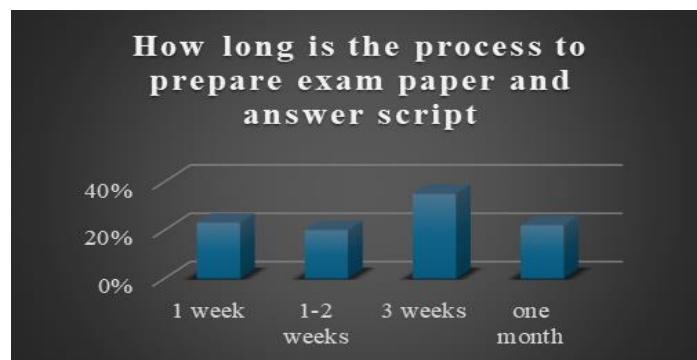

Figure 3. Number of hours taken to mark exam paper

Figure 4. Number of hours taken to mark exam paper

According to fig 4. Lecturers seem to spend huge amounts of hours marking exam questions. The survey question presented in fig 4 is based on lecturer marking one subject only with total number of students between 25 – 60. If a lecturer has more than one subject then the number of hours will increase which means neglecting other important tasks such as research, course development for the sake of marking just to meet the deadline.

Experiment

To evaluate the effectiveness of the proposed system, a comprehensive experiment is designed to assess its performance, reliability and the impact of the lecturer's performance quality.

- Experiment design: First group contains 20 lecturers conduct the examination using the normal method (old system) paper-based system. The second group contains 20 lecturers who conduct the examination using the proposed system.

- Data collected: time taken to conduct the examination from first to the last step, number of errors occurred during the examination, lectures performance, students' performance, number of misconducts, students' performance.

Implementation of intellegent examination system

The system contains several functions and features to perform in the best quality possible, the features are presented as follows:

1. Dashboard Overview

   a. Log in. b. Create an account.

2. Main Interface (based on table 3)

Table 2. Features of main interface

1. Select faculty	2.Select department	3.Select subject
4.Select exam type	5.Select number of sets	6.Level of difficulty
7. System provides the sets of exams as required		
8. Lecturers verify the questions		
9.System provides the answer scheme		10.lecturer verify
11.Send to second verifier.		
12.Second verifier perform verification		
13. System confirms set of exams and send to admin and exam unit		

3. Question Bank Interface

   a. Keyword search.

   b. Filter by subject. Difficulty level (Bloom's Taxonomy), question type (MCQ, true/false, open-ended questions, short answers).

   c. Tags and categories for easy access.

4. Question List View

   a. List of questions with details such as difficulty, subject, exam type.

   b. Actions: edit, Delete, View, add.

5. Exam Creation Interface

   • Exam details form

      a. Title of exam, Description.

      b. Select subject.

      c. Select bloom's taxonomy levels.

      d. Set time and number of questions.

   • Auto generated questions

      a. Based on the selected criteria.

      b. Select a question from the bank or edit it or add new question.

      c. Preview of exam format from the student side.

6. Exam Management Interface

   a. List of exams: upcoming, completed, on going

   b. Manage results: edit results, accept results, conform results

   c. Monitor exam: real time monitoring during exam.

   d. Reports: exam results, students' performance, analytical reports.

   e. Customized reports: filed, passed, best performance, worse performance, most questions answered, best questions answered, worse questions answered, time taken for each question, questions left empty.

The system works based on multiple-pool selection to ensure students are tested based on their knowledge and skills, not based on what they have temporarily memorized in the classroom. The selection structure will be random based on the following structure:

1. Question based on two options and student answer one option only.

2. Question based on three options and student answer one option only.

3. Question based on three options and student answer two options only.

4. Question based on four options and student answer one option only.

5. Question based on three options and student answer two options only.

6. Question based on five options and student answer three options only.

7. The scenario question and answer is one of three options only.

8. One open ended question based on opinion only.

The arrangement of these questions will be random to prevent students from picking up the consistency of answers to make sure they understand the question and not answering blindly to increase the quality of education. Fig 4 illustrates the home screen.
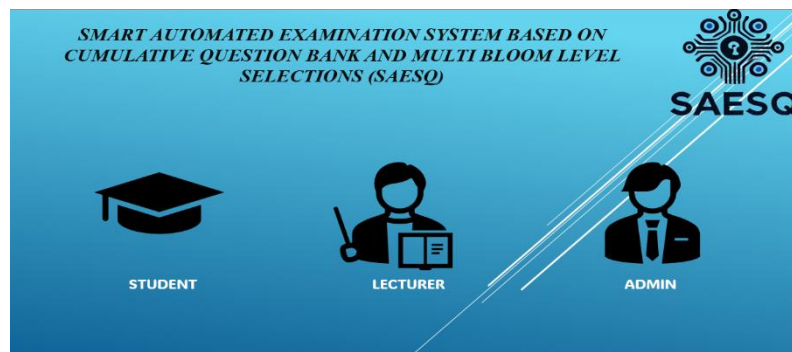

Figure 4. Home screen

Based on the selection of the user category, the system will load the authorized functions. for instance, if the student is to login the home functions of student will be presented as illustrated in fig 5.
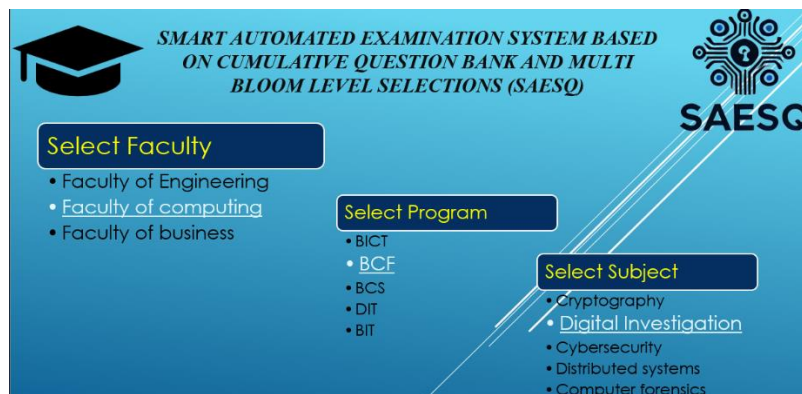

Figure 5. Student function home screen

After the student selects the subject, then the screen of the questions will appear where the student can answer the questions then click submit for each part that appears to the student. As the student submits the answers, the system automatically mark the exam and send a report to the lecturer, then the lecturer will verify the marks whether to accept or amend then send to the exam department. Fig 6 illustrates the exam question screen for the student.
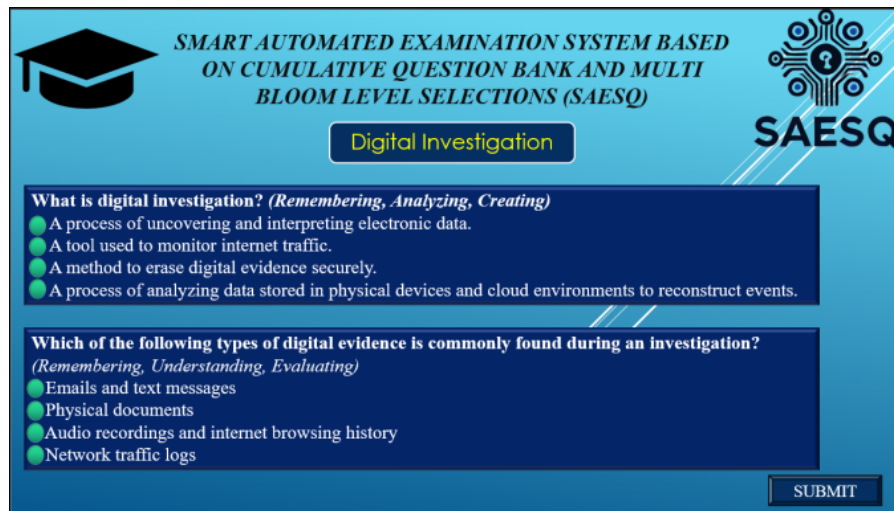

Figure 6. Student exam screen

Marking the exam questions will be based on an algorithm to make sure that the questions are properly marked from the system, the algorithm is presented in the following code.

```
Public double marking()

{

int correctanswer = 0;

int totalcount = correcttotal.length;

for (String studentanswer : studentanswers){

if(iscorrectanswer (studentanswer)){

totalcount++;}}
```

To calculate the total score for each student based on their answers the following snippet is applied.

```
double score = (double) thecorrectcount / thetotalcount;

return score;

private Boolean iscorrectanswer(String studentanswer){

for (String correctamswer: correctanswers){

if (studentanswer.equals(correctanswer)){

return true; } }

return false;

public static void main(String[] args) {

String [] correctanswers = {"first", "second", "third"}

String [] correctanswers = {"first", "second", "third", "fourth"}

Multselectionmarking marking = new Multselectionmarking(correctanswers, studentanswers);

Double score = marking.markanswers();
```

System.out.println("the final score is " + score);}}

At the end of the process the system will send a full report to the lecturer with the students' names and their marks. More details will be sent to the lecturer such as Most answered question correctly, most answered question wrongly, longer question duration of answer, shorter question duration of answer. These data will help the lecture to analyze the performance of the students, which will later help in the course development. Fig 6. Illustrates the options the lecturers have in their own interface to manage the subject performance
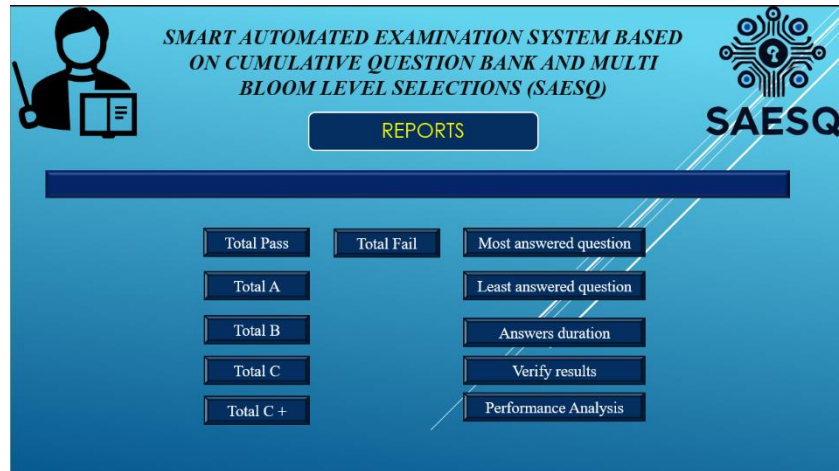

Figure 6. Lecturer function home screen

Evaluation of user experience

A survey conducted among lecturers after using the smart examination system. Most lecturers specially from technological background and in the age ranged from 35 to 45 prefer to use the new system rather than traditional as it automates the entire process of examination. The lecturers tested the system for the first time, the feedback is illustrated in fig 7. The longest time consumed to perform examination using the new system was one day, these results were from lecturers who used the system for the first time with feedback that the system is easy to learn and use.
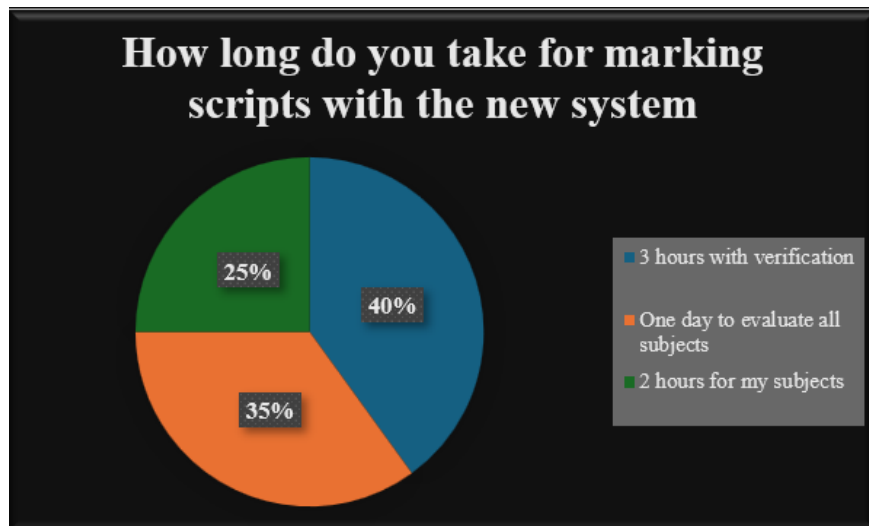

Figure 6. Duration spent to perform manage exam using the new system

Lecturers have revealed that they do prefer to use the new system as it has saved huge amounts of time and resources, the system helped the lecturers to create good quality exams and marked them sufficiently, most of the lectures didn't have to edit the questions and approved right away. The system helped the lecturers to create different types of reports to analyze students' performance. Fig 7. Illustrates the lecturers' preferences of selecting the new system over the traditional.
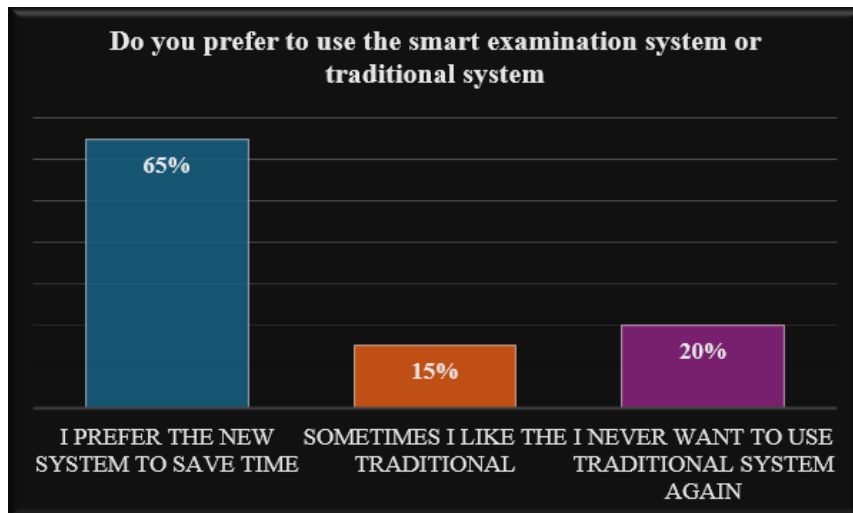
Figure 7. lecturer's preferences on using the new system

CONCLUSION

Smart Automated Examination System is a revolution in the education industry as it addresses the limitation of the current examination systems. The main difference between the proposed system and current systems is it tests the students based on their understanding and skills; students do not need to memorize huge amounts of information temporarily till exam time[21]. The system minimizes errors and human involvement, minimize paperwork, and saves massive time for the lecturers and admins. Students do not have to wait for a long period of time to get their results, the appeal cases of re marking will be less. The system have minimized the working hours of lecturers, which means the lecturers can utilize the time for self-development, research and modules and courses enhancement for better education quality.

REFERENCES

[1] J. Akinboboye and M. Adekunle Ayanwale, "Bloom Taxonomy Usage and Psychometric Analysis of Classroom Teacher-Made Test," 2021. [Online]. Available: https://www.researchgate.net/publication/348621347

[2] D. Reddy, K. I. Chugh, and R. Subair, "Automated Tool for Bloom's Taxonomy," International Journal of Civil Engineering and Technology, vol. 8, no. 7, pp. 544–555, 2017, [Online]. Available: http://iaeme.com/Home/journal/IJCIET544editor@iaeme.comhttp://iaeme.com/Home/issue/IJCIET?Volume=8&Issue=7http://iaeme.com/Home/issue/IJCIET?Volume=8&Issue=7http://iaeme.com/Home/journal/IJCIET545.

[3] Mariana, Raykova., Hristina, Kostadinova., George, Totkov. (2011). Adaptive test system based on revised Bloom's taxonomy. 504-509. doi: 10.1145/2023607.2023692.

[4] M. Liu, "An overview on the impact of the exam-oriented education in China," SHS Web Conf., vol. 180, p. 02036, 2023, doi: 10.1051/shsconf/202318002036.

[5] G. Alandjani and S. Pervez, "Role of Internet of Things (Iot) in Higher Education," Proc. ADVED 2018- 4th Int. Conf. Adv. Educ. Soc. Sci., no. October, pp. 1–9, 2018.

[6] L. K. Siong, H. Azman, and K. Y. Lie, "Investigating the undergraduate experience of assessment in higher education," GEMA Online J. Lang. Stud., vol. 10, no. 1, pp. 17–33, 2010.

[7] Y. S. Park, S. J. An, and Y. J. Lee, "Direction of contents development for smart education," Proc. Int. Conf. e-Learning 2013, pp. 369–373, 2013.

[8] Unesco, Smart Education Strategies for Teaching and Learning: 2023.

[9] S. N. Akinwalere and V. Ivanov, "Artificial Intelligence in Higher Education: Challenges and Opportunities," Bord. Crossing, vol. 12, no. 1, pp. 1–15, 2022, doi: 10.33182/bc.v12i1.2015.

[10] J. Wijayanayake, L. Erandika, and J. Prasadika, "Analysing the impact of student engagement on learning outcomes in e-learning platforms: a systematic review of literature," Adv. Knowl., no. May, 2023, [Online].

Available: http://repository.kln.ac.lk/handle/123456789/27406%0Ahttp://repository.kln.ac.lk/bitstream/handle/123456789/27406/DRC   2023   VOL   2   7.pdf?sequence=1%0Ahttps://www.researchgate.net/publication/376456861_ANALYZING_THE_IMPACT_OF_STUDENT_ENGAGEMENT_ON_LEARNING_O

[11] M. R. I. Sattar et al., "An advanced and secure framework for conducting online examination using blockchain method," Cyber Secur. Appl., vol. 1, no. June 2022, p. 100005, 2023, doi: 10.1016/j.csa.2022.100005.

[12] R. J. R. Cardona, Miguel A., "Artificial Intelligence and the Future of Teaching and Learning," no. May, pp. 1–64, 2023, [Online]. Available: https://www2.ed.gov/documents/ai-report/ai-report.pdf

[13] S. Dikli, "Assessment at a distance : Traditional vs . Alternative Assessments," Turkish Online J. Educ. Technol., vol. 2, no. 3, pp. 13–19, 2003, [Online]. Available: http://www.tojet.net/articles/v2i3/232.pdf

[14] S. Dikli, "Assessment at a distance : Traditional vs . Alternative Assessments," Turkish Online J. Educ. Technol., vol. 2, no. 3, pp. 13–19, 2003, [Online]. Available: http://www.tojet.net/articles/v2i3/232.pdf

[15] F. R. Awad Ahmed, T. E. Ahmed, R. A. Saeed, H. Alhumyani, S. Abdel-Khalek, and H. Abu-Zinadah, "Analysis and challenges of robust E-exams performance under COVID-19," Results Phys., vol. 23, p. 103987, 2021, doi: 10.1016/j.rinp.2021.103987.

[16] Waheeda, F. Muna, A. Shina, and F. Shaheeda, "Benefits of online assessments in higher education institutions: Lessons from Covid-19 pandemic," J. Bus. Soc. Sci., vol. 2023, no. January, p. 3, 2023.

[17] M. K. SAEED, A. M. SHAH, K. MAHMOOD, M. UL HASSAN, J. KHAN, and B. NAWAZ, "Usage of internet of things (iot) technology in the higher education sector," J. Eng. Sci. Technol., vol. 16, no. 5, pp. 4181–4191, 2021.

[18] S. Singh, "Examinations in the Higher Education Space," Electron. J. Knowl. Manag., vol. 20, no. 1, pp. 63–75, 2022, doi: 10.34190/EJKM.20.1.2769.

[19] 张可昀, "Design and Implementation of Online Examination System Based on Web," Softw. Eng. Appl., vol. 11, no. 04, pp. 690–700, 2022, doi: 10.12677/sea.2022.114072.

[20] R. Bajaj and V. Sharma, "Smart Education with artificial intelligence-based determination of learning styles," Procedia Comput. Sci., vol. 132, pp. 834–842, 2018, doi: 10.1016/j.procs.2018.05.095.

[21] S. Vincent-lancrin, "New England Journal of Public Policy Smart Education Technology : How It Might Transform Teaching (and Learning) Smart Education Technology : How It Might Transform Teaching (and Learning)," vol. 34, no. 1, 2022.

[22] Sarsby, A Useful Guide to SWOT Analysis. 2012. [Online]. Available: https://www.cii.co.uk/media/6158020/a-useful-guide-to-swot-analysis.pdf

[23] O. Díaz-parra, A. Fuentes-penna, and R. A. Barrera-cámara, "Smart Education and future trends International Journal of Combinatorial Optimization Problems and Smart Education and future trends," Int. J. Comb. Optim. Probl. Informatics, vol. 13, no. 1, pp. 65–74, 2022.

[24] S. Analysis, C. Enterprises, P. Ricard, and L. Ice, SWOT Analysis SWOT ANALYSIS, vol. i. G. N. Shah and D. Z. A. Nadaf, "Examination In Higher Education: Concerns & Trends To Reform," Sanshodhan Chetana, no. 63299, pp. 155–163, 2019.