

The development of E-Equation Easy System (3E System)

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Abstract. E-Equation Easy System (3E System) is a web-based system created to solve simultaneous equation calculations using the Matrix method (Cramer Rule Method) which is faster and easier as an alternative to manual calculation methods. This application will be able to be used by lecturers and students but the level and form of access are different to control the security of questions. This innovation project targets the following two objectives which are the first; to help lecturers in facilitating the preparation of theory and practical questions for students, and secondly, to reduce the calculation time required in providing accurate answers. In terms of the functionality of this innovation project, 3E System has been able to be used by students through an open user module and by lecturers through a registered user module. This application is also able to meet the calculation of solutions for two types of simultaneous equations, namely two variables and three variables, and it makes it easier for lecturers to get answer schemes and create simultaneous equation questions by just entering the values of the variables. The use of this application has indeed been able to help in solving the problems faced by lecturers in the implementation of the teaching and learning process. 3E system was developed using PHP as a chosen scripting language, MySQL as a database, Bootstrap as an open-source web user interface, Javascript and Cascading Style Sheets (CSS) are also attached with them. This system has also successfully gone through the testing phase and can be used online safely. This responsive system, can be accessible using a desktop or mobile phone, helps access from all over the world and can collect feedback from users regarding the level of satisfaction with the use of the system.

1 Introduction

This title of this innovation project is called e-Equation Easy System or 3E system. The system was fully completed around July 2020. It is a computer web application which solves the calculation of simultaneous equations using the Cramer Rule method as an alternative to the manual calculation method. This web application opens for use by students through open

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user modules and by lecturers / teachers through the registered user module. Among the advantages of using 3E System is that this application is easily accessible via the internet on a smartphone or computer, user friendly interface, the ability to satisfy 2 types of equations simultaneously, namely 2 variables and 3 equation variables, high accuracy and fast giving answers. In addition, through the registered user module, lecturers / teachers will be able to test their similarities and then save them for reference future. Various parties will be able to take advantage of the inclusive 3E System such as students, lecturers, institutions, ministries of education and even the service sector public as a whole.

There are also nearly similar systems developed by developers which can solves the calculation of simultaneous equations using the matrix method (Cramer Rule method). The Cramer's Method Calculator program is developed by Haruka Kido [1]. The Cramer's Method Calculator Program is written in C++ for hardware configurability for sample 3 x 3 matrix. User has been asked by the C++ code to input the coefficient values for 3x3 matrix, including the values for the solution vector. As per the user's inputs, the program then prints out the linear system of equations for the matrix. The results of the determinant, the numerators, the X=, Y=, and Z= fractions, and the solution to X, Y and Z will be printed by the program. Mobile Calculator Inverse Method and Cramer's Rule developed by A. Baharum et al. is another similar system that can help student's difficulties in answering Inverse Method or Cramer's Rule questions. This Mobile Calculator app focuses on the process of calculating simultaneous linear equations using the Inverse Method and Cramer's Rule [2]. There are other existing matrix calculators that calculate using Cramer Rule method such as EMH Cramer's Rule Calculator [3], Mera Calculator [4], Cramer's Rule Calculator (ncalculators.com) [5] and so on. From the literature that has been done on existing Cramer's Rule calculators, these systems only can do calculation but cannot save the questions generated from the calculator into the system like the 3E system that has been developed as mentioned in this paper.

Some steps have been taken to create a method based on technology called e-Equation Easy System (3E System) where this system is able to solve simultaneous equation calculations using the matrix method. This project will be able to increase effectiveness teaching and learning process for Business Mathematics Course and Mathematical Computing at Kuching Sarawak Polytechnic in particular and the institution other higher education and also general secondary schools. After getting approval from the relevant SME management project that has been selected, then the distribution of tasks has been done along with the scope of their respective responsibilities.

Linear equation calculation system using start web application designed by two members who act as System Developers. Project specifications have been listed according to careful planning so that projects can be implemented according to a certain period of time. There are four phases in the production of applications namely Inception Phase, Elaboration Phase, Construction Phase and Transition Phase.

Use by students through open user modules and by instructors / lecturers through the registered user module. This application is able to meet the calculation of the solution for two types simultaneous equations that are 2 variables and 3 variables. This application makes it easy for lecturers to create equation questions simultaneously by only entering variable values.

Problem identification is done through brainstorming methods. Some problems in the Teaching and Learning (P&P) process for Mathematics courses have been identified such as the following the attitude of students who are not focused and are not serious about learning, the lecturer is not skilled, lack of practice questions and uncomfortable environment. Through a vote conducted among members, the majority chose "Deficiency training questions" as problems that need to be addressed to improve teaching effectiveness and improving student understanding.

2 Methodology

2.1 List suggested solutions

Continuing from the cause of the problem that has been analysed, the group has produced two proposed solutions namely:

1. Provide practice books.
2. Create a web application to generate questions and answers.

Both of these proposals are described according to their suitability using the method SMART (Specific, Measurable, Achievable, Reliable and Time period). Results from the SMART analysis, group members agree to choose "Creating a web application to generate questions and answers" as the most appropriate recommendation. SWOT analysis (Strengths, Weaknesses, Opportunities and Threats) also carried out to determine the pros and cons of the proposal this solution.

Table 1. SWOT analysis.

| | |
|---|---|
| <p>STRENGTH</p> <ul style="list-style-type: none"> • Have expertise • Multi-functional system • dual users • can be used in long period • always possible improved • Saving time | <p>WEAKNESSES</p> <ul style="list-style-type: none"> • A long time to prepared • Lack of support facilities • The solution is in the form of theoretical questions only |
| <p>OPPORTUNITIES</p> <ul style="list-style-type: none"> • More widespread use • Many users (teachers, lecturers, students) | <p>THREATS</p> <ul style="list-style-type: none"> • The possibility exists almost the same system • Lack of finances to create platform |

Next the group determines the appropriate topic to develop application system. Through the Brainstorming method, the matrix method (Cramer's Rule method) for the solution of simultaneous equation calculation has been selected. Terminology Simultaneous Equations is a synonym in mathematics at Certificate of Education level Malaysia and Diploma. Concurrent Equations seem simple, but they exist various constraints that arise in the teaching process and preparation of questions. One of the problems is that it takes a long time to test equation using manual calculation method.

2.2 Analysing the cause of the problem

In this step, the group has analysed the causes of "Lack of practice questions" problem using the Ishikawa Diagram. From four main factors (materials, people, methods and environment), the group has identified that there are three factors that are the cause of the problem:

1. Materials – lack of exercise books
2. Humans - lecturers did not have time to prepare questions and answer schemes
3. Methods - techniques of preparing questions by lecturers are less effective

Next from the results of the 4W1H analysis (What, Who, Where, When and How), the majority of group members agree to choose the Method factor ie "question preparation techniques by lecturers are less effective" as the cause which needs to be overcome.

2.3 Rational Unified Process (RUP)

The software development methodology used to develop this system is Rational Unified Process (RUP). RUP provides a structured approach to software development. It is suitable for larger and more complex software projects. Use-case driven, Iterative (repetition of the process), and Incremental (increase in value) by nature, delivered online using web technology, can be customized or tailored in modular and electronic form are some characteristics of RUP. RUP reduces unexpected development costs and prevents wastage of resources [6]. Developing a matrix calculator using Cramer's Rule, which is a mathematical technique for solving systems of linear equations, is a relatively simple task that may not require the full rigor of RUP. However, some RUP principles have been used to assist the development process of this project. Here are the processes involved for each phase in the RUP.

2.3.1 Inception phase

1. User Identification: Identify the users for the calculator matrix project. These might include math lecturers, teachers, students, or anyone who needs to solve linear systems using Cramer's Rule.
2. Requirements Gathering: Define the functional and non-functional requirements for this calculator matrix. Identify the input and output formats, user interface design, and any other criteria.

2.3.2 Elaboration phase

1. System Architecture: Design the overall architecture of this calculator matrix. Determine how to represent and manipulate matrices and implement Cramer's Rule algorithm.
2. Risk Assessment: Identify risks in the project, such as technical challenges or changes in requirements, and develop mitigation strategies.
3. Prototype: Develop a simple prototype of your calculator matrix to validate the architecture and user interface with key stakeholders.

2.3.3 Construction phase

1. Coding: Write the code for calculator matrix, including the implementation of Cramer's Rule method.
2. Testing: Perform unit testing and integration testing to ensure that the calculator matrix functions correctly.
3. Documentation: Document the code, including comments and user documentation to help users understand how to use the calculator.

2.3.4 Transition phase

1. User Training: Provide training materials or user guides to help users understand how to use the calculator matrix effectively.
2. Deployment: Deploy the calculator matrix to a platform where users can access it.
3. Feedback Gathering: Collect users feedback regarding the system to make improvements or bug fixes.

2.3.5 Monitoring and maintenance

1. Monitor the calculator matrix continuously for any issues or performance disruption and solve it immediately.
2. Update the calculator matrix as needed to accommodate changes in requirements or to add new features.

2.4 Technology used

Web technology used to develop this system is using PHP scripting as a web programming language, Javascript, AJAX, MySQL as a database, Cascading Style Sheet (CSS) to make interface more attractive, Bootstrap as an open-source web user interface and web hosting to publish the e-Equation Easy System.

2.5 Conceptual design

2.5.1 Use case diagram

To produce a use case diagram, among the actors involved are non-member users, member users, system administrators and moderators (system administrator assistants). The following diagram shows a use case diagram for developing this system. Figure 1 shows use case diagram for user, while Figure 2 shows use case diagram for administrator. Use case diagram for user divided into two types of user including user level 2 and open user. User level 2 consists of lecturers and teachers while open user consists of students. Level 2 user need to sign up as a member and can login into the system before creating a questions with answers, while open user can directly access the calculator without need to sign up as a member. But open user need to fill in feedback form if want to give comments and suggestions.

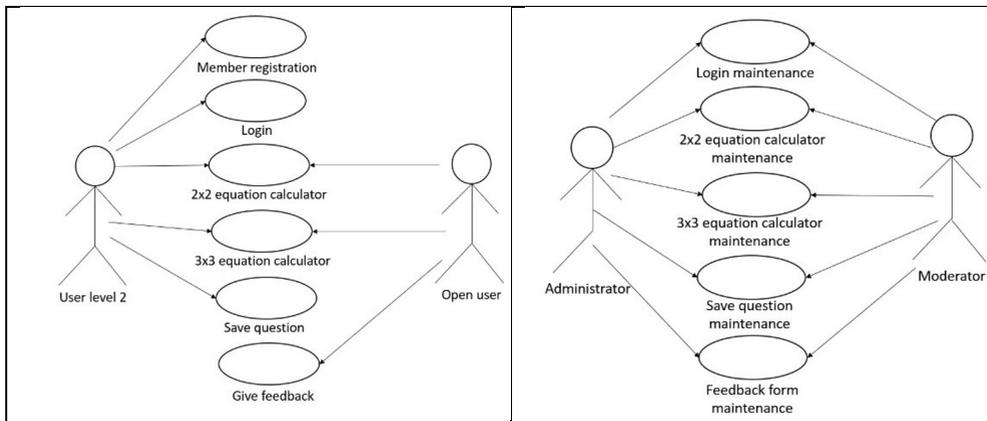


Fig. 1. Use case diagram (User).

Fig. 2. Use case diagram (Administrator).

2.5.2 Entity relationship diagram

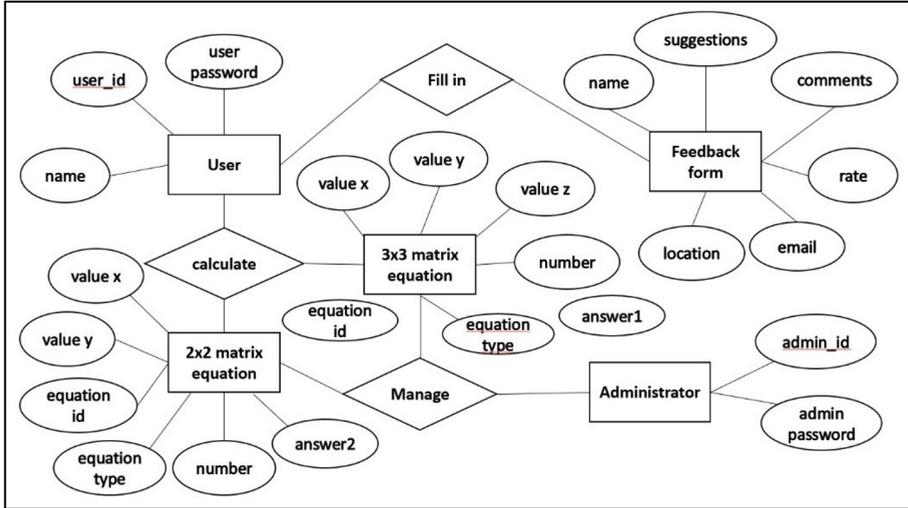


Fig. 3. Entity Relationship Diagram (ERD).

Figure 3 shows the Entity Relationship Diagram (ERD) for database design of calculator 3E system. It has 5 entities such as user, administrator, 2x2 matrix equation, 3x3 matrix equations and feedback form. For each entity has their own attribute and also relation between the entities.

3 Results and discussion

3.1 Analysis using questionnaire

Before developing 3E system, pre-questionnaires have been distributed to respondents which consists of 11 educators (level 2 user) and 24 students (open user) to get feedback regarding current method they used to produce equation and matrices questions with answers for level 2 user and current method used by open user to get answer from equation and matrices questions. Here are the results after received feedback from the respondents.

3.1.1 Demographic of the respondents

Figure 4 shows demographic of the respondents who fill in pre and post questionnaires for level 2 user (educators) while figure 5 shows demographic of the respondents who fill in pre and post questionnaires for open user (students).

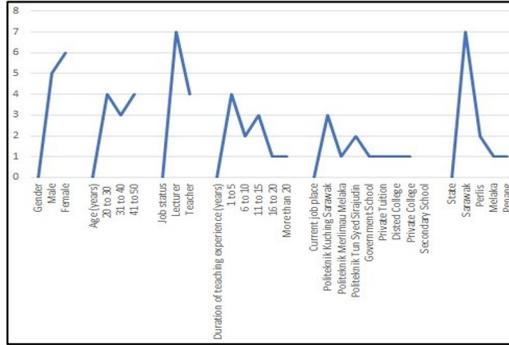


Fig. 4. Demographic of respondents (level 2 user).

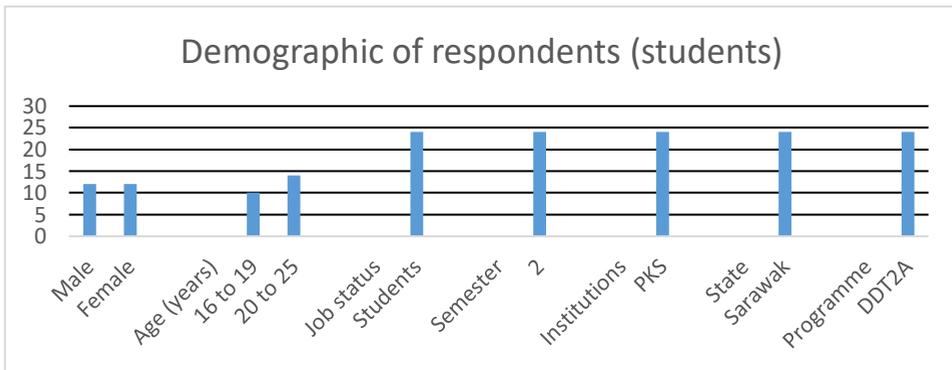


Fig. 5. Demographic of respondents (open user).

3.1.2 Survey done before develop calculator 3E System (Pre Questionnaire)

Figure 6 shows results for feedback received from respondents who filled in pre-questionnaires for open user while Figure 7 shows results for feedback received from respondents who filled in pre-questionnaires for level 2 user.

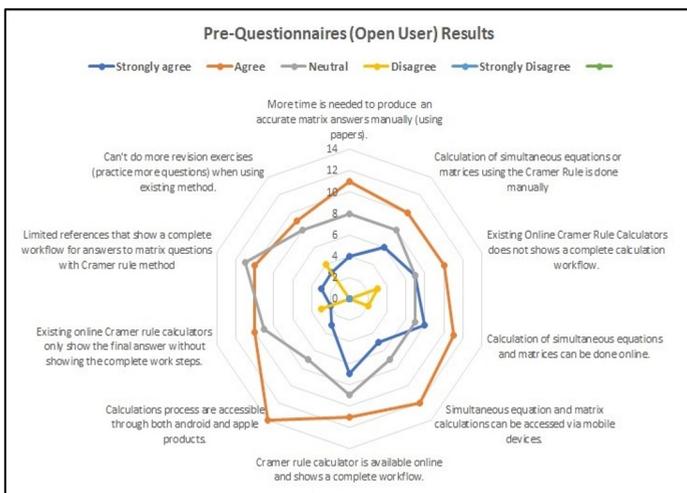


Fig. 6. Pre-Questionnaire (Open Users) results.

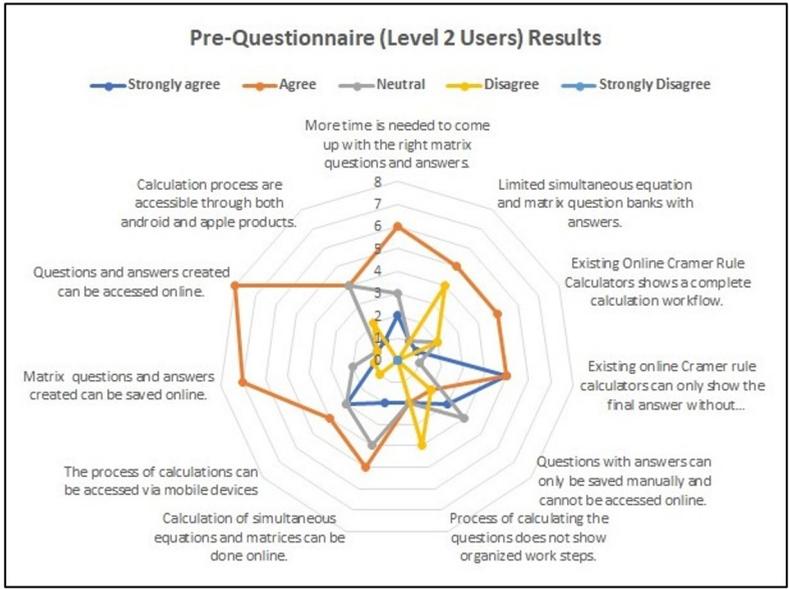


Fig. 7. Pre-Questionnaire (Level 2 Users) results.

3.1.3 Survey done after developing and using 3E System (Post Questionnaire)

Figure 8 shows results for feedback received from respondents who filled in post-questionnaires for open user while Figure 9 shows results for feedback received from respondents who filled in post-questionnaires for level 2 user.

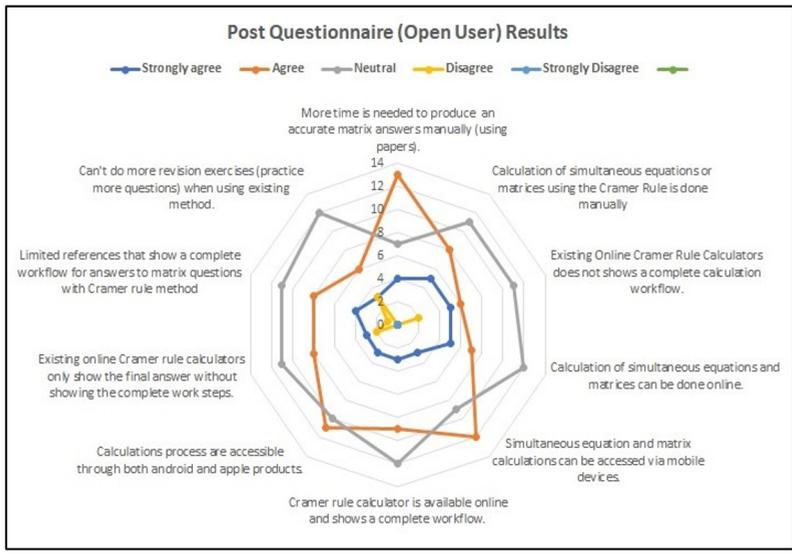


Fig. 8. Post-Questionnaire (Open Users) results.

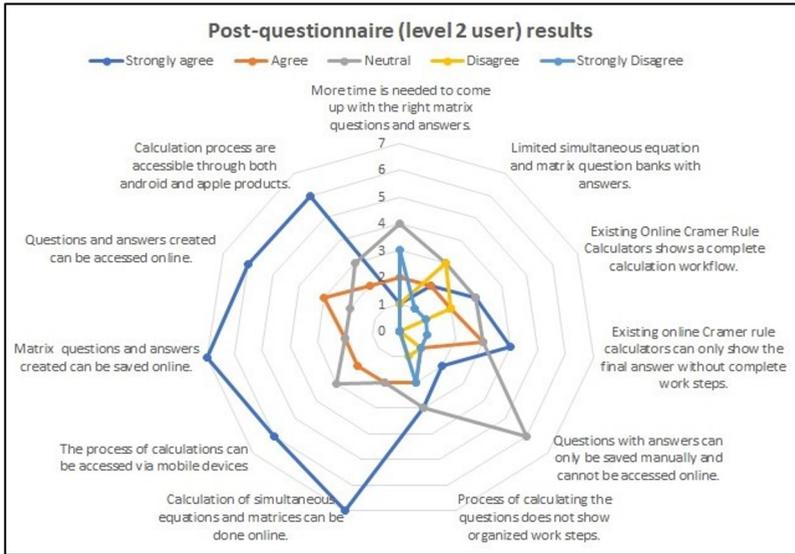


Fig. 9. Pre-Questionnaire (Level 2 Users) results.

For user level 2 respondents who already gave responds show that most of them support the use of calculator 3E system can help them to create equations and matrices questions with answers. Open user respondents who already gave responds through post-questionnaire also said that calculator 3E system can help them doing revision on equations and matrices questions quickly.

4 Results and discussion

4.1 System interface

Figure 10 until Figure 15 shows system interfaces for 3E system. Figure 10 shows login page for level 2 user, Figure 11 shows calculator of 2x2 matrix equations, Figure 12 shows matrix questions, Figure 13 shows matrix answers with complete workflow, Figure 14 shows save sample questions and finally Figure 15 shows calculator of 3x3 matrices.

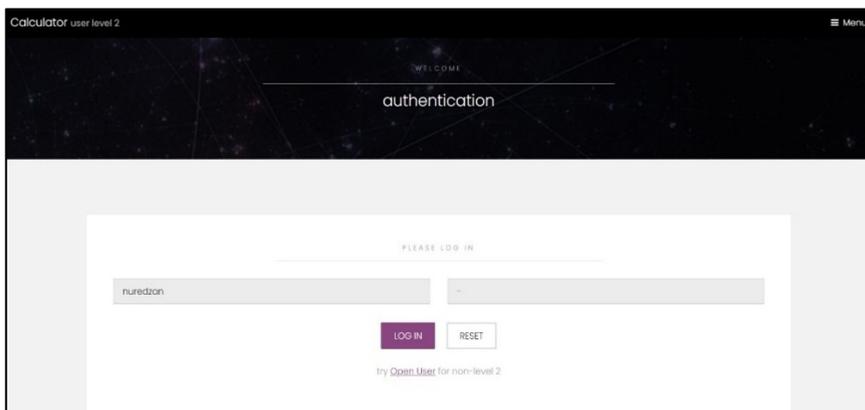


Fig. 10. Login page for level 2 user.

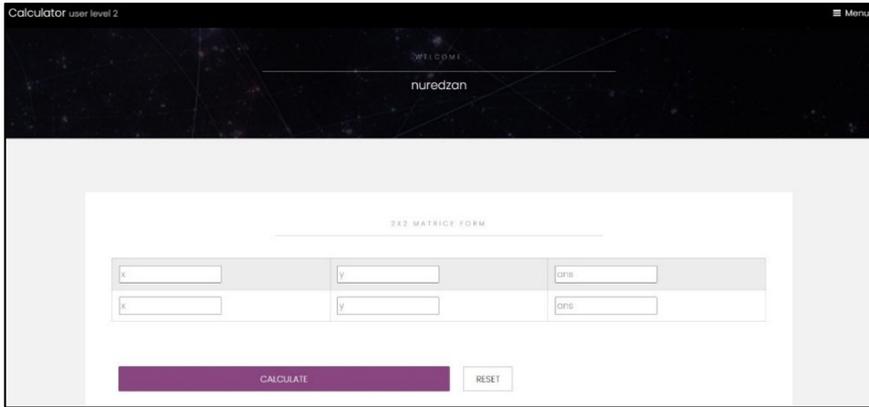


Fig. 11. calculator of 2x2 Matrix équations.



Fig. 12. Matrix questions.

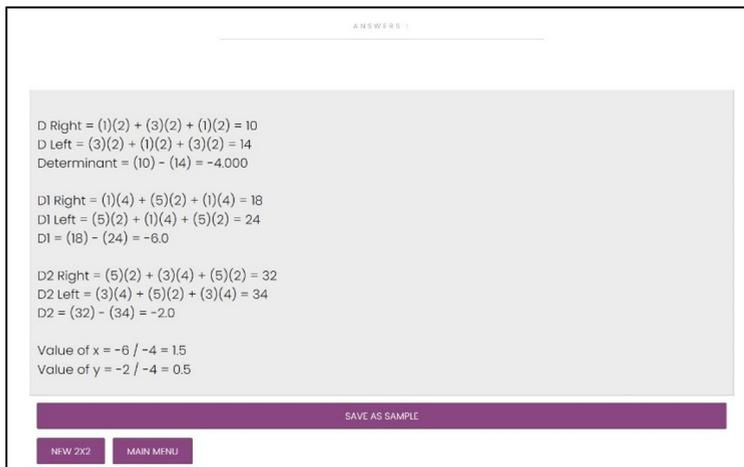


Fig. 13. Matrix answers with complete workflow.

| SAVED SAMPLE : | |
|----------------|--|
| 4 | $-5x - 3y = -29$ $-7x + 5y = -13$ Ans : Det = -46,000 x = 4.0 y = 3.0 |
| 5 | $2x + 2y = 4$ $3x + 1y = 5$ Ans : Det = -4,000 x = 1.5 y = 0.5 |

Fig. 14. Saved sample questions.

| 3x3 MATRICE FORM | | |
|--------------------------------|----------------------------------|--------------------------------|
| <input type="text" value="x"/> | <input type="text" value="y"/> | <input type="text" value="z"/> |
| = | <input type="text" value="ans"/> | |
| <input type="text" value="x"/> | <input type="text" value="y"/> | <input type="text" value="z"/> |
| = | <input type="text" value="ans"/> | |
| <input type="text" value="x"/> | <input type="text" value="y"/> | <input type="text" value="z"/> |
| = | <input type="text" value="ans"/> | |

Fig. 15. calculator of 3x3 matrices.

5 Conclusion

In conclusion, E-Equation Easy System (3E System) can help students and educators in the process of teaching and learning activities for subject simultaneous equation and matrix. By using this system, it is hoped that it can further improve student understanding related to this course and also ease the burden of educator in creating practice exercises related with this subject.

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