ISSN 2354-0082

Development of Web-based Matrix Operations Calculation as a Learning Media

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Received on October 2nd, 2017
Accepted on December 20th, 2017

***Abstract*—Learning media stimulate and support the students in learning process, especially in matrix cases. Many students poses the difficulties in learning due to the usage of non-interactive learning media, such as books or lecturer notes. This study aims to build a web-based matrix operations application that support the students learning process as a learning media. This learning media is built using prototyping model process. The process is divided into four main stages, namely communication, quick plan, quick design, construction, and deployment. The result of this study is a web-based matrix operations application that has basic features of addition, subtraction, multiplication, determinant, and transpose matrix.**

***Index Terms*—learning media, matrix, prototype model, web-based**

I. INTRODUCTION

Based on some observation in the particular class at Kalbis Institute, many students are having a difficulties in learning matrix. Students is supported with several learning resources such as books and lecturer notes. These learning resources are categorized as non-interactive learning media, since the media does not cover the dynamic input and explanation as well. Students lack their initiative about their misunderstanding.

The potential learning media is about the media which connected to computer technology [1]. Computer technology equipped with the intelligent support system able to identify the student's individually, perform calculation operations, and provide stimulants. Utilizing computer technology facilitate students in learning because it provides a visual representation [2] [3].

The matrix operations application in this study cover basic features such as operation of addition, subtraction, determinant, and transpose matrix. Meanwhile the other features are displaying the steps of calculation algorithm and the theories of matrix. The application calculating matrix with the maximum size is about 3 x 3 matrix.

II. METHODOLOGY

A. *State of the Art*

Earlier study, creating a learning media application use Android based learning application which is built by using Software Development Life Cycle method [4]. The learning media from this study is intended for users of Primary School at 1st to 3rd grade. Further, the study of developing multimedia based mathematics learning media application by using Multimedia Development Life Cycle [5] was intended for Primary School at 6th grade. Themed learning application based on multimedia. [6], and also Android based mathematics learning application game using Waterfall method by [7] were intended for Primary School at 6th grade. Whereas the application intended for the college or high school students is still required.

B. *Prototyping Model Process*

Prototyping models is commonly used to develop software. There are five main stages of prototyping model displayed in Fig. 1.

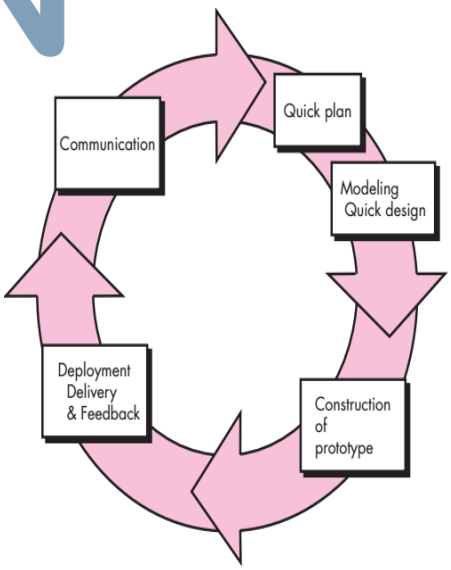


Fig. 1. Prototyping model process [8]

The prototyping model process has the following steps [8]:

- **Communication**. At this step, the researchers analyze the system by conducting interviews with the research object and studying the literature correspond to the research.
- **Quick plan**. The researchers plan the application briefly and quickly.
- **Modelling** quick design. The researchers perform modelling of application design using modelling tools.
- **Construction** of prototype. Build the prototype and perform testing.
- **Deployment** delivery. The application is launched and installed.

C. Framework Design

The framework design is shown at Fig. 2.

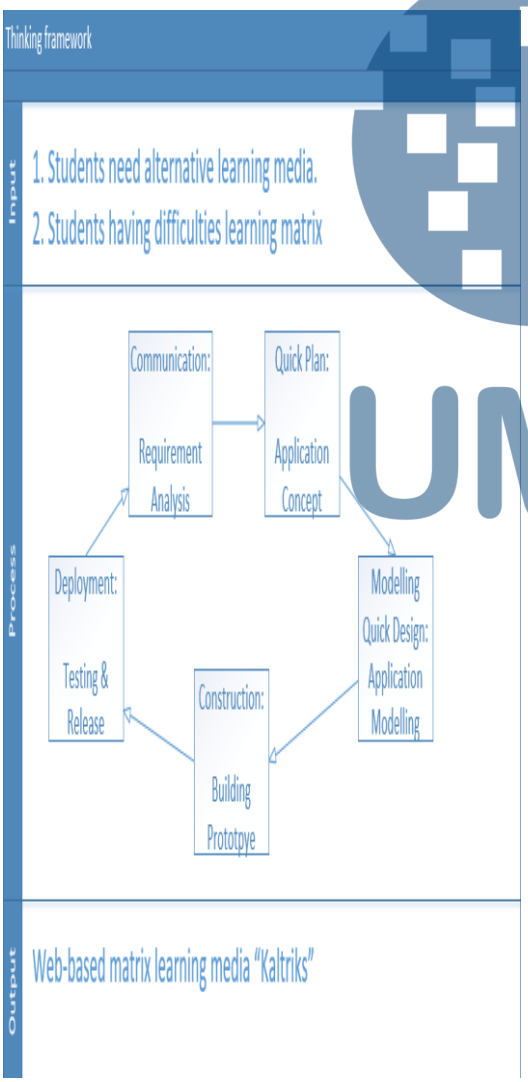


Fig. 2. Thinking framework

This study is motivated by the need for matrix learning application for college students or high school student. The study will be processed using prototyping model which is divided into five main stages, namely communication, quick plan, modelling quick design, construction, and deployment. This application will produce a web-based matrix operations calculation application called "**Kaltriks**".

At the communication stage, the researchers discussed the tools and equipment needed during the study, and determine user requirement. After the communication phase completed, then proceed to quick plan stage. At this stage, the researchers design and plan the concept of the application. From this concept, the researchers able to build the model of the application. The modelling is using Unified Modelling Language (UML) such as use case diagram and sequence diagram. This application model will be constructed into prototype and will be tested. Once the application tested, further it will be released.

III. DISCUSSION

This study is using prototyping model process. In this chapter the researchers will discuss the results of each stage of the prototyping model process.

A. Communication

At this stage, the researchers create the need of user requirement and the system requirement. The user requirement of this application are:

- The application able to calculates matrix operation such as addition, subtraction, multiplication, determinant, and transpose.
- The application displays the calculation steps.
- The user might enter numbers into the matrix and might use the matrix operations button.
- The application provides the theories of matrix.
- The application provides a notification of matrix calculation terms.

The system requirement of this application are:

- Minimum Windows XP Operating System.
- Has an internet browser.
- Minimal RAM is 512 MB.
- Connected to the internet.

B. Quick Design

This application is categorized into two main functions, namely calculate matrix operations and displaying the calculation steps. Displaying calculation step consider as the support to the student to be able to understand about how the calculation work. This learning media is designed to calculate

matrix operations from the number entered into the corresponding field by the user.

The result of matrix operation will be displayed on the result matrix, while the operation steps will be displayed in the blank space below the result matrix. The menu button of this application is shown on Table 1.

Table 1. Application Menu Button

Menu Button	Description
+	Performing matrix addition operation
-	Performing matrix subtraction operation
X	Performing matrix multiplication operation
D	Performing Determinant matrix operation
T	Performing matrix transpose operation
DELETE	Delete matrix element
Addition	Displaying matrix addition theory
Subtraction	Displaying matrix subtraction theory
Determinant	Displaying Determinant matrix theory
Multiplication	Displaying multiplication matrix theory
Transpose	Displaying matrix transpose theory
Benefit of Matrix	Displaying the benefit of matrix
EXAMPLE_A	Entering random numbers into matrix A
EXAMPLE_B	Entering random numbers into matrix B
DELETE ALL	Delete the entire matrix and annotations
EXAMPLE ALL	Entering random numbers into matrix A and matrix B at once

C. *Modelling Quick Design*

Based on outcome of quick design phase, further the modelling stage is conducted by using use case diagram. The prototype will be built from this model. The matrix learning application use case diagram is shown in Fig. 3.

The users use this application to perform matrix operations calculation. Users must enter numbers into the matrix provided, Matrix A and Matrix B, meanwhile Matrix H is disable since it is used as a result display matrix. The matrix operation menu button provided are addition, subtraction, multiplication, determinant, and transpose.

Users able to view the matrix theory by choosing the button marked as: Addition, Subtraction, Determinant, Transpose, and Benefit of Matrix. The explanation will be displayed in the column of matrix theory.

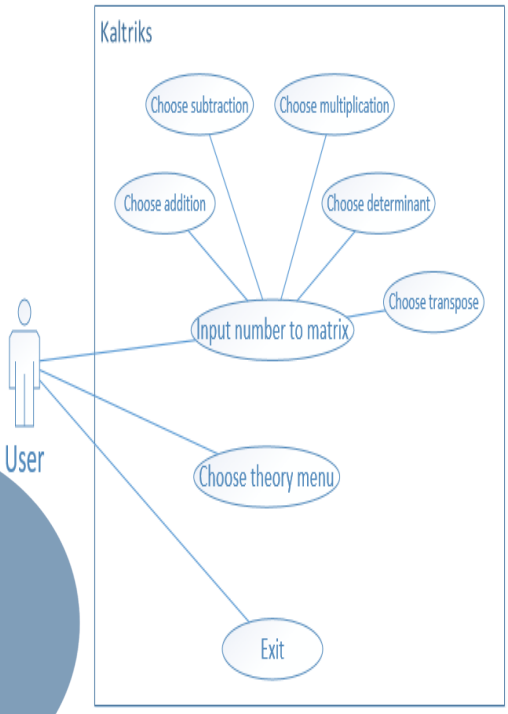


Fig 3. Matrix application use case diagram

D. *Construction of Prototype*

The construction stage generates a paper prototype. A paper prototype is a set of mock ups of the application on each action. Some of the mock ups are shown in Fig. 4 and Fig. 5.

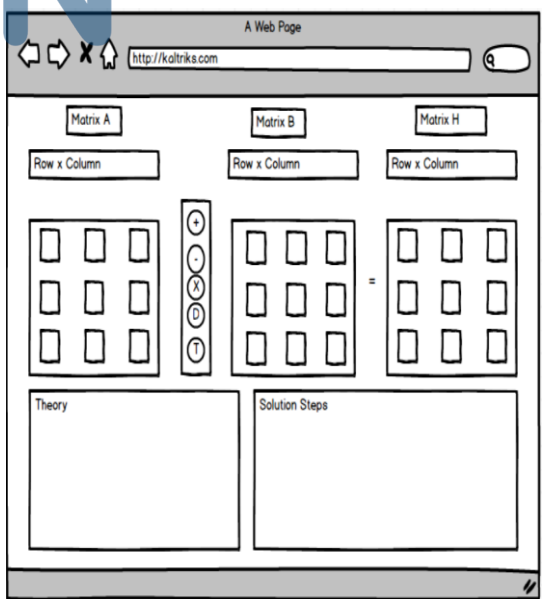


Fig. 4. Home page application

Fig. 4 shows the home page of matrix learning application. There are 3 matrix called: “Matrix A”, “Matrix B”, and “Matrix H”. “Matrix H” shows the displays of the matrix operation result.

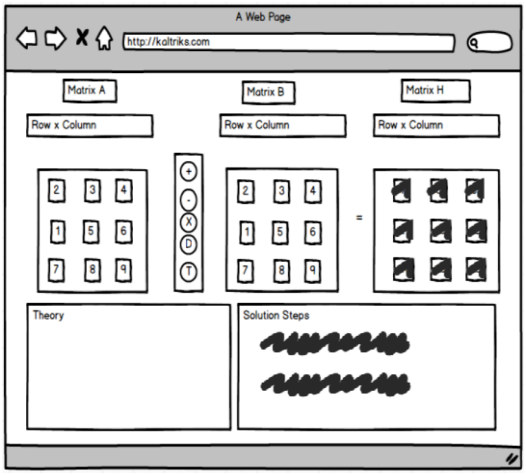


Fig. 5. Matrix addition operation

Fig. 5 shows the matrix addition operation. The result will be displayed on “Matrix H”, while the explanation the operation is shown at the column “Solution Steps”.

E. Deployment

The application is tested and released in this stage. The application is tested by black box testing to ensure that all the features in application is completed and perform user experience testing to obtain the feedback.

1) Kaltriks Matrix Calculation Application

The matrix learning application is already released thus students or public users can accessed the application on url http://kaltriks.net. The Kaltriks application home page image is shown in Fig. 6.

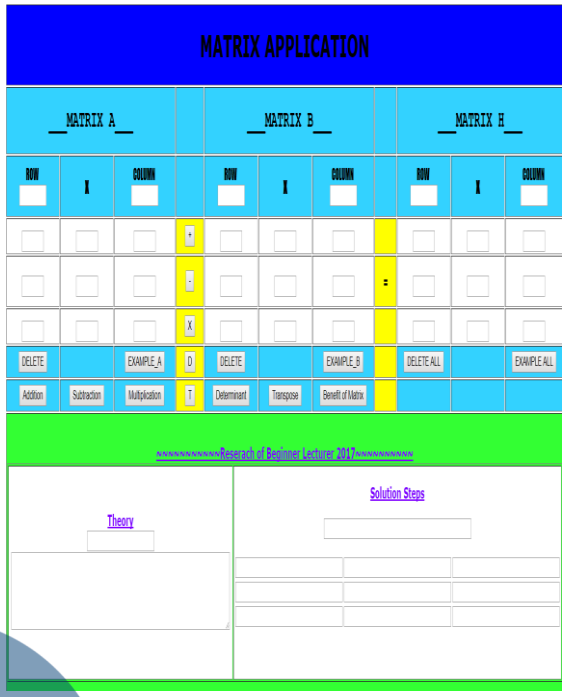


Fig. 6. Kaltriks home page

The application has feature to calculate determinant, multiplication, addition, subtraction, and transpose. The result of these operations are shown in Fig. 7 to Fig. 11.

Fig 7. Addition result

Fig. 7 shown the result of Matrix A and Matrix B addition. The result shown in Matrix H,

meanwhile the solution steps are shown in "Solution Steps" column.

Fig. 8 Multiplication result

Fig. 8 shows matrix multiplication result between Matrix A and Matrix B. The matrix multiplication can only be calculate if matrix A's column dimension is equal to matrix B's row dimension. Fig. 9 shows the notification if matrix multiplication is not operable. Matrix A is 3x2 and Matrix B is 3x2, the column dimension of Matrix A is not equal to the row dimension of Matrix B, therefore the matrix is not operable.

Fig. 9 Multiplication notification

Fig. 10 shows determinant of Matrix A, the determinant belongs only to the square matrix (row and column dimension are equal).

Fig. 10 Determinant result

The determinant of Matrix A is displayed in Matrix H. The solution explanation is displayed in "Solution Steps" column. Fig 11 shows the notification if the matrix has no determinant. In Fig. 11, Matrix A is 3x2, therefore Matrix A has no determinant.

Fig. 11. Determinant notification

The transpose calculation of Matrix A is shown in Fig. 12. Transpose is to change the dimension of the matrix into column × row.

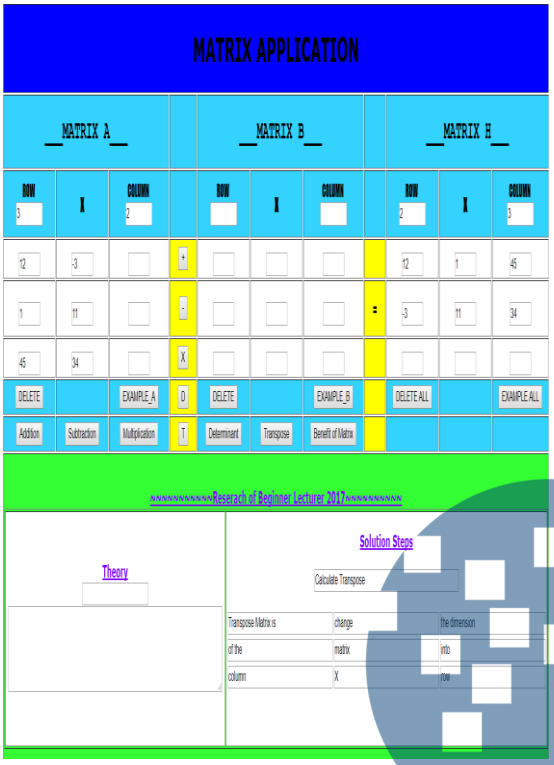


Fig. 12. Transpose result

2) Black Box Testing

The application has been successfully tested using black box method. The result is shown in Table 2.

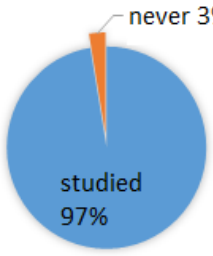
Table 2. Black Box Testing Result

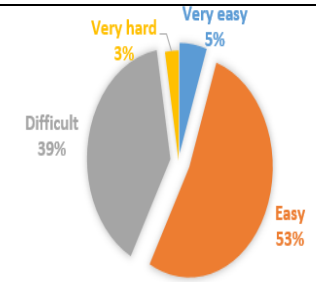
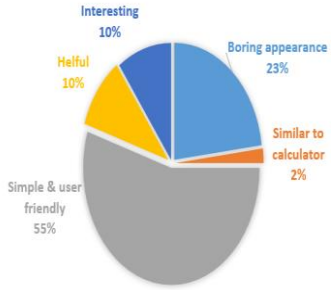
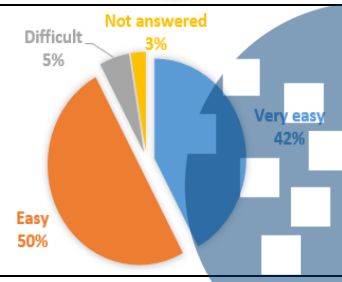
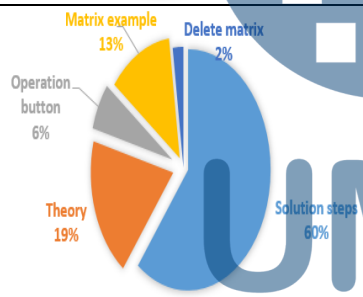
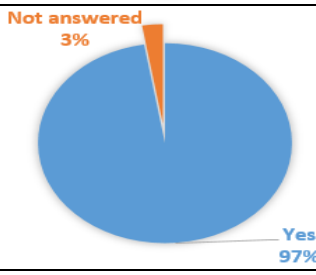
Test Description	Expected Result	Actual Result
The numbers entry into Matrix A and Matrix B	The number can inserted into Matrix A and Matrix B	The number can successfully inserted into Matrix A and Matrix B
Run addition operation	Matrix A and Matrix B can operate if the orders of both matrix are the same	Matrix A and Matrix B can be summed and get the correct result then shown in Matrix H
Run subtraction operation	Matrix A and Matrix B can operate if the orders of both matrix are the same	Matrix A and Matrix B can be subtracted and get the correct result then shown in Matrix H
Run multiplication operation	Matrix A and Matrix B can operate if the column order of Matrix A is equal to the row order of Matrix B	Matrix A and Matrix B can be multiplied and get the correct result then shown in Matrix H
Run Determinant operation	Calculates the Determinant of matrix A if it is a square matrix	The Determinant of Matrix A gets the correct result then shown in Matrix H
Run transpose operation	Form the transpose matrix of Matrix A	Transpose Matrix A can be formed and displayed on Matrix H
Run theory menu (Addition, Subtraction, Determinant, transpose, multiplication, benefit of matrix)	Displays theoretical explanation on the matrix theory column	The theoretical explanation is successfully displayed on the matrix theory field
Solution steps feature	Displays the solution steps of selected matrix operation	The solution steps are displayed in the Solution field
Pressing the "Delete" button	Delete the matrix element	Matrix element deleted
Operation notification	Displays a notification if the matrix is not operable	A notification message appears if the matrix does not meet the operating criteria

3) User Experience Testing

The matrix application has been tested by 38 respondents who mostly are the first year college students who will study matrix in particular course. The summary of user experience testing is shown in Table 3. The respondents are student of Kalbis Institute.

Table 3. User Experience Testing Result

Question	Result
Have you ever study matrix?	

Question	Result
Is matrix easy to learn?	
How the matrix application user interface?	
Is the application easy to use?	
What is the most interesting feature of the application ?	
After using this application, do you become more understanding about the matrix?	

After the 38 respondents finished the test, respondents gave feedbacks. The feedbacks are:

- Change the application color.
- Added matrix dimension.
- Added image or animation to solution steps.
- Added other matrix operations.
- Make the navigation menu bigger.

IV. CONCLUSION

It can be concluded the following:

- From 38 respondents in user experience testing, 50% of respondents (19 respondents) stated that the matrix application is easy to use, 42% of respondents (16 respondents) stated the matrix application is very easy to use, 5% (2 respondents) stated the matrix application is difficult to use, while the rest, 3% (1 respondents) leave the empty answer.
- 60% of 38 respondents (29 respondents) stated that the solution steps feature is the most interesting feature of the matrix application.
- After using the matrix application, 97% of respondents (37 respondents) stated that they are improving their understanding regarded matrix operation.

ACKNOWLEDGMENT

The authors thanks to Kemenristek DIKTI for the fund regarded this research through “Beginner Lecturer Research” scheme.

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