

Calculus Problem Solution And Simulation Using GUI Of Matlab

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Abstract: This research aims to develop the project application in teaching and learning Calculus using Graphical User Interface (GUI) of Matlab. The scope of the development result includes (1) PreCalculus, (2) Function Limit, (3) Derivative and its application, and (4) Integral and its application. Every aspect of development is presented according to the standards of material competence, learning achievement indicators, and solutions or settlement steps on each issue presented. This project application can be used by lecturers and students in universities to improve motivation, mastery of material and student learning outcomes in the Calculus course. Development of this project application is done through 4 stages called 4-D namely: Define, Design, Development, and Dissemination. Based on the data analysis, the results obtained at the validation stage of expert validity level average of 3.575, which means "quite valid". Then on a limited trial the average student gave a response of 92.00% which means "very good". While in the first field trial the average student gave a response of 89.30% which means "very good", and in the second field trial the average student gave a response of 90.15% which means "very good". Besides that, we also solve computational calculus problems in Edwin J. Purcell Dale Varberg's Book of Volume 1 of Edition 5 of 48 questions that are divided into 64 cases.

Index Terms: GUI of Matlab, Teaching, Learning, Calculus.

1 INTRODUCTION

Calculus is one of the areas of mathematics that deals mostly with the basic concepts of mathematics, such as (1) Real Number Systems, (2) Functions, (3) Limit, (4) Derivatives, and (5) Integral [1]. Calculus serves as one of the compulsory courses of students throughout Indonesia, especially in the field of science, as a basis for studying various other fields of mathematics. Therefore, Calculus serves as a prerequisite course for other courses such as Advanced Calculus, Differential Equations, Numerical Methods, Real Analysis, Mathematical Statistics, Complex Variable Functions, and others. However, field facts are still found lecturers gives abstractly and not optimal in learning calculus, it is necessary media solution and simulation based to explain the material in order to improve understanding of the concept in each student and able to help students to comprehend widely Calculus material. Development of ICT-based learning especially Calculus must use accurate and optimal simulation based software [1, 2], so MATLAB is the recommended software in this case. MATLAB (matrix laboratory) is a program for numerical analysis and computer, is an advanced mathematical programming language that is in the form of rationale using the properties and form of matrix [6]. Another opinion says that MATLAB is a high-compliant programming language in the computing field, not only has the ability in terms of computing, but also the ability of good visualization. MATLAB has the ability to integrate computing, visualization (simulation) and programming [7].

2 GUI OF MATLAB

Matlab (matrix laboratory) which consists of 5 main components namely:

- Toolbar** contains various control tools for Matlab.
- Current Folder** as a place of folders or files that have been stored and connected with Matlab.
- Windows Command** as the main worksheet in Matlab where users build regular scribes direct execution.
- Workspace** as a workspace where files or variables are stored in Command Windows [3.7].
- Graphical User Interface (GUI)** is one of the components of Matlab to create a more efficient and appealing mathematical problem solving interface [4].

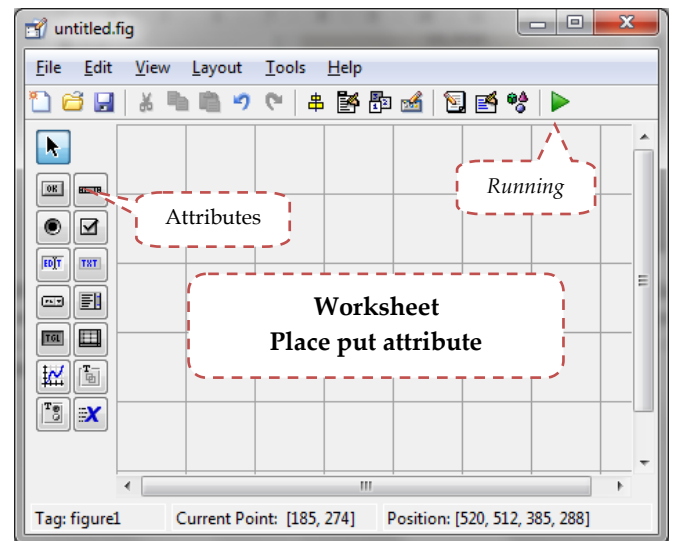


Fig. 1 Graphical User Interface Matlab

MATLAB has the following benefits: (1) mathematical calculation, (2) numerical computation, (3) simulation and modeling; (4) visualization and data analysis; (5) graphics for science and engineering; and (6) application development, For example by utilizing the GUI. The structure of the programming language used in the application development consists of three logic namely (1) sequential structure, (2) looping structure like: for, while, and repeat until and (3)

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branching structure like: if then else, and case of. Looping structure is generally used for graph-based simulation-based application development while branching structures are used to solve optimization cases. The attributes used are tailored to the built application, there are seven attributes that are often used in application development besides toolbar as additional settings and attributes when running. But in this study not all attributes are used. The attributes used in the development of this application that is *EditText*, *StatisText*, *PushButton*, *Table*, *Axes*, *Panel*, and *BtnGroup*. While the usefulness of each attribute is described in Table 1 below.

TABLE 1 : ATTRIBUTES OF GUI AND ITS FUNCTIONS [5]

Name	Icons	Function
PushButton		As a button (process, delete, etc.)
Slider		Minimize the screen display
RadioButton		To put a choice
CheckBox		To put a choice
EditText		As a place of input or output
StaticText		As the property label is used
Pop-upMenu		Same with Check Box
ListBox		Output in a large number of strings
ToggleButton		Same with Push Button
Table		Make output in tabular form.
Axes		To draw a graph / histogram
Panel		Unify attributes in one group
BtnGroup		Unify attributes in one group
Activex Control		Brings up some important controls.

3 DEVELOPMENT METHODS

3.1 Development Model

The product produced in this development research is application program as teaching and learning media of Calculus. The development model used in this research is 4-D (Define, Design, Development, and Dissemination) developed by Thiagarajan, Semmel and Semmel (1974) modified [8, 9].

1. *Define*. At this stage, the researcher performs a final preliminary analysis, learning achievement indicator, test model used, and selection of application outline.
2. *Design*. At this stage, the researcher builds the initial GUI design, selects the formats and attributes, optimizes the layout of the form design, resulting in the first prototype.
3. *Development*. At this stage the researchers divide the 3 activities of validation, limited trials, and field trials. We select expert experts in their respective fields as validators to assess and provide feedback to build a reliable and optimal GUI. After the application is "quite valid" level, we then proceed to the limited trial stage to see the practicality of the product being developed, and lastly we conducted a field trial involving many respondents and cross-colleges.

4. *Dissemination*. The last stage is the distribution of product development to the general audience, especially lecturers and students of the early semester who are taking Calculus courses to be used as media and tools in order to improve understanding and learning outcomes.

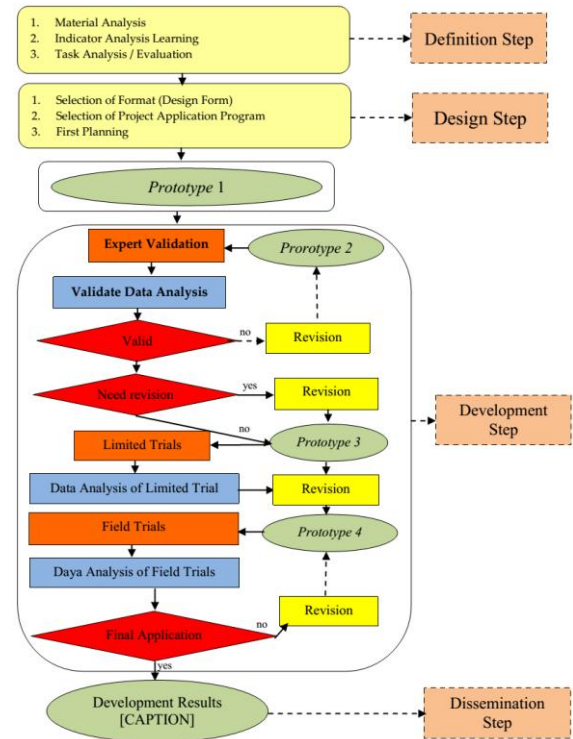


Fig. 2. Product Development Model

3.2 Data Collection Instruments

Instruments used in this research are (1) Expert Validation Sheet/Format, (2) Questionnaire Sheet of Limited Trials, and (3) Questionnaire Sheet of Field Trials. At the validation stage, we selected 3 experts as assessors according to their respective fields of programming, media, and materials. The respective assessment aspects are described in Table 2 below.

TABLE 2: VALIDATOR AND ASPECT ASSESSMENT

No	Validator	Aspect
1	Programming	Media efficiency, Function keys, and physical quality
2	Media	Quality of design (appearance), quality of buttons
3	Material	Quality of material (input), quality of language, and quality of output (reporting)

While in the questionnaire of respondents combined from the assessment of experts is aspects of programming, content and appearance (design).

3.3 Data Analysis Techniques

Technical Analysis of Validity

The process of data analysis of the validity of the developed product is done by formula [9]:

$$R = \frac{\sum_{i=1}^n V_i}{n} \dots (1)$$

1. Determine the degree of validity based on the conversion of the average values obtained with the validity level interval as shown in Table 3 below:

TABEL 3: INTERVALS OF VALIDITY VALUE

Intervals	Level of Validity
R = 5	Very valid
4 ≤ R < 5	Valid
3 ≤ R < 4	Quite valid
2 ≤ R < 3	Less valid
1 ≤ R < 2	Invalid

2. Declare a product that meets the validity criteria, if the minimum validity level achieved is **quite valid**. Then the product continued to be used or used in limited trials and field trials.

Technical Analysis of Product Trials

Data of student response result through questionnaire collected, then tabulated. The result of tabulation of each response is calculated for percentage, by formula [9]:

$$Percentage (P) = \sum \frac{Score \ Per \ Item}{Maximum \ Score} \times 100 \% \dots (2)$$

TABLE 4: CATEGORY INTERVALS OF APPLICATION

Percentage (%)	Categories
P ≤ 20	Not Good
20 ≤ p < 40	Less Good
40 ≤ p < 60	Pretty Good
60 ≤ p < 80	Good
P ≥ 80	Very Good

4 DEVELOPMENT RESULT

4.1 Result of Expert Validation

Expert validation is performed after initial design or Prototype 1 is completed. Expert validation is performed to ask for advice or input related to 3 aspects, there are content (outline of material), programming, and display. At this stage, the expert team places more emphasis on visualization of the applications being built, such as the suitability of colors in each component with the background of each GUI, the breadth of performance indicators, the compatibility and consistency of the button display, and the memory capacity of the files for easy distribution. Based on the validation results obtained the average expert assessment is 3.575 which means "**quite valid**". From the results of this validation then proceeded to a limited trial and field trials. Some revisions in this stage such as (1) the position of some buttons is set well, (2) maximize tools have been activated, (3) sub menu hints and programmer and some simulation picture have been completed.

4.2 Result of Limited and Field Trials

Result of Limited Trials

After the revision according to the instructions or input from the expert, then obtained the design or Prototype 2 for later conducted a limited trial. Limited trials were conducted on 5 students. The results of the limited trial are according to Table 5 below.

TABLE 5: RESULT OF LIMITED TRIALS

Variables	Respondents					Average
	1	2	3	4	5	
Average	4.25	4.65	4.60	4.70	4.80	4.60
Percentage	85.0	93.0	92.0	94.0	96.0	92.0

Based on the calculation of Table 5 above, the average student gave a response of 92.00% which means the application being developed is categorized "**very good**". However, based on the results of questionnaires from respondents there are still some shortcomings such as the sentence part of the solution case, the suitability of the use of images, clarity and language communication used, the suitability of the selection of the size and typeface. Some sections are revised in Prototype 2 such as (1) improvements in size and typeface, (2) Simulation size (graph) is maximal, and (3) Sub menu is adjusted indicator of learning achievement.

Result of Field Trials

After conducting a limited trial, then some revision of the advice of the students (respondents) in the limited trial stage so that obtained Prototype 3 which is then used for field trials. Field trials were conducted twice, with 20 respondents (students) each trial. In the first field test, the respondent gave an additional assessment on the aspect of the speed of the button reaction, this is because the file size is too large and the number of attributes used so that it is rather slow in displaying the output both the completion step and simulation graph. In addition, there is also the use of less communicative language, the suitability of the selection of the size and type of letters, the layout of text and images, the suitability of GUI background selection, and there are words / sentences that have not match the performance indicators. The results of field trials are as in Figure 3 and Figure 4 below.

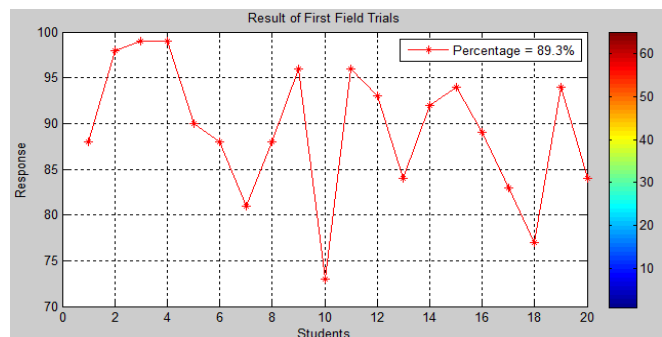


Fig. 3 Result of First Field Trials

Based on the data calculation in Figure 3 above, the average student gives a response of 89.3% which means the application being developed is categorized "**very good**".

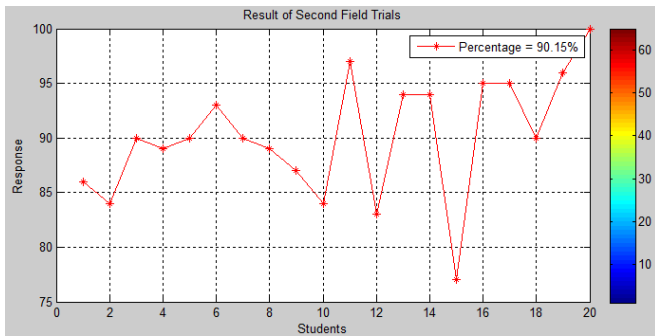


Fig. 4 Result of Second Field Trials

While in the second field trial obtained the average students gives a response of 90.15% response which means the application is being developed categorized "very good". Nevertheless, there are still some drawbacks regarding the aspect of the display which is almost identical to the outcome in the first field trial. The remaining deficiencies in Prototype 3 have been enhanced as follows: (1) Regular color combinations on some GUI forms, (2) some "Exit" buttons have been removed because they have no significant functionality, and (3) Already in running in project form.

4.3 Final Product

From the validation and trial activities both limited and field of the application has been developed there are some advice from the validator and respondent, both related to the content (outline) of the application, programming settings (input, output and graphics), and display. Based on the results of validation and product testing obtained the following chart:

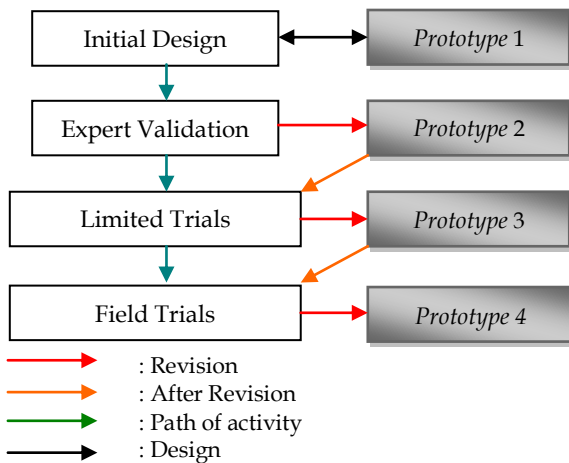


Fig. 5 Step Product Development Activity

The result of the revision resulted in the application of GUI Matlab-based project for the settlement of Calculus cases, so the research team gave the name of this application as "CAPTION (Calculus Problems Solution)", we have successfully developed 25 GUI for simulation of calculus case with the details of the development result as follows:

TABLE 6: OUTLINE OF CAPTION APPLICATION

Menu	Sub Menu
Help	Programmer Team, Manual Book
PreCalculus	Distance Between Two Points, Midpoints, Straight Line Equations, Circle Equations, Equations and Quadratic Functions, Function Graphs, and Function Operations.
Limit and Function Derivative	Function Limit Simulation, Limit Operation, Function Derivative and Its Application.
Integral	Definite and Indefinite Integral, Area dan Volume of Rotary Object.

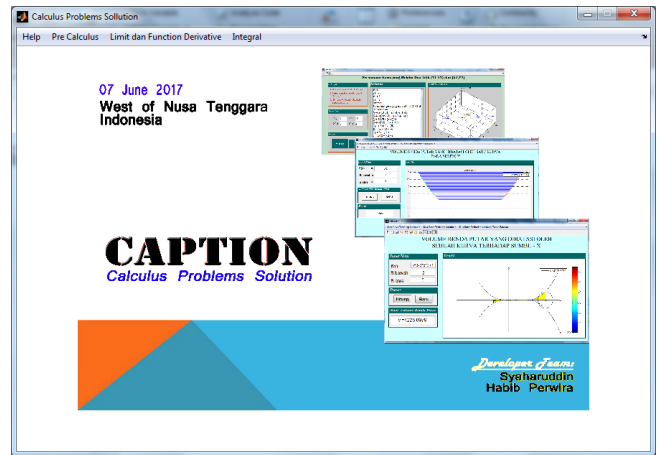


Fig. 6. Font Design of CAPTION

CAPTION (Calculus Problem Solution) is a specially constructed application of Calculus, especially Basic Calculus given to early semester students. Based on the results of the development that has been done, we provide more value to the application in terms of simulation and solution-based.

1. Presented in menus and sub menus easily operated by users (students and lecturers)
2. Indicators are adapted to the curriculum applicable to Indonesian universities in general.
3. In each GUI given input components, process (count), and output in the form of problem solving and graph simulation.
4. In the simulation part of the graph is given the time rhythm so that the simulation looks effective.
5. Each performance indicator is presented with multiple case solutions
6. Each graph is given a 3-dimensional attribute
7. Can be developed in more directions using GUI by adding many more features.

In addition to the application development in the form of GUI above, we also developed a computing algorithm that plays at the m-file level to solve the calculus problems contained in Edwin J. Purcell Dale Varberg's Book of Volume 1 Issue 5, which comprises 48 computing categories of divided problems in 64 cases. Because these problems require computational scribs to perform simulations and determine their numerical solutions.

4 DISCUSSION

This CAPTION (Calculus Problems Solution) project application needs to be developed on a larger scale and a broader range of indicators (outlines) in order to be fully utilized by students at every level of the university. For example for numerical problems such as:

1. The derivative and integral application in the transcendent function, the volume of the broader rotary object with multi variables.
2. Numerical methods such as simulation equation solutions and systems of nonlinear equations, approximation and interpolation, derivatives and numerical integral, and numerical differential equations.

5 CONCLUSION

1. The result of the product developed in the form of an application program which is then called "CAPTION" abbreviated as "Calculus Problems Solution".
2. The final product results developed in the form of Graphical User Interface (GUI) based applications include: (1) Precalculus (Distance Between Two Points, Middle Point, Straight Line Equation, Equation of Circles, Equations and Quadratic Functions, Function Graphs, and Function Operations), (2) Function and Derivative Limit (Function Limit Simulation, Limit Operation, Derivative Function and Its Application), (3) Integral (Definite and Indefinite Integral, Area and Volume of Rotary Object).
3. In the expert validation stage obtained the level of validity and the average of 3.575 which means "quite valid". Then on a limited trial the students gave an average response of 92.00% which means "very good". While in the first field trial the student gave an average response of 89.30% which means "very good", and in the second field trial the student gave an average response of 92.15% which means "very good".

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