Penerbit Akademia Baru

Journal of Advanced Research in Computing and Applications

Journal homepage: www.akademiabaru.com/arca.html
ISSN: 2462-1927

Development of Quadric Surfaces Learning Tool for Engineering Students using MATLAB GUI

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ABSTRACT

Mathematics is the most challenging subject to learn even in higher learning education. The problem encountered in learning mathematics could lead to the lack of interest in understanding the concepts in mathematics. In the development of communication technology, it is believed that hybrid learning environment can be an initiative in improving learning system. Face to face classroom delivery with utilization of application tool and system become useful in this type of environment. This paper aims to the development of learning tool using MATLAB GUI for multivariable functions of quadric surfaces. This paper focus on this topic as student feels difficulty in understanding the concepts in that topic. It is believed that this tool able to help student to visualize the concepts effectively for more understanding.

Keywords:
Mathematics; MATLAB GUI;
multivariable function; quadric surfaces

1. Introduction

Students who are having difficulty in solving mathematics problem leads to an increasing failure rate of the subject. There are variety of factors that contributed to this failure rate [11]. Among the factors, absenteeism during lecture results in lack on thorough knowledge and there is a significant relationship with the exam score [9]. Furthermore insufficient or lack of exercises and practice also contributed to this problem. Besides that, students also easily distracted by surrounding and this contribute to the loss of focus and attention. There are large numbers of students who do not gain the basic skills for mathematics especially in problem solving [3]. Based on students perception, mathematic is something that is quite difficult to learn. The difficulties in developing all the mathematics skills and concept by student may become worse if and only if the environment of learning process is not very effective for some students.

Most of the student begin to struggle and need help in learning calculus starting from the traditional method of teaching, which involved text book, the writing board and may be some exercises sheets. From a preliminary survey, over the past few semesters, failure rate for an engineering calculus in one of the public university ranges from 25 to 45 percent. It is considered high since engineering background student should possess good mathematical thinking. There are many factors that contributed to this figures, some even think that they do not need mathematics while

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taking an undergraduate program in engineering. Some student have problem in memorizing all the formulas, which makes us think that they do not exactly understand the concept behind the topic, hence the need to memorize. The main reasons that student usually encountered are the difficulty in retrieving and understanding the concepts, formula, facts and procedure, lacked of ability to visualize mathematics problems and concepts.

In literature, extensive studies have been carried out to find the root causes of high student failures in mathematics. Tambychik and Meerah [10] studied the mathematics skills that cause and influence the students‟ difficulties in mathematics problem solving. According to this study, incompetency skills in mathematics and lacking in cognitive ability are the main difficulties faced by students. Lack of understanding in Mathematics, large class size, wrong manipulation of approaches in problem solving and insufficient class hours are the main reasons that encourage the development of interactive learning with traditional learning [10]. Tachie and Chireshe [14] have identified that a shortage of teaching aid materials, incompetency of teachers and lack of students‟ efforts in studying mathematics are the reasons that contribute to the high failure rate. Learning mathematics will be rticipation in small groups and classroom which were above average, other instructional systems such as students‟ participation in laboratory and full of errors and misconceptions as the basic concept of teaching and learning not understood by both parties of lecturers and students [8]. Too much depend on lectures notes as basis for learning make the student too dependent [4]. Despite of the students‟ pausage of concrete materials for mathematical exploration were below average.

Allen *et al*., [1] identified specific connections between teacher-student interactions in classroom using a standardized scoring system. The scales are organized into three domains, namely emotional support, classroom organization and instructional support. It was found that emotional support and instructional support were strongly related to achievement in small classroom. This is because the sensitivity of student needs or high quality feedback to students might have great effect when they are concentrated with fewer students. Sakiz *et al*., [12] explored the importance of perceived teacher affective support in relation to sense of belonging, academic enjoyment, academic hopelessness, academic self-efficacy and academic effort in mathematics school classrooms. It was reported that greater sense of belonging in mathematics class has leads to higher academic enjoyment. In addition, there is a negative correlation between sense of belonging and academic hopelessness. Other than this, academic enjoyment has direct relations with academic hopelessness and academic self-efficacy due to the presence of perceived teacher affective support and perceived sense of belonging.

In the field of educations, there are many challenges that teachers or lecturer have to face in order to make sure all their student understands about what they learns. Fuller *et al*., [6] see that anxiety, especially exam anxieties; seem to be a causative factor to enlighten why students do not successfully complete the course requirements. There are several factors that contribute to higher failure rate of this subject. A preliminary study has been conducted to investigate the problem. Based on those preliminary surveys, some features contributed to the higher failure rate. Most of the student cannot imagine and visualize the shape of function in 3-dimensional. Besides, formulas that are being used are difficult to understand plus the complicated problem to be solved.

The usage of learning media could create effective learning condition. The learning media can be groups to Graphic, print materials, and still images, Silent media projection, Audio media, Silent audio media, Live audio / movie media, Television media and Multimedia [15]. Anyway, with the advancement of technology media, mathematics can be learning in a fun way. Since the explosion of computer, many researchers have found a way to get student find interest in learning calculus. A lot of computer software and applications have been developed since then, to help student understand better. Kumar and Kumaresan [7] listed most popular free and commercial mathematical software that developed since late 1970‟s. MATLAB, Mathematica and Maple are examples of commercial

software that widely used. Maple is strong in symbolic computation and complete in its mathematical coverage while MATLAB is powerful for good numerical computation with necessary „toolboxes" [13]. Now is the era of technology, students are more attracted to study using technology itself. There is a plenty of software or application available. Students can use math software or application to help them understand the subject better. On a recent survey, it is reported that about 55.26 percent out of 836 engineering student agreed that they encountered difficulty in visualizing any function in 3-dimensional space, for instance sphere, cone, paraboloid or other quadric surfaces. Besides focusing on more tutorial and exercises, they also require learning tools to help them with the tutorial and visualization.

One of the features stated above is the problem of visualizing solid in 3-dimension. This is called spatial ability. By definition, spatial ability is a capacity for mentally generating, rotating, and transforming visual images. This ability most important for developing expertise in learning and work settings since it is one of the three specific cognitive abilities. Not all of the student have these ability to help them when studies. Some of them were very struggles for understanding topic for 3-dimensional. They will not be able to solve the questions if they cannot understand what the questions all about.

Now, there are solutions on how to help student to increase the understanding of mathematic by using the learning tools called interactive learning. According to Formaneck [5] these mathematical software help students in the middle of solving a problem when dealing with some complex question. It may help students to improve their programming skills and prepare them for future use, especially when their future working environment requires them to use some sort of programming languages. Also, all these learning tools can really help the student to understand better, where a simple task, such as plotting a 2- dimensional or 3-dimensional function can be solved by the computer. With some changes on the parameter, different curve or graphs can be easily plotted. This way, students have more time to focus more on the fundamental knowledge of the subject itself.

Anyway, with these mathematical tools and the technology facilities in educational system, students get to learn in a fun and enjoyable ways, besides gaining knowledge of using a variety of tools. However, some of the downsides of these software or tools are obvious. Clearly, they are expensive. Students get to use it only when they are connected to the internal university"s server. Besides that, teachers have lack of controlling in student interaction. This is where the role of teacher is also important as they provide ways of thinking and strategies besides solve and prove the given questions [2].

Due to the difficulty in visualization in 3-dimensional, this paper has set up following objective. The objective is to develop an interactive learning tool for some engineering calculus sub topic of quadric surfaces. The accurate visualization is important as there implies too many application in the world around us such as in radio telescope, microphones, satellite dishes and nuclear reactors. The scope of this paper involved the topic of quadric surfaces containing parabolic, cylinder and sphere functions in different axes.

The paper starts with the introduction that elaborates on the study background, some literature in teaching environment and the objectives in Section 1. Section 2 addresses the methodology and implementation involved in this study. Section 3 discusses the results produced from the learning tool. Finally, Section 4 summarize with some concluding remarks.

2. Methodology

In this stage, a learning tool using MATLAB R2009a is developed. The MATLAB is used as it has the ability to plot data for easy visualization. The chosen subject is Engineering Calculus. At the

beginning, it was decided to developed tools for three subtopics from multivariable functions are developed. The tool concentrates on plotting parabolic, cylinder and sphere functions. It is our intention to further on this research by extending it to all subtopics under multivariable functions.

In the application of development stage, MATLAB Graphical User Interface Development Environment (GUIDE) is applied. Figure 1 portrays the layout design for the parabolic function layout in MATLAB. The layout consists of axes, radio button, input of parameters and plot button. The axes id used for presenting the graph. The radio button is used to allow user either to plot the function in x-axis, y-axis or z-axis. The user is required to key in the appropriate parameters in the respective field. The plot button is to visualize the selection of the graph by user

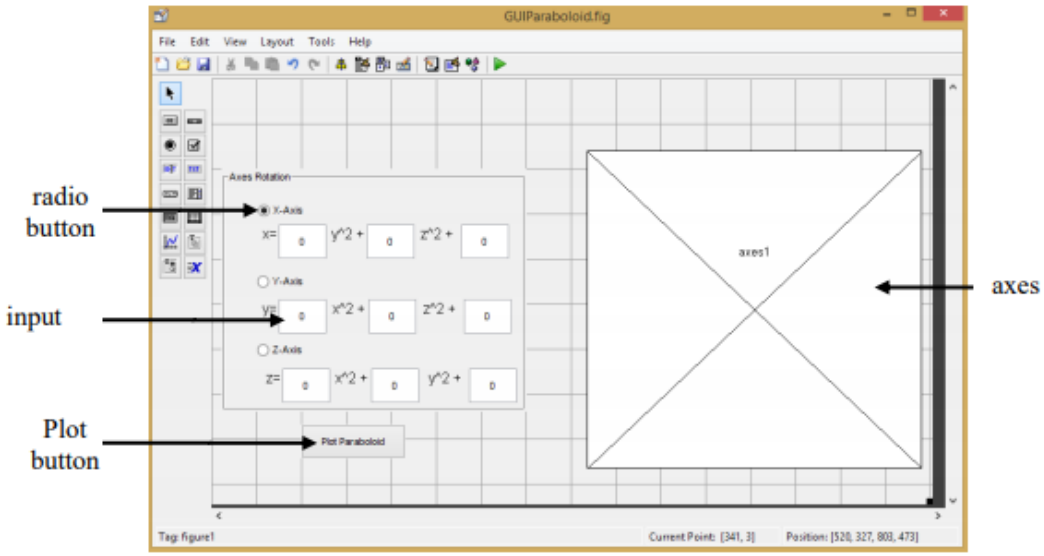

Fig. 1. Parabolic Function GUI Layout

In order to make the plot button perform the required actions, the callback function need to be set. Figure 2 shows the process to set the callback function in that button. User is requires to write a program to give user ability to control the output from that page.

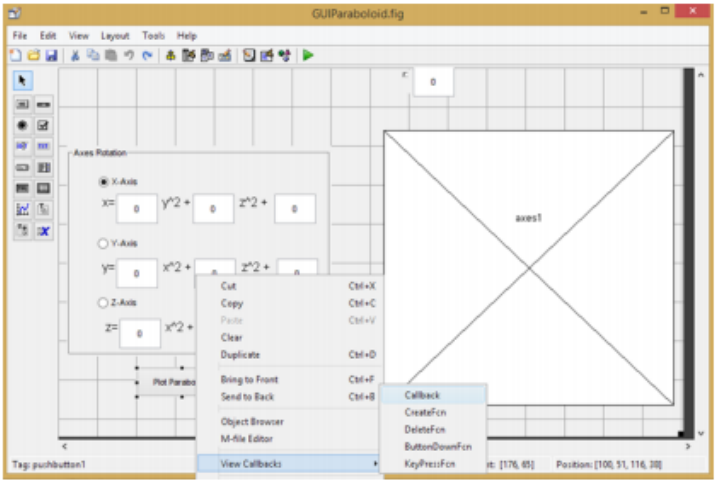

Fig. 2. Setting the Callback Function

If a button consists of certain condition that need to be satisfy, “Switch” command is required. Figure 3 shows the fragment of the code of the “Switch” command that act when the radio button is „on“. The radio button presents the function to plot surfaces in different axis that can be selected by user.

```
aa111=get(handles.edit8,'String');
a2=str2num(aa111);
aa222=get(handles.edit9,'String');
b2=str2num(aa222);
aa333=get(handles.edit10,'String');
c2=str2num(aa333);

r=10;

blah=get(handles.uipanel1,'SelectedObject');
axisRotation=get(blah, 'String');
switch axisRotation
    case 'X-Axis'
        n=20; m=20; % grid spacing
   [y,z]=cylinder(linspace(0,r,n),m);
   x=a*y.^2+b*z.^2+c;
       h=surf(z,x,y);%# rotation around X
       title(['The graph of x=',int2str(a),'y^2+' ,int2str(b),'z^2+',int2str(c),' in three-space.'])
 case 'Y-Axis'
       n=20; m=20; % grid spacing
   [x,z]=cylinder(linspace(0,r,n),m);
   y=a1*x.^2+b1*z.^2+c1;
```

Fig. 3. Fragment of “Switch” Command for Click Action

3. Results

In this paper, the results obtained from the application tools are presented in three sections. The first section is the surfaces representation for parabolic function. The second section is the cylinder function and lastly is the sphere function. Figure 4 shows the result of paraboloid surface in y-axis which is plotted by the input parameters by user. This is a paraboloid with the vertex at the origin that opening along the y-axis.

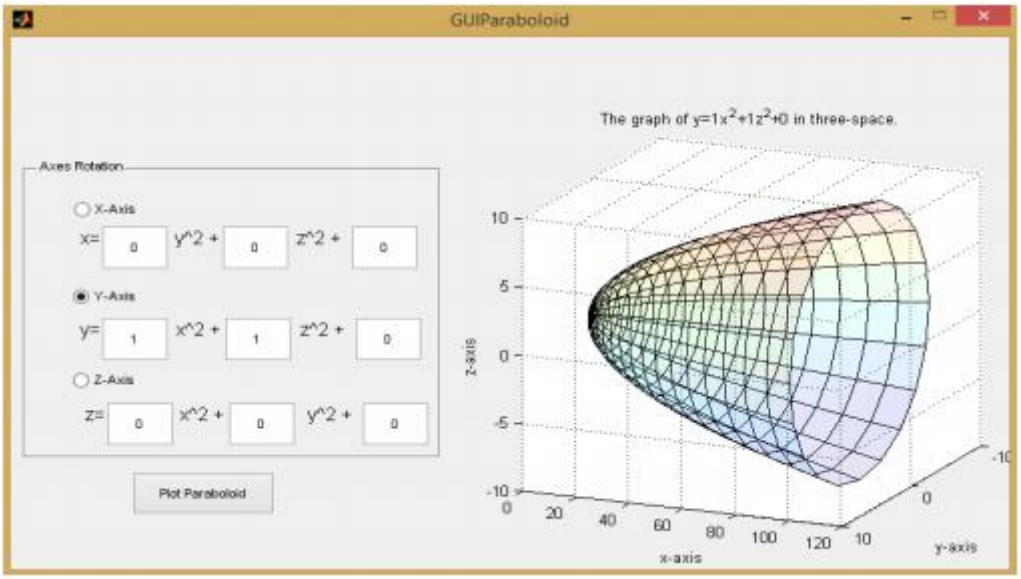

Fig. 4. Plotting Surfaces for Parabolic Function on y-axis

Figure 5 shows the result of paraboloid surface in z-axis which is plotted by the input parameters by user. This is a paraboloid with the vertex at the origin that opening along the z-axis.

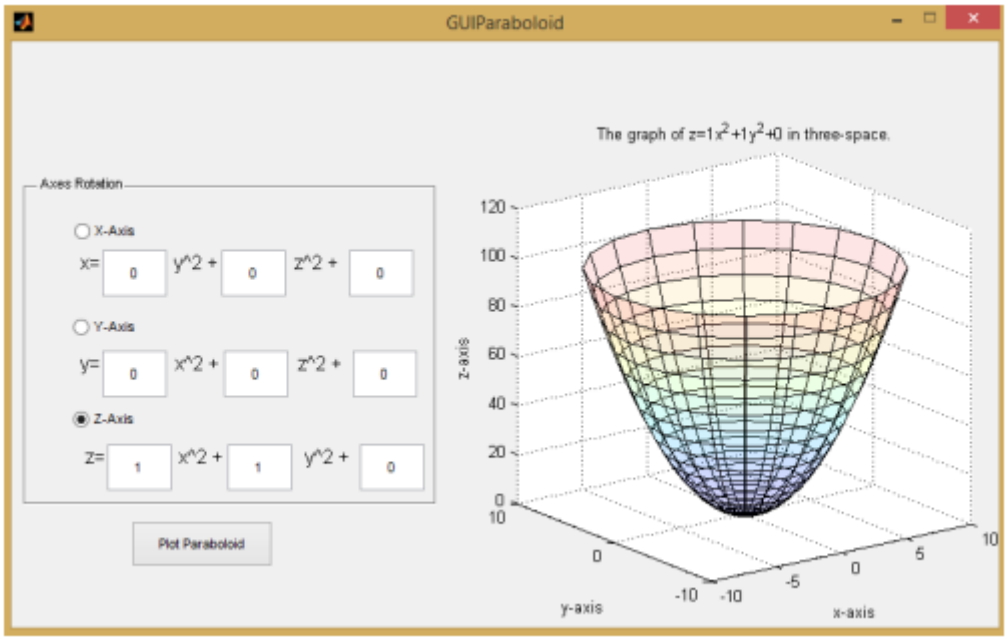

Fig. 5. Plotting Surfaces for Parabolic Function on z-axis

In the second section, the tool illustrates the plotting of cylinder surface. Cylinder is a surface that is created from parallel lines. Figure 6 and Figure 7 show the cylinder surface plotted in x-axis and z-axis respectively.

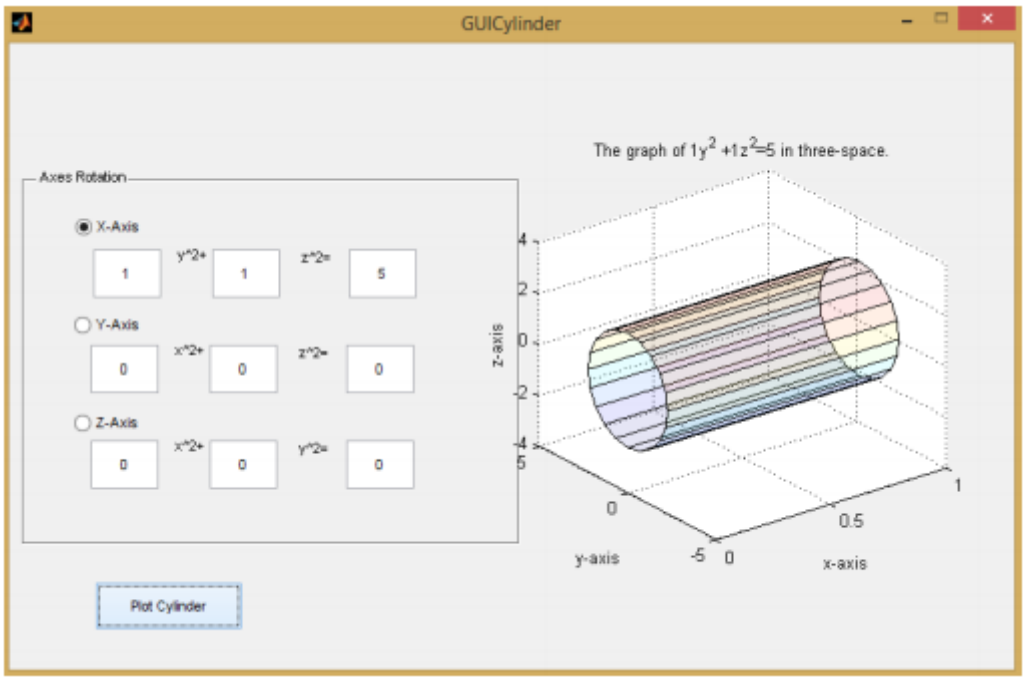

Fig. 6. Plotting Surfaces for Cylinder Function on x-axis

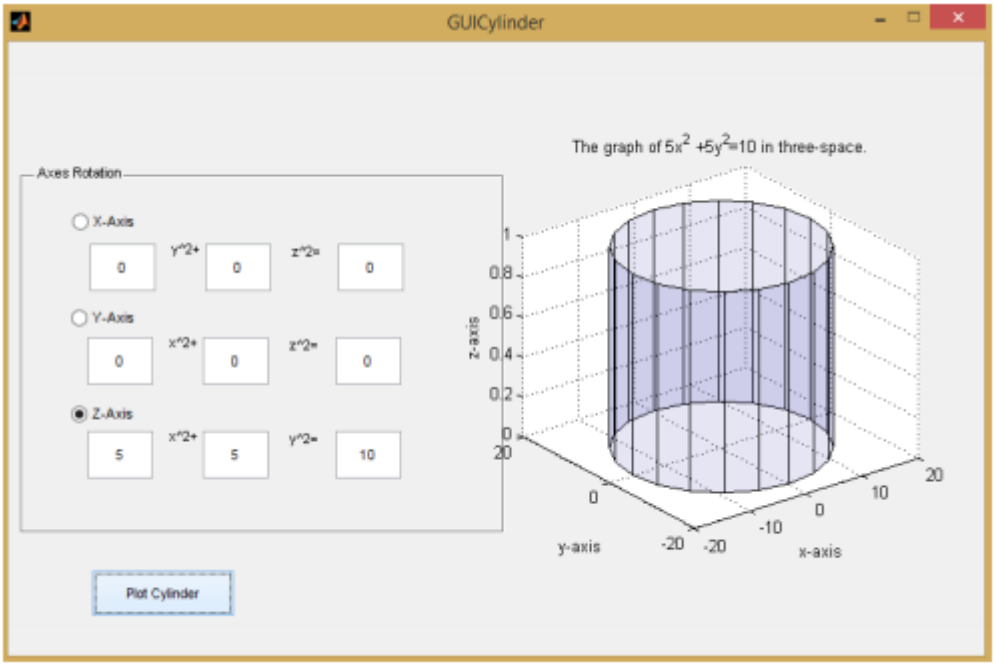

Fig. 7. Plotting Surfaces for Cylinder Function on z-axis

In the third section, the tool illustrates the plotting sphere surface. Figure 8 shows the sphere surface plotted.

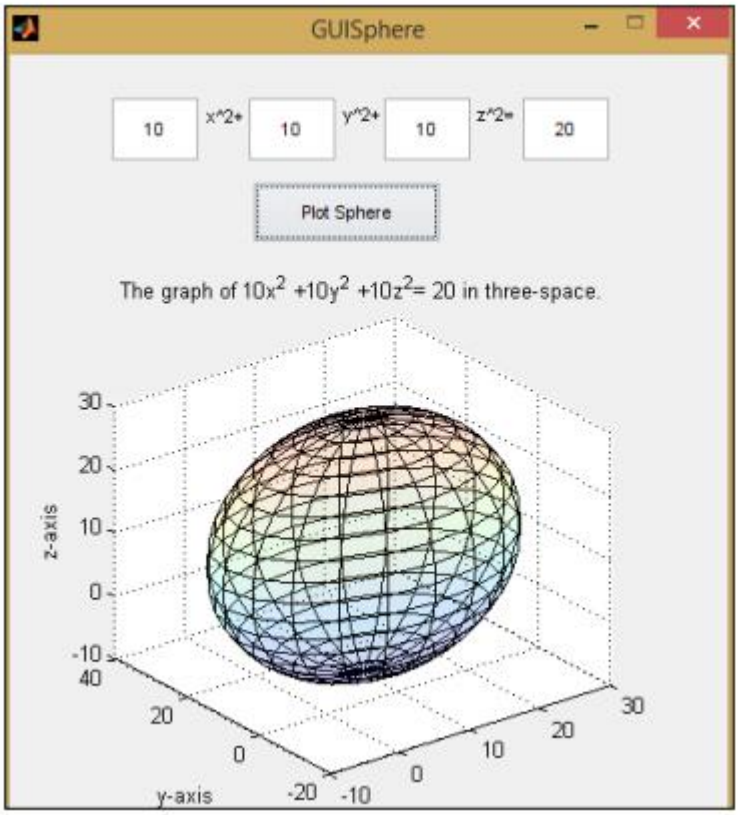

Fig. 8. Plotting Surfaces for Sphere Function

This tool helps in develop visual understanding to the students. Besides that, it offers the advantage of active learning approach which student could involve in the discovering and understanding process especially in problem solving. In addition, people without sound mathematical knowledge also can utilize the tool easily.

4. Conclusion

This study elaborates on the development of a tool that can be implementing in class session that could helps in reducing the high failure rate in the topic of quadric surfaces. In this paper, three types of surfaces are looked into, namely parabolic, cylinder and sphere function. As for conclusion, the learning tool using MATLAB was developed successfully for one of the engineering mathematics subtopic. The tool can be used in a classroom by the instructor and most of all; it enables to visualize the graph of quadric surfaces correctly. In addition, it also able to helps student with their tutorial and assignment. This project will be continued in future on different topic of engineering calculus.

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