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Build an Interactive Application "Matica" for Teaching and Learning Mathematics

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Abstract:

Mathematics is one of the interesting and important subject to learn. Unfortunately, many students have difficulties with Mathematics. There are some reasons why the students have mathematical learning difficulties. They might be have continous failure experience in math and therefore, they believe they can not improve their mathematical capacities. Their lack of confidence, passive learners, memory and attention problem could be the other reasons. The use of technology such as computer software can do what a textbook will never can do. The concepts in a textbook may be introduced by teachers and software program will visualize it. By exploring mathematical phenomena via visualization, the students can improve their mathematical concept understanding. In this paper, an application built with Mathematica 8.0. named MATICA has created as students project works and introduced as one of Mathematical visualisation program that bring the students generate illustrative example by themselves. The materials discussed here include graph and function, matrix and determinant and systems of linear equation. An interesting and visual example were given in order to stimulate the students's curiosity and increase their understanding.

1. Introduction

Most of students tend to avoid mathematics class. They view mathematics as boring and difficult rather than fun and interesting. Little training in mathematics does not make it better, since mathematics learning requires patience, persistence and perseverance. According to Sharma[4], students become frustated when the teacher/lecturer taught only at the abstract level. Thus they do not know why they learn math topics. It will be worse when the teachers even do not khow why they are teaching particular math topics.

Bourne [1] suggested that the teachers should make math learning meaningful, start with concrete example and an interesting real world problem, use computer to do complex calculation, and give the project works. Glaister and Glaister [2] discussed how applications and project work play role in the enhancement of mathematics teaching and learning. Learning mathematical properties and principles can be enhanced through visualization using computer graphics[3]. Furthermore, National Council of Teacher of Mathematics (NCTM) [4] explained that technology is an essential tool for learning mathematics and teachers should maximize the potential of technology to develop student's understanding, stimulate their interest and increase their proficiency in mathematics. Niess[5] investigated that integration of technology can motivate students to enhance their learning as long as the teachers

This paper focuses on implementation of project works to the students of mathematics of computation class of Informatics college diploma Sebelas Maret University. Mathematics of computation subject focuses on mathematics and computation where computation is finding solution of a problem by using mathematics

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and logic. In this case, students can use a computer program Mathematica to do computations. This project assignment is designed to accelerate and deepen students understanding of math and not just how to compute them. Mathematica 8.0 is chosen in order to hold students' interest, to challenge them and to make learning more interesting.

2. Main

When the students are taught by using textbooks, workbooks and examinations, many students will be boring. They think difficullties in the material. According to Sharma[6], they have a tendency to forget after the class is over. Therefore, some innovative teaching strategies are needed. Based on Sweller[7], teacher should minimize load that is unimportant to the learning goal and direct student activity to thinking what they should be learning. Computer can be useful to reduce the load of student thinking, and help them to focus on more advanced skills and concepts.

The observation was done in mathematics of computation class, consisting of 45 students. Students were divided into eight teams. Each team, consisting of up to six students, should build an interactive application by using Mathematica software and then present their project in front of class for further discussion of their mathematical journey with other teams and teacher. Lecture material covers matrix and determinant, system of linear equations, graph and function, limit and continuity, and application of derivatives and integral. Project works discussed in this paper are implemented to the three first course materials.

NCTM [4] explained that the use of computer cannot replace conceptual understanding. Thus, in every topic, teacher introduces the concept at beginning and then guides the students so they can use computer and Mathematica software to support and extend mathematical reasoning and sense making, gain access to mathematical content and problem solving contexts, and enhance computational fluency. Teacher gives a simple Mathematica program and the students are expected to develop it. Finally, by those three assignments below, students can use Mathematica for computation, construction and representation as they explore problems.

Project Work 1: operation in matrix

A simple example given to the students is presented below.

```
While[True, pilih = Input["Select :
0. Exit
1. Addition of two matrices with size 2 x 2
Pilih :
"];
 If [pilih == 1,
  do =
   A1 = Input["entry A11 :"];
  A2 = Input["entry A12 :"];
  A3 = Input["entry A21 :"];
  A4 = Input["entry A22 :"];
  MA = {{A1, A2}, {A3, A4}};
```

```
    B1 = Input["entry B11 :"];
    B2 = Input["entry B12 :"];
    B3 = Input["entry B21 :"];
    B4 = Input["entry B22 :"];
    MB = {{B1, B2}, {B3, B4}};
    Print[" A = ", MA // MatrixForm , " B = ", MB  // MatrixForm ,
      " A+B = " , MD = MA + MB ; MD // MatrixForm];
   ];
   If[pilih == 0, Print["Thank you :)"]; Break[]];]
```

Based on the concept that have been described previously by the teacher and a simple program above, every team was asked to build a program to find addition, substraction and multiplication of two matrices with size n x m, where n and m are positif integer. The following program is one of project works written by students.

```
nama = Input["welcome, insert your name please:-)"];
While[True, pilih = Input["Hello", nama, "select please :
1. addition
2. subtraction
3. multiplication
0. Exit !!
Pilih : "];
If [pilih == 1,
 do =
  MA = Input["input matrix A : for example, matrix 3x2 is written by {{1,2},{2,3},{3,4}} "];
 MB = Input["input matrix B : for example, matrix 3x2 is written by {{1,2},{2,3},{3,4}} "];
 Print[" A = ", MA // MatrixForm , " B = ", MB  // MatrixForm , "A+B= " , MD = MA + MB ; MD // MatrixForm];
];
If [pilih == 2,
 do =
  MA = Input["input matrix A : for example, matrix 3x2 is written by {{1,2},{2,3},{3,4}} "];
 MB = Input["input matrix B : for example, matrix 3x2 is written by {{1,2},{2,3},{3,4}} "];
 Print["A = ", MA // MatrixForm , " B = ", MB  // MatrixForm , "A-B= " , MD = MA - MB ; MD // MatrixForm];
];
If [pilih == 3,
 do =
  MA = Input["input matrix A : for example, matrix 3x2 is written by {{1,2},{2,3},{3,4}} "];
 MB = Input["input matrix B : for example, matrix 3x2 is written by {{1,2},{2,3},{3,4}} "];
 Print["A = ", MA // MatrixForm , " B = ", MB  // MatrixForm , "AxB= " , MD = MA * MB ; MD // MatrixForm];
];
If[pilih == 0, Print["End of Program, Thanks for use it :)"]; Break[]];]
```

Once they present, they can answer all questions correctly. Students understand the concepts well and able to present them in a Mathematica program. This is probably because the material is still relatively easy.

Project Work 2 : solving system of linear equations

Each team of the students was asked to write a program that prints the solution of a linear system:

$$ax + by + cz = A$$
$$dx + ey + fz = B$$
$$gx + hy + iz = C$$

where a, b, c, d, e, f, g, h, i, A, B, C are constant real. See the program written by a student project team below,

```
Clear[matA, a, b, c, d, e, f, g, h, i, j, k, l, result]

a = Input["Equation 1 (ax+by+cz=A), enter the value of a"];
b = Input["Equation 1 (ax+by+cz=A), enter the value of b"];
c = Input["Equation 1 (ax+by+cz=A), enter the value of c"];
d = Input["Equation 1 (ax+by+cz=A), enter the value of A"];
e = Input["Equation 2 (dx+ey+fz=B), enter the value of d"];
f = Input["Equation 2 (dx+ey+fz=B), enter the value of e"];
g = Input["Equation 2 (dx+ey+fz=B), enter the value of f"];
h = Input["Equation 2 (dx+ey+fz=B), enter the value of B"];
i = Input["Equation 3 (gx+hy+iz=C), enter the value of g"];
j = Input["Equation 3 (gx+hy+iz=C), enter the value of h"];
k = Input["Equation 3 (gx+hy+iz=C), enter the value of i"];
l = Input["Equation 3 (gx+hy+iz=C), enter the value of C"];
Print[{{a, b, c}, {e, f, g}, {i, j, k}} // MatrixForm, {d, h, l} // MatrixForm];
Obe = {{a, b, c, d}, {e, f, g, h}, {i, j, k, l}};
Obe1 = Obe // MatrixForm;
RowReduce[Obe];
A = {{a, b, c}, {e, f, g}, {i, j, k}} // MatrixForm;
A1 = {{d, b, c}, {h, f, g}, {l, j, k}} // MatrixForm;
A2 = {{a, d, c}, {e, h, g}, {i, l, k}} // MatrixForm;
A3 = {{a, b, d}, {e, f, h}, {i, j, l}} // MatrixForm;
Print["A:", A]
Print["A1:", A1]
Print["A2:", A2]
Print["A3:", A3]
A11 = Det[{{a, b, c}, {e, f, g}, {i, j, k}}];
A22 = Det[{{d, b, c}, {h, f, g}, {l, j, k}}];
A33 = Det[{{a, d, c}, {e, h, g}, {i, l, k}}];
A44 = Det[{{a, b, d}, {e, f, h}, {i, j, l}}];
x = A22/A11;
y = A33/A11;
z = A44/A11;
cc = {{a, b, c}, {e, f, g}, {i, j, k}};
xx = {{x}, {y}, {z}};
ff = {{d}, {h}, {l}};
dd = Solve[cc.xx == ff, {x, y, z}];
hh = LinearSolve[cc, ff];
```

```
Print["Solution for the system of linear equation is: "]
Print["Cramer: x->", x, ", y->", y, ", z->", z]
Print["OBE:", RowReduce[Obe] // MatrixForm]
Print["Solve:", dd]
Print["LinearSolve:", hh]
```

From the program above, it can be seen that the command is quite interactive and easy to understand. Users or other students can run the program easily by following the instructions listed in the program. It seems that students start to think mathematically when they build the program.

On the other hand, the project work helps the students to do some simulation and explore many other linear system and their solutions. Finally they will understand that any system of linear equations probably has no solution, unique solution or infinitely many solutions.

Project Work 3: Graph of functions

Students were asked to build a program to display graph of one function or more in the same rectangular coordinate system. The program should show the lower and upper axis limit so users can input a certain interval of the graph. See the following program written by one of teams.

```
If[pilih ==1,
  a1 = Input["input function of x, f(x)= "];
  min1 = Input["lower axis limit ="];
  max1 = Input["upper axis limit ="];
  Print["Graph of  f(x) = ", a1, " on the interval [", min1, ",", max1, "]"]
   Print[Plot[a1, {x, min1, max1}, Frame → True, GridLines → Automatic, PlotStyle → Blue, FillingStyle → Green, PlotLabel → "Grafik F(x)"]]
  ,];
Clear[pilih, a1, b1, max1, min1, var, a2, a3, min2, max2, a4, a5, a6, min3, max3, a, b, p, q, max4, min4]
While[True, pilih = Input["Function of one variable, menu  :
1. Graph of a function
2. Graph of two functions
3. Graph of three functions
0. Exit
select 1, 2, 3 or 0  :"];

If[pilih ==2,
  a2 = Input["input the first function of x, f1(x) ="];
  a3 = Input["input the second function of x, f2(x)="];
  min2 = Input["lower axis limit ="];
  max2 = Input["upper axis limit ="];
  Print["Graph of f1(x)=", a2, " and  f2(x)=", a3, " on the interval [", min2, ",", max2, "]"];
  Print[Plot[{a2, a3}, {x, min2, max2}, Frame → True, PlotStyle → {Red, Green}, PlotLabel → "Graph of f1(x) and f2(x)"]]
  ,];
```

```
If[pilih == 3,
  a4 = Input["input the first function of x, f1(x)="];
  a5 = Input["input the second function of x, f2(x)="];
  a6 = Input["input the third function of x, f3(x)="];
  min3 = Input["lower axis limit="];
  max3 = Input["upper axis limit="];
  Print["Graph of f1(x)=", a4, ", f2(x)=", a5, ", and f3(x)=", a6, " on the interval [", min3, ",", max3, "]"]
   Print[Plot[{a4, a5, a6}, {x, min3, max3}, Frame → True, PlotStyle → {Red, Green, Blue}, PlotLabel → "Graph of f1(x), f2(x), and f3(x)"]]
  ,];
If[pilih == 0, Print["Good bye, thank you:)"]; Break[]];]
```

Once they present, they can explained the behaviour of graphs. They can see that function can have "hills and valleys". They can also describe the point where the function reaches its maximum or minimum value. In addition, they will explore whether it may not be the maximum or minimum for the whole function, but locally it is. Otherwise, students may finding an intersection points of two or more graphs. Finally, they will realize that the point of intersection is the solution to a system of equations.

Those three of assignments could be developed in other materials. Students need more experience in doing project work that is related to other subjects they are studying. Since they will probably not eventually become mathematicians, it is important that students understand the concepts of mathematics and how to use them when they confronted with different real problem..

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