



APPLICATION OF MATHEMATICAL MODELS IN SCIENCE AND ENGINEERING

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ABSTRACT

Math's outlines an exciting field of science, unique, challenging to learn even able to hypnotize the mind to continue to assess and review of its uniqueness. Math categorized into two, namely that of applied mathematics (applied mathematics) and pure mathematics (pure mathematics). In the field of applied mathematics is often used in economics and engineering, while in the field of pure mathematics are often used by experts in the science of designing algorithms. The algorithm is the foundation that must be mastered by every student who wants to solve a problem in a structured, effective, and efficient. One of the computer software that is closely related to mathematics MATLAB (Matrix Laboratory) is a software-based mathematical computing on vector and matrix. Use of graphics, coordinate systems and the utilization of independent variables and the dependent variable is a regular activity in the economy, such as the use of demand and supply curves, calculation of profit and loss, the calculation of subsidies and so forth.

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Contribution/ Originality

This study contributes to the development of computer sciences, engineering and economics, especially in the use of mathematics formula in each principle. This study emphasis that since the applicated symbols and the problem solving are different, the formula used in those principles are basically the same.

1. INTRODUCTION

Mathematics is the science interesting, unique, and challenging to learn even able to hypnotize the mind to continually assess and review of its uniqueness. Many important titles pin by philosophers of mathematics. Many philosophers believe that mathematics is a science based on experiments and not science that is expressed by certain definitions attributed by experts.

Mathematics can be divided into two categories, namely pure mathematics and applied mathematics.

In the world of education mathematics is often referred to as "the Queen of Science". The title is attached because the math does have a major contribution to various branches of science. In the process of mathematics learning, consciously trained to be able to think critically, logically, analytically and systematically. It is also the reason why mathematics is introduced from the age of toddlers, children, and even until adulthood. If interpreted in general, the goal of learning mathematics is to establish a person's thinking patterns so they can think critically, logically and systematically.

Mathematics can clarify and simplify a situation that initially abstract, idealistic, or generalizations in the form of a study or problem-solving. Mathematics made a significant contribution in the development of information technology. Various applications and programs on the computer can not be separated from the application of mathematical applications, including the operation of Boolean algebra, graph theory, discrete mathematics, symbolic logic, odds and statistics. The complexity of life requires human resources that are reliable and able to use computer applications.

The field survey shows the tendency of the importance of basic math skills in determining the success and progress of the nation. From the results of PISA 2012 organizers note that Indonesia ranks 64 out of 65 participants. PISA is an international test that measures the ability of students across the state in reading, math and science. PISA 2012 organizers generally concluded that student achievement in mathematics to determine the success and progress of the nation, both in improving the quality of education and political participation.

The development of rapid sciences is due to the support of mathematics as it strengthens the structure and mathematical reasoning. Abu Abdullah Muhammad Ibn Musa al-Khwarizmi a mathematician from Uzbekistan is famous for his discoveries in the field of algorithms says that the use of the algorithm can create effectiveness and efficiency in computer programming, file size and use of mathematical logic, arithmetic, computer number systems, relations common use of data structures, artificial intelligence digital systems, databases, theory of computation, neural networks, and so forth.

Many areas of mathematics that have been applied by using a computer, among which mat lab, Visual Basic, Delphi, Java and others. Visual programming is a visual tool in a computer that can be used to display the results of applied mathematics using computer applications.

From the background, the researchers wanted to research on the application of mathematical models in other sciences and engineering.

2. ILLUSTRATIONS

a. Applications of Mathematics in Engineering

The algorithm is the foundation that must be mastered by every student who wants to solve a problem in a structured, effective, and efficient. The topics of algorithms can be core courses for student's computer science majors; it means that the algorithm is a key element in preparing the computer programs in solving a problem. Abu Ja'far Muhammad ibn Musa al-Kwarizmi is

mathematician and astronomer, author of "Algebra Wal Muqabala" in 850 is regarded as the originator of the first algorithm as in the book he describes the steps in solving mathematical problems [1].

The uses of mathematical algorithms are very often applied in the preparation of computer programs, ranging from the preparation of a simple computer program to the programs that have been classified as complex. The use of the structure of a simple algorithm such as when it will calculate the area of a circle with spokes input from the circle. The area of a circle is $\pi * \text{radius} * \text{radius}$ ($L = \pi. r. r = \pi. r^2$).

The area of a circle _ Algorithm

{ calculate the area of a circle when the radius of the circle is given }

Declaration

{ Definition of constant name }

const N = 10;

const phi = 3.14;

{ Definition of variable names / variable }

radius _ radius estate, area;

Description

read (radius _ radius);

area = pi * radius _ radius * radius _ radius;

write (wide);

The matrix material in mathematics learning is an example of material that often becomes barriers for students or even students in the process, but by collaborating between mathematics and computer make the topic becomes easier to teach, for example:

1. Finding the inverse (opposite) matrix inverse matrix A^{-1} is a matrix which, when multiplied by the original matrix A will yield the identity matrix I, or $AA^{-1} = I$.
2. If the inverse matrix B is assumed as the matrix equation becomes $AB = I$, so that the matrix B can be solved by Gauss-Jordan elimination method.

$$\begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{bmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

In essence, if the note then the solution can be obtained by performing Gauss-Jordan elimination process three times, or a column of the matrix B.

3. One other way that comes from the process of elimination and has proven to be successful is to create a matrix A and matrix I side by side. Then the Gauss-Jordan elimination applied to the matrix so that the matrix A in the end be the identity matrix I, and at that moment I became the inverse matrix of A.

$$\begin{pmatrix} a_{11} & a_{12} & a_{13} & 1 & 0 & 0 \\ a_{21} & a_{22} & a_{23} & 0 & 1 & 0 \\ a_{31} & a_{32} & a_{33} & 0 & 0 & 1 \end{pmatrix}$$

This matrix is manipulated to obtain:

$$\left(\begin{array}{ccc|ccc} 1 & 0 & 0 & b_{11} & b_{12} & b_{13} \\ 0 & 1 & 0 & b_{21} & b_{22} & b_{23} \\ 0 & 0 & 1 & b_{31} & b_{32} & b_{33} \end{array} \right)$$

b. Applications of Mathematics in Computer Science

One of the computer software that is closely related to mathematics MATLAB (Matrix Laboratory) is a software-based mathematical computing on vector and matrix. According Math Works [2] MATLAB is the scope of integrated computing mixing numerical computation, graphics, visualization, simulation, and high-level computer language. The syntax of the language contained in the MATLAB there are similarities with the modern languages C, C++ or Java.

The discovery of the machine tool mechanical calculations, for the first time was also invented by a French mathematician named Blaise Pascal (1623 - 1662) which was later named by Pascal's Machine Arithmetic or commonly known as the Pascal line. The workings of this tool until now are still being used in modern computers. In the year (1646 - 1716) Gottfried Wilhelm von Leibniz a mathematician then develops machines made by Pascal.

Furthermore, George S. Boole an ultimately explores the logic of logic in mathematical symbols based on three logical operations AND, OR and NOT, which became the basis of his theory on the workings of a computer circuit [3]. Application of Boolean algebra to computer circuitry is if an electronic switch is open (disconnected stream), given the symbol 0, while when the electronic switch is closed (connected flow) given the symbol 1. The relationship of the switch logic is said to be one of 0 and 1 said to be true in the logic of Boolean algebra. An output C contains flow when both switches A and B closed (current connected) and is described by the Boolean expression A AND B (written with symbols $A \cap B$). Logical Operator AND will produce an output current, when the two other switches closed. If one switch is open, then the output doesn't contain the flow. An output C will produce a current when one switch A or switch B is closed (current connected) and is described by Boolean algebra statement A OR B (written with symbols AB). OR logical operators will produce output currents when one switch is closed. If both switches are all open, then no current obtained.

c. Applications of Mathematics in Economics

Economics is essentially the study of how society manages the resources are always limited, or scarce [4]. Therefore, in managing the resources are always facing the facts to compare all the costs and benefits of each course of action, in order to answer these questions, and then we will be dealing directly with the mathematical calculations.

The calculation of the cost of the course uses economic models. One of the economic models that are often used is the "production possibility frontier" that was built by using mathematical tools. The production possibilities frontier is a graph that shows the combinations of output that may be produced by an economy with a particular factor of production and the available production technology, which is known in the mathematical understanding of the function of an equation that is prepared using the dependent variable "y" and the independent variable "x", which is described into the graph of the equation.

In principle, in economics graph has two purposes: first at the time of developing the economic theory, a graph is a way to express ideas visually, which may be less obvious when using mathematical equations or words. Second, when analyzing economic data, graphs are a way to see exactly how the variables are interrelated. So in the economy is often described as a graph "glasses to be able to recognize the forest of many trees". The type of chart that is often used is the pie chart (pie chart), bar graph, and the time-series graph.

Although graphs can be useful in showing how a variable changes over time or across individuals, but the graphics have limitations in explaining the various information. Graphs are only able to show the information with a single variable, while the economy is often associated with the relationship between variables. Therefore, the necessary knowledge of higher mathematics to become an economist, suppose ability to show two variables on a single graph in a coordinate system is done by using a positive correlation or negative correlation. If the variable has more than two, then the mathematical sciences provides ease in economics by using the curve in the coordinate system, of which the most common used in the economic principle is the demand and supply curves.

The demand curve will show a number of items purchased depending on the price of the goods, while its revenues are considered fixed. Therefore, because of the price and quantity demanded associated negative, then the demand curve is downward sloping downhill. In mathematics these changes are known as "variable", constant prices is known as "constant" and the slope of the graph known as a "gradient".

Influenced by the market forces of supply and demand, demand and supply are the two words which are most often used by the economists as both supply and demand are the forces which make the market economies work. Supply and demand can be more easily noticed through the demand curve and the supply curve. Demand curve shows what happens to the quantity demanded of a good when its price changes by assuming a constant determinant of demand other woods, when one of the other determinants changes, the demand curve will shift. The supply curve shows what happens to the quantity of goods on offer when the price changes, assuming the entire determinants of the quantity supplied constant other. If one of these factors changes, the supply curve will shift.

3. RESULTS

In the last years there has been an increase of in the United States of the Use of standards-based education and the use of standardized testing as a means of student assessment. The No Child Left Behind (NCLB) Act of 2001 requires that all students be assessed in reading and mathematics in grades 3 through [5]. Therefore, in the United States assessment of student achievement in mathematics special attention compared to the other educational achievements. Such attention may be due to advances in technology more advanced American countries, because many important activities born from growing through the application of mathematics and mathematics.

Aschraf & Kirk reveals that In mathematics, an affect such as anxiety causes personal distrust of intuition and a consequent lack of effort, which are seen as learners' greatest barrier to achievement" [6]. Furthermore Alfio [7] revealed that "mathematical modeling aims to describe the

different aspects of the real world, their interaction, and their dynamist through mathematics”. Thus, it can be seen that the pillars of science and engineering carried out by more than two disciplines, such as theory analysis and experimentation. At the present time, the mathematical model has also been a key role in the field such as daily life and industry.

The use of mathematics in everyday circumstances at this time often emphasizes learning for traditional or manual which makes it difficult the understanding of mathematical algorithms that abstract. However, by applying technology in learning mathematics, it will provide a lot of convenience, because learning the nuances of the technology will combine education with entertainment so abstract mathematics can be learned with a pleasant atmosphere. Emut [8] say that one form of the use of learning technologies that can combine elements of education and entertainment element is the use of computer-based information technologies. With the use of computer media such as Mat lab, Visual Basic, Delphi, Java, and CABRI is expected to be one of the innovative ways in delivering learning materials mathematics. But the software software-formed using languages, symbols and mathematical algorithms, such as MATLAB (Matrix Laboratory) are a software-based mathematical computation on vectors and matrices. Thus, it can be said between mathematics and computer science has a reciprocal relationship that intertwined with each other and be able to produce positive benefits for both the scientific component.

Based on the analysis, it is found that the system matrix is by using Cramer's rule as MATLAB can be used to assist in correcting the answers to the lecturer, as long as the system can easily detect the location of errors made by students without having to check one by one. Utilization of this system can be developed using Borland Delphi application, which for engineering and computer science communities is not a stranger anymore. Use of Borland Delphi application can be done by entering formulas into the application of Cramer's rule.

The system of linear equations is a part of mathematics that studies how to solve problems using linear algebra techniques. The methods studied in this course are an algorithm of a resolution of the various issues that can be used so that these methods can be implemented in a computer program [9]. Completion of the inverse matrix is applied in the computer can be completed with the following steps:

Algorithm Flip_ Matrix

{Applying the Gauss-Jordan method to find the inverse of a matrix }

Declaration

```

    real m;
    integer brs=3, klm=3

    real A[brs][klm], B[brs][klm];

    integer ib, ik, il, factor;

```

Description

```

    write ( “enter the matrix elements “ );
    for ( ib=1 to brs step 1 )
        for ( ik=1 to klm step 1 )

```

```

        read ( A[ib][ik] );
    endfor.
endfor.

{the matrix identity is B}
for ( ib=1 to brs step 1 )
    for ( ik=1 to klm step 1 )
        if ( ib = ik )
            then B[ib][ik] ← 1;

            else B[ib] ← 0;

        endif.
    endfor.
endfor.

{process of elimination}
for ( ik=1 to klm step 1 )
    for ( ib=1 to brs step 1 )

        {elimination except the diagonal}
        if ( ik != ib )
            then m ← - A [ib][ik]/A[ik][ik];

            for ( il=ik to klm )

                A[ib][il] ← A[ib][il] + m*A[ik][il];

                B[ib][il] ← B[ib][il] + m*B[ik][il];

            endfor.
        endif.
    endfor.
endfor.

{show results}
for ( ib=1 to brs step 1 )
    for ( ik=1 to klm step 1 )

        write (B[ib][ik], “ “);

    endfor.

```

write ();
endfor.

Examples of its use are as follows:

$$x + y + 2z = 9$$

$$2x + 4y - 3z = 1$$

$$3x + 6y - 5z = 0 \quad [10]$$

When calculated using manual calculation, it will be steps are as follows:
The solution:

Steps can be taken to resolve the above system of equations is:

1. Write the expanded matrix of the above system of linear equations:

$$\left(\begin{array}{ccc|c} 1 & 1 & 2 & 9 \\ 2 & 4 & -3 & 1 \\ 3 & 6 & 5 & 0 \end{array} \right)$$

2. Fox (Reduce) matrix expanded with the help of Elementary Row Operations (OBE) into epsilon lines as follows:

$$\left(\begin{array}{ccc|c} 1 & 1 & 2 & 9 \\ 2 & 4 & -3 & 1 \\ 3 & 6 & 5 & 0 \end{array} \right) \begin{array}{l} \sim \\ -2(I) + (II) \\ -3(I) + (III) \end{array}$$

$$\left(\begin{array}{ccc|c} 1 & 1 & 2 & 9 \\ 0 & 2 & -7 & -17 \\ 0 & 3 & -11 & -27 \end{array} \right) \begin{array}{l} \sim \\ II \left(\frac{1}{2} \right) \end{array}$$

$$\left(\begin{array}{ccc|c} 1 & 1 & 2 & 9 \\ 0 & 1 & \frac{-7}{2} & \frac{-17}{2} \\ 0 & 3 & -11 & -27 \end{array} \right) \begin{array}{l} \sim \\ -3(II) + III \end{array}$$

$$\left(\begin{array}{ccc|c} 1 & 1 & 2 & 9 \\ 0 & 1 & \frac{-7}{2} & \frac{-17}{2} \\ 0 & 0 & \frac{-1}{2} & \frac{-3}{2} \end{array} \right) \begin{array}{l} \sim \\ III(-2) \end{array}$$

$$\left(\begin{array}{ccc|c} 1 & 1 & 2 & 9 \\ 0 & 1 & \frac{-7}{2} & \frac{-17}{2} \\ 0 & 0 & 1 & 3 \end{array} \right)$$

3. Write the system of linear equations of the matrix rows epsilon

$$x + y + 2z = 9 \quad (1)$$

$$y - \frac{7}{2}z = \frac{-17}{2} \quad (2)$$

$$z = 3 \quad (3)$$

4. Do it backward substitution to obtain its solution

Since it is known that $z = 3$, then substitute into equation (2)

$$y - \frac{7}{2}z = \frac{-17}{2}$$

$$y - \frac{7}{2}(3) = \frac{-17}{2}$$

$$y - \frac{21}{2} = \frac{-17}{2}$$

$$y = \frac{-17}{2} + \frac{21}{2}$$

$$y = \frac{4}{2}$$

$$y = 2$$

The substitution $z = 3$ and $y = 2$ into equation (1), becomes

$$x + y + 2z = 9$$

$$x + 2 + 2(3) = 9$$

$$x + 8 = 9$$

$$x = 1$$

Thus, the completion of a system of linear equations is: $\{1, 2, 3\}$

Calculation perceived complicated and difficult when done manually, then with the use of computer science applications in mathematics can be done with a little lighter.

The workmanship is as follows

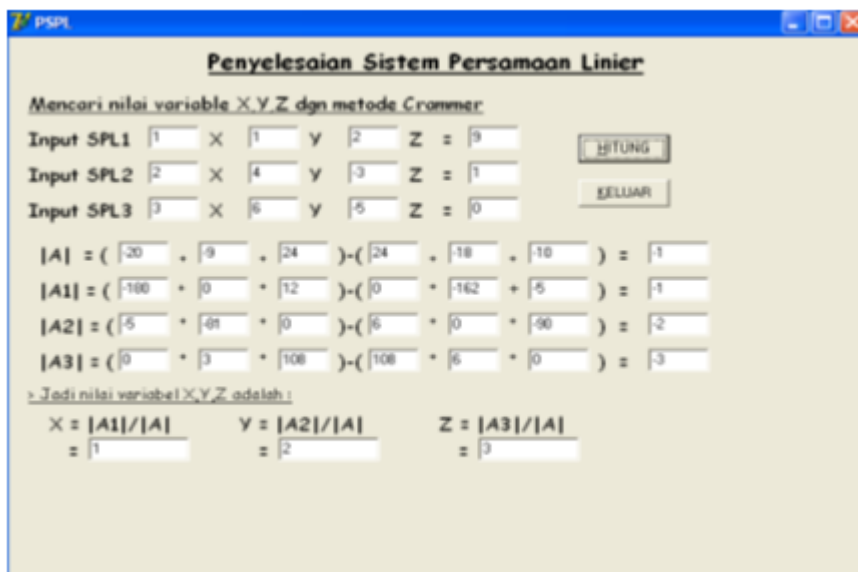


Figure-1. Calculation with the use of computer science applications in mathematics

Use the principles of mathematics in economics, including the calculation of the elasticity of demand and supply, the calculation of profit and loss, tax and subsidy calculation, calculation of average cost and marginal cost the company even monopolistic competition in the long term and short term by using mathematical principles.

Our findings on the relationship between the computer and mathematics, engineering, mathematics and even economics with mathematics shows that the traditional view of society who believe that mathematics is an exact science that stands alone is not up to date, and always constant indicates the opposite situation, where when one study mathematics then by inadvertently then that person is actually looking into other sciences. Vice versa, when one studies other disciplines such as computer science, economics and even the actual techniques he is continually linking the activities of the higher mathematics and the use of mathematical algorithms increasingly complex.

The result of the integration of the data with the real state providing a deeper understanding of the different variables that allow for the exploration of a different route in promoting understanding, benefits, as well as the learning objectives of mathematics, because, according to [Maria De Lourdes, et al. \[11\]](#) reveals that the motivation towards math was measured through a version of the IMI (Intrinsic Motivation Inventory), directed towards Mathematics, taking into considerations three dimensions: Perceived Competence, Perceived Choice and Value / Utility.

4. CONCLUSION

The results of this study are as follows:

1. That material related to mathematics, the calculations can be made in the form of applications, such as materials or methods of numerical linear algebra.
2. Mathematical modeling has a key role Also in Reviews such fields as the environment and industry, while the contribution is potential in many other areas is becoming more and more evident.

3. Numerical analysis of the discipline that allows mathematical equations (algebraic, functional, differential, and integrals) to be solved through algorithms had a leading role in solving problems linked to mathematical modeling derived from engineering and applied sciences.

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