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THE SURVEY OF NUMERICAL METHODS APPLICATION IN ENGINEERING EDUCATION

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Abstract. *Numerical methods are the study of algorithms for the problems of continuous mathematics in different field including engineering education. The objective of numerical methods is the design and analysis of techniques to give approximate but accurate solutions to hard problems. Ways of computation of numerical methods are either manual or using mathematical software. Manual way of calculation is hard, takes time, and prone to error. Currently, there are mathematical software available in market such as Matlab and Maple that are being used in engineering education. However, the limitations with the existing software are that they are expensive, very general and not user-friendly. There are some commands that user needs to learn in order to generate the answer and different software had different command. It becomes difficult when the mathematical problem is complicated. Therefore, this research aims to produce mathematical engineering education software that is customized to specific need of students, lecturers, and researchers and more user-friendly. This paper presents a survey of numerical method application in engineering education to find out the most common calculation used by students, lecturers and researchers and to identify their requirements of good numerical methods software. The finding will be used as a basis to develop a numerical methods engineering education software that fulfills the requirement of users.*

Keywords: Mathematical Software, Numerical Method, Engineering Education, Mathematical Survey

Introduction

The computer technology advancement has enabled many in science and engineering to apply numerical methods to simulate physical phenomena (Kim *et al.*, 2003; Sert, 2005). Numerical methods are often divided into elementary ones such as finding the root of an equation, integrating a function or solving a linear system of equations to intensive ones like the finite element method. Intensive methods are often needed for the solution of practical problems and they often require the systematic application of a range of elementary methods, often thousands or millions of times over (Bruaset, A.M. and Langtangen, H.P.,1997; Bosilca *et al.*, 2006).

In the development of numerical methods, simplifications need to be made to progress towards a solution: for example general functions may need to be approximated by polynomials and computers cannot generally represent numbers exactly anyway (Kim *et al.*, 2003). As a result, numerical methods do not usually give the exact answer to a given problem, or they can only tend towards a solution getting closer and closer with each iteration. Numerical methods are generally only useful when they are implemented on computer using a computer programming language (Bruaset, A.M. and Langtangen, H.P.,1997).

The learning and teaching of engineering is a challenging task for the students, lecturers and researchers (Shacham *et al.*, 1998). The comprehension of difficult, mathematically formalized concepts can be greatly enhanced by the aid of high level simulation and visualization capabilities of numerical software, which can improve the learning efficiency by bringing to life the equations describing various physical phenomena (Bruaset, A.M. and Langtangen, H.P.,1997; Bosilca *et al.*, 2006).

The application of this kind of software in higher education makes it possible that engineering students gain a much deeper knowledge and understanding of any particular field of engineering, which they are interested in (Sert, 2005). In addition, engineering students who usually not very involved in the detailed mathematical description of the solution of formally defined problems, a numerical software can help really a lot to understand problems of engineering and interpret their solutions in a visual, user-friendly environment (Bruaset, A.M. and Langtangen, H.P.,1997; Sert, 2005; Bosilca *et al.*, 2006).. To the lectures it help them in educating the students by easily describe concepts through the visual, and easy to explain representation of the solutions. To the researchers it aids them to

quickly understand and getting results to any problem related to numerical methods and guide them in choosing the best methods available (Boisvert, 2000).

Currently, there are mathematical software that support numerical methods available in market such as Matlab, Maple and Mathematica (Boisvert, 2000; Kim *et al.*, 2003). However, the limitations with such software are that they are expensive, very general and not user-friendly (Boisvert, 2000). The license pricing is quite high and is not affordable to most of students, lecturers and researchers. Some of the commands users need to learn in order to generate the answer and different software had different command. It becomes difficult when the mathematical problem is complicated (Kim *et al.*, 2003).

Therefore, this research aims to produce numerical methods software for engineering education that is customized to specific need of students, lecturers, and researchers. The software will be affordable, more user-friendly, and easy to learn. However, prior to develop the software a survey is carried out to the specific users in order to identify the most mathematical problem and numerical methods they used, the limitations with current mathematical software package, and requirements for good mathematical software. This paper presents the design of the questionnaire, the way we undertook the survey and the results of the survey. Based on the results, we did some analysis to conclude the findings. The findings will be used in the next stage as a basis to develop a numerical methods engineering education software that fulfills the requirement of users.

This paper has been organized as follows. The next section presents the design and details of the questionnaire for the survey with three types of users that are students, lecturers, and researchers. The following section discusses the findings from the survey with details explanation and judgment. In the last section, conclusions and suggestions for further research are dealt with.

The Questionnaire

This survey is conducted by using questionnaire method. The questionnaire was distributed to respondents who are students, lecturers and researchers in Universiti Teknikal Malaysia Melaka(UTeM). Objectives of this survey are:

- to identify what are the problems in numerical usually occur in engineering education
- to investigate the difficulty in using current mathematical software
- to know user expectations on good mathematical software
- to identify application in engineering education which involved mathematical problem

The respondents have to tick on the suitable answers given and write down their answer if the answers given are not applicable.

This questionnaire consists of nine questions. First question is about respondent status whether they are student, lecturer and researcher. Second question covers on topics in numerical method usually occur on work or study. The topics are roots of equations, linear algebraic equations, curve fitting, interpolations, numerical differentiation, numerical integration, eigen values and eigen vectors, ordinary differential equations and partial differential equations. On this question respondent can tick more than one answer. Third question is respondents have to choose whether they usually use manual calculation, mathematical software or both in order to solve mathematical problem. Fourth question is about the reason why respondents choose manual calculation. The answers given are prefer to do manual calculation, when simple calculation occur only, mathematical software is expensive to buy, have to go to lab, do not know how to use software and other answer state by respondents. Fifth question, respondent have to tick one or more mathematical software they had used or usually used and the answers given are Matlab, Mathematica, Maple, Mathcad or other software state by the respondents. Question number six respondents have to answer yes if they feel mathematical software help them or no if it is not helpful. Next on seventh question respondent have to tick one or more for the problem usually occur when they use mathematical software. The answer given are hard to use, not user friendly, too many command to learn, different command between software, had to find suitable method to use, had to renew software license, toolbox not available, can not solve all mathematical problems, different version issues and other problems state by the respondents. On question number eight respondents have to give their expectations in good mathematical software. The answer given are easy to use, user friendly, simply touch one button to get the answer, auto generate(auto select the best method to use), had the simple note about the method, had to pay once for the license, cover all mathematical problem and other expectations state by the user. Finally, on number nine respondents have to state any application in their work or study involved mathematical problem.

Results

From this survey the descriptive information data is found by using Statistical Package for the Social Sciences (SPSS) version 15.0.

Based on the data, it is found that our respondents were 55.9% students, 41.2% lecturers and 2.9% researchers (refer Table 1). We found that topic in numerical methods usually occurs on work or study was roots of equations about 61.8% (refer Table 2). From the data collection, it was showed that most of the respondents used manual calculation on solving mathematical problem. The percentage was about 70.6% (refer table 3). The most popular reason why the respondents preferred to solve manually was when simple calculation occur only and the percentage was about 64.7% (refer Table 4). About 94.1% of the respondent had used or usually used Matlab rather than other mathematical software (refer Table 5). 91.2% of the respondents felt that mathematical software really help them (refer Table 6). Problem usually occur when the respondents used mathematical software was too many command to learn about 64.7% (refer Table 7). Most of the respondents' expectations that good mathematical software must had user friendly features. The percentage was about 82.4% (refer Table 8). Respondents had stated that the applications in their work or study involved mathematical problem were control system, computational fluid dynamic (FEA), composite structure analysis, thermal analysis, thermodynamics, fluid mechanic, heat transfer, welding simulation, structure analysis, digital signal processing, electromagnetic, circuit analysis, signal analysis, partial fraction expansions, fuzzy logic, statistical process control (failure mode and effect analysis), analysis on suspension and transmission systems, FEM analysis and car modeling.

Table 1. Respondents

Respondent	Percentage (%)
Student	55.9
Lecturer	41.2
Researcher	2.9

Table 2. Topic usually occur

Topic	Percentage(%)
Roots of equations	61.8
Partial differential equations	58.8
Linear algebraic equations	55.9
Numerical differentiation	52.9
Ordinary differential equations	44.1
Interpolations	41.2
Numerical integration	41.2
Curve fitting	38.2
Eigen values and eigen vectors	17.6

Table 3. Method usually used

Method	Percentage (%)
Manual calculation	70.6
Both methods	23.5
Mathematical software (matlab, mathematica, maple & etc)	5.9

Table 4. Reasons that respondents prefer to solve manually

Reason	Percentage (%)
When simple calculation occur only	64.7
Like to do manual calculation	20.6
Don't know how to use software	32.4
Software is expensive to buy	5.9
Have to go to lab	0
Others	0

Table 5. Software usually used

Software	Percentage (%)
Matlab	94.1
Mathcad	5.9
Maple	2.9
Other	2.9
Mathematica	0

Table 6. Respondents feeling about mathematical software

Answer	Percentage (%)
Yes (helpful)	91.2
No(not helpful)	8.8

Table 7. Problem usually occur

Problem	Percentage (%)
Too many command to learn	64.7
Different command between software	61.8
Not user friendly	29.4
Had to open book first to find which is suitable method to use	29.4
Had to renew the software license	17.6
Cannot solve all mathematical problems	14.7
Different version issues(such as compatibility)	14.7
Toolbox not available	5.9
Others	0

Table 8. Expectations on good mathematical software

Expectation	Percentage (%)
User friendly	82.4
Easy to use	79.4
Cover all mathematical problem	55.9
Simply touch one button to get the answer	52.9
Auto generate or select the best method to use	47.1
Had a simple note about the method	41.2
Had to pay once for the license	29.4
Others	2.9

Conclusions

We have noticed that mathematics is important to engineering educations. Most of the applications of the mathematics problems need to solve numerically. We need mathematical software when difficult mathematics problems occur but many of us feel that the current mathematical software is hard to use because the command to learn and different command between software. The good mathematical software must have good features like user friendly, easy to use, cover all mathematical problems and simply touch one button to get the answer. Furthermore, from this finding we will design and develop numerical methods engineering education software that fulfills the requirement of users. This software will cover some engineering applications like composite structure analysis and heat transfer.

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