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Mathematical Dictionary System

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Abstract: Mathematical content has many ambiguities (the same symbol used for different purposes etc) which are not understood by the current search systems. The current search systems have their focus placed on the search by keywords of the mathematical terms, symbols and formulas. This paper introduces a Mathematical Dictionary System (MDS) which contains three dictionaries: The first is a mathematical terms dictionary from/to Malay to English. Secondly, a mathematical symbols dictionary that contains three classes of symbols; Greek symbols, operation symbols and notation symbols. Thirdly, there is the mathematical formulas dictionary that contains six classes of formulas; number system, polynomials, sequences, functions, differentiation and integration. MDS has two categories of users, namely students and lecturers. The MDS has two processes; inserting data, and updating data. Data can come in the forms of new symbols, new formula, and new terms (English-Malay terms or English-Arabic terms). Lecturers can even add new data. There is also a keyboard for mathematical symbols which is displayed on the screen. MDS provides multiple ways of searching. Searching can be narrowed to finding a symbol, a formula, a part of word, and a keyword. Users can listen to the pronunciation of words after they search; and it is considered as another added value for the MDS besides searching. The results of the usability test show that the system is easy to learn, and it is relatively efficient to use.

Key words: Online Mathematical Dictionary, Mathematical Symbols, Bilingual Dictionary, Mathematical Formulas.

INTRODUCTION

The mathematical words and symbols that are used to solve number problems constitute a kind of language. This mathematical language is made up of many kinds of special symbols. In order to understand the mathematical language, it is important for one to learn to understand the meanings of the symbols and words conveyed by this mathematical discourse.

The web-based mathematical dictionary contains an alphabetical list of words, with information given for each word, usually including meaning and pronunciation, and like other dictionaries, used as a tool for referencing. It is used to look up meanings for a word or might also be used to look up the pronunciation of a word, among other linguistic uses. Nowadays, there are a lot of dictionaries being produced worldwide, where some are printed whilst some others can also be found on the Internet. On the other hand, online mathematical dictionaries have been used to fill the gap and are taken to serve as another alternative to the printed mathematical dictionaries. Beside, the existing online mathematical dictionaries do not do much more than the simple search of the mathematical information. The MDS, however, can provide many ways of accessing the mathematical terms.

This paper presented the mathematical dictionary system (MDS) in an easier way, where it is based on a system that can be accessed through regular web browsers as shown in figure 1. The MDS contains mathematical terms from Malay-English/ Arabic-English, mathematical symbols and mathematical formulas. The MDS can help distance learners understand mathematical knowledge, with the freedom and flexibility offered by the online environment.

Background:

The Internet has assisted in the education of mathematics by providing a lot of mathematics sites for students and teachers. Furthermore, the Internet can be used as a means of looking up various kinds of mathematical things for various purposes. This technological tool has been used by students as a mathematical reference source such as dictionaries or encyclopedias (Kissane 2008). Researchers have begun to make attempts to deliver mathematics education materials over the web/Internet. It is found that a lot of web sites have already provided courses and tools for mathematics education. Such sites include Livemath, Mathwright, WebMathematica, Calc101, ActiveMath and MathWeb (Mikusa *et al* 2004). This is added by the fact that the past few years have seen much increase in the research activity in making mathematical computation accessible on the Internet. With the MathML presentation encoding and pending support by popular web browsers, the

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viewing of static mathematical content on the web is no longer difficult (Wang *et al* 2004). Also, the Internet is now one important component of available technology for education, offering new opportunities for students to learn mathematics and to learn about mathematics (National Council of Teachers of Mathematics 2008). More and more users are turning over to the Internet to publish math content, share information and find solutions to their mathematical problems (Adeel *et al* 2008). Also, it is noted that the mathematical literature being published on the web is increasing day by day (Guidi & Schena 2003), (Miner & Munavalli 2007), (Kohlhase & Sucan 2006), and (Asperti *et al* 2006). This further solidifies the proposition that the application of computer technology in education has become increasingly important as we move into the information age (Wang *et al* 2005).

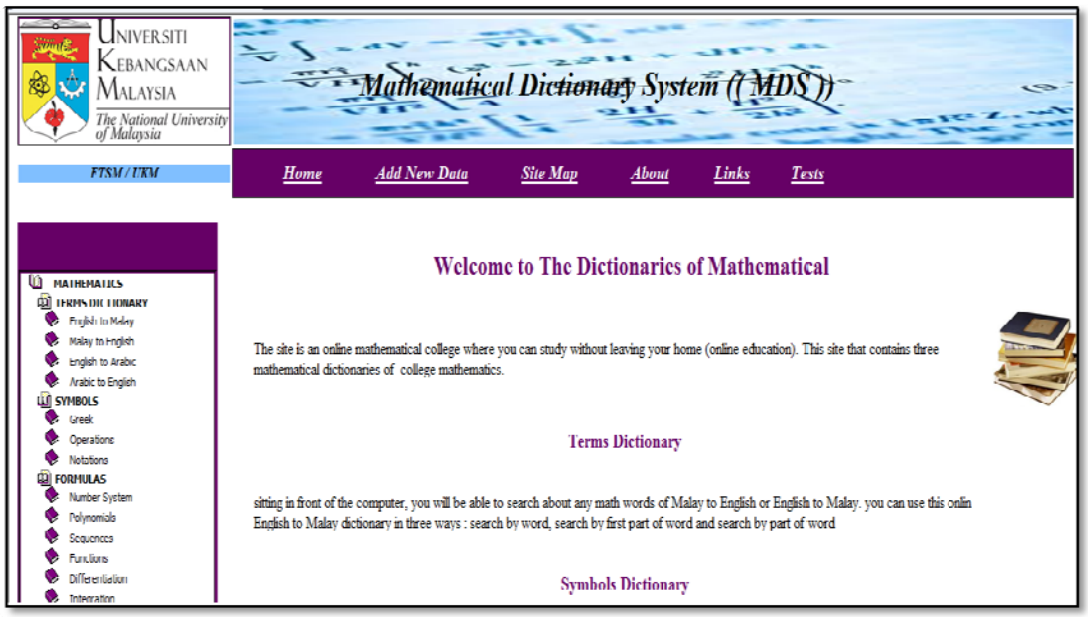

Fig. 1: The Interface of the Mathematical Dictionary System.

The school textbooks do not include a glossary or sometimes even an index for the given mathematical terms and concepts. For this reason, the Internet mathematics dictionaries should well be more accessible to students than other kinds of mathematics dictionaries, and should be more helpful than the paper dictionaries (PDs), because of the possibility of cross-linking the entries and even dynamic interactive definitions. To respond to this, the Internet mathematics dictionaries in English are presently available at a range of levels across the school years (Kissane 2008).

Existing Mathematical Dictionaries:

A number of online mathematics dictionaries exist to give clear and understandable definitions of mathematics to students at all levels of learning. Some users would only need simple mathematics dictionary, but users who participate in high-level and complex mathematics may require a more specialized dictionary that focuses on the academic track or a specific discipline of study (Math symbols 2010) such as Illustrated Math dictionary, Mathwords dictionary, Math dictionary for kids, Intermath dictionary, and Math dictionary.

Comparison between Online Mathematics Dictionaries:

In this section we will draw a comparison between the existing mathematical dictionaries that have been stated previously. Looking at this comparison, we have focused on the functions provided by these dictionaries. This is exhibited in table 1. This comparison has specifically concentrated on the existing mathematical dictionaries. The comparison elements are functions, the keyboard for mathematical symbols, ease of use, and language. The existing mathematical dictionaries have provided one function that is the search function. They have presented two main search functionalities: The first is searching by keyword, and the other for alphabet. As it is, they have used English language to translate the mathematical terms, but they are very easy to use. On the other hand, looking up mathematical symbols can be difficult if the English words for them are unknown or unfamiliar. In this instance, these dictionaries do not focus on mathematical symbols; only a display of a list of commonly used mathematical symbols, where we have to scroll through to find the symbol(s) needed. Information on what the symbol is, how it is read, how it is used, and an example given for symbols are listed.

The Proposed Mds:

A conceptual model describes essential features of a mathematical dictionary system (MDS) and identifies the principal processes taking place as shown in Figure 2. A conceptual model for MDS includes two issues: The first issue is functionalities, and the second issue is keyboard.

Table 1: Comparison between Online Mathematics Dictionaries.

Online Mathematical Dictionaries	Functions							Keyboard for Mathematical Symbols	Language
	Search					Listen	Authoring capability		
	Alphabet	Keyword	Part of Word	Symbol	formula				
Illustrated Math Dictionary	Yes	Yes	No	No	No	No	No	No	English
Mathwords Dictionary	Yes	Yes	No	No	No	No	No	No	English
Math dictionary for kids	Yes	Yes	No	No	No	No	No	No	English
Intermath Dictionary	Yes	Yes	No	No	No	No	No	No	English
Math Dictionary	Yes	No	No	No	No	No	No	No	English

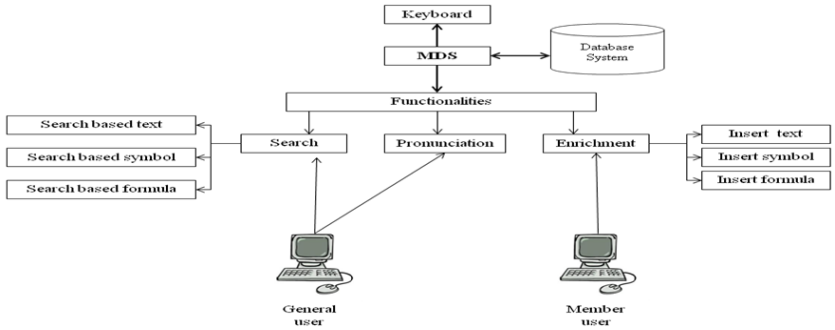

Fig. 2: Conceptual Model of MDS.

MDS Implementation:

1. MDS Functionalities: The MDS provides three functionalities: The first is for searching, the second for pronunciation, and the other for enrichment. Search Function: The MDS provides the searching development capability. Searching can be narrowed to any symbol, formula, term, first part of term, part of term, and symbol of formula. We develop the symbol-based and formula-based search.. Pronunciation Function: The MSD provides the pronunciation of the mathematical terms using English language. Enrichment Function: The MDS has two processes; inserting data, and updating data. Data can be new symbols, new formula, and new terms (English-Malay or English-Arabic terms). New symbol data contains the symbol itself, symbol's name, symbol type, and meaning of symbol, for example by inserting the $f(x)$ symbol. New formula data contains the formula, and explanation of formula, and formula type for example by inserting the $[a + b = b + a \text{ and } ab = ba]$ formula. New English and Malay term data contains English term, and Malay terms. New English and Arabic term data contains English terms, and Arabic terms.

2. MDS Keyboard: MDS provides three keyboards for mathematical symbols which are displayed on the screen. They are a keyboard for Greek symbols, a keyboard for operations symbols, and a keyboard for notations symbols. They help users who want to search by symbol.

3. Symbols Entry: The symbols of the mathematical entry pose a problem. We have solved this by using the Character Map of the Microsoft Windows.

4. MDS Content: Preliminary data of MDS depends on two sources. First, the bilingual dictionary which is called "Kamus Matematik Analisis" where it is a Malay dictionary of mathematical terms, with English equivalence. It is published by "Dewan Bahasa dan Pustaka". It is an only reference available for Malaysian students, to date. Secondly, "Mathematics for Matriculation Semester 1" is a comprehensive course book written for students studying mathematics in local matriculation courses in Malaysia. This reference book is based on the latest syllabus issued by the matriculation division, the Ministry of Education Malaysia. It aims to motivate students' interest in mathematics and help them gain a firm understanding of important principles and concepts in mathematics. In addition, it provides mathematics examination for students. The book involves:

Numerous examples, practice exercises after subtopics, summary of key concepts and formulae at the end of each chapter, exam-type questions at the end of each chapter, answer key, English–Malay list of mathematical terms, and two sets of model examination papers. The result of this phase is a database for "Kamus Matematik Analisis" dictionary and "Mathematics for Matriculation Semester 1" book that becomes the kernel of our mathematical dictionary system. There are 500 terms in the terms dictionary of "Kamus Matematik Analisis", 80 symbols in the symbols dictionary and 100 formula in the formula dictionary of "Mathematics for Matriculation Semester 1".

MDS Interface:

The mathematical dictionary system interface is divided into TreeView and search form. TreeView is on the left side of the MDS interface. It also contains elements of search that allows the user to browse the system. The MDS search form consists of three basic components: term search, symbols search, and formula search. For the search term process of the Term dictionary, when user starts typing the term in form, it should start showing a list of suggestions. Also, the user will be able to know the pronunciation of the term.

Fig. 3: Search Term.

Figure 4 shows the search symbol process of the symbols dictionary. When user makes use of the on-screen keyboard for mathematical symbols, he or she will see a table containing the symbol's name and meaning of this symbol in English.

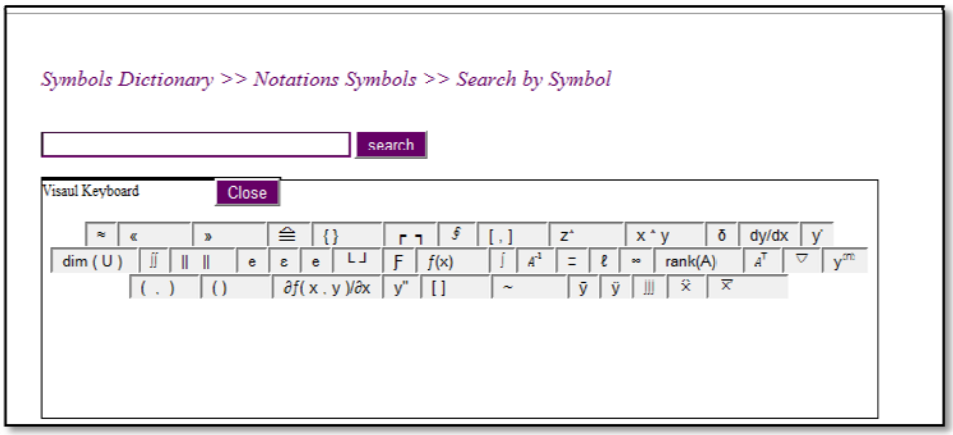

Fig. 4: Search Symbol.

Figure 5 shows the search formula of the formula dictionary. When user the on-screen keyboard for mathematical formulas, he or she will see a table containing formula name and explanation this formula in English language.

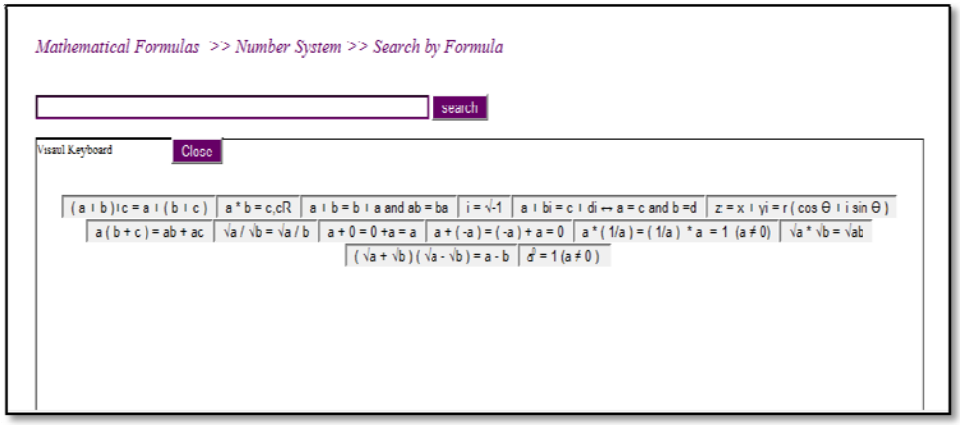

Fig. 5: Search Formula.

Figure 6 shows the search by symbol of formula of the formula dictionary. When user chooses a symbol on the on-screen keyboard for mathematical symbols, he or she will see a table that contains all the formulas carrying this symbol and explains these formulas in English.

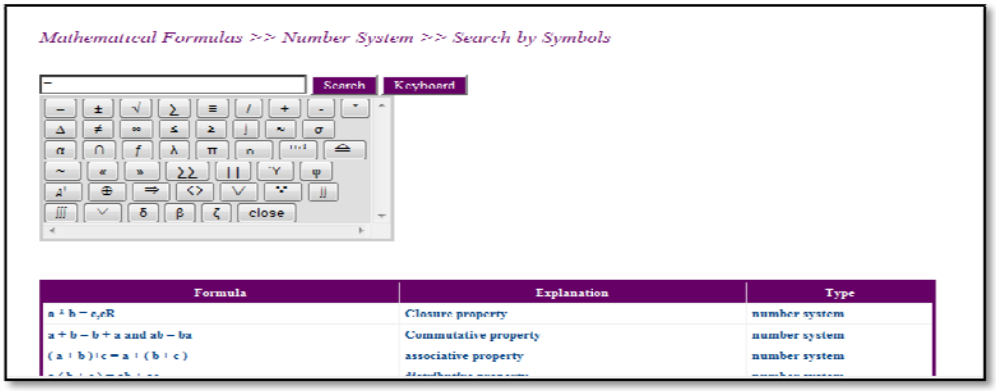

Fig. 6: Search by Symbol of Formula.

Evaluation:

The evaluation stage is a very important phase throughout the whole MDS development process where its function is to evaluate the performance of the MDS, in order for it to be accepted by the user. In order to evaluate the MDS application; we have used the system testing and usability testing. The usability testing study is conducted at the School of Mathematical Sciences, Faculty of Sciences and Technology (FST) of University Kebangsaan Malaysia (UKM). The purpose of conducting this test is for users to test the system as a whole, to determine the advantages and disadvantages of the system. The questionnaire is divided into four sections: Ease of use of the MDS (5 questions), features of the MDS (6 questions), the search processes of the MDS (6 questions) and the screen design and layout of the MDS. The user evaluation process involves six participants. The participants are lecturers of (FST) at the (UKM).

Analysis and Discussion of Results:

The evaluation of the ease of use of the system reveals these details: terms dictionary (5 respondents, 83%), symbols dictionary (4 respondents, 76%), formula dictionary (3 respondents, 50%), The task of adding new data (2 respondents, 33%) has been found by the respondents to be very easy, while (1 respondent, 17%) has found terms and symbols dictionary, (2 respondents, 33%) formula dictionary, (4 respondents, 67%) the add new data function, to be somewhat easy. Except for the formula dictionary (1 respondent, 17%) and symbols dictionary (1 respondent, 17%) the respondents are not sure about their ease of use. The evaluation of the features of the MDS also reveals that 83% of the 5 respondents had strongly agreed that the classification of symbols dictionary with the MDS is very helpful while 17 % or 1 respondent agreed. 50% of the 3 respondents strongly agreed that the classification of formula dictionary with the MDS is very helpful while 50 % of the 3 respondents agreed. 67% of the 4 respondents strongly agreed that the translation of English-Malay of the terms

dictionary with the MDS is very helpful while 33 % of the 2 respondents agreed. 67% of the 4 respondents strongly agreed that the pronunciation function with the MDS is very helpful while 33 % of the 2 respondents agreed. 83% of the 5 respondents strongly agreed that the on-screen keyboard to mathematical symbols with the MDS is very important while 17 % of the 1 respondent agreed. The evaluation of the search function reveals that five users (83% respondents) strongly agreed that these six types of search functions are very helpful, while one user 17% respondents agreed. The evaluation of the information displayed by the MDS shows that 50% of 3 respondents had agreed that the screen layout is well-designed and 2 respondents or 33% strongly agreed, while 1 respondent 17% demonstrated that they are not sure. 83% of 5 respondents had agreed that the interface is properly formatted and understandable, while 1 respondent 17% had agreed. 83% of 5 respondents had agreed that the icons' filed labels are understood, while 1 respondent 17% was not sure about this.

The Comparison of the MDS with Other Online Mathematical Dictionaries:

Comparing the MDS with the other online mathematical dictionaries is also a way of evaluation. This section compares some of the features of the MDS related to some of the design suggestions (Noël & Robert 2004) The MDS has covered most of the important features of online mathematical dictionaries. Table 2 includes the MDS within the listed online mathematical dictionaries. The features of the MDS compared to the other tools are as highlighted below:

Translation of the term of English-Malay and English-Arabic: in the MDS, the users are free to use the translation of the term of English to/from Malay and English to/from Arabic.

Pronunciation of the term: in the MDS, the users can listen to the pronunciation of the term.

On-screen keyboard for mathematical symbols: in the MDS, the users can use an on-screen keyboard for mathematical symbols, when they want to search for the mathematical symbols while working.

On-screen keyboard for mathematical formula: in the MDS, the users can use an on-screen keyboard for mathematical formula, when they want to search for the mathematical formula while working.

Authoring capability: in the MDS, the lecturers can insert a new mathematical term, symbol, and formula; and modify the existing ones, without having any knowledge of the Web programming.

Search function: in the MDS, the users can use six types of search. He/she can search by term, Search by the first part of term, Search by part of term, search by symbol, search by formula, and search by the symbol of formula.

Table 2: Comparison of the MDS with other online mathematical dictionaries.

Features / Application	Translation English-Malay	Pronunciation of the term	On-screen keyboard for math symbols	On-screen keyboard for math formulas	Authoring capability	Search function					
						Term	First part of term	Part of Term	Symbol	Formula	Symbol of formula
Mathwords dictionary	English	No	No	No	No	Yes	No	No	No	No	No
Illustrated math dictionary	English	No	No	No	No	Yes	No	No	No	No	No
Math dictionary for kids	English	No	No	No	No	Yes	No	No	No	No	No
Math dictionary	English	No	No	No	No	Yes	No	No	No	No	No
Intermath dictionary	English	No	No	No	No	Yes	No	No	No	No	No
MDS	English-Malay & English-Arabic	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Conclusion:

The MDS aims to be an effective and easy-to-use learning tool in mathematics education. It empowers lecturers of mathematics to contribute to the mathematics education. It is flexible as it allows students and lecturers to access mathematical contents, without them having to gain any prior knowledge of XHTML or experience Web programming. The architecture of the system and structured contents makes it possible to search and learn mathematical knowledge as well as to apply it to other conforming applications. It can be accessible via regular Web browsers at any given time (the Internet Explorer and Firefox). Therefore, the real target for this system is a new step towards a new generation and a new approach to the user in adopting the "Online Mathematical Dictionary" as a module of study and useful reference that is user-friendly and simple. This paper has described the usability test conducted at the School of Mathematical Sciences, Faculty of Sciences and Technology, University Kebangsaan Malaysia (UKM). It also shows the usability test and some measurements used to describe the overall satisfaction of the MDS prototype system. The results of the usability

test show that the system is easy to learn, and that it is relatively efficient to use. It has been found that the MDS has helped the users to better understand mathematical symbols and formula. On the other hand, we have compared the MDS with some other online mathematical dictionaries; even though the MDS is still in the prototyping stage, it has been found that it also includes the main features found in other similar systems. Yet, some improvements are thought to be necessary, still, to make the system perform better. The suggestion is to equip the Mathematical Dictionary System with instructions in English, Malay and other languages. We have suggested that including instructions in other languages would encourage other users who do not understand or speak these two languages, but are still interested in learning Mathematics. Languages such as French and the pronunciation of words in these languages are some possible ideas that can instill better confidence within users.

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