COMPARISON OF OPEN SOURCE SOFTWARES IN MATHEMATICS EDUCATION

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Abstract. Most of the Universities in the world widely use open source softwares in education for teaching mathematics. In education using computer offers to provide opportunities applications of mathematics. OSS (Open Source Softwares) are Maxima, Octave, Sage, Xcas, Edubuntu respectively. In this article, free and open source CAS software were compared in mathematics education.

1. Introduction

It is observed that the method of using technology in education changes constantly today. While technological tools such as calculator and computer were considered as materials which can be utilized in improving mathematical communication and reasoning of students in 1991 in line with reports of the council (NCTM "Professional Standards for Teaching Mathematics") established by mathematics teachers upon these changes, report entitled "Principles and Standards for School Mathematics" (NCTM, 2000) which was published in 2000 accepted these tools as one of the fundamental principles of high-quality mathematics education. It is indicated in this report that technology is one of the principal tools in learning and teaching of mathematics and it can contribute to in-depth comprehension of mathematics by students by improving their learning if used appropriately in mathematics courses (MoNE, 2009).

All technologies utilized in realization of such processes as processing, production, storing, using and sharing information are called as "Information Technology". As it is known, these technologies in question are also based on computer technology. Thus, information technologies in mathematics education mean teaching mathematics by using computer-based cognitive tools very specifically. This is called "Computer-Aided Mathematics Education" (Baki, 2002).

Another property of computer which is more important than being an effective calculation tool is its ability to concretize the abstract mathematical concepts in electronic media. Therefore, this new technology has not only made calculation

and graph-drawing easier but has also changed nature of important problems in mathematics and research methods of mathematicians. Computers are also used in mathematics for such purposes as teaching some subjects, formulizing some algorithms, making some operations and carrying out solution, analysis and researches. In this sense, computer plays the role of a bridge where the mathematician can bring his/her knowledge and skills to the forefront (Baki, 2002).

The main purpose of computer aid in mathematical education is elimination by teachers and students of their future concerns by using the new advancing technologies and teaching methods. However, in order to achieve this, first of all it has become inevitable for mathematics teachers to be informed of information technologies, follow the developments and therefore apply them in class environment in the current century (Özüsağlam, 2001).

In short, Open Source Programme is the name given to the roof under which programmes mostly distributed freely are gathered and where source code of the software can be obtained by those who desire. The best-known ones include Linux, Libre Office, GNU and Debian.

Today, usage of open source software becomes increasingly common in various education fields. Open source programmes can be used in network field of educational institutions (Network, Mail and Web Servers, Firewall etc.), administrative and academic desktop and office software (Open Office, Libre Office, multimedia, Web Browser etc.) and thirdly, in education and training as educational tools. As well as Octave (Erdal et all 2009), Excel (Erdal et all, 2009), Edubunda (Erdal and Ali, 2009) programmes, which are used commonly in mathematical education field, usage of MAXİMA and XCAS programmes which will be strong alternatives for programmes with high licence fees such as Maple and Mathematica on CAS (Computer Algebra System) platform can be deemed indispensable.

It is known that in mathematics education, using concrete expressions instead of abstract ones is the way to help students at every educational stage to enjoy and learn mathematics easily. In this context, it is emphasized that not replacement of teachers by computers, which was discussed in the past, but on the contrary, guidance role of teachers in computer-aided education is inevitable. Through computer-aided mathematics education, mathematical operations are concluded much faster; new information is obtained and mathematics courses are rendered more interesting by using graphs, sounds, animations and shapes. In this way, students can solve the problems they have identified step-by-step and reveal their mistakes through practice with the programmes with which they will be provided. Thus, concepts are learned by a more effective method and students can assess their individual performances. These facilities provided by computer-aided mathematics education are the most significant gains (Özüsağlam, 2004).

Among the most important reasons for Open Source Software to be used in education are its simple installation, easy usage and the fact that it allows users at every level to carry out all mathematical operations easily. As an alternative for license fees, it offers, as a solution, free and easily comprehendible programmes which can improve institutions in such a way that they make profit economically and which can constitute an equivalent of all educational applications.

There are most popular mathematical softwares that are used in mathematics education. We should not forget that we will benefit in terms of the country's economy there is in alternative solution which is open source software.

Therefore the technology can strengthen students learning process by presenting content numerically, graphically, as well as symbolically without extra burden of spending time to calculate the complex computational problems by hand. Moreover, integrating technology into a mathematical courses will increase awareness among the students and help them to evaluate and correct themselves. Instead, the main aim in use of technology should be to enrich students' learning process by providing interactive experience. The CAS (Computer Algebra System) which are Maxima, Sage, Octave, XCAS, Edubuntu and Geogebra have been used to teach Calculus, Algebra, ODE, Geometry, Linear Algebra, as well as many mathematical topic.

Using Computer Algebra System's tools support the student to understand mathematics easily and gain some skills. Therefore the main objectives of this paper as follows:

(i) Using OSS in mathematics education to carry out the necessary computational calculations and to draw the students' attention to focus on strategies.

(ii) To provide collaboration among the students in the completion of their assignment and projects.

2. Open Source Softwares in Mathematics Education

The term OSS "Open Source Softwares" refers to something which can be modified and distributed. Because OSS's design is publicly accessible. The OSS developer-user who both uses the softwares and contributes to its development.

OSS that must be distributed under a free license that redistribute, modify, and use the software. There are many licence agreement which are GPL (General Public License which use very common OSS Licence) , MPL (Mozilla Public License) and BSD (Berkeley Software Distribution License

CAS (Computer Algebra Systems), which are Maxima, Sage, Octave, XCAS, Edubuntu and Geogebra effectively material for teaching and learning mathematics. Many research show that Open Source Softwares can be used to encourage to solve applications of mathematics, learning in class and their visualization features can be effectively employed in teaching to generate conjectures (Lavicza 2006, Kreis 2004).

Open source Softwares us efor mathematics learning from primary scholl to the university.

Licenced Software has source code which can't be modified by anyone. This kind of software is called " closed source software " or " licenced software ". Maple, Mathematica and Matlab are examples of licenced software. To use software, computer users must agree that they will not do sharing.

OSS have many facilities such as,

Graphical and Computer Algebra and Numeric representations of objects, Powerful Commands Flexible Nice Graphical User Interface (GUI) and Easy-to-Use Java-based (IPad or Android platforms) Large Amount of Educational Applications Open Source and Free

for teachers to implement their pedagogical ideas; for students to explore and create understandings for themselves. Moreover, there are many advantages and disadvantages during using OSS, advantages are

- Using OSS solutions with zero licence cost allowing you to focus budgets on other areas,
- Free licence administration and easy to updating software,
- Most of OSS supported on Windows and Linux platform,
- Easy to installation,
- Goverment, Universities Community Project capable individuals all release software for other to improve and use
- More control of overall IT strategy
- Open Source Promotes innovation and ensure customisation and

and There are barries to overcome,

- All IT needs support and the education sector has limited budget
- There is generally less support in the business space for OSS
- Too much software – how to choose what is useful
- Users expectations – Personality using (Open Office versus MS Office)

OSS, just like any other but free of licence cost. OSS that come with licence that provides their users with certain freedoms (to use, to copy, to view, to modify, to redistribute). OSS use in many way in Institue,

Infrastructure: E-mail, firewall, desktop

Administration: Learning Manegement Sys, Distance Education, School Tool

Applications: Open Office, Qcad, Scribus

System Software: Open LDAP, Statistics, Network Monitoring

OSS offer many benefits to the mathematics education. By using OSS, many mathematicians and students can develop software that can be used and improved. m

Nowadays, there are many popular technological OSS tools which are commonly used in mathematics education. A number of CAS packages for courses are available such as Maxima, XCAS, Sage,

Edubuntu

Edubuntu is powerful and cost-effective education platforms for schools bring education into 21st century Designed for fast and easy setup without technical expertise, delivers the effective Linux Terminal Server Project (LTSP)

Applications to;

Kids : Pre-School aged children should have educational and full games and activities, (TuxMath)

Teacher: The tools teachers need to manage their class should be easily installed and usable with minimal worry. Student : Students, K-12 and beyond, should have the best open source educational software available

Personality : Full Office suite, Instant Messaging, graphing app., sound and videos.

Among these for first and secondary schools include different educational and scientific software. This software, as well contribute to the child's learning and intelligence, as well as course work becomes more enjoyable.

A version of Ubuntu for Education Includes extra programs useful in the classroom.

Edubuntu is to be the administrative center of the configuration in the classroom, learning and design process, creating cooperation with educational institutions.

- LibreOffice (Writer(Word), Calc(Excel), Impress(Power Point), Draw (Paint), Base (SQL), Math (MS Equation)
- Educational Programs: Gcompris, Kalzium, Kanagram, Kbruch, Khangman, Kig, KmPlot
- Also Internet browser Mozilla and e-mail software provider is Thunderbird.

Maxima

This, free software had an earlier incarnation, Macsyma. Developed by Massachusetts Institute of Technology in 1960's, it was maintained by William Schelter from 1982 to 2001. In 1998, Schelter obtained the permission to release MAXIMA. It is a computer algebra system, distributed under the General Public License. It has, both, capability of symbolic , as well as numerical operations. Subsequently, he released the source code to the world later that year. Since his passing in 2001, a group of MAXIMA enthusiasts have continued to provide technical support.

Content of Maxima Arithmetic, Algebra, Calculus, Matrix Calculations, Plotting 2D-3D, Linear algebra
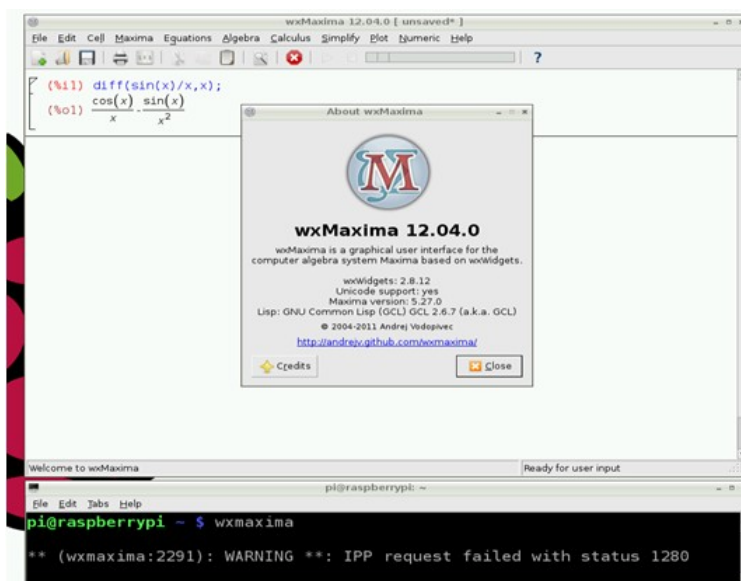
There are several application of Linear Algebra as follow (matrix, echelon form, transpose, etc.)
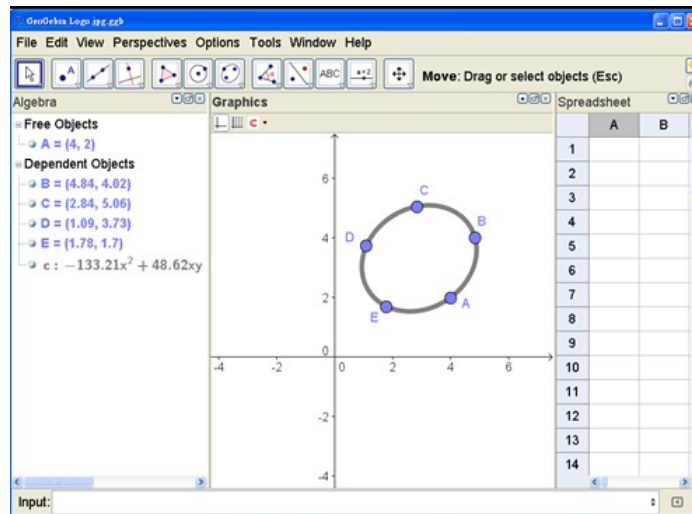
Geogebra

GeoGebra is dynamic mathematics and geometric software which is use in teaching geometry, mathematics, algebra, statistics, calculus in class. It was developed by Markus Hohenwarter, at the University of Salzburg in 2002, and international team of programmers. They did a brilliant jod and we as mathematics teachers and lecturers must salute them.

In Geogebra software includes, points, vectors, line, polygons, lines, all conic sections and functions in x, dynamic constructions, coordinates, equations, numbers and commands, easy-to-use interface, multilingual menus, commands, help, Midpoints, Angle bisectors, Perpendicular bisectors, Transformations, Conjecture / proof.
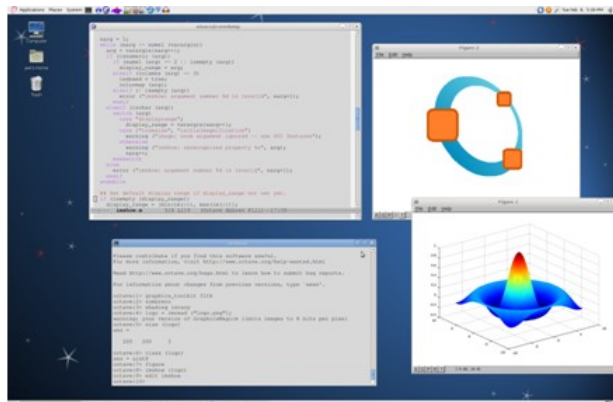
Octave

It was developed by J. W. Eaton in 1988. Octave is freely redistributable, open source software in undergraduate school. Octave includes high-level programming languages, numerical computations. solving linear and nonlinear equations numerically, Matrix arithmetic, Graphical output – 2D and 3D. To start Octave type the

shell command octave. You see a message then a prompt:

Axiom

Axiom is a general purpose Computer Algebra system. It is useful for doing mathematics by computer and for research and development of mathematical algorithms. It defines a strongly typed, mathematically correct type hierarchy. It has a programming language and a built-in compiler. Axiom has been in development since 1973 and was sold as a commercial product. It has been released as free software.

This software to; develop a better user interface, make it useful as a teaching tool, develop an algebra server protocol, integrate additional mathematics, rebuild the algebra in a literate programming style, integrate logic programming, develop an Axiom Journal with refereed submissions.
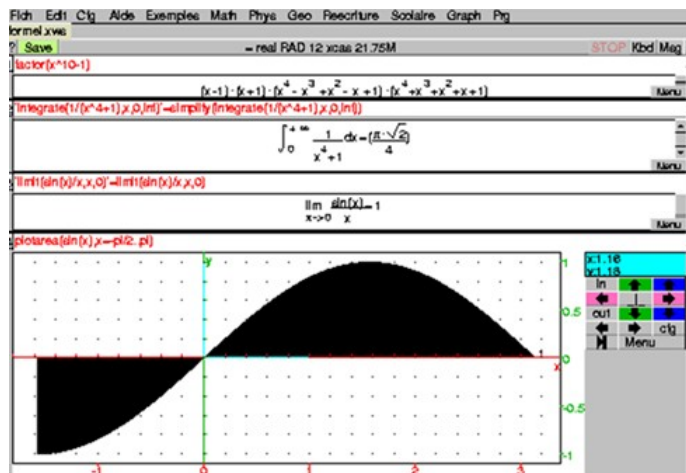

Xcas

Xcas is a main computer algebra system. It can be use Windows, Mac OS X and Linux-based operating systems. It has developed by Bernard Parisse. It has written in C++ and it has a general public licence. It is suitable for the use of

the secondary education, under graduate and graduate. It has the main menu, Equation, Calculus, Simplify, Aritmetic and Linear Algebra. It is a program that can be used for Function operations, 2D and 3D graphics, spreadsheets statistical computation and programming.

It has the main menu, equation, calculus, simplify, aritmetic and linear algebra, plot 2D and 3D, spreadsheets statistical computation programming. In addition, there are applications of high school 9, 10 and 11 class topic. Multivariate, polynomial multiplication, division operations, includes fast algorithms commonly used for transactions.

Let us examine the visual examples presented calculations associated with point range, surface graphics, calculus, limit account, force expansion and basic calculations.
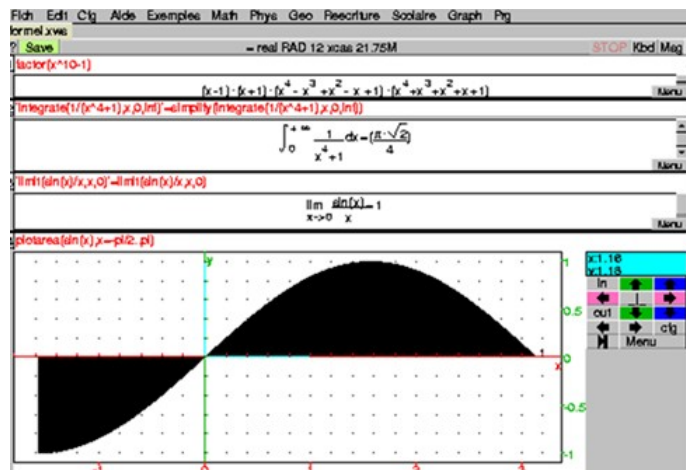
Sage

SAGE is free, open source math software that supports research and teaching in algebra, geometry, number theory, cryptography, numericl computation and related areas. Both the sage development model and the technology in sage itself are distinguished by an extremely strong emphasis on openness, community, cooperation, an collaboration: we are building the car, no reinventing the wheel. The overall goal of sage is to create a viable, free, open source alternative to Maple, Magma and MATLAB.

Designed for use with algebra, calculus, elementary to very advanced number theory, cryptography, commutative algebra, group theory, combinatorics, graph theory, exact linear algebra and many others. Graphical front-end to local (or remote) Sage web server via AJAX and jsMath. Object-oriented, user extensible Python environment interface to third-party software such as Mathematica, Maple and Magma, Support Linux and Windows.

TABLE 1. According to Platforms, Licence Type, Education of Levels

Software	OS	Download & Document	Licence Type	Platform	Specified	Level	Document
Geogebra	Linux, Windows MAC Android	www.geogebra.com	Free GPL	Java, HTML	DGS	Primary, High, Undergraduate and Graduate School	Online
Maxima	Linux, Windows MAC, BSD Solaris	www.sourgeforge.net	Free GPL	Common Lisp Lang.	CAS, DGS	Secondary, High, Undergraduate and Graduate School	Online
XCAS	Linux, Windows MAC, BSD Solaris	www-fourier.ujf-grenoble.fr	Free GPL	C++ Progr. Lang.	CAS	Secondary, High, Undergraduate and Graduate School	Online
Octave	Linux,	octave.en.softonic.com	Free GPL	Compatible with Matlab	Algebra and Progr.	High, Undergraduate and Graduate School	Online
Sage	Linux, MAC Solaris	www.sagemath.org	Free GPL	Pyhton and Cuthon Progr.Lang.	CAS	Secondary, High, Undergraduate and Graduate School	Online
Maple	Linux, Windows MAC, BSD Solaris	www.maplesoft.com	Private Licenced	C Progr. Lang.	CAS, DGS	Secondary, High, Undergraduate and Graduate School	Online
Mathematica	Linux, Windows MAC	www.wolfram.com	Private Licenced	C++, C, Java	CAS, DGS	Secondary, High, Undergraduate and Graduate School	Online

TABLE 2. According to Functionality of Calculus, Geometry, Algebra, Linear Algebra, Tensor

Software	Calculus	2D	3D	Algebra	Linear Algebra	Tensor
Geogebra	−	+	+	+	+	+
Maxima	+	+	+	+	+	+
XCAS	+	+	+	+	+	-
Octave	−	+	+	+	+	-
Sage	+	+	+	+	+	+
Maple	+	+	+	+	+	+
Mathematica	+	+	+	+	+	+

```
def f(x):
    return x*sin(1/x)
evaluate

derivative(f(x), x).rational_simplify()
        (sin(1/x)*x - cos(1/x))/x

max = -1
for i in [0.01,0.0125..1]:
    temp = abs(sin(1/i)-cos(1/i))
    if temp > max:
        max = temp
        mi = i

max; mi
        1.41420607832605
        0.42500000000000
sqrt(2.)
        1.41421356237310
1/0.115750000000000
        8.63930885529158                    jsMath
```

After introducing each software in general, their functionalities, operating system, Platform, Education of Levels, Funcionality according to (Calculus, Graphing, Algebra, Linear Algebra, Tensor), usability are compared in Table 1 and Table 2.

DGS: Dynamic Geometry System, OS: Operating System, CAS:Computer Algebra System

3. Applications of OSS in Linear Algebra

In this section, all operations of especially matrix algebra which are basic operations of Linear Algebra are carried out from "Algebra" menu. Applications pertinent to matrix writing, inverse matrix, determinant calculation, transposition of a matrix, characteristic polynomial of a matrix given and an additional matrix and calculation of eigenvalue and eigenvector linked to this polynomial can be conducted under this menu (Figure 1).
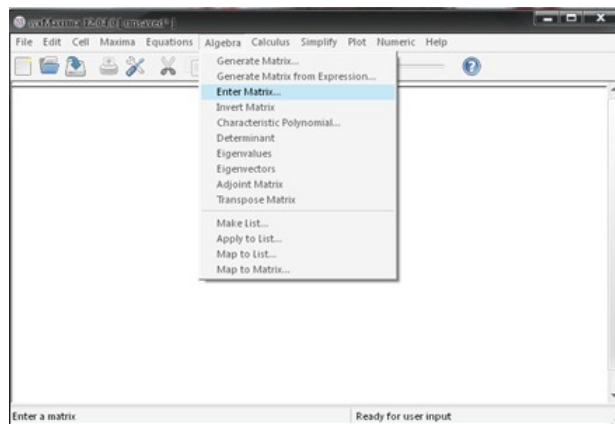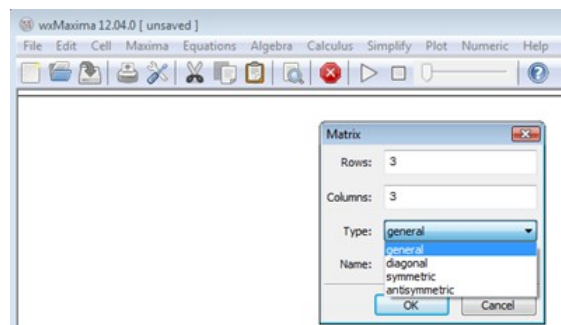

Figure 1: The sub-menus where we can carry out mathematical operations under algebra menu of Maxima

"Enter Matrix" sub-menu is selected from "Algebra" menu for entry of matrix data in matrix applications of Linear Algebra section and matrix's name (can be preferred when programming will also be used), row and column numbers are entered from Figure 1 screen.

For example, image of A matrix entered in 3x3 type is given.

Let's show entry, transposition, inversion and determinant calculation operations of square matrix of 3×3 type given as $A = \begin{bmatrix} 3 & -1 & 0 \\ 2 & 1 & -3 \\ 0 & -1 & 2 \end{bmatrix}$;

Figure: Screen of linear algebra application operations performed from Algebra menu

A characteristic polynomial entered for matrix operations, which is among linear algebra application subjects, and accordingly, eigenvalue and eigenvector values can also be calculated.

In operations depending on calculation of determinant of a matrix entered, it gives warning in calculations depending on the determinant value in the event that determinant of the matrix entered is zero as it is shown in figure 7.

Figure 7: Warning screen as the determinant result is not significant for calculations

4. Result

Usage of OSS in mathematics education has created a very effective learning environment. In this context, the fact that these software have GPL (General Public License), they are free, and that their source codes can be developed by users on the basis of volunteerism constitute the valid grounds for preference. It is also an advantage that language of these software can be translated into any language by mathematicians engaged in software subject. In addition, we emphasized the increasingly important role of free open-source software packages for mathematics teaching world-wide. Open-source packages do not only offer opportunities for teachers and students to use them both at home and in the classroom without any restriction, but they also provide a means for developing support and user communities reaching across borders. CAS has been suggested that these systems will benefit K12 education to postgraduates in mathematics, geometry.

As a consequence, free and open source CAS software were compared in mathematics education and it was proven that Maxima, Xcas and Sage software was able to compete with Maple and Matlab software, which are most-commonly known ones among mathematics software in the sector. Furthermore, when country's economy is considered, economical usage of sources and their effective utilization in mathematics education give rise to finding a valid reason for not using Maxima.

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