

## Freeware and Open Source Software Tools for Distance Learning in Mathematics

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**Abstract:** With the contemporary growth of modern technology a number of free and open source software tools have been emerged to support online or distance education for basic level Mathematics. Technological aids for example; digital learning material, videos, recorded lectures, open tools to solve mathematical problems, online discussion boards, and online classrooms enhance the ability of students to solve mathematical problems. This research paper enlists the freeware and open source software tools for teaching and learning in mathematics and describes the role of technology for improved delivery of mathematical concepts. It also shows that how freeware and open source software tools are useful for distance education to achieve learning outcomes in a better flexibility and dynamism than ever before.

**Key words:** Freeware, Open Source Software Tools, Distance Learning, Basic Level Mathematics

### Introduction

Advancement in technological developments has opened up the new ways in teaching and learning basic level mathematics. State of the art computers, user friendly software and interactive communication technologies have introduced the new methods of teaching and learning. Availability of a range of free and open source software tools for basic level mathematics can play a vital role in mathematics teaching and learning particularly in distance learning environment.

Free software also known as 'software libre' or 'libre software' is software that can be used, modified, copied and redistributed either without any restriction or with restrictions allowed by the manufacture and are generally available without any charge (Subramanyam and Xia 2008). Open source software (OSS) is software that is available in source code under a software license that permits users to study, modify, improve and distribute information to other users (Hauge, Ayala et al. 2010). Open source software is available within the public domain and individuals who have expertise in software development and an interest in its free distribution very often develop it collaboratively. OSS is not generally subject to copyright restrictions and access to the source code means that software developers can modify it for their own particular purposes. Free and open source software does not necessarily mean inferior or substandard software. There are some very significant open source software products that have revolutionized many areas of activity. Probably the most famous open source software is the operating system UNIX, now by far the mainstay of large computer installations and even PC operating systems such as Linux and Mac OSX. Using open source software can provide some advantages, the most significant being usually a cost advantage (Ven, et al. 2008).

One of the problems faced by educators who are interested in using free and open source software as alternatives to commercial software for basic level mathematics education is first identifying what alternative free and open source software is available, what the software does, and where it can be accessed from. Currently there is no one place with information on free and open source software for basic level mathematics education. In undertaking the research for this paper, to identify appropriate free and open source software, different categories of software are identified and enlisted that can be used for teaching and learning for basic level mathematics.

### Freeware and Open Source Tools for Distance Learning in Mathematics

Freeware and open source software tools like calculators, interactive geometry softwares, computational softwares, visual Maths applications and equation solver have given new direction in basic level mathematics teaching and learning. iPods, iPad, iPhone and Android apps are playing a pivotal role for teaching

mathematics at primary to secondary and even higher levels of education. Use of such tools is supporting student's learning in terms of problem solving and computational fluency.

Distance learning has become an increasingly important part of educational programs. Computers, video phones, interactive graphics, discussion boards and interactive whiteboards are being used as an integral component of distance learning. Electronic learning (e-learning) as a form of distance learning is being promoted as the educational medium of the future (O'Malley, 1999). Educational institutes are extending their digitally linked resources and providing a flexible delivery of content material. Means and Haertel, (2004) argue that technology supports learning process when appropriately integrated with teaching pedagogy, curriculum, and assessments.

Technology aids and facilitates the distance learning process by enhancing communication and collaboration and building strong education communities. Communication software is enabling better discourse among students, collaborative learning, and discussion forums and out of class learning. In this perspective communication software enable teachers to have better awareness of their students and assist student to learn from their peers.

Growing number of technology have caused a shift from a focus on local resources to global resources. With the help of technology better websites, portals and various electronic resources can be created and developed which can be used for lesson planning and better transmissive of knowledge. In the context of distance education communication technologies has provided a favorable space and environment to share knowledge and beliefs about mathematics. Table 1, 2 & 3 provides some online free resources for maths teachers that can be used in distance education for improved delivery of mathematics teaching.

LibreOffice math is a tool used for mathematics documents creation provides feature of a full office suite e.g. Word processor, Presentation, Spreadsheets and Database). This interactive and easy to use tool has the possibility to create worksheets and exam for mathematics.

Xournal in combination with a tablet computer and a projector serves as a cost effective interactive whiteboard. The main advantage of Xournal is that hand written lecture notes can be saved digitally and are accessible for later use.

Online mathematics resources Classroom Aid, <http://classroom-aid.com/educational-resources/mathematics/#respond> combine free math lessons, videos and activities. These resources covers a variety of Maths topics; Algebra, Plane Geometry, Trigonometry, Calculus, Coordinate and Solid Geometry.

Use of software in Mathematics teaching and learning provides a number of benefits in cognitive process; first, memory load of students is reduced and problem solving process is clearer. Second, cognitive load is shared by reducing computation time. Third, provide a clear display of problem that contributes to have a better insight into a problem which leads to better student engagement towards problem solving. Fourth, software support logical reasoning and help students to test hypothesis (Lajoie, 1993).

Technology in maths teaching can be used either as a constructional toolkit or its role can be only to do maths more efficiently and quickly (Olive and Makar, 2010). Keeping same concept in view mathematics software has been classified in two categories. First, emphasize on visualization and enable students to understand maths concepts easily and more clearly (Table 2) and second, are more focused on calculation and computation of complex problem (Table 3). This classification should not create the misconception that computational software doesn't have visualization ability or visualization softwares are not capable of fast computation instead classification is based upon the stronger aspect of the software.

**Table 1:** Online mathematical resources and tools for mathematics teaching and learning

Online Mathematics Resources	Tools for Mathematics Documentation Creation	Videos
<ul style="list-style-type: none"> <li>• Math Open Reference, <a href="http://www.mathopenref.com/">http://www.mathopenref.com/</a></li> <li>• RealWorldMath, <a href="http://www.realworldmath.org/">http://www.realworldmath.org/</a></li> <li>• HelpingwithMath (<a href="http://www.helpingwithmath.com/">http://www.helpingwithmath.com/</a>)</li> <li>• A+ Click Maths, <a href="http://www.aplusclick.com/">http://www.aplusclick.com/</a></li> <li>• Free Math Help, <a href="http://www.freemathhelp.com/">http://www.freemathhelp.com/</a></li> </ul>	<ul style="list-style-type: none"> <li>• LibreOffice Math, <a href="http://www.libreoffice.org/discover/math/">http://www.libreoffice.org/discover/math/</a></li> <li>• Xournal Digital Notebook-Math Worksheet Generator <a href="http://www.pil-network.com/Resources/Tools/Details/852875ce-b376-4b49-8f79-41c5cd75b067#">http://www.pil-network.com/Resources/Tools/Details/852875ce-b376-4b49-8f79-41c5cd75b067#</a></li> <li>• Math Editor , <a href="http://www.openmath.org/software/">http://www.openmath.org/software/</a></li> </ul>	<ul style="list-style-type: none"> <li>• Karl Fisch’s algebra movies, <a href="http://karlfisch.wikispaces.com/algebra+videos">http://karlfisch.wikispaces.com/algebra+videos</a></li> <li>• Khan Academy , <a href="http://www.khanacademy.org/">http://www.khanacademy.org/</a></li> </ul>

### Software for Visual Representation of Mathematical Concepts

Visualization is the ability to draw mental images, visualization software helps to conceptual understanding of complex mathematics topics. Mathematical visualization software (Table 2) offers multiple visual representations of mathematical concepts into real form with the aid of special computer graphics, diagrams, geometric figures and moving images helps students to understand complex mathematical phenomena. In this way software facilitate the process of mathematical learning by enhancing critical and higher order thinking and logical reasoning in a dynamic environment. These characteristics make them a ‘construction toolkit for mathematical learning’.

Geogebra is a free, open source, multiplatform, dynamic mathematics software. Integration of dynamic geometry, algebra, calculus, and spreadsheet features into a single interactive package make it different from other mathematical software packages. Strong connection of algebra and geometry offers the multiple representations of mathematical concepts.

Sage was developed with the goal to promote open, collaborative and cooperative tools for math learners that can be used as an alternative to high cost licensed software such as Maple, Mathematica, Magma, and MATLAB.

GeoEnzo is specially build for mathematics teaching with main feature, easy to draw various types of geometrical shapes such as triangle, circle, cube, line, cones and many more allow teachers to teach geometry more confidently and easily. GeoEnzo is a windows application that offers the option of instruction languages to English, German, French, Spanish and Dutch.

Graph is an open source application which helps to draw mathematical graphs in a user friendly environment. This application can be used to draw mathematical graphs in a coordinate system. There is possibility to visualize a function and past it into other mathematical programs. Graph provides the possibility to insert point series, trend lines, relations and labels, as well as create custom functions and constants.

PTC Mathcad Express can be used to solve, analyze, document and share calculations. This is free engineering math software which has functions to work with symbolic algebra and 3D plots. It helps to visualize complex datasets qualitatively and quantitatively. Works as an extension of Microsoft Excel and have a leverage data in existing spreadsheets.

**Table 2:** Software for Visual Representation of Mathematical Concepts

Software	Brief Description	Operating System	Website
GeoGebra	GeoGebra provides a sound platform to math students to learn math and solve mathematical problems of various topics such as linear programming, complex numbers, vectors, probability, discrete mathematics, calculus, statistics, algebra, functions and graphs, geometry etc.	Windows	<a href="http://www.geogebra.org/cms">http://www.geogebra.org/cms</a>
Sage	Sage supports research and teaching in algebra, geometry, number theory, cryptography, numerical computation, and related areas.	Linux, Mac OSX, Windows	<a href="http://www.sagemath.org/index.html">http://www.sagemath.org/index.html</a>
GeoEnzo	With the help of this freeware mathematics teacher can teach geometry to math students. This freeware lets you easily draw various types of geometrical shapes such as cone, triangle, circle, cube, line and many more. This freeware is very useful for teaching geometry to math students.	Windows	<a href="http://geoenzo.com/geoenzo/geoenzo.htm">http://geoenzo.com/geoenzo/geoenzo.htm</a>
Graph	Graph is an open source program which helps to draw mathematical graphs in a user friendly environment. Graph provides the possibility to insert point series, trend lines, relations and labels, as well as create custom functions and constants.	Windows	<a href="http://graph.software.informer.com/4.3/">http://graph.software.informer.com/4.3/</a>
PTC Mathcad Express	This is free engineering math software which has functions to work with symbolic algebra and 3D plots. It helps to visualize complex datasets qualitatively and quantitatively.	Windows	<a href="http://www.ptc.com/product/mathcad/download-free-trial">http://www.ptc.com/product/mathcad/download-free-trial</a>

## Computational Software Tools

Computational software helps to solve algebra problem quite easily. Table 3 gives a brief description of a range of computational software tools. Here we have briefly describes the most useful computational tools. For example, Microsoft mathematics software helps this free ware have feature of drawing two dimensional and three dimension images which is a value addition to its computational capabilities. CompliCalc includes algebraic calculators and allow calculating square root, factorial, discount and distance. Other good examples of computational software are; SpeQ Mathematics, Euler Math Toolbox, Xfunc, Tibi's Mathematics and MathforChild.

SpeQ Mathematics provides in built support to solve equation and working with variables. General function calculations can be cried out easily. Trigonometric problems can also be solved using SpeQ mathematics. Euler Math Toolbox also offers the functionality to solve simple to complex equations.

Using Xfunc various types of equations in mathematics can be written and solved. You can utilize various functions to make different mathematical expressions with the help of Xfunc.

Tibi's Mathematics Suite is useful for to solve mathematical problems of graphs, matrices, permutation and combinations. Online digital calculators offer a range of functionality form very basic level of mathematics to very advanced mathematics level. Calculators for kids are used to carry out simple mathematical operations such as addition, subtraction, multiplication and division.

MathforChild, is free software basically developed for young kids to teach Maths in a friendly and fun way. This is interactive software that support audio mode that enables kids to learn and explore mathematics easily and quickly.

**Table 3:** Computational Software

<b>Computer Algebra System</b>			
<b>Software</b>	<b>Brief Description</b>	<b>Operating System</b>	<b>Website</b>
Microsoft Mathematics	Microsoft Mathematics is a free math software for your computer. With the help of this freeware math students can solve complex math problems easily. It basically helps math students to solve problems in algebra. Apart from that you can also draw 3D and 2D images with the help of this utility. The main objective of this freeware is to teach students the basic of math, physics and chemistry.	Windows	<a href="http://download.cnet.com/Microsoft-Mathematics-32-bit/3000-20417_4-75450134.html">http://download.cnet.com/Microsoft-Mathematics-32-bit/3000-20417_4-75450134.html</a>
Maxima	Maxima is simply a command line interface (CLI) that provides access to different commands that can be used to solve symbolic and numerical expressions including differentiation, integration, Taylor series, Laplace transforms, ordinary differential equations, systems of linear equations, polynomials, and sets, lists, vectors, matrices, and tensors	Linux, OSX, Windows	<a href="http://andrejv.github.io/wxmaxima/">http://andrejv.github.io/wxmaxima/</a>
XCAS	Xcas is an interface to perform computer algebra, function graphs, interactive geometry (2-d and 3-d), spreadsheet and statistics, programming.	Linux, OSX, Windows	<a href="http://www-fourier.ujf-grenoble.fr/~parisse/giac.html">http://www-fourier.ujf-grenoble.fr/~parisse/giac.html</a>
CompliCalc	This freeware also includes various functional and algebraic calculators. CompliCalc lets you perform a wide variety of operations such as calculate square root, factorial, discount and distance. To use this freeware you need to specify the task you want to perform on the main interface of this freeware.	Windows	<a href="http://sourceforge.net/projects/complicalc/">http://sourceforge.net/projects/complicalc/</a>
<b>General Calculation Software</b>			
SpeQ Mathematics	SpeQ Mathematics helps to learn math and solve complex problems in mathematics. It has inbuilt support for a wide variety of variables, constants and mathematical functions.	Windows	<a href="http://download.cnet.com/SpeQ-Mathematics/3000-2053_4-10634760.html">http://download.cnet.com/SpeQ-Mathematics/3000-2053_4-10634760.html</a>
Euler Math Toolbox	With the help of this software you can carry out various calculations in mathematics such as subtraction, addition, calculus problems, algebra, matrices, functions and complex equations. This freeware is very useful for math students as they can solve nearly all types of mathematics problems by using this freeware.	Windows	<a href="http://sourceforge.net/projects/eumat/">http://sourceforge.net/projects/eumat/</a>
Xfunc	By using this software you can write various types of equations in mathematics solve them and also see their solutions. You can utilize various functions to make different mathematical expressions with the help of Xfunc.	Windows	<a href="http://www.softpedia.com/get/Science-CAD/xFunc.shtml">http://www.softpedia.com/get/Science-CAD/xFunc.shtml</a>
Tibi's Mathematics Suite	Tibi's Mathematics Suite lets you solve mathematical problems in various topics such as graphs, matrices, permutation and combinations etc. Tibi's Mathematics Suite also includes a scientific calculator.	Windows	<a href="http://sourceforge.net/projects/tibimathematics/">http://sourceforge.net/projects/tibimathematics/</a>

MathForChild	With the help of this freeware your kids can learn mathematics easily. MathForChild will teach various math operations such as multiplication, subtraction and addition to your kids. This software is very useful for kids as they can learn and explore mathematics easily and develop problem solving skills.	Windows	<a href="http://mathforchild.en.softonic.com/">http://mathforchild.en.softonic.com/</a>
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We have already indicated one of the main adventures in using open source software that is they are generally free. However, the cost of operating and using software is not always just to do with the purchase of that software, but may also include maintenance and support of the software installation, and indeed, may require the purchase of additional hardware. Any teacher or institution considering implementing an open source solution will need to weigh up all of the advantages and disadvantages of doing so. In any case, a full evaluation of an installation should be undertaken before opening up software to staff and students.

A further advantage of using open source software is that it ensures that users are compliant with copyright law. Copyright is an important consideration in the application of any software within education institutions. However, quite often in institutions in developing countries, administrators and teachers are less concerned about copyright issues and there have been instances where pirated copyrighted software have been used illegally. The use of open source and free software clearly makes issues of copyright less a problem.

In addition to the software useful for teaching and learning in mathematics that is listed in the table from, there are other useful and often quite sophisticated open source software available for education purposes. For example, Moodle is an open source Learning Management System used by many universities throughout the world including some of the world’s largest universities (for example, UK Open University). Also, the open source office suite of programs provided by OpenOffice.org is an excellent free substitute to the Microsoft Office suite.

## Conclusion

Our review shows that free and or open source software tools are available for most of the areas where computer software is used for mathematics teaching and learning. A more detailed examination also reveals that several free and open source software tools are as good as proprietary software, particularly for conceptual construction and mathematic efficiency. However, if an institute chooses to use free and open source tools for mathematics teaching and learning then the appropriateness of the particular software tools needs to be assessed. The licenses used by free and open source tools typically ensure that there is no cost for the software itself and low or no cost for its acquisition and installation. However, there may be cost implications for management, support and maintenance of the software. Much open source software is customizable and adaptable to different teaching and learning context. In short, we believe that the use of free and open source mathematics software can provide a viable alternative to proprietary software – and we hope that this brief review helps to increase access and use of free and open source mathematic software for basic level teaching and learning.

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