

African Virtual University

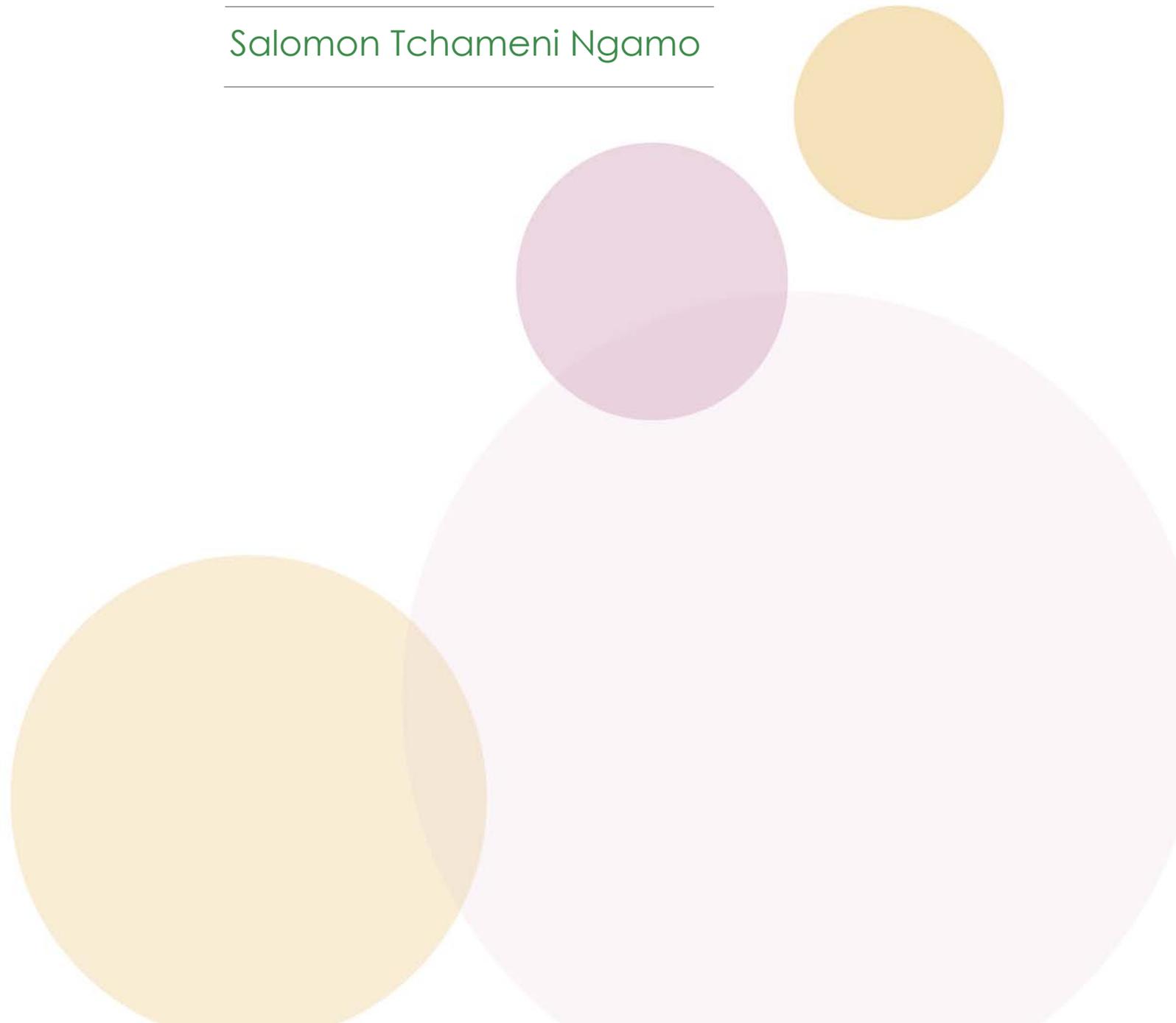
Education: Education EDU22

# **INTEGRATING** ICT IN MATHEMATICS EDUCATION

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Salomon Tchameni Ngamo

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# Foreword

The African Virtual University (AVU) is proud to participate in increasing access to education in African countries through the production of quality learning materials. We are also proud to contribute to global knowledge as our Open Educational Resources (OERs) are mostly accessed from outside the African continent. This module was prepared in collaboration with twenty one (21) African partner institutions which participated in the AVU Multinational Project I and II.

From 2005 to 2011, an ICT-integrated Teacher Education Program, funded by the African Development Bank, was developed and offered by 12 universities drawn from 10 countries which worked collaboratively to design, develop, and deliver their own Open Distance and e-Learning (ODeL) programs for teachers in Biology, Chemistry, Physics, Math, ICTs for teachers, and Teacher Education Professional Development. Four Bachelors of Education in mathematics and sciences were developed and peer-reviewed by African Subject Matter Experts (SMEs) from the participating institutions. A total of 73 modules were developed and translated to ensure availability in English, French and Portuguese making it a total of 219 modules. These modules have also been made available as Open Educational Resources (OER) on [oer.avu.org](http://oer.avu.org), and have since then been accessed over 2 million times.

In 2012 a second phase of this project was launched to build on the existing teacher education modules, learning from the lessons of the existing teacher education program, reviewing the existing modules and creating new ones. This exercise was completed in 2017.

On behalf of the African Virtual University and our patron, our partner institutions, the African Development Bank, I invite you to use this module in your institution, for your own education, to share it as widely as possible, and to participate actively in the AVU communities of practice of your interest. We are committed to be on the frontline of developing and sharing open educational resources.

The African Virtual University (AVU) is a Pan African Intergovernmental Organization established by charter with the mandate of significantly increasing access to quality higher education and training through the innovative use of information communication technologies. A Charter, establishing the AVU as an Intergovernmental Organization, has been signed so far by nineteen (19) African Governments - Kenya, Senegal, Mauritania, Mali, Cote d'Ivoire, Tanzania, Mozambique, Democratic Republic of Congo, Benin, Ghana, Republic of Guinea, Burkina Faso, Niger, South Sudan, Sudan, The Gambia, Guinea-Bissau, Ethiopia and Cape Verde.

The following institutions participated in the teacher education program of the Multinational Project I: University of Nairobi – Kenya, Kyambogo University – Uganda, Open University of Tanzania, University of Zambia, University of Zimbabwe – Zimbabwe, Jimma University – Ethiopia, Amoud University - Somalia; Université Cheikh Anta Diop (UCAD)-Senegal, Université d' Antananarivo – Madagascar, Universidade Pedagógica – Mozambique, East African University - Somalia, and University of Hargeisa - Somalia

The following institutions participated in the teacher education program of the Multinational Project II: University of Juba (UOJ) - South Sudan, University of The Gambia (UTG), University of Port Harcourt (UNIPORT) – Nigeria, Open University of Sudan (OUS) – Sudan, University of Education Winneba (UEW) – Ghana, University of Cape Verde (UniCV) – Cape Verde, Institut des Sciences (IDS) – Burkina Faso, Ecole Normale Supérieure (ENSUP) - Mali, Université Abdou Moumouni (UAM) - Niger, Institut Supérieur Pédagogique de la Gombe (ISPG) – Democratic Republic of Congo and Escola Normal Superior Tchicote – Guinea Bissau

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# Production Credits

This second edition is the product of a review process based on the first edition of this module. The information provided below, except the author of first edition, refers to the second edition.

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# I. Integrating ICT in Mathematics education

## II. Prerequisite

ICT basic Skills Access to a computer Access to Internet\* (highly recommended for many activities)

## III. Time

120 h (40h focusing on general teaching skills in the use of ICTs in education ; 80 h specific to Mathematics)

## IV. Material

The compulsory materials for each activity are those supplied. All other materials are additional, which means they can be very useful, but are not compulsory.

### Activity 1

Readings

- ICT and Mathematics: a guide to learning and teaching mathematics 11-19, Becta, 2004 (File name on course CD: BECTA-ICTandMathematics)
- Entitlement to ICT in Secondary Mathematics, Becta, 2004 (File name on course CD: NC\_Action\_Maths\_ICT-Entitlement)
- Graphical Calculators, Becta, 2001 (File name on course CD: BeCTA\_Gra- phical\_Calculators)
- Software
- Open Office
- MSW Logo

### Activity 2

Readings

- ICT bringing advanced mathematics to life (T-cubed New Orleans), Adrian Oldknow, 12 March 2004 (File name on CD: AO Tcubed 2004)

Software

- Graph
- wxMaxima
- GeoGebra

## V. Module Rationale

Excellence in education calls for the integration of various media, technologies and techniques to teaching and learning environment. Access to a new generation of ICT has brought new opportunities to teachers and learners in the sciences. However the effective integration of such applications depends on educator's familiarity with and command of the new resources. A module on the integration of ICT in the science classroom is therefore a valuable addition to progressive science and mathematics educators' progressive development.

## VI. Content

### 6.1 Overview

The process of integrating ICT in education is rarely a simple and linear one - overlaps are often noted, with some elements operating in parallel, in partnership and cyclically. The sequence of steps varies from one activity or situation to the next and must take context into account in order to be effective. The process is thus necessarily incremental and relies on clearly defined objectives to succeed in improving the efficiency of ICT use in education.

This document presents major themes to assist educators in better integrating ICT with their teaching, and particularly allowing them to offer higher quality distance education programs to Mathematics, Biology, Chemistry and Physics students. An introduction to the theories and principals of ICT integration is presented within six themes, and further developed into seven specific learning objectives, which can be adapted according to the specific subject of the program.

### 6.2 Outline

The integration of Information and Communication Technology in preparing and piloting learning activities, and managing teaching tasks, is a complex process yet should subject to a set of guiding parameters. As well, a minimum level of competency is required on the part of both educators and students. These parameters and competencies constitute the pedagogical principles required to effectively integrate ICT in Mathematics, Chemistry, Physics and Biology education. The principles are presented below, in the following form:

### Section I: Conceptual framework

- 1.1 Required course materials
- 1.2 Module Rationale
- 1.3 General objectives, Specific objectives
- 1.4 Learning activities
  - 1.4.1 Pre-assessment
  - 1.4.2 Key concepts
  - 1.4.3 Required readings
  - 1.4.4 Multimedia resources
  - 1.4.5 Useful links

### Section II: ICT integration in specific disciplines

- 1.1 Crosscutting learning activities
  - 1.1.1 Report on required readings + evaluation
  - 1.1.2 Report on selected readings + evaluation
- 1.2 Discipline-specific learning activities
  - 1.2.1 Activity one + evaluation
  - 1.2.2 Activity two + evaluation
  - 1.2.3 Activity three + evaluation
- 1.3 Module synthesis
- 1.4 Final evaluation
- 1.5 References

### 6.3 Graphic Organizer

Pedagogical integration of ICT in Biology, Chemistry and Mathematics

#### **Part one Conceptual framework**

Required course materials

General objectives Specific objectives

Learning activities

Pre-assessment

Key concepts

Required readings

Multimedia resources

### **Part two ICT integration in disciplines**

Crosscutting learning activities

Discipline-specific learning activities

Report on required readings + evaluation

Report on selected readings + evaluation

Activity one + evaluation

Activity two + evaluation three

Activity three + evaluation

### **Module synthesis**

Activity four + evaluation

### **Final evaluation**

### **Biography of the module author**

### **References**

## **VII. General objective(s)**

This module's general objective is to help learners to develop their techno-pedagogical competencies, allowing them to better use technology during lesson- planning, research, communication, problem-solving, professional development, and to, in turn, facilitate their student's use of ICT as a learning tool.

### VIII. specific learning objectives

(Instructional objectives)

1. The principles of ICT integration in education are expressed here as seven specific learning objectives for Mathematics, Biology, Chemistry and Physics. Students should be capable of:
2. critically engaging the pedagogical principles of ICT integration in education.
3. critical engagement while teaching Mathematics
4. evaluating appropriate opportunities to use ICT while teaching Mathematics
5. communicating, using appropriate and varied multimedia tools (emails, websites etc) while teaching Mathematics
6. efficiently using ICT in research and problem solving.
7. efficiently using ICT for professional development in the teaching of Mathematics
8. teaching with ICT and helping students take ownership of ICT in their learning.

### IX. Teaching and learning activities

#### 9.1 Pre-assessment: are you ready for this module?

Learners

In this section, you will find self-evaluation questions that will help you test your preparedness to complete this module. You should judge yourself sincerely and do the recommended action after completion of the self-test. We encourage you to take time and answer the questions.

Instructors

The Pre-assessment questions placed here guide learners to decide whether they are prepared to take the content presented in this module. It is strongly suggested to abide by the recommendations made on the basis of the mark obtained by the learner. As their instructor you should encourage learners to evaluate themselves by answering all the questions provided below. Education research shows that this will help learners be more prepared and help them articulate previous knowledge.

## 9.2. Self evaluations associated with ICT

Evaluate your ICT using ability. If you score greater than or equal to 60 out of 75, you are ready to use this module. If you score something between 40 and 60 you may need to revise your previous ICT basic skill course. A score less than 40 out of 75 indicates you need to do a basic ICT skill course.

Try the following questions and evaluate where you are in the ICT user spectrum.

Area of competence	Level of confidence				
	Low 1	Need help 2	Good 3	High 4	Very High 5
A) General					
1. Familiar with the AVU Basic ICT Skills (using word processors, spreadsheet software, web navigator, etc. See list of prerequisites).					
2. Confident in guiding AVU's ODeL trainee. (lesson Planning, reference links, etc.)					
3. Using a software (interactive whiteboard software to create and save flip charts. (Annotation desktop mode, flip chart, paste in objects, load images.)					
B) Using ICT in Numeracy					
4. Whole class teaching & group work Software e.g. Geogebra, Graph, ActivPrimary, Easiteach Maths, RM Maths, ICT in Maths, websites. Using RM Maths					
C) Using ICT in Literacy (Whole class teaching & group work)					

## I. Integrating ICT in Mathematics education

<p>5. Software e.g. ActivPrimary Creating resources</p> <p>in generic software (e.g. TWAW, Talking First Word, My World3), websites.</p>					
<p>D) Using ICT in Physics</p>					
<p>6. Using virtual labs and simulations (e.g. Optics Bench Applet <a href="http://www.hazelwood.k12.mo.us/~grichert/optics/intro.html">http://www.hazelwood.k12.mo.us/~grichert/optics/intro.html</a>, Physics 2000),</p> <p>7. Using physics modelling software (e.g. Crocodile clips).</p> <p>8. Use of other ICT resources (e.g. Junior Insight &amp; Sensing/sensor equipment, digital camera, E-microscopes).</p> <p>Active Primary for whole class teaching</p>					
<p>E) Using ICT in Science</p> <p>9. Using generic software to present information and for creating pupil resources in (e.g. TWAW, Talking First Word, My World, data handling programs),</p> <p>Research using websites &amp; CD ROMS,</p> <p>F) Using ICT in other curriculum areas</p> <p>10. Active Primary, creating resources in generic software (e.g. TWAW, Talking First Word, My World), websites, Micropedia CD ROM, other specific CD ROMs, digital camera, digital video camera.</p> <p>11. Using the shared areas on the AVU and/or PI site (Read, Write &amp; Homework) to put templates and files for the pupils, to share work.</p>					

## Integrating ICT in Mathematics Education

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12. Using Office software (Word, Excel, Powerpoint) for professional use e.g. to create and adapt teaching resources, write reports, plan out timetables, record pupil data.					
13. Use the Internet for professional development (teaching resources, teaching information, copying images) 14. Use software to record pupil's progress. 15. Use of other ICT resources (e.g. scanner, digital camera)					

## Pre-Assessment for Integration of ICT in Mathematics :

1. Access the internet and go to the MathsNet site (link 1 above). Follow the 'about us' link on the home page and find out who is the creator of MathsNet. Is it:
  - a. Ola Obusanje
  - b. Rahema Khan
  - c. Bryan Dye (correct)
  - d. Katie Arnold
  
2. Look at a computer which has Word or OpenOffice Writer (or a similar word processor). In the Insert Menu choose Symbol (in Word) or Special Character (in Writer). In the Font selection choose Symbol. What is the character code for the less than (<) sign? (In Word you will need to select from (symbol(hex))).
  - a. 26
  - b. 3C (Correct)
  - c. 8A
  - d. 92
  
3. In Microsoft Office you can insert an Equation using a piece of software which comes as part of Microsoft office. In Word, Excel or PowerPoint, you choose the Insert menu and select Equation. Do this to find the name of the software. (If you cannot find this function, you may need to reinstall Microsoft Office and choose a full or custom installation). In OpenOffice, there is a separate piece of software which is one of the OpenOffice suite of programs which is used for creating equations. What are these pieces of software called? (You only need to answer for the office suite you are using).
  - a. Equation Editor and Math (correct)
  - b. Equate and Math Edit
  - c. Equation Writer and Math Print
  - d. Equas and Matheditor

4. Look at a computer which has Excel or OpenOffice Calc. Launch the program ensure you have a new blank spreadsheet in front of you. In the the Insert menu, choose Function. In the category menu, select mathematical or maths & trig. Find the function that gives the absolute value of a number. How should it be entered?
  - a. ABS(number) (correct)
  - b. Absolute(x)
  - c. Abs(value)
  - d. Absolute(valx)
  
5. Find the MSWLogo\_SetUp file in the Software folder. Make sure you are using a computer on which your are allowed to install software. Double click this file and install the software. Launch the program. An information card is shown when the program is launched. It says that the Core of the program was written by Brian Harvey. At which University did he do this?
  - a. King's College, London.
  - b. University of Cape Town
  - c. University of Malaya, Kuala Lumpur
  - d. University of California, Berekely (correct)

### 9.3. Precautions/Misconceptions in e teaching and learning (Wrong notions.)

#### Learners

This section offers support to students who are apprehensive of working with computers or using the Internet. You will also find a number of precautions to help avoid some of the more common pitfalls and prejudices. To maximize learning outcomes, it is important to step back and cast a critical eye on the risks, perceived and real, of teaching with ICT.

Misconceptions about ICT differ from mistakes and misunderstandings in that a pupil has an existing mental model of how things work, which diverge from accepted views

Misconception may be due to fundamental misunderstanding in younger pupils. Children may have fundamental misunderstandings about the way computers work, crediting them with intelligence and insight beyond the capabilities of any current machine.

Misconceptions often involve children's attitudes to, and understanding of, the nature of technology. Children are quick to pick up and adopt the attitudes of those around them. Images of ICT presented in the media, or attitudes about technology displayed by others are often adopted by children (and adults).

Address misconceptions by discussing issues with older pupils. "The Internet is dangerous and people just want to sell you things"; "Computers are 'boys' toys' and not interesting or useful for girls".

You can consider your own attitudes and preconceptions about ICT. You will be an important role model for your pupils:

#### Misconceptions

1. That a graphics file is a different kind of thing or entity from a text file, or a word processor file. More, that an application file, e.g. Winword.exe, is a different kind of entity from the document files that it produces.
2. That a file currently being edited is merely a copy of the file in hard storage (and important too to note the exception for database files).
3. People (pupils) think that a data file for a picture is as different from a data file for text as a photograph is from a printed page. But this is of course not true.
4. People (pupils) think that if they edit their document in a word processor then they are changing the data file. But this is not true (until it is re-saved). The exception is a database in which any edits immediately change the data file.

5. All webpage appear, to pupils, indefinitely available. As this is not always the case, you need to test out the web site addresses, which you are going to use before hand. Check whether they have limited life and whether they are about to change.

### Precautions

Students need guidance on the fine details of searching information from the net:

- Avoid vague “search the Internet for.....” type activities. Most pupils need more direction than that. If you do want pupils to do an Internet search, give them a preparatory activity where they consider appropriate keywords to enter into a chosen a search engine. This can be a very worthwhile focusing activity. Check that the key words produce the desired results before the lesson.
- Check the download times of material from your chosen sites. If these are long you may have to adjust your lesson plan if you want pupils to download items
- Check the languages used in your chosen web sites
- You may need to make a short list of keywords and concepts for explanation to pupils before they attempt your web site activities.

Your first choices may not be available:

- List some alternative web site addresses in case your first choices are unavailable.

Undesirable links and updates:

- Search your chosen web sites for links to undesirable web sites and advertising material. New links appear all the time, check this just before the lesson.
- Search your chosen web sites for features, which invite responses by email. See if a school email address can be submitted or if the option can be disabled. Avoid using web sites, which invite personal response by e-mail.

**Key words:** Their usefulness and Limitations:

- Check for American spellings especially of key scientific words, e.g. Sulfur.

Access on the school computer may be limited:

- Some school computers are programmed to block the saving and downloading of files, or the saving of files is limited.
- Some school computers block certain web sites, denying access.
- Check the computers, which you will use, for these features before the lesson.

Backup an important aspect of ICT:

- Try to give out web site addresses in an electronic format, either saved to favourites, as an e-mail, on a floppy disk or on a CD ROM. Avoid writing long addresses on a board for typing into computers by hand. Typing wrong web site addresses can be very motivating for pupils.
- Keep a spare copy of your list of web site addresses on your own personal flash disc, floppy disk or CD ROM and keep this with you during the lesson.
- Once you have made your list of safe web sites, make it available to the pupils outside of school hours electronically through a departmental web site, an electronic conference like First Class, or e-mail.
- If possible, try to save your chosen sites to "Favourites" on the computers, which you will use. After you click the "Add Favourite" button, click to tick the box "Make available offline". Not all sites can be saved in this way. Those that can, will be saved onto the machines, which you are using. This gives you the option to use the web site during the lesson without an active Internet link. Alternatively, you could burn CD ROM copies of the web sites, which you wish to use during the lesson, using a CD rewriter. You can load the web site from these CD ROMs before the lesson starts. The disadvantage of this approach is the CD ROM copies of the web site are not updated when the web site is updated.

Not all students have internet access at home:

- You can tell pupils to use the Internet to support homework. However, you should provide computer access at school before the homework deadline for those who do not have access to a computer at home.
- If you present your small selection of web sites to the pupils as a CD ROM they do not have to go on-line and they can have a virtual Internet experience Current and likely future developments in ICT.

Predictions about future development trends for ICT generally involve adjectives such as 'smaller, faster, and cheaper'. Increasing miniaturisation, portability and capacity of systems mean that the range of uses for ICT is increasing exponentially. The next major developments are likely to be:

- Wider adoption of technology such as USB, which will cut down the number of leads trailing from the back of computers as more devices will be 'piggy-backed' on to a single connection;
- 'Bluetooth' technologies, which make use of radio linking and will cut out the cables altogether. Faster access to the Internet with 'broadband' connections becoming widespread, which will lead to increased use of online multimedia resources such as audio and video. The implication for schools is that they must continue to play 'catch up', devoting significant resources to investment in technology and training.

## X. Key Concepts (Glossary)

### Learners

In this section, you will find key concepts useful in order to complete this module. You shouldn't consult them right away. Instead, we encourage you to briefly read over their descriptions and move on to the next section.

### Instructors

The key concepts placed here introduce learners to the resources available to them in order to complete this module. As their instructor you should encourage learners to read the descriptions provided before moving on to the learning activities. Education research shows that this will help learners be more prepared and help them articulate previous knowledge.

### Key Concepts

**Dynamic Geometry:** This refers to a range of software programmes which allow Euclidean geometric constructions to be created. Points, lines and arcs are constructed according to the rules of Euclidean geometry. Hence relationships can be found and tested by checking all possible cases by dragging the lines, points and arcs around the computer screen. (Activity 1 and 2)

**E-Learning:** is a term used to refer to learning which takes place online. Self-directed learning plays an important role in this type of education, demanding an increased level of learner autonomy. E-learning programs can be completed remotely using the Internet, or can include short sessions of face-to-face teaching.

**CAS:** This is an acronym for Computer Algebra System. This is software which is capable of manipulating algebraic statements symbolically. Generally it will also allow graphs of functions to be drawn. (Activity 1 and 2)

**Synchronised communication:** Refers to a mode of real-time communication, using tools such as Instant Messaging, chat rooms, discussion forums, conferencing systems and bulletin boards.

**Data Logging:** In a scientific experiment, data is recorded as the experiment progresses. For example, the temperature is recorded at different time intervals as a liquid cools. Specialist ICT equipment is available to collect data of this sort automatically. For example, a probe or sensor is attached to a computer or graphical calculator. A special software programme is run on the computer/calculator. When the experiment takes place, the data is logged according to settings made on the software. (Activity 1)

**E-portfolio:** Also called a digital portfolio, this tool is unique in that it can manage about a dozen file types (text, images, audio, video, presentations, hyperlinks). This new technology allows learners to subscribe to a portfolio, to organise their work, to be advised of updates, and to take tests and quizzes, in real-time.

**Graphical Calculators:** These are large scientific calculators which have a range of additional mathematical functions. Notably they can draw graphs of functions. Additionally they can create statistical charts and graphs and calculate statistics. The most sophisticated also contain CAS and dynamic geometry software. (Activity 1).

**ICT:** Information (I) and Communication (C) Technology (T) - the term ICT encompasses innovative audiovisual, computing and telecommunications techniques which allow the acquisition, processing and storage of information. Many of these techniques come directly from computing and communications. A number of acronyms are used, including IT, NT and IS. The term ICT is becoming more and more common in science, in Open and Distance Learning, and in the Pedagogical Integration of ICT.

**Internet:** Connection to a very large number of computers using communication networks, such as telephone lines, to exchange information worldwide. The Internet is, however, distinct from the World Wide Web (www), which, like email, is only one of the principle services available through the Internet.

**Intranet:** This concept generally designates regulated connection between a group of authorised users. A password can be required for members to access and exchange information on these smaller networks (which use similar technology to the internet). Web sites, or web pages, are examples of networks that use Intranet. In E-learning Intranet networks are an efficient way of exchanging information between learners, educators, and peers. It is possible to communicate with the owner of a portfolio on edu-portfolio.org, either by email, or via the “comments” function. Overall this tool is flexible, simple and easy to use, allowing information and evaluations to be organised and exchanged. Its potential applications offer very attractive prospects to E- learning programs.

**LOGO:** a software programming language created in the late 1970's to provide tools for school students to engage with computer programming. This was seen as an exciting possibility for giving students new ways to understand mathematics. (Activity 1)

**Non-synchronised communication :**

E-learning offers the option to de-synchronise educator and learner time, allowing them to communicate based on their own schedules, in a non-synchronised manner, through multimedia information exchange networks – for example using email or e-platforms to submit work.

**Software:** These programs are initially conceived to facilitate consumer use of ICT. There are various types of programs used in the Pedagogical Integration of ICT including learning, open source and “free” software. A number of support mechanisms exist to assist teachers and students in becoming comfortable and efficient with ICT. This support is often presented in the form of CD-ROMs, tutorials, exercises or other didactic material.

**Pedagogical Integration of ICT :** This concept is not limited to the establishment of networks and/or the installation of equipment. It includes the use of technology in schools to improve learning and to facilitate educational development. Among other definitions, this concept implies a process of appropriate, regular, and regulated use of interactive technology with incurred beneficial changes in school practices and student learning.

**Web Sites:** These are a collection of files (HTML pages, images, PDF, audio, video, Flash-animations) and folders forming the structure of a site, placed together in computer memory (on a work station during the development phase and a server when published), and linked together using hypertext. Access to a website can be global, using the World Wide Web, or limited to a local network. For any site to be accessible externally, web-server software must be operating on the server where the site is stored.

To enhance your vocabulary on E-learning click on these useful links

<http://www.ymca-cepiere.org/guide/glossaire.htm>

**Probe/Sensor:** Data logging equipment consists of software to control the logging of the data and probes or sensors to take the measurements. Common probes would include thermometers to measure temperature and voltmeters to measure potential difference. Common sensors include gas pressure sensors and sensors to measure distance. (Activity 1)

## XI . Compulsory Readings

### Learners

In this section, you will find compulsory readings useful in order to complete this module. You shouldn't consult them right away. Instead, we encourage you to briefly read over their descriptions and move on to the next section.

### Instructors

The compulsory readings placed here introduce learners to the resources available to them in order to complete this module. As their instructor you should encourage learners to read the descriptions provided before moving on to the learning activities. Education research shows that this will help learners be more prepared and help them articulate previous knowledge.

### Compulsory reading 1

Complete reference: UNESCO (2004). Technologies de l'information et de la communication en Education: Un programme d'enseignement et un cadre pour la formation continue des enseignants. Division de l'enseignement supérieur. ED/HED/TED/1

Abstract: This book has two objectives: the first to delineate an ICT educational program for secondary school teaching that responds to current international trends. The second objective is to outline a professional development program and to support teachers in its implementation. In addition, it lends a practical and realistic approach to educational programs and teacher training, which allows efficient implementation with a given set of resources.

Rationale: This book is a UNESCO offering which aims to support educators and students in better integrating ICT, including multimedia, e learning and distance education, in the processes of training and knowledge sharing in the field of education. A particularly well-organized document, it offers examples of ICT applications in Mathematics, Biology, Physics and Chemistry teaching.

### Compulsory Reading 2

Complete reference: Becta (2005). The Becta Review 2005 : Evidence on the progress of ICT in Education. Becta ICT Research

Abstract: This document is a scientific journal that surveys the impact of ICT in education. In particular, it notes the recent progress in classroom instruction. This journal also explores the inherent and current challenges of fully integrating ICT in education in a dynamic policy environment. In short, while demonstrating an increase in comfort with ICT amongst users, and that their use has increased significantly in the last two years, this document reveals that there is also real evidence of the positive impacts of ICT use in education.

Rationale: This document is a valuable resource with allows a better comprehension of the importance of ICT as a set of educational support tools, especially in Open and distance learning which retains, as elsewhere, multiplex challenges. The evidence clearly presented in this text suggests directions for the development of new content for e-learning programs.

### Compulsory Reading 3

Complete reference: UNESCO (2004). Schoolnetworkings: Lessons learned. Bangkok: UNESCO Bangkok (ICT lessons learned series, Volume II).

Abstract: This document is a collection of references for teaching with ICT. It presents a variety of methods to integrate ICT in teaching. The document, compiled by specialists, synthesizes a number of examples, and presents lessons learned on ICT use in schools in a variety of countries. These lessons could help improve the planning and integration of ICT in education. The text suggests tools to guide both policy makers and users in their advocacy, as well as to support ICT initiatives in education.

Rationale: This document is a reference for ICT use in teaching and learning in specific discipline such as Biology, Chemistry and Physics. Like other texts in the series it helps to better understand the process of integrating ICT in teaching the disciplines and in the use of technology to enhance learning.

### Compulsory Reading 4

Complete reference: Becta (2002). ImpactCT2: The Impact of Information and Communication Technologies. ICT in Schools Research and Evaluation Series - No. 7, Department for education and skills.

Abstract: This text is the next in a series of research reports produced by the UK organisation BECTA, on the educational impact of ICT. It addresses issues related to the use of ICT in disciplines such as math and science. It presents, in four stages, the relative gains of regular and occasional users of ICT in each discipline.

Rationale: It is important to read this document to better appreciate the benchmarks, and the real and potential impacts, for and of ICT use on learning in scientific disciplines. African teachers and learners faced with substantial challenges in their education systems can benefit from the experiences presented in this study to integrate ICT in their training practices.

### Compulsory Reading 5

Complete reference: UNESCO (2002). Teacher Education Guidelines :Using open and distance learning. Education sector, Higher Education Division, Teacher Education Section in cooperation with E-9 Initiative.

Abstract: This document addresses decision-makers, teachers and students who are faced with the daily challenge of broadening educational programs through Open and Distance learning. Among other objectives, this document attempts to bring to light responses to fundamental questions in open and distance learning for teachers. What does this training consist of, what is the curriculum and who are the educators, is this training appropriate, who are the users, how should it be planned and organised, what technologies can be applied, how can it be financed, how can teachers develop competencies, how can they access these? These are the major questions broached in this important reference document for open and distance learning.

Rationale: This document addresses the inherent challenges of teaching in Open and distance learning. As a resource the text provides suggestions for financing, planning organising and activities, educational practices and evaluation. The document therefore presents useful information for collaborative work and further success in the field of Open and distance learning.

### Compulsory Reading 6

Complete reference: Tchameni Ngamo S. (2006). Pedagogical Principles and theories of ICT integration in Education. AVU Teacher Education Authoring content Workshop. Nairobi - Kenya, 21st August to 2nd September.

Abstract: This text presents the fundamental ideas, which mark the way for ICT integration in education. The theories herein centre around six poles, which together provide the elements essential for consideration in the process of bringing ICT to learning the sciences.

Rationale: A clear objective is only as useful as a clear path towards it – this principal certainly finds application in education – for, while targets may be well defined, the path towards them must also be marked. It thus seems appropriate to gain familiarity with the issues facilitating the integration and application ICT, so as to prepare and pilot learning activities and to manage teaching.

### Compulsory Reading 7

Complete reference: Becta (2004). ICT and Mathematics: a guide to learning and teaching mathematics 11-19. Update version produced as part of the DfES «KS3 ICT offer to schools».

Abstract: A detailed review of the use of ICT to support mathematics teachers and learners. The report details the variety of possible ways in which ICT can support mathematics education. It details the range of possible software and hardware available. Finally, it presents a range of details case study examples of the use of ICT to support mathematics education.

Rationale: This is a key document for mathematics educators. A full reading will give the student a comprehensive view of the range of ICT resources and applications. It should be read with a careful view of the issues of the local context, while enabling exciting possibilities should be viewed as problems to be solved.

### Compulsory Reading 8

Complete reference: Becta (2001). Information sheet on Graphical Calculators.

Abstract: This report outlines the capabilities of graphical calculators. The range of features and functionality is described together with a list of possible mathematical applications. A collection of references in print and on the web is given for further research.

Rationale: Graphical calculators provide a rich source of opportunity for mathematics educators. They not only draw graphs of functions, but allow learners to look deeply at the relationships between function, table of values and graphs. Also, they have excellent statistical facilities. Although these are rare in the African context, they are very reliable, need only batteries to operate and are relatively inexpensive compared to computer hardware. Also, teachers can see the range of possible software possibilities to support learners in mathematics.

### Compulsory Reading 9

Complete reference: Becta (2004). Entitlement document to ICT in secondary mathematics

Abstract: A collection of mathematics activities are shown with presentations of ICT being used to support them. There is a list of links to web site showing further examples and sources of free software to enable their use.

Rationale: This is a collection of classroom activities which can be done using free software. The students should make every effort to try them out and think about how they support a deeper understanding of mathematical ideas and hence present opportunities to the teacher of mathematics.

## Compulsory Reading 10

Complete reference: Adrian Oldknow (2004). ICT bringing advanced mathematics to life – T-cubed New Orleans - March.

Abstract: A report to the Teachers teaching with Technology conference in New Orleans, 2004. A collection of mathematical ideas are presented. They are all addressed using specialist mathematics education software or graphical calculators. The ideas presented are topics in an English A-level mathematics course, but are suitable for all higher level school courses.

Rationale: This is a collection of more sophisticated mathematical problems than were presented in the earlier activities. Although they are shown using TI<sup>2</sup>Interactive!, a specialist software, most of the activities can be done using Graph and Maxima, provided with this course. Students should follow the mathematical ideas first and then consider how the ICT is supportive of their understanding.

## Compulsory Reading 11

Complete reference: Chartwell-Yorke (2006). Your Guide to Exploring Mathematics with ICT

Abstract: Details specifications and review information for a large range of specialist mathematics education software. This is a product catalogue for a distributor of software in the UK.

Rationale: This is a very comprehensive guide to the best available software. It is a product catalogue and hence shows pricing and order details, but students should not think they are encouraged to buy from this company. Instead, the catalogue provides a very detailed description for the full range of mathematics software and hence allows the student to engage with the possibilities. Students should consider how any of this software would be supportive of themselves as teachers or their students as learners.

### **XII. Multimedia Resources**

#### Learners

In this section, you will find multimedia resources useful in order to complete this module. You shouldn't consult them right away. Instead, we encourage you to briefly read over their descriptions and move on to the next section.

#### Instructors

The multimedia resources placed here introduce learners to the resources available to them in order to complete this module. As their instructor you should encourage learners to read the descriptions provided before moving on to the learning activities. Education research shows that this will help learners be more prepared and help them articulate previous knowledge.

The ICT resources for this unit are contained in the folder named Resources Unit 1. These consist of worksheets and files to use. All of the files can be operated using software which is open-source (i.e. free to use) and is contained on the CD. Specific references are contained in the activity sections.

The open source software itself is also included on the course CD. You will need access to a computer on which you are able to install software. You will need to install all of the software provided. Most of the activities are designed for use on an office suite of software. The most common suite is Microsoft Office (Word, Excel and PowerPoint). However, we would strongly recommend that you use OpenOffice, which is an open source suite included on the course CD.

#### Dynamic Mathematical Software

The earliest mathematical programs simply did the mathematics for the user, since the programming languages already had a full range of mathematical functions, this was easy to achieve. They would solve linear and quadratic equations. They would solve simultaneous equations. They would perform algebraic manipulations: factorisation, simplification, expansion, etc. They would perform calculus: integration and differentiation, both numerically and symbolically. This type of software is referred to as CAS software. This stands for Computer Algebra System. Mathematicians became familiar with programs such as Maple, Mathcad, Mathematica and many more. The current versions of these programs are all very expensive, so happily there is open-source (freeware) software. We have put a copy of a good system called Maxima on the disc accompanying this course. We will refer to it later in this unit.

Mathematics provides means of expressing relationships. These can be expressed in many different ways. Which way is best depends on the circumstances. For example, a mathematical function can be expressed as:

1. Algebra
2. Graph
3. Table of values

If the function is in algebra, then we can manipulate it algebraically, for example, to find identities or to rearrange to a more convenient form for comparing with other functions. In graphical form, we can get a quick feeling for the location of the roots, or the rates of change at different points. The table of values gives us specific information useful for practical situations and to get a numerical feeling for the function.

If we change the function, for example, by adding a constant term, then the graph will change and the table of values will change to reflect the new function. Equally if we started from a graph and made a change to the graph, then this would represent a changed function with a new table of values. The algebraic form, the graphical form and the table form are all dynamically linked. A change in one necessarily generates a change in the others. This is a key feature of mathematics.

### Different Types

The computer algebra software we talked about earlier is the first example of software in which mathematical presentations could be linked dynamically. Hence, we sometimes refer to this as dynamic algebra software. The next area which was developed was geometry. The relationships between points in space created by geometric constructions were made available in software. This led to a range of software referred to as dynamic geometry software. The most common programs of this type are Cabri Geometre and The Geometers Sketchpad. Again, an excellent open source program called GeoGebra is available on the course CD.

It is difficult to draw graphs of functions, especially complicated functions, most especially functions in 3 dimensions! Hence, there is a long tradition of software which focusses on the graph and provides very sophisticated facilities for graphing. The two most common commercial programs are Autograph and Omnigraph. These are examples of dynamic graphing software. Once again we have included high quality open-source software called Graph on the CD.

There has been a long tradition of software that does statistics for you. It will calculate key statistics and perform statistical tests and generate graphs and charts. SPSS is the most well know program. However, it is not dynamic. It starts from the data and generates the charts and the statistics. The only truly dynamic statistical software is called Fathom. This allows you to modify a chart (e.g. by dragging one bar on a bar chart up) and to see the effect this has on the data. There is no open-source equivalent, so we will not spend much time with Fathom, but it is interesting to review nonetheless.

Graphical Calculators are able to run many of the software programs which we have listed as dynamic software. However, they are just another hardware possibility and this unit is about a particular type of software.

This unit is designed to introduce you to dynamic mathematical software. As we have discussed, this is software which creates dynamic links between different mathematical presentations. We will look at dynamic software for algebra, geometry, graphing and statistics.

Hardware and Software Examples Live Links

Hardware

Graphical Calculators.

- Texas Instruments
- Casio
- Sharp
- Hewlett Packard

Data Logging equipment.

- Vernier
- Pico

Software

Generic Software.

Open Office.

Mathematical Software.

Dynamic Geometry:

Examples: Cabri Geometre, The Geometers Sketchpad, GeoGebra (open source)

Dynamic Statistics:

Examples: Fathom, An index of open-source statistical software o Graphing software:

Examples: Autograph, Omnigraph, Graph (open source) o Computer Algebra Systems (CAS):

Examples: Maple, MathCad, Mathematica, Derive, Maxima (open source), EigenMath (open source)

LOGO:

Examples: Imagine Logo, MSW Logo (open source)

Mathematical Typesetting and Diagram systems.

Efofex FX Draw

Math Type

Examples: WinEdt, MiKTeX

Mathematical Activity Software.

Examples: Zoombinis (Broderbund), DLK

Computer Learning Systems.

### XIII. Useful links

Learners

In this section, you will find useful links in order to complete this module. You shouldn't consult them right away. Instead, we encourage you to briefly read over their descriptions and move on to the next section.

Instructors

The links placed here introduce learners to the resources available to them in order to complete this module. As their instructor you should encourage learners to read the descriptions provided before moving on to the learning activities. Education research shows that this will help learners be more prepared and help them articulate previous knowledge (please copy the link and open it in a new browser)

#### Useful links 1

Educ - Portfolio

[www.eduportfolio.org](http://www.eduportfolio.org)<http://www.eduportfolio.org/>



*New to Eduportfolio.org?  
Register to obtain a portfolio*

*You already have a portfolio  
Login here!*

#### **Eduportfolio.org 3.0 is here!**

<http://www.eduportfolio.org/>

Description: Edu-portfolio is a website which presents, in a clear and straightforward manner, a virtual portfolio – a very important training tool in distance learning.

Rationale: A secure method for organising work is primary to success in an open and distance learning program. A portal through which to archive content, in addition to a discussion platform, makes for a dynamic educational environment.

### Useful links 2

Unesco Bangkok: ICT Resources for Teachers CD-ROM

<http://www.unescobkk.org/index.php?id=3871>

Description: ICT Resources For Teachers CDROM contains a set of ICT-based resources for teaching and learning of science, mathematics, etc. for secondary- level students, including simulations, video clips, interactive learning objects for quizzes, animation, and other kinds of multimedia learning activities. The materials and lesson plans provided here are organized and relevant to subjects. A separate directory is provided to give an overall view of the types of resources available.

Rationale: In pedagogy the use of a variety of available resources stimulates learning. Appropriate audio-video support for learning activities which include diverse, information-rich, content, seems to hold learner's attention throughout the training process. Additionally, learning activities appear less monotone. This UNESCO website is worth a visit because it provides a collection of these resources for learning math and the sciences.

### Useful links 3

4Teachers: Home Page

<http://www.4teachers.org/http://www.4teachers.org/>



The screenshot shows the 4Teachers.org website. The logo features a large yellow '4' followed by 'Teachers.org' in blue, with the tagline 'Teach With Technology' below it. Navigation links for 'Home' and 'About Us' are visible in the top right. The main heading is 'Success Stories', followed by the text 'Hear firsthand accounts about trials and triumphs with technology in the classroom.' Below this, there are two bullet points: 'Teacher Testimony: (http://4teachers.org/testimony/)' with the note 'all archived stories are written by teachers for teachers.', and 'Kids Speak: (http://4teachers.org/kidspeak/)' with the note 'Learn how students are taking their tech-know-how to a higher level.'

<http://www.4teachers.org/>

Description: 4Teachers.org works to help you integrate technology into your classroom by offering FREE online tools and resources. This site helps teachers locate and create ready-to-use Web lessons, quizzes, rubrics and classroom calendars. There are also tools for student use. Discover valuable professional development resources addressing issues such as equity, ELL, technology planning, and at-risk or special-needs students. Here you will find some of our resources to help you integrate technology into your curriculum, along with links to stories written by teachers who personally conquered integration challenges.

Rationale: Online learning is facilitated when available resources include a variety of multimedia resources and examples. As well, when these resources reflect real experiences of technology integration, they allow educators to discover new ideas and enhance their professional development.

### Useful link 4

Education World: The Educators' Best Friend

<http://www.education-world.com/http://www.education-world.com/>

<http://www.education-world.com/>



The image shows a screenshot of the Education World website. The header features the logo "education world" in white lowercase letters on a red background, with the tagline "Connecting educators to what works" below it. A teal navigation bar contains the date "March 29, 2016" and three menu items: "Teacher Essentials", "Administrators", and "Lesson Plans". Below the navigation bar, there is a featured article with a photograph of a school hallway. The article title is "Country's Largest School Districts Hire More Security Officers Than Counselors" in bold black text. Below the title, a short paragraph reads: "Concerning new data analysis finds the nation's largest school districts hire more security officers than counselors."

<http://www.education-world.com/>

Description: The Website provides free featuring collaborative projects, virtual field trips, educational games, and other interactive activities.

Rationale: Problem-based and collaborative learning are standard pedagogical approaches in Open and distance learning. It is thus appropriate that learners and educators in the field visit this site, where projects and interesting interactive activities are available.

### Useful links 5

Resources to help students practice skills needed on state assessments

<http://www.internet4classrooms.com/>

Description: This Website provides resources to help students practice skills required on various assessments. Online Modules are available for elementary, Middle and high school students' assistance.

Rationale: The Internet holds an increasingly important place in schools. Because they are considered role models teachers must not fall behind their student's ability to use email and navigators. ICT use generally, and the Internet in particular, requires at least basic competencies. Internet4Classrooms provides a portal that reviews material to assist educators in effectively using the Internet.

### Useful links 6

<http://www.unescobkk.org/index.php?id=1366>

Description: This website includes a number of free, downloadable resources and provides substantial support for childhood education. Also available is free software for educators.

Rationale: Games play an important role in children's lives. They contribute, in large part, to motor and cognitive functions as well as accelerating the process of gaining social skills and knowledge. This UNESCO website is an easy-access source for a variety of interactive learning activities which supports different aspects of childhood development.

### Useful links 7

Unesco-Bangkok : ICT in Education

<http://www.unescobkk.org/index.php?id=1366>

Description: Five principal themes related to ICT integration policy are available on this UNESCO website. Teacher training, teaching, learning and monitoring are explored.

Rationale: Teacher training is only one, but perhaps the foremost, among the multiple preconditions necessary for the successful integration of ICT in education. In addition to reviewing information related to learning and teaching, this website also provides useful information on ICT integration policy.

## List of relevant Useful Links in Mathematics

Mathsnet: interactive maths from the UK

- <http://www.mathsnet.net/>
- [Interactive Multipurpose Server](#)
- [http://wims.unice.fr/wims/en\\_home.html](http://wims.unice.fr/wims/en_home.html)

Maths Online: Interactive Maths from Austria

- <http://www.univie.ac.at/future.media/moe/>
- Google Books On-Line (With a search for calculus) [http://books.google.com/books?q=calculus&as\\_brr=1](http://books.google.com/books?q=calculus&as_brr=1)

Online mathematics textbooks

- <http://www.math.gatech.edu/~cain/textbooks/onlinebooks.html>
- [WikiBooks. Online maths books which are always in development.](#)
- <https://en.wikibooks.org/wiki/Subject:Mathematics>

Wolfram MathWorld an extensive maths resource

- <http://mathworld.wolfram.com/>

MIT Open Source Courseware in Mathematics

- <http://ocw.mit.edu/OcwWeb/Mathematics/index.htm>

Mathematics in Action

- <http://www.ncaction.org.uk/subjects/maths/ict-lrn.htm>

Chartwell Yorke

- <http://www.chartwellyorke.com/>

Oundle School/TSM

- <http://www.tsm-resources.com/suppl.html>

## I. Integrating ICT in Mathematics education

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Seymour Papert's personal site:

- <http://www.papert.org/>

MSW Logo (free software and a collection of resources and materials):

- <http://www.softronix.com/logo.html>

More suggested resources

- As part of helping students to develop mathematics skills, they can play mathematical games at: Math Game ( <http://hotmath.com/games.html>), Math play (<http://www.math-play.com/>) and Google math (<https://sites.google.com/site/gameonlearning/math-high-school-games>) web sites after having games modeled by the teacher so that the purpose of each has been identified.
- Observe a teacher conducting a search of say 'Geometry.' The teacher will write down the names of 4 of the websites containing suitable maths games as well as bookmarking them in the class 'favourites' folder.
- Show and tell useful maths websites. Consider a maths topic, for example Geometry. Find a website useful for increasing class understanding. Each day two students will show their selected website to the class and talk them through the website. While searching for a suitable website, search terminology should be modified to seek desired results; for instance in a search on 'Geometry', the search could be changed to 'Geometry tutorials' or 'Geometry maths' if the original search did not return adequate results.
- Problem solving and collaborate within a maths forum such as Math Help Forum

([www.mathhelpforum.com/math-help/math-help-forum-lounge/](http://www.mathhelpforum.com/math-help/math-help-forum-lounge/)).

# Learning activity 1

(Crosscutting activities for all modules)

## **Title of Learning Activity: Written report on compulsory reading**

To note: Reading is an especially important activity in Open and distance learning. To best grasp the concepts of the pedagogical integration of ICT, the readings for each activity are compulsory. Two texts accompany activities #1.1 and #1.4, and a single text for #1.2 and #1.3

### Activity 1.1: Reading critique

#### **Summary of learning activity**

Read thoroughly the UNESCO (2004) text on continuing education for teachers, and the integration of ICT in scientific disciplines (lessons-learned and best- practices for ICT in Mathematics, Biology, Physics and Chemistry teaching programs).

Reference for the compulsory reading

- UNESCO (2004). Technologies de l'information et de la communication en Education : Un programme d'enseignement et un cadre pour la formation continue des enseignants. Division de l'enseignement supérieur. ED/HED/ TED/1
- UNESCO (2004). Schoolnetworkings : Lessons learned. Bangkok: (ICT lessonslearned series, Volume II).

Detailed description of the activity

Suggestions for completing the assignment.

Read the UNESCO (2004) text and produce :

- A 3-page (maximum 1300 words, 1.5 line spacing) summary report. The report should clearly bring out the major points of a professional development plan that would allow teachers to succeed in integrating ICT in their discipline.
- A synthesis table presenting the basic skills necessary to apply ICT in pedagogical practices.
- An analysis of the important themes developed in the two texts, noting opportunities to integrate them in your discipline or teaching practices.

### Formative evaluation

The evaluation of the learning activities is based on the quality of the learner's analyses, arguments, and examples, and the depth, richness and variety of their ideas. As well, the structure of the submitted work, how well it is organised, its style and language and presentation, are important. In line with these expectations, the evaluation of this activity will be weighted as following:

- Summary report (40%)
- Synthesis table of basic ICT skills (30%)
- Analysis and opportunities for integration (30%)

### Activity 1.2: Creation of a trainer profile in distance learning.

UNESCO (2002). Teacher Education Guidelines: Using open and distance learning. Education sector, Higher Education Division, Teacher Education Section in cooperation with E-9 Initiative.

### **Summary of the learning activity**

Fundamentals concerning the use of ICT by teachers in the context of Open and distance learning.

Detailed description of the activity

Suggestions for completing the assignment.

Having read the UNESCO (2004) text (reference below?):

- Write a brief critique (600 words, or two pages at 1.5 line spacing) responding to the major challenges faced by teachers in Open and distance learning, as presented in the text.
- Illustrate, in a table, the competencies required of, and the ideal profile for an Open and distance learning educator.

### Formative evaluation

The evaluation of this activity will focus on both content and presentation. 60% will be dedicated to the quality of the analysis, and 40% to its presentation, particularly the competency table.

### Activity 1.3: Reading critique.

Tchameni Ngamo S. (2006). Pedagogical Principles and Theories of integration of ICT in Education. AVU Teacher Education Authoring content Workshop. Nairobi - Kenya, 21st August to 2nd September

#### **Summary of the learning activity**

The theories and guiding principles of the pedagogical integration of ICT in education.

Detailed description of learning activity

Suggestions for completing the assignment.

Read thoroughly the text on the fundamentals of ICT integration in education, and write a report that briefly (in two pages, 1.5 line spacing) presents the important aspects of ICT integration, as outlined in the document.

In an additional section, critique the text, and relate its themes to professional development for educators.

#### **Formative evaluation**

The evaluation of the learning activities is based on the quality of the learner's analyses, arguments, and examples, and the depth, richness and variety of their ideas. As well, the structure of the submitted work, how well it is organised, its style and language and presentation, are important. In line with these expectations, the evaluation of this activity will be weighted as following:

- Report on the reading (50%)
- Critical analysis and link to professional development (50%)

### Activity 1.4: ICT impact "success stories".

Reference for the reading

- Becta (2005). The Becta Review 2005: Evidence on the progress of ICT in Education. Becta ICT Research
- Becta (2002). ImpactCT2: The Impact of Information and Communication Technologies. ICT in Schools Research and Evaluation Series - No. 7, Department for education and skills.

### Summary of the learning activity

Various positive impacts of ICT use in mathematics and science.

Detailed description of the activity

Suggestions for completing the assignment.

Begin by reading the two Becta (2005) texts on the evidence of positive impacts of ICT on learning, then:

- Write a one-page synthesis report and create a PowerPoint presentation on the positive impacts of ICT on the process of learning.
- Present two success stories related to teaching using ICT (or two personal accounts of the same). Note links to the advantages outlined in the text. The accounts must highlight the important lessons to be learned (while noting significant risks and challenges).

### Formative evaluation

The evaluation of the learning activities is based on the quality of the learner's analyses, arguments, and examples, and the depth, richness and variety of their ideas. As well, the structure of the submitted work, how well it is organised, its style and language and presentation, are important. In line with these expectations, the evaluation of this activity will be weighted as following:

- Production of the synthesis report and PowerPoint presentation (50%)
- Presentation of success stories/accounts (50%)

# Learning activity 2

(crosscutting activity for all disciplines):

## **Report on reading of your choice.**

Detailed description of the activity

Suggestions for completing the assignment.

Choose two readings available on the Internet, draw from them two opposing or contradictory scientific opinions. Now report (in 600 words, about two pages) information from various sources – what does this demonstrate? For example – both Darwin’s theory of evolution and Creationism are found on Wikipedia ([www.wikipedia.org](http://www.wikipedia.org)). Your report should conclude by drawing out the challenges you may face in this context, as a teacher working with students.

### Formative evaluation

- The authenticity of the readings (20%)
- The brief resumé of the two texts (40%)
- The critical analysis of the readings (20%)
- Presentation of the material, within the defined parameters the assignment (20%)

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# Learning Activity 3

(specific in Mathematics):

## ICT Resources in Mathematics Education

### Summary of the learning activity

In this activity you will engage with the range of possibilities for ICT to be supportive of learners of mathematics. You will look at different types of software, either specially written to support mathematics and mathematics learners, or general software which can be used to support mathematics. You will consider different hardware possibilities and evaluate them in the African context.

### List of relevant readings

1. ICT and Mathematics: a guide to learning and teaching mathematics 11-19, Becta, 2004 (File name on course CD: BECTA-ICTandMathematics)
2. Entitlement to ICT in Secondary Mathematics, Becta, 2004 (File name on course CD: NC\_Action\_Maths\_ICT-Entitlement)
3. Graphical Calculators, Becta, 2001 (File name on course CD: BeCTA\_Graphical\_Calculators)
4. Seymour Papert, Mindstorms: Children, Computers, and Powerful Ideas, 1980, ISBN 0-465-04674-6 (Library Only)

### List of relevant resources

The ICT resources for this unit are contained in the folder named Resources Unit 1. These consist of worksheets and files to use. All of the files can be operated using software which is open-source (i.e. free to use) and is contained on the CD. Specific references are contained in the activity sections.

The open source software itself is also included on the course CD. You will need access to a computer on which you are able to install software. You will need to install all of the software provided. Most of the activities are designed for use on an office suite of software. The most common suite is Microsoft Office (Word, Excel and PowerPoint). However, we would strongly recommend that you use OpenOffice, which is an open source suite included on the course CD.

### List of relevant useful links

- Maths Net: <http://www.mathsnet.net/>

This is a very wide ranging site which contains reviews of many maths software and hardware. The site also has a large collection of activities for teachers and students.

- Mathematics in Action: <http://www.ncaction.org.uk/subjects/maths/ict-lrn.htm>

This is a UK government site to look at the teaching of mathematics. The link is to the part of the site dealing with using ICT in mathematics teaching.

And two more sites:

- Chartwell Yorke: <http://www.chartwellyorke.com/>
- Oundle School/TSM: <http://www.tsm-resources.com/suppl.html>

Detailed description of the activity

This activity is composed of three sections:

1. A discussion of the opportunities and difficulties in using ICT to support the teaching of mathematics. 2. A survey of types of software and hardware and a discussion of advantages and disadvantages.
2. Examples of using ICT to support teaching and learning in mathematics.

### Pre-Assessment

Each question in the pre-assessment is designed to test your ability to gain access to one of the essential tools required for the activity. If you were unsuccessful in any of the questions, this indicates that you will need to spend additional time practicing with the tool being looked at in the question:

1. Access the internet and go to the MathsNet site (link 1 above). Follow the 'about us' link on the home page and find out who is the creator of MathsNet. Is it:
  - a. Ola Obusanje
  - b. Rahema Khan
  - c. Bryan Dye
  - d. Katie Arnold

### Learning Activity 3

2. Look at a computer which has Word or OpenOffice Writer (or a similar word processor). In the Insert Menu choose Symbol (in Word) or Special Character (in Writer). In the Font selection choose Symbol. What is the character code for the less than (<) sign? (In Word you will need to select from (symbol(hex)):
  - a. 26
  - b. 3C
  - c. 8A
  - d. 92
  
3. In Microsoft Office you can insert an Equation using a piece of software which comes as part of Microsoft office. In Word, Excel or PowerPoint, you choose the Insert menu and select Equation. Do this to find the name of the software. (If you cannot find this function, you may need to reinstall Microsoft Office and choose a full or custom installation). In OpenOffice, there is a separate piece of software which is one of the OpenOffice suite of programs which is used for creating equations. What are these pieces of software called? (You only need to answer for the office suite you are using).
  - a. Equation Editor and Math
  - b. Equate and Math Edit
  - c. Equation Writer and Math Print
  - d. Equas and Matheditor
  
4. Look at a computer which has Excel or OpenOffice Calc. Launch the program ensure you have a new blank spreadsheet in front of you. In the the Insert menu, choose Function. In the category menu, select mathematical or maths & trig. Find the function that gives the absolute value of a number. How should it be entered?
  - a. ABS(number)
  - b. Absolute(x)
  - c. Abs(value)
  - d. Absolute(valx)

5. Find the MSWLogo\_SetUp file in the Software folder. Make sure you are using a computer on which you are allowed to install software. Double click this file and install the software. Launch the program. An information card is shown when the program is launched. It says that the Core of the program was written by Brian Harvey. At which University did he do this?
  - a. King's College, London.
  - b. University of Cape Town
  - c. University of Malaya, Kuala Lumpur
  - d. University of California, Berkeley

**Pre-assessment solutions:**

1. c 2. b 3. a 4. a 5. d

Evaluation Commentary for pre-assessment

**Activity 3**

Each question in the pre-assessment is designed to test your ability to gain access to one of the essential tools required for the activity. If you were unsuccessful in any of the questions, this indicates that you will need to spend additional time practicing with the tool being looked at in the question:

1. Using the MathsNet web site on the internet.
2. Using a standard word processor (OpenOffice Writer, Microsoft Word or similar)
3. Locating the software for producing mathematical equations in your office suite.
4. Using a standard spreadsheet programme (OpenOffice Calc or Microsoft Excel)
5. Installing and launching the MSW Logo software from the supplied materials. Ensure that you are able to gain access to all of these tools. Ask your fellow students or your course tutor for help if needed.

### Overview

Universities have been using computers since they were first developed in England, the USA and Russia in the late 1940s. Students would learn to program and operate computers as part of computer studies courses. Computer programming languages such as Fortran, Pascal and later C++ have mathematical functions built in to them. Hence, students of mathematics have been able to use software to support them in solving mathematical problems for a long time. However, the idea that a computer could help you learn mathematics was not considered.

The first significant change was the availability of electronic calculators. These became cheap enough that they could be bought for use in schools in the early 1970s. Teachers of mathematics then had to consider: what is the point learning long multiplication, if I can buy a cheap machine that will do it for me? It is interesting to see that schools in the UK still teach long multiplication even when a calculator can be bought for US\$1.

However, more thoughtful teachers recognised that calculators offered opportunities to devise activities where students would be able to explore numbers and number patterns. They still taught written and mental methods for calculating, but they also set up activities where students could experiment.

From the late 1970s, the price and size of computers came down to a point where they too could be considered possible resources for schools. Initially students were taught to program the computers using the most common built in programming language BASIC. However, educationalists from the Massachusetts Institute of Technology led by Seymour Papert developed a new programming language called LOGO. This provided a set of functions which the user could use as the starting point to develop their own functions. As their work progressed they would be able to create their own worlds, called Microworlds. The ideas behind this were published as a book which has become famous in the history of school computing. The book is called *Mindstorms* (Papert, 1980).

### **Access the internet**

#### **Activity 3.1.1 Internet Reading**

Look at Seymour Papert's personal site to follow the history of LOGO: <http://www.papert.org/>

Find MSW Logo (this is free software) and a collection of resources and materials: <http://www.softronix.com/logo.html>

### Activity 3.1.2 Using Logo

1. Install MSW Logo
2. Launch MSW Logo
3. Click OK twice to get past the welcome messages.

You will see two separate windows. The top one has a triangle in the middle. This can be moved and is called the turtle. The bottom window is where you type in your instructions. It is called the commander, because you can type and record your commands. The commander has an upper part where commands are recorded. You can only type in your commands in the line at the bottom. This is called the command line.

4. Click in the commander.
  - Type FD 50 and press RETURN on your keyboard. (Important: There must be a space between FD and 50).
  - The turtle in the middle should move 50 units forward.
  - Type RT 90 and press RETURN.
  - The turtle should have turned to the right by 90°.
  - Type FD 50 and press RETURN on your keyboard.
  - The turtle should have moved 100 units forward.

You have now learned some basic LOGO commands. FD stands for Forward. So FD 20 moves forward 20 units. RT stand for Right. So RT 60 turns right 60°. [Remember: you must type a space between FD and 20 and press RETURN]

You should experiment with LOGO. First make sure you can make the turtle draw a square. Here are some extra commands which will be useful:

- CS stands for clear screen. This puts the turtle back at the start.
- LT stands for Left. So LT 30 will turn left 30°. [Remember to press RETURN]

When you are ready, look at the help files. Click the Help menu and select Index. Choose the getting started section. Select Where to Start. Work through the suggestions in this section. You will see how you can make new commands which use variables.

### Formative Assessment

#### Activity 3.1.3 Supporting mathematical understanding using LOGO

Write a short passage (500 words) to suggest how LOGO can help students better understand mathematical concepts. Include examples of LOGO commands you have used.

### Opportunities and Difficulties

There is now a very wide range of software and hardware which can support learners with their mathematics. These provide different opportunities support learners in different ways.

### **Reading Activity**

#### Activity 3.2.1 Entitlement to ICT in secondary mathematics

BECTA is a UK government agency whose task is to report on the use of ICT in schools. 'Entitlement to ICT in secondary mathematics' is a 9 page report designed to explain the different opportunities learners are entitled to experience in their maths lessons in UK schools.

Read the report. Make notes from your reading to remind you of the different experiences. When you read the description of different hardware and software types below, you should identify which hardware and software could be used to provide each different experience.

### Hardware and Software to Support Learners of Mathematics

You should be familiar with general computer equipment from your ICT basic skills course. These are the types of facility that are used to support mathematics lessons in schools:

#### **Hardware:**

- Computer workstations with some form of internet access. The most common operating systems are Windows, (98 or XP); Macintosh (system 9 or OSX); Linux.
- Graphical Calculators. These are small handheld machines which look like large calculators. They have screen capable of showing many lines of text and graphics. All are capable of drawing graphs of different functions. Some are capable of doing algebra symbolically. Essentially, they are small computers capable of running some of the same software that works on computer workstations.
- Basic and Scientific calculators. Standard calculators can be used in classrooms to give learners opportunities to explore number concepts. They need to be used with care to avoid students relying on them to do calculations. However, well designed activities are very supportive. The most modern type have two lines in their display and can show letter as well as numbers for some algebra activities.

- **Data Logging equipment.** This is more common for scientists, but mathematicians use it as well. This is equipment which collects data from experiments, for example taking the temperature every 2 seconds for an hour, to look at the cooling of a hot liquid. The equipment comes with many probes to measure different things e.g. temperature, light intensity, potential difference, etc. etc. Different types of equipment is available for both computer workstations and for graphical calculators.

### Software:

There are different types of software available to support learners of mathematics. An example of each type is available for both Windows and Macintosh computers and some are also available for Linux. High quality open-source (free) software is available for the most important types. The disk supplied with this course contains a complete library of open source software. You will be introduced to it in section 1.3. Also in section 1.3 there will be examples of all different types of software being used.

**Generic Software.** Standard software types which can be used for specific mathematical applications:

- **Spreadsheets.** Spreadsheet programs are very commonly used in mathematics teaching. Spreadsheet functions can be used to do numeric algebra and to set up sequences. These can then be graphed as  $(x, y)$  plots. They are very powerful for statistical calculations and charting.

Examples: Microsoft Excel, Lotus 1-2-3, Corel Quattro Pro, Appleworks, Open Office.

- **Word Processors:** All word processors have software for printing mathematical expressions neatly and correctly. This often has to be specially installed and is not included unless you make changes when installing for the first time. For most paid for word processors the software is called Equation Editor.

Examples: Microsoft Word, Lotus Write, Corel Wordperfect, Appleworks, Open Office.

- **Presentation Graphics:** Teachers can make clever presentations to demonstrate mathematical ideas to their students. The presentations can include movement and opportunities for the student or teacher to control what happens.

Examples: Microsoft PowerPoint, Appleworks, Open Office.

### Mathematical Software.

- **Dynamic Geometry:** This software allows the user to create geometric constructions as if they were using ruler and compasses. At first they look like drawing software. However, you can only draw according to geometric rules. This means that students can explore the effects of constructions. They can make and test hypotheses.

Examples: Cabri Geometre, The Geometers Sketchpad, GeoGebra (open source)

- **Dynamic Statistics:** With this software users can analyse statistical data, making calculations and creating statistical charts. One particular software (Fathom) allows users to see the effect on the data of making changes to the chart. It also allows hypotheses to be set and tested.
- Examples: SPSS, Fathom o Graphing software: This software allows the user to draw graphs of functions. The graphs can be in 2 dimensions or often 3 dimensions. Often graphs of differentials can be shown. Also, some systems include statistical charts and calculations.

Examples: Autograph, Omnigraph, Graph (open source)

- **Computer Algebra Systems (CAS):** This is software that performs algebra symbolically. It can integrate and differentiate functions in symbols, giving general results. The most sophisticated of these are used by professional mathematicians to do the routine mathematics involved in their work. In schools they allow students to explore algebra and symbolic mathematics.

Examples: Maple, MathCad, Mathematica, Derive, Maxima, EigenMath

- **LOGO:** A computer programming language designed to allow learners to explore in a structured environment.

Examples: Imagine Logo, MSW Logo (open source)

### Mathematical Typesetting and Diagram systems.

o It is very difficult to write mathematics neatly and accurately on a computer. Firstly equations and expressions are very difficult to typeset properly. Secondly there are many detailed and complicated diagrams, including charts and graphs. There are a number of different software alternatives to help.

- FX Draw has facilities to typeset equations, and a library of standard diagrams, charts and graphs which can be quickly modified to produce what is needed.
- Math Type produces equations from a library of standard templates. (Math Type is the full version of Equation Editor which is included in many popular word processors).
- LaTeX is a standard system for setting out equations. It uses a special code which must be learned. It is the standard way for professional mathematicians to publish their work in journals and books. There are many different software tools to make the process easier.

Examples: WinEdt, MiKTeX

### Mathematical Activity Software.

o There are many examples of software games and activities which are designed to help learners understand particular mathematical topics. Sometimes these take the form of teaching sequences, with examples and exercises. Other examples are in the form of computer games in which mathematical problems need to be solved to make progress in the game. Finally some examples provide mathematical settings where users can explore a particular topic with opportunities to change specific features, for example, transformational geometry. The user can decide the vertices of a shape and chose from a menu of transformations to see the effect.

Examples: Zoombinis (Broderbund), DLK

### Computer Learning Systems.

o This software provides a complete teaching course. The entire syllabus of a course in mathematics is organised so that each topic has teaching material, examples, exercise and activities. The user will be tested and guided to work on particular topics according to need.

Examples: Research Machines Maths Alive!

### **Access the Internet**

Appendix 1 contains a copy of the examples sections for all of the software mentioned above. All of the examples have live links to websites with information about the software. Follow all of the links to get a better idea of the software being discussed.

### Formative Assessment

#### Activity 3.2.3: Local Issues in Using ICT

Consider your local circumstances:

- (a) As a student learning on this course, and
- (b) As a teacher of mathematics in a local school.

Write a short piece (500 words) to describe in both cases, what access to ICT facilities exist now and could possibly exist in the near future. Consider the possibility of pupils, students and teachers being able to:

- Spend some time at a computer.
- Access the internet.
- Install and use open source (free) software from the CD provided with this course.
- Buy and use commercial software.

You should consider all local circumstances, such as internet cafes, local colleges and other institutions who can share facilities.

#### 3.2.4 Commentary

Sometimes access to ICT facilities can be very difficult. Graphical calculators are very rare indeed. It is often difficult for a student to gain access to a single computer, just to use open source software. Internet access is sometimes unreliable and can be expensive. In Europe and the USA it is common for schools to have rooms fully equipped with enough computers for every student to have one each. However, things are changing. Through the African Virtual University (AVU) and other agencies more computers are becoming available in the principle Universities and in regional centres. Computers are getting cheaper and cheaper making them easier for smaller schools and colleges to buy at least one. This course has been designed to show you the different possibilities to allow you to evaluate the possibilities for improving the teaching and learning of mathematics. It is important to make clear that in Europe and the USA, there is not a clear view as to the improvements which are possible. There are many computers, but the change in teaching practice is slow. In the African context, it is possible to be part of the development of good ideas in mathematics education, even before widespread use of the technology in schools.

Almost all of the best ideas for using ICT to support teaching and learning in mathematics can be done on software which is free (and is available on the course CD). The commercial software is often very clever and has many advanced functions. However, for teaching in schools these are not necessary. Of the categories in section 1.2.2 the last two sections contain the most expensive software. A copy of a computer learning system can cost a license fee of US\$5000 per year for one school. This is clearly too expensive for many schools. Happily, the evidence

suggests that these are not very effective and that good teaching with books and paper can be a lot better.

Also, mathematical activity software is now being replaced by a large collection of well produced activities which are available on the internet. All of the generic software and the mathematical software is available in open-source (free) versions which provide the most interesting possibilities for students and schools.

### 3.3 Examples of using ICT to support teaching and learning in mathematics using Generic Software

#### **Software Activity**

You need to have access to a computer with a common office suite installed. There will be differences between different software. However, the activities should work on all common office suites. If there is no office suite installed, the open source office suite, open office is available on the disc accompanying this course. All parts of this suite works very well indeed and are a more than adequate alternative to expensive standards such as Microsoft Office.

#### **Activity 3.3.1 Using a Spreadsheet to investigate sequences.**

- Find the 5 activity sheets S1, S2, S3, S4 and S5 called Spreadsheet Sequences.
- Work through the activities step-by-step.
- Worksheet S5 has a collection of mathematical tasks to complete.

[The sheets were originally prepared by the author for the Lewisham talent ICT training service. The screen shots show Microsoft Excel].

#### **Activity 3.3.2 Using a Spreadsheet to investigate data with statistics.**

Find the spreadsheet: Scatter\_Plot.

Look at each tab in turn:

- In Data the data has been typed in.
- In Chart an x/y scatter plot has been created using the Chart Wizard
- In Stats the chart is selected and Insert Statistics has been used to insert a

linear regression line (line of best fit). Also, the function correl has been used in cell B15 to calculate the correlation coefficient.

### Activity 3.3.3 Using a Presentation Graphics program to produce an interactive demonstration.

- Find the 3 Presentation Files: Fraction Arithmetic, Fractions Presentation and Pythagoras presentation.
- Double click on each file in turn to run the open the presentations. Press F5 or choose View Show.
- In the Fraction Arithmetic presentation: only use your mouse to click on buttons DO NOT use the spacebar or arrow keys. Click on the fraction you want to view, then click on the Forward and Start buttons.
- In Fractions Presentation: click on different points on the graph. See how many different fractions you can find AGAIN - DO NOT use the spacebar or arrow keys.
- In the Pythagoras presentation: use the spacebar to show the presentation.

When you have worked through the presentations, you should work through the document Making a Fraction Arithmetic Presentation in the Resources Unit 1 folder. This shows you step-by-step how to create the Fraction Arithmetic Presentation. The document shows Microsoft PowerPoint, but it works equally well with OpenOffice.

### Formative Assessment

#### Activity 3.3.5 Evaluating the generic software activities

Write a short piece (500 words total) to evaluate the 4 generic software activities (1.3.1 to 1.3.4). You should comment on:

- Any advantages (or disadvantages) in student's understanding of the mathematical ideas presented.
- The requirements for this approach to be available to students and teachers considering your own working circumstances.

# Learning Activity 4

(specific in Mathematics):

## **Maths Activities with Dynamic Software.**

### **Summary of the learning activity**

In this activity you will look at the range of dynamic software available to support teaching and learning in mathematics. You will evaluate different types of software and graphical calculators and consider their use in the African context. You will compare free open source software with commercial alternatives. You will discuss and develop activities to integrate dynamic software into teaching programs.

### List of relevant readings

1. ICT bringing advanced mathematics to life (T-cubed New Orleans), Adrian Oldknow, 12 March 2004 (File name on CD: AO Tcubed 2004)
2. Exploring Mathematics with ICT, Chartwell Yorke, 2006 (Note: this is a product catalogue from a commercial company – this is not intended to promote the company, but to benefit from their descriptive summary of available software)

### List of relevant resources

The ICT resources for this unit are contained in the folder named Resources Unit 2. These consist of worksheets and files to use. All of the files can be operated using software which is open-source (i.e. free to use) and is contained on the CD. Specific references are contained in the activity sections.

The open source software itself is also included on the course CD. You will need access to a computer on which you are able to install software. You will need to install all of the software provided. In this unit all of the software is specialist mathematics software.

### List of relevant useful links

Maths Net: <http://www.mathsnet.net/>

This is a very wide ranging site which contains reviews of many maths software and hardware. The site also a large collection of activities for teachers and students.

Chartwell Yorke

<http://www.chartwellyorke.com/>

This site belongs to a commercial company who sell dynamic mathematics software. It is nonetheless the best place to see the range of commercial dynamic software. The site also contains links to trial software and downloads.

Oundle School/TSM

<http://www.tsm-resources.com/suppl.html>

A site containing a categorised set of links to the internet sites of software authors and manufacturers.

Detailed description of the activity

This activity is composed of three sections:

1. A discussion of the types of dynamic software.
2. A detailed overview of the different types of dynamic software available for mathematics education.
3. Designing and developing activities to integrate dynamic software in the teaching and learning of mathematics.

## 4.1 Overview

### Introduction

Mathematicians and mathematics educators have a very wide range of excellent software available to them. The strong relationship between computer programming and mathematics has meant that software that does mathematics has been developed since the earliest days of computing. All high level computer programming languages contain commands for mathematical functions. Computer programmers need to make objects move at different speeds. They make this happen using the equations of motion, that mathematicians study in mechanics courses. So, the programming language must have the functions needed to do this. When a computer generated character appears on screen, their position is fixed using coordinates. The movement from place to place is calculated using trigonometry. So, the programming language naturally uses  $(x, y)$  coordinates and includes a full range of trigonometric functions.

### Reading Activity

#### Activity 4.1.1

Read Exploring Mathematics with ICT by Chartwell Yorke. This is the product catalogue of a commercial company who sell maths software to schools. However, they have produced this excellent little book which gives a clear and thorough overview of the range of dynamic software available to support mathematics educators.

Explore pages 2 up to 31, to see the functions of a wide range of dynamic maths software.

Write your own summary of the different programs giving examples of the mathematical ideas that they are able to support. You will notice the prices that this software is sold for in the UK (prices in GB pounds) at the back of the booklet. This suggests a clear issue for teachers, schools and students gaining access to this software. However, many of the functions are available in open source (free) software which you will explore in this unit.

### Reading Activity

#### 4.2 Dynamic Software

In this section you should explore and become familiar with three types of dynamic software: graphing, algebra and dynamic geometry.

#### Activity 4.2.1 Bringing Maths to Life

Read the article by Professor Adrian Oldknow called ICT bringing advanced mathematics to life. (File name on CD: AO Tcubed 2004). This can be a complicated article to understand if you are not familiar with maths software. However, our intention is that you get an overview of the types of software which can be useful. Also, we want you to see some pieces of mathematics which can be supported using sophisticated software.

Make notes from your reading under two headings:

- Name of software and what it does.
- Mathematical problems that can be supported using this software.

### Software Activity

#### Activity 4.2.2 Using Graph drawing software

Install the program called Graph. You should double click the SetupGraph file in the folder called Software Unit 2. When the program is installed launch it. Click CLOSE to get rid of the 'tip of the day' and maximise the window.

- On the Function Menu, click Insert Function. (Pressing the Insert key is a shortcut).
- Click in the line next to = and type:
- (See the box below for tips on typing other functions)
- Click OK
- You should see a graph of
- You can immediately see the roots of the equation )
- On the Function Menu, click Insert Function. (Pressing the Insert key is a shortcut).
- Click in the line next to ) = and type:
- You should see graphs of and  $f(x) =$
- You can immediately see approximate solutions to the equation
- We can use the Zoom functions to get a closer look.
- On the Zoom menu choose Window. Click and drag diagonally to cover one of the two points of intersection. This will zoom in on the window you create.
- Now point your cursor to the point of intersection. In the bottom right hand corner of the screen you can see the position of the cursor, which tells you the solution.
- You can repeat the process by zooming in again, to get a more accurate solution.
- If you get lost you can go back to the original zoom by choosing Standard on the Zoom menu.

#### Entering algebra into maths software

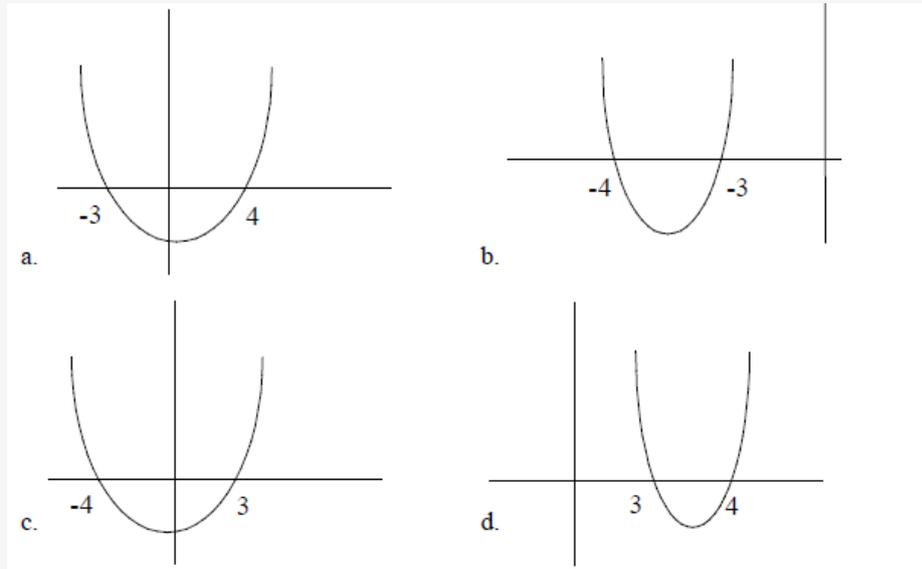
Typing algebra is difficult. So maths software uses certain standards for typing. Follow these tips:

- Don't add spaces. Type  $x + 3$  not  $x + 3$
- Only use a full stop as a decimal point. Do not put them at the ends of statements. Type 2.3 not 2.3.
- Use ^ (above the 6 key) to mean 'to the power of'. Do not try to use superscript. Type  $2^3$  not 23
- Use brackets to make the order of operations clear. Type  $\sin(x)$  not  $\sin x$ . Type  $3^{1/2}$  not  $3^{1/2}$
- Special functions are possible, for example: Type  $e^x$  for the exponential. Type  $\sqrt{x}$  for the square root. Type  $x$  for the natural logarithm.

You should experiment with the software. Find out as much as you can about what it can do. Especially experiment with the Function menu and the Calc menu. The help menu has a list of available functions. Also choose Contents and Index and select How to use Graph for an introduction. You should explore the help pages for guidance.

### Formative evaluation

1. Sketch a graph of clearly showing the roots. Choose which is the correct graph:



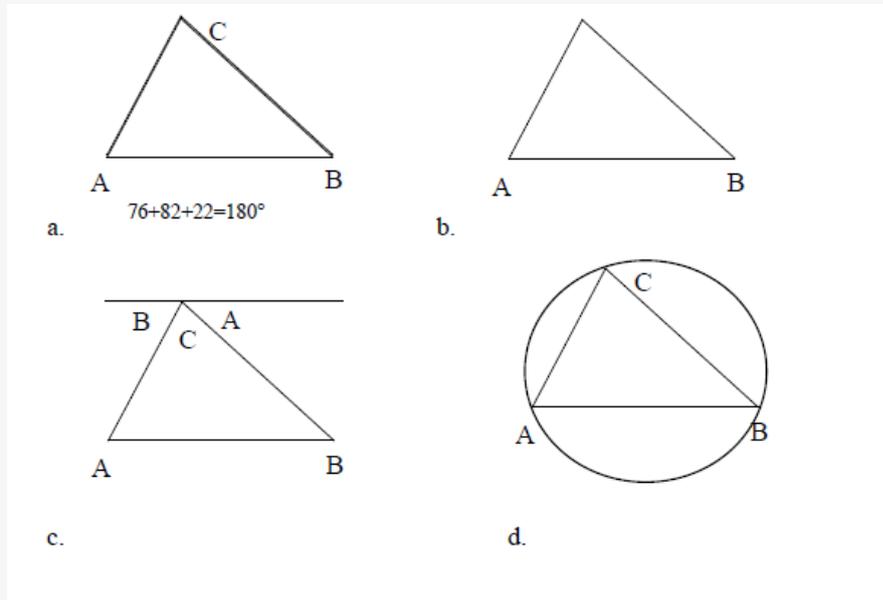
- 2.

2. Integrate:  $\int(x^2 + 5x)dx$

- a.  $\frac{x^3}{3} + 5 + C$
- b.  $\frac{x^3}{3} + \frac{5x^2}{2} + C$
- c.  $2x + 5 + C$
- d.  $3x^3 + 5x^2 + C$

## Learning Activity 4

3. Which diagram could be used to prove that the sum of the interior angles in a triangle is  $180^\circ$ ?



4. Install the program called Graph onto a computer. The setup file is called SetupGraph and is in the Software Unit 2 folder on the course CD. Click CLOSE to close the 'Tip of the day'. In the Help menu choose About. Who holds the copyright for this software?
- a. Ivan Johansen
  - b. Jane Parker
  - c. Hung Nguyen
  - d. Matola Ndabagoya
5. Install the program called Maxima onto a computer. The setup file is called Maxima\_SetUp and is in the Software Unit 2 folder on the course CD. Launch the program wxMaxima. (Be careful to choose the one which starts with 'w'). Click CLOSE to close the 'Tip of the day'. What is the first item in the calculus menu?
- a. Differentiate
  - b. Taylor's Expansion
  - c. Fourier Analysis
  - d. Integrate

Formative Assessment

### Activity 4

1. b                      2. b                      3.a                      4. a                      5.d

Each question in the pre-assessment tests a different aspect of the requirements for the activity. If you are unsuccessful in any question it is very important that you do the additional work suggested.

Note especially that questions 1, 2 and 3 test your knowledge of high school maths. If you are at all unsure about these questions, you should spend time making your knowledge at this level more secure.

1. You will need to review your knowledge of polynomial functions and their graphs. Review your high school work and practice drawing and identifying graphs of a range of linear, quadratic and cubic functions.
2. You will need to review your knowledge of basic integration. Review your high school work and practice finding the integrals of a range of linear, quadratic and cubic functions.
3. You will need to review your knowledge of Euclidean geometry. Review your high school work on constructing simple proofs of angle relationships. Make sure that you are clear about what the requirements of a proof are.
4. You will need to be able to load the supplied software onto a computer and begin to use it. If you were unsuccessful with this question you will need to seek help from your fellow students or your tutor. The same as question 4. You will need both of these programmes. Also, make sure that you can successfully install and run the GeoGebra software.

### Software Activity

#### Activity 4.2.3 The Advantages and Disadvantages of using Graph

In the Resources Unit 2 folder, you will find two 2-page worksheets designed for school students. The first guides them to explore linear graphs and the second to explore quadratic graphs. They are called Linear Graphs Worksheet and Quadratic Graphs Worksheet. Work through these activities yourself using Graph.

Use the worksheets as a guide to prepare a short report (500 words) describing the advantages of using software like Graph to support school student's understanding of graphs and functions. Especially considering your local circumstances comment on any difficulties you might face in using this software. Suggest how you would be able to overcome them. Also, comment on any disadvantages to the learner in using software such as this.

### Activity 4.2.4 Computer Algebra: Getting Started with Maxima

Computer Algebra Systems (CAS) are generally designed for students of mathematics and professional mathematicians. They are not designed to be easy to use! This means that it is very important to think carefully about how they might be used in a school situation. Students will need very clear instructions and quite a lot of help.

However, you are a student of mathematics and of education, so you should be well placed to explore the possibilities of CAS. It is important to understand that we could not possibly show you all of the possibilities in this type of software. We will only show you the most basic starting point. However, we hope that this will be enough to encourage you to explore the software and think about possibilities for use with your students.

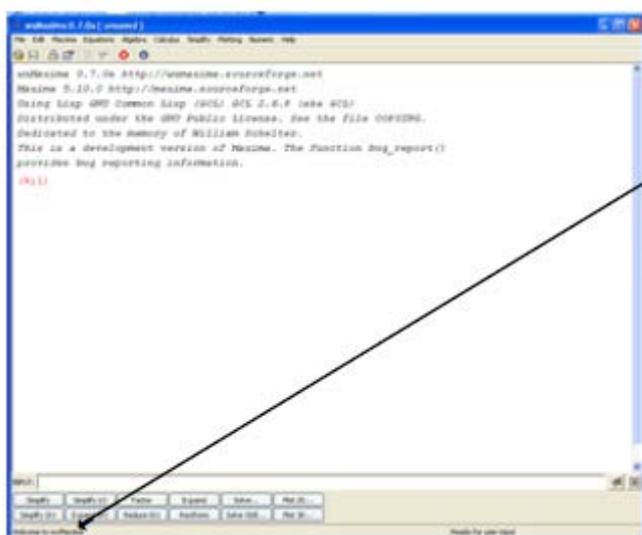
The course CD contains a copy of a CAS system called Maxima. This is open- source software and is free for anyone to use. The Setup file is in the Software Unit 2 folder, it is called Maxima\_SetUp. Double click on this file to install the software.

This software is initially similar to MSW Logo, that you used in Unit 1 of this module. It relies on commands which are typed into the system on a special line which is ready to accept them. This is know as command line software. Programmers normally use software that works like this.

Before you begin, it is important to understand that Maxima works in a very mathematical way. You have to define functions, variables and matrices before you can use them. You have to be very careful with exactly how you type everything. You will get lots of messages telling you that you have made a mistake! We will get started by trying some algebra. Be very careful with brackets. Maxima always puts in a closed bracket as soon as you type an open bracket. This means that you are often left with too many closed brackets!

You should launch now Maxima. You should use the version called wxMaxima. Check carefully that you are using the correct version. The screen should look like this:

Type your commands in here



Type your commands in here

## First Steps with Maxima

### 1. Factorisation

#### 1. Factorisation

Click in the input space and type:

```
(%i1) factor(3*x*y+6*x);
```

```
(%o1) 3 x(y + 2)
```

- ◆ `factor(3*x*y+6*x)` and press the ENTER key.
- ◆ Maxima has factorised the expression for you. Notice that you must put a \* sign in for every multiplication. If you just type `xy` then Maxima thinks this is a single variable `xy`. If we type `x*y` then maxima knows there must be two variables `x` and `y`.

#### 2. Expansion

Click in the input space and type:

```
(%i1) expand((x+1)^4);
```

```
(%o1) x^4 + 4 x^3 + 6 x^2 + 4 x + 1
```

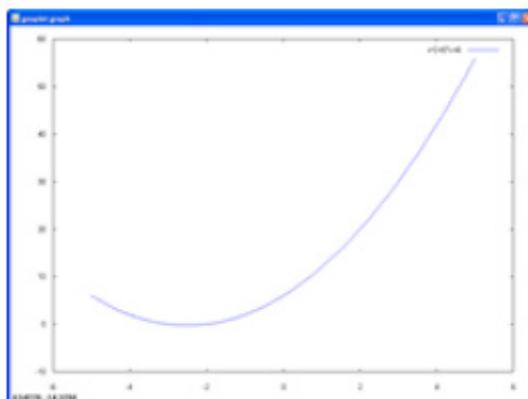
```
(%i2)
```

- ◆ `expand((x+1)^4)` and press the ENTER key.

### 4: Graphs

We graph the functions we have already entered.

Click in the input space and type: `plot2d(f(x),[x,-5,5])` and press the ENTER key.



[Notice that we say the function we want to plot, then put a comma then put a list inside square brackets with the variable, the minimum value and the maximum value. In this case the variable is `x` and the graph is to be drawn from -5 to 5]

The graph is drawn in a new window. Close this new window when you are ready to move on.

### 5: Calculus

You should now spent time experimenting with Maxima. Here are some hints and tips:

- Many functions can be found in the menus. When you use the menu, Maxima provides a helpful dialogue box to help you get the entry correct. This is sometimes easier than typing the command yourself.
- The help menu contains a full manual for the software. In the Help menu choose Maxima help.

### Commentary

Although CAS systems can take some time to learn, they speak the language of mathematics. A proficient user of maxima is learning to speak mathematics in a sophisticated way, as they learn to use the software. At it's simplest level, Maxima does the algebra and the calculus for you. So, you can check your working and you could explore and experiment with lots of different possibilities. For example, you could explore which functions can be integrated and which cannot. Students could explore the factorisation of a range of expressions and make a presentation on how to factorise based on what they have found.

The professional mathematician might use Maxima to find solutions to sophis- ticated problems. However, the student of mathematics can use it to explore the types of solutions that exist in different circumstances and the ways that algebra can be used to modify the form of an expression.

## Formative Assessment

### Activity 4.2.5 The Advantages and Disadvantages of using Graph

Prepare a short report (500 words) giving examples of mathematics that you have done using Maxima. Describe the advantages of using Maxima to support your understanding of algebra and calculus. Explain how this could be useful for school or college students learning mathematics with yourself as their teacher. Consider your local circumstances to comment on any difficulties you might face in using this software. Suggest how you would be able to overcome them. Also, comment on any disadvantages to the learner in using software such as this.

## **Software Activity**

### Activity 4.2.6 Dynamic Geometry: Using GeoGebra

Dynamic Algebra software is designed to offer facilities for users to work with Euclidean geometry. At first look it seems to be like a drawing program. In fact it is a very poor drawing program, because you are not allowed to draw anything that could not be done with a ruler and a pair of compasses. True Euclidean geometry does not allow for a ruler. However, dynamic geometry programs have the extra facility of measurement. You can measure lengths of lines, angles and even areas of closed shapes.

From the learner's point of view, it is important to see that dynamic geometry programs use correct mathematics. Especially, you must use correct terms for constructions and for transformational geometry. In using this software, the user must learn to speak mathematically.

The course CD contains a copy of a dynamic geometry system called GeoGebra. This is open-source software and is free for anyone to use. The Setup file is in the Software Unit 2 folder, it is called GeoGebra-2.7.1.0. Double click on this file to install the software. Notice that you must have java installed on your computer for GeoGebra to work. If it doesn't work, you will have to install Java (also free). Try the Setup file called geogebra\_setup\_jre. This includes Java. Go to the GeoGebra installation page (see below) on the internet for the most up-to-date files.

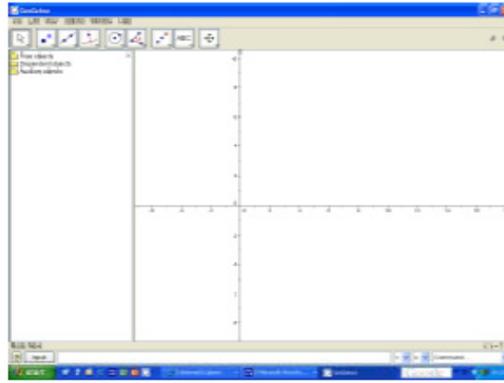
Web Links for GeoGebra:

- Home Page
- Installation Page
- Teaching Resources Page

Launch GeoGebra.

The opening screen should look like this:

## Learning Activity 4



The main functions of the software are controlled by the large buttons underneath the menu.

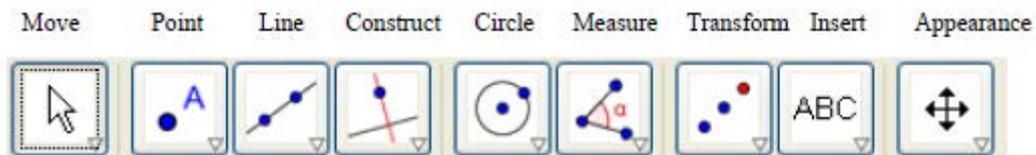
Move your mouse slowly over these buttons. This will tell you that they are for. If you click the middle of the button it will do what it says. Notice that each button has a small triangle in the bottom right hand corner. In fact each button is really a menu. Clicking the triangle brings down a list of all of the functions on the menu. This is what the menus are for in general:

he software operates graphically, so it is difficult to describe how to use it in words. We will give some instructions to get you started. However, you must read the information in the help files and use this to explore how the software works.

Screen capture

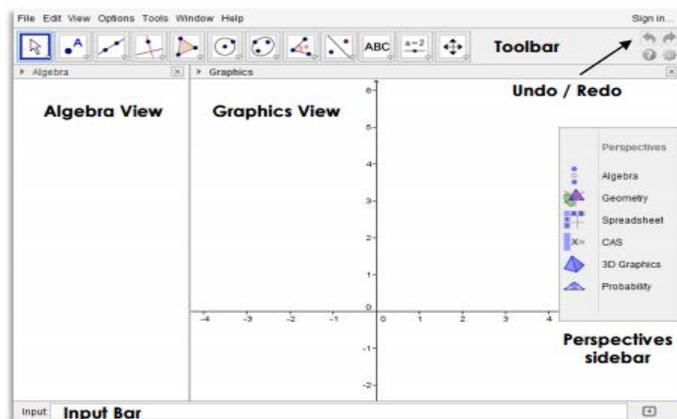
African Virtual University 76

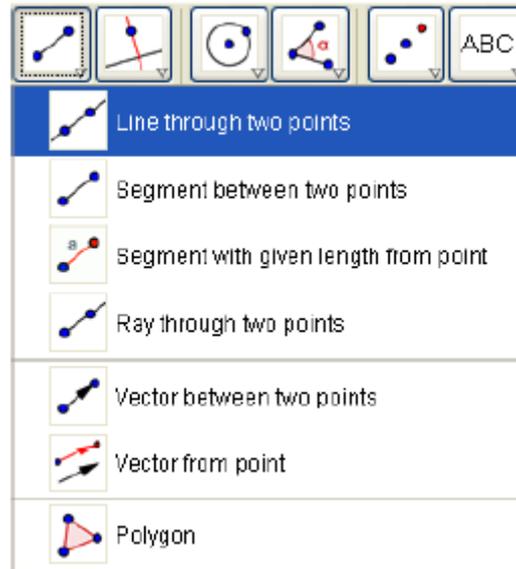
Move Point Line Construct Circle Measure Transform Insert Appearance



- GeoGebra is also an authoring tool for teachers to create interactive worksheets. Find free classroom materials and share your own on [www.geogbratube.org](http://www.geogbratube.org).

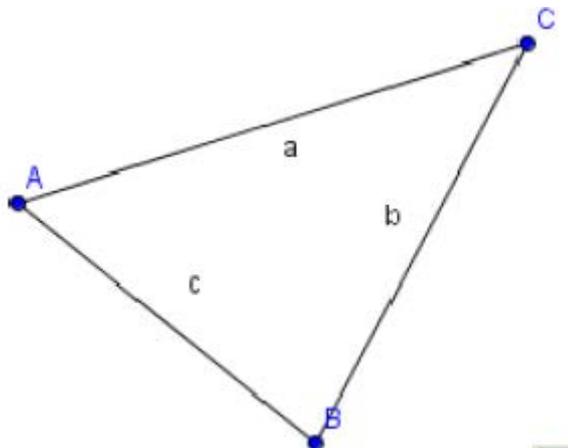
## Getting Started





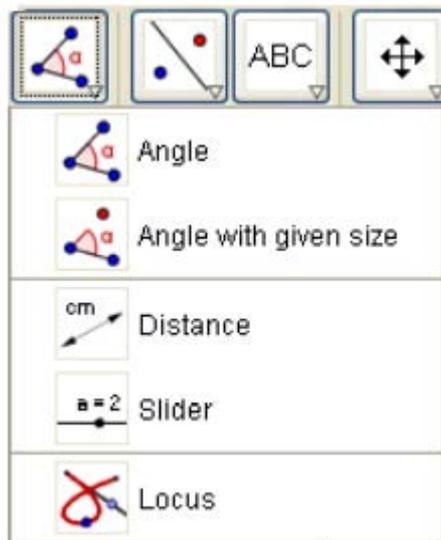
### First Steps with GeoGebra

- Click the point button
- Click in three different places on the screen (these will be the vertices of a triangle)
- Click the small arrow on the line menu (to show the whole menu)
- Choose Segment between two points
- Move the mouse carefully to the first of the points you made. Click on it.
- Move to the second point you made and click again.
- You should have joined the points with a line segment.
- Now click again in the second point and then click in the third point to join them with a line segment.
- Now make click in the third and first points to complete a triangle.



## Learning Activity 4

- Now you can see that this is dynamic! Click (and hold) on any one of the vertices and drag it to a different place. Leave it in a reasonable place before continuing.
- Use the measure button to choose Angle
  - Click on the point A
  - Click on the point B
  - Click on the point C
- On the left hand side you will see that the angle ABC has been measured.
- Now click and drag the point B and watch the angle measurement changes to show the new size as you move the point.



- Notice that the position of your points and the lengths of the lines are measured automatically.

Now Practice:

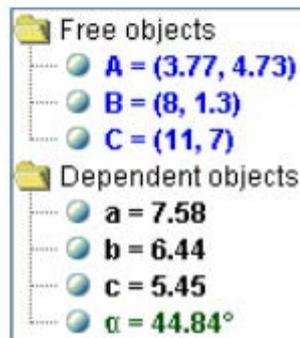
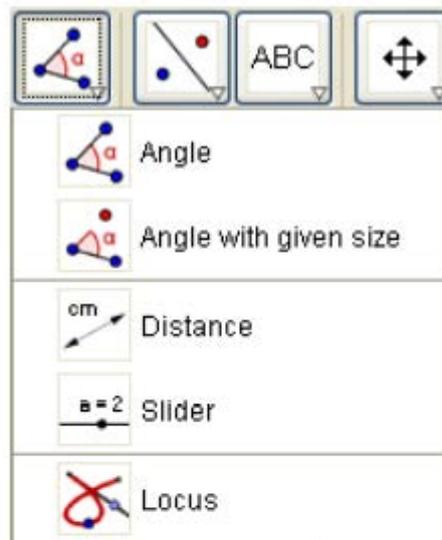
- Experiment constructing different lines.
- Experiment constructing polygons.
- Experiment constructing circles.

## Second Steps with Geogebra

- Use the Line button, choose Polygon to create an irregular quadrilateral.
- Use the Line button, choose Line through two points and construct a roughly vertical line a little to the right of the quadrilateral.
- Use the Transform button and choose Mirror object at line.
- Click in the middle of the quadrilateral then click on the line. This will create an image of the quadrilateral reflected in the line.
- Now check that it is dynamic. Click and drag one of the vertices of the object quadrilateral. See that the image quadrilateral changes accordingly.

Now Practice:

- Experiment with all of the different transformations.
- Now experiment with transformations: Construct a line and choose to construct a perpendicular to that line. Then drag the line to see that the perpendicular remains perpendicular! Now create other constructions.



### Activity 4.2.7

Construct a square in GeoGebra. You have succeeded ONLY when you can drag any point and the shape you have created remains a square.

### **Commentary**

The most difficult thing for the student is to visualise. Drawing one diagram takes a long time and requires the student to understand the construction or the transformation in order to make sure that it is correct. With dynamic geometry software, the student can create a transformation. Then they can change the image shape and see the effect. They can change the position of the mirror line and see the effect. With rotations they can change the position of the centre of rotation. In this way they will build up a mental picture of what transformations look like.

Students can explore angle relationships. They can measure the three angles in a triangle and check that they always add to  $180^\circ$ . They can move any of the vertices to check a vast number of different triangles very quickly. This is a very convincing demonstration for the student. However, they can extend this idea, by constructing diagrams and looking for interesting relationships. They can check them by dragging the points. If they find something, they should leave the computer and try to prove the relationship using geometry. Try constructing the angle at the centre and at the circumference in a circle. Measure the angles and check the relationship.

Euclidean geometry is all about creating constructions with ruler and compasses. The issue is to see what can be constructed. Did you succeed in constructing the square? Can you trisect an angle? Try to do this in GeoGebra.

### Formative Assessment

### Activity 4.2.8 The Advantages and Disadvantages of using GeoGebra

Prepare a short report (500 words) giving examples of mathematics that you have done using GeoGebra. Describe the advantages of using GeoGebra to support your understanding of construction, transformation and measures. Explain how this could be useful for school or college students learning mathematics with yourself as their teacher. Consider your local circumstances to comment on any difficulties you might face in using this software. Suggest how you would be able to overcome them. Also, comment on any disadvantages to the learner in using software such as this.

## 4.3 Designing and Constructing Teaching Activities

### Introduction

Dynamic maths software gives learners the opportunity to explore mathematical ideas. They can create mathematical statements, functions or diagrams and explore the effect of making changes on these.

There are effectively two different ways that the teacher can support the student in this process.

1. Use the software to demonstrate mathematical ideas in a dynamic way.
2. Create exploratory activities for students to engage with.

### 4.3.1 Demonstrations: Commentary

To use a computer for classroom demonstration requires a very large screen! The use of computer projectors and screen has become common in some countries. There are even touch sensitive screens that allow the teacher to control the computer just by pressing their finger (or a special pen) onto the screen. These are called interactive whiteboards. However they are very expensive and difficult to maintain. This is unlikely to be a useful possibility in less developed countries for some time to come.

However, if the teacher can get access to a computer and get some students to gather round and view the screen, then it is possible to show them a dramatically new way of looking at mathematics. A single laptop computer would be an excellent starting point. The teacher would need to prepare the presentation in advance and save it ready to show the students.

It is now quite common to find ready made presentations on the internet that teachers can use. GeoGebra has a wide community of users who share ideas on the internet. If you have access to the internet click these links to go to sites with teaching ideas:

- [GeoGebra English Page](#)
- [GeoGebra Main Page](#) (the best selection is in German)

## Formative Assessment

### Activity 4.3.2 Creating a Teaching Demonstration

On the course CD you will find a folder called Resources Unit 2. This contains some sample demonstration files. Open these files using GeoGebra. If the programs are installed, then double clicking on the files will open them. Read the commentary and try out the demonstrations.

#### **GeoGebra**

##### a. Triangle\_Interior\_Angle

Double click on  $\varepsilon = 180^\circ$  on the right hand side. You will see that  $\varepsilon = \alpha + \beta + \gamma$ . So the sum of the interior angles is  $180^\circ$ . Click and drag on all vertices of the triangle moving them freely to check that the sum remains  $180^\circ$  whatever you do to the individual angles. (You may need to click the Move button to get started.)

##### b. Circle\_Angles\_Centre\_Circumference

Notice the size of the angle subtended at the centre and the angle subtended at the circumference (shown in the left hand panel). Click and drag point D around the circumference. Notice that while it remains the angle in the major segment it remains the same. Look for a relationship between the angle in the major segment and the angle in the minor segment. Put point D back into the major segment. Compare the angle at the centre with the angle at the circumference as D moves around the circumference. This demonstration shows two of the circle angle theorems very clearly.

##### c. Rotation\_with\_axes

You can see an object shape ABCDE and an image shape A'B'C'D'E'. The coordinates of all of the points are in the left hand panel. The transformation is rotation about the origin. The angle of rotation is controlled by the angle in the circle. Click and drag on point H in the circle to see the effect of different angles of rotation. Compare the coordinates of the vertices of the object with the coordinates of the vertices of the image. Especially compare them when the angle of rotation is  $90^\circ$ ,  $180^\circ$ ,  $270^\circ$  and  $360^\circ$ .

**Activity:** Create a GeoGebra demonstration of your own. Decide on a piece of geometry to demonstrate. Use GeoGebra to create a dynamic diagram. Write brief notes to tell the user what to do with the demonstration.

### 4.3.3 Exploratory Activities: Commentary

One major advantage of dynamic software is that it allows learners to explore mathematical ideas. The teacher's role is to decide how to engage the learner in the idea. In this unit, we have created activities for you to engage with. As a teacher your task is to create activities for your students to engage with. After we introduced the software called Graph we asked you to work through two worksheets activities to investigate linear and quadratic graphs. This approach is simple to achieve and relatively cheap. Teacher can use copying machines (even using old style wax stencil copiers) to produce worksheets of their own design. The software is free and copies have been provided to you, so you can pass them on to your students. This means that the only resource required is a computer. Even if there is only one computer in the school (or indeed one in an internet café in the nearest town), the teacher can make sure that the software is installed. Then the student just needs the worksheet to go and explore some mathematics.

The worksheet then contains instructions to the student to tell them what to do. A common difficulty is in deciding how much detail to go into. It would be better if the student had practiced using the software before coming to your worksheet. Then you can describe the mathematics more clearly. However, this is always a compromise, so it is probably best to give fairly detailed instructions on using the software, while also explaining how to explore the mathematical idea.

The only problem with the printed worksheet is that the student has to follow instructions from the starting point of the software. In the previous section you worked with files that had been provided ready to use. These are often referred to as dynamic worksheets. To make them more useful to the student it is common to put the instructions into the document itself.

GeoGebra is able to save its files as HTML. This means that they can be used even if the software is not installed, just using an internet browser. In the File menu choose Export and select Dynamic Worksheet as Webpage. This brings up a dialogue in which you can type a title, say who the author is and date it. You can also give some instructions to the user. This is a true Dynamic Worksheet. Try out the worksheet version of Rotation\_with\_axes called Rotation\_with\_axes\_worksheet; this is in the Resources Unit 2 folder. Double click on the file and it will open in your internet browser.

Modify one of your files from Activity 2.3.2 to check that you can do this for yourself.

### Formative Assessment

#### Activity 4.3.2 Creating an Exploratory Activity

Open the worksheet called Investigating Binomials. Work through the activity using wxMaxima. Look carefully at how the worksheet has been constructed.

Look carefully at the dynamic worksheet Rotation\_with\_axes\_worksheet.

Look at the two graphing activities Linear Graphs Worksheet and Quadratic Graphs Worksheet, think about how they have constructed to support students in the activity.

Prepare:

1. A worksheet to engage students with a graphing topic in secondary maths using Graph. 2. A worksheet to engage students with an algebra topic in secondary maths using Maxima. 3. A dynamic worksheet to engage students with a geometry topic in secondary maths using GeoGebra.

## **XV. Synthesis of the Module**

### Summary of the principles and theories of pedagogical ICT integration

The scientific literature contains a broad range of statements on the principles and theories of ICT integration into instructional practices. This module identifies 28 key principles regrouped into 5 main orientations, each comprising a set of professional competencies to be developed in a teaching/learning context. Accordingly, teachers must be able to:

Exercise critical judgment and sensitivity regarding the real benefits and limitations of ICT as teaching and learning resources.

This first orientation includes 5 key principles:

- Vigilance and careful assessment of the impacts of ICT on their students and on their own work
- Alertness to social inequality or exclusion resulting from inability to access resources
- The principle that ICT are not of themselves generators of innovative educational change - The principle that ICT serve the behaviorist, cognitive, constructivist and instructive approaches equally well
- The principle that ICT should facilitate learning integration and transfer, make learning more meaningful, and help students develop their talents, imagination, resourcefulness, creativity, and the like.

- Identify and assess the potential of computer software and networking technologies to develop targeted educational competencies.

The 5 key principles stemming from the second orientation are:

- Exploring a number of educational sites to identify appropriate resources in the teacher's subject area or teaching field
- Maintaining an activity bank to help students with their learning and to support other educational practices
- Assessing resources not designed for instructional purposes and adapting them for the competencies targeted in the study program. Evaluating tools and selecting those that best develop the intellectual and relational competencies targeted. An assessment of the potential of computer software and networking technologies to develop targeted competencies would appear to be critical for achieving educational targets, seeing that many commonly used resources (grammar checkers, Web sites, audiotapes and videotapes, CD-ROMs, etc.) have not been specifically designed for educational purposes.
- Determining instructional needs and equipment requirements and eliminating items that are attractive but of little educational value.
- A thorough analysis of educational software to evaluate the content breakdown, presentation of learning and/or problem-solving steps, tracking reportage, and data handling.

Identify and communicate with a variety of appropriate multimedia resources (e.g., email), collaborative tools to which ICT can make a significant contribution.

Using ICT effectively, teachers can build networks for information sharing and professional development in their teaching fields and practices, bringing together the work and reflections of individuals with similar interests but from disparate locations. This orientation includes 9 pedagogical principles of effective communication that generate a "collective intelligence":

- Collaboration, teamwork, joint action, and utilization of the collective intelligence of individuals located at a distance
- The use of thematic, research, peer email, discussion group, databank, image, and sound networks. - Selection of interactive resources and audiences for specific objectives
- The necessity of establishing selection criteria for professional development resources
- The use of collaborative peer networks to help train new graduates as well as colleagues
- Building networks of teachers who share the same expertise - Guiding student-directed interactive learning - Helping students target, formulate, and refine their questions so that ICT information searches are relevant, meaningful and suitable.
- Careful precision in terms of the quality of language used.

## Learning Activity 4

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Use ICT effectively to search for, interpret, and communicate information and to solve problems

To better integrate learning resources, the information obtained must be converted into secondary culture (i.e. schooling) objects through the development of knowledge transfer competencies. The use of ICT therefore imposes new demands on teachers' ways of working: how they structure collective teaching, teamwork, individual work in the classroom, and homework. In this perspective, teachers must adopt 4 essential principles to help students use ICT productively for research and problem solving:

- Targeting of information, and critical analysis and conversion or transformation of useful resources into learning objects for educational activities
- Tracking of students' progress and interrupting their work as needed
- Raising awareness of Internet navigation and providing guidance, e.g., pointing out pitfalls
- Getting students back on track through suggestions, questions, and tips to help students develop critical search strategies.

Help students familiarize themselves with ICT and use it to carry out learning activities, assess their own use of ICT, and exercise critical judgment toward the information they find on the Internet.

Teachers must also have certain competencies and abilities in order to support student learning with ICT. Accordingly, 5 fundamental pedagogical principles must be applied:

- Developing basic and essential ICT competencies, with an emphasis on computer literacy: introduction to ICT functions and tools (familiarity with common software such as Word, Excel, PowerPoint, etc.) and basic operations (downloading, saving, and filing educational materials, compiling and organizing information).
- Choosing the appropriate tools for a given task, integrating a number of tools to solve actual problems, and using them on an everyday basis in a critical and productive way to serve as a model for the students.
- Using a diversity of ICT software to teach, learn, communicate, and solve problems in different subjects, and adopting clearly expressed, critical stance toward these technologies.
- Developing projects and the accompanying documentation (e.g., worksheets, digital portfolio) that integrate various aspects of the course content and extend the meaning of the information beyond the classroom. - Evaluating the learning achieved through specific questions, effective work processes (e.g., integrated online self-evaluative learning, access to glossaries and extra class notes at Internet-accessible hypertext sites, etc.)

The following figure illustrates the main orientations of the key pedagogical principles of ICT integration.

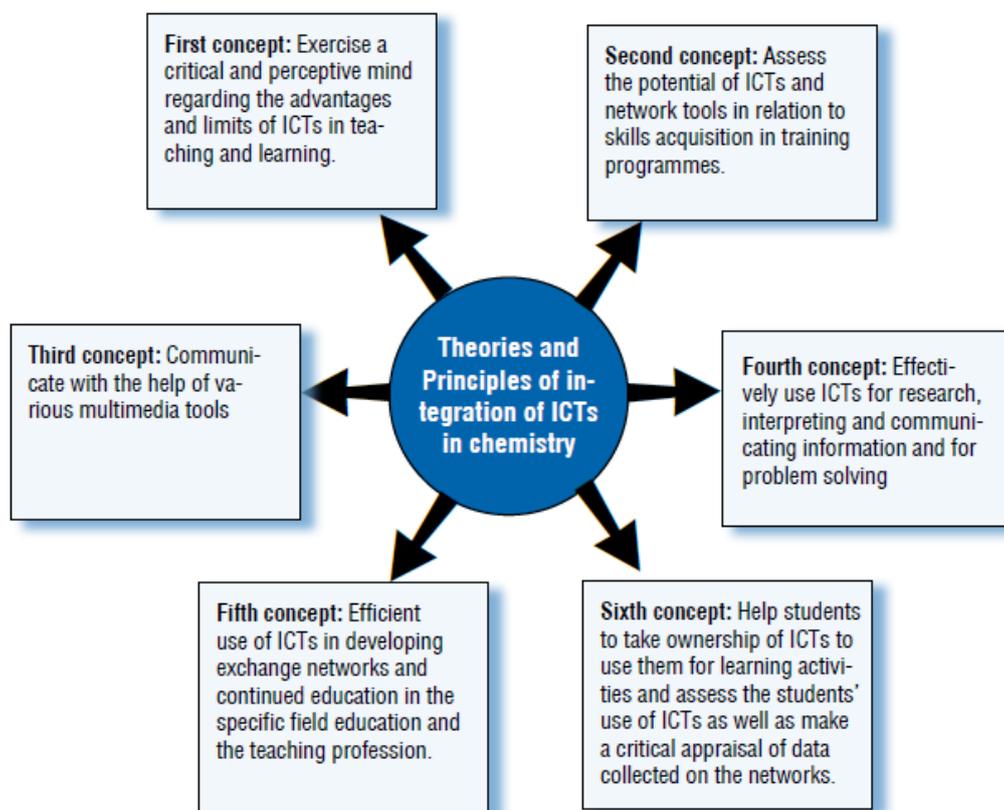


Illustration of Major concepts in the integration of ICTs in education

Learners should be able, through this module, to identify the key-concepts in the process of ICT integration, and to critically engage the required readings and resources (an important skill in Open and distance learning). Examples of learning activities, which can be modified to suit specific disciplines, are provided, as are a number of useful links (illustrated with screen captures), the latter presenting pedagogical resources and serve to guide educators and learners in their knowledge-seeking and training processes. A bibliography is provided to further support techno-pedagogical skills, facilitate research, lesson planning, teaching, problem-solving, professional development, and most importantly to enhance student's learning through ICT.

Sixth concept: Help students to take ownership of ICTs to use them for learning activities and assess the students' use of ICTs as well as make a critical appraisal of data collected on the networks.

## 15.2 Summary (specific in mathematics)

### Origins

We have looked at the beginnings of ICT use in mathematics education, starting with the development of the Logo programming language. You should now have access to a computer with MSW Logo installed and be able to use simple commands and words, such as FD 50 to move the Logo Turtle 50 units forwards. Early ideas such as MicroWorlds gave educators a vision of a possible technological future. However, these have been less influential in recent practice.

### Hardware and Software

We have considers the full range of hardware and software available for supporting mathematics education.

#### Hardware:

- Computer workstations
- Graphical Calculators.
- Basic and Scientific calculators.
- Data Logging equipment.

#### Software:

- Generic Software. o Spreadsheets. o Word Processors o Presentation Graphics
- Mathematical Software. o Dynamic Geometry o Dynamic Statistics o Graphing software o Computer Algebra Systems (CAS) o LOGO
- Mathematical Typesetting and Diagram systems.
- Mathematical Activity Software.
- Computer Learning Systems.

### **Using Generic Software**

We have considered classroom activities using spreadsheets and presentation graphics software. You should now have access to a computer running Open Office which is free software (or Microsoft Office or similar).

### Dynamic Software

We have considered the full range of dynamic mathematics education software and looked in detail at what it can do.

- **Dynamic Geometry:** This software allows the user to create geometric constructions as if they were using ruler and compasses. At first they look like drawing software. However, you can only draw according to geometric rules. This means that students can explore the effects of constructions. They can make and test hypotheses.
- **Dynamic Statistics:** With this software users can analyse statistical data, making calculations and creating statistical charts. One particular software (Fathom) allows users to see the effect on the data of making changes to the chart. It also allows hypotheses to be set and tested.
- **Graphing software:** This software allows the user to draw graphs of functions. The graphs can be in 2 dimensions or often 3 dimensions. Often graphs of differentials can be shown. Also, some systems include statistical charts and calculations.
- **Computer Algebra Systems (CAS):** This is software that performs algebra symbolically. It can integrate and differentiate functions in symbols, giving general results. The most sophisticated of these are used by professional mathematicians to do the routine mathematics involved in their work. In schools they allow students to explore algebra and symbolic mathematics.

### Graph, Maxima and GeoGebra

You should have access to a computer on which Graph, Maxima and GeoGebra have been installed. We have described a range of functions in each these programmes which are supportive of mathematics education.

### Creating Teaching and Learning Activities

We seen how many software programmes can be used to create activities to support learners. The software can be set up to demonstrate particular mathematical ideas in a dynamic way. For example we saw how we can draw a triangle in GeoGebra, mark its angles and add them up. The vertices of the triangle can be dragged around the screen in any direction allowing the triangle to assume all possible shapes. Hence, a vast number of different angle combinations can be shown and yet the sum of the interior angles remains at  $180^\circ$  regardless of the shape and size of the triangle. This provides a very convincing demonstration to the learner, who is able to move the vertices themselves.

## VI. Summative Evaluation

1. Use MSW Logo to create a new word POLYGON which takes two variables. The first should be the number of sides and the second should be the side length. Create the word using TO POLYGON :A :B. We recommend using the editor to do this. Submit a print out with sample polygons and the code used for you word. Sketch diagrams showing the input used and handwritten code is acceptable.
2. Write a 1000 word report entitled: Using ICT to Support Mathematics Education. You should choose one or two different hardware possibilities and 2 or 3 software possibilities. Explain (a) how you would be able to make these available to your students, with special reference to how you would solve any difficulties of cost, availability or reliability in your locality, and (b) how this approach would improve the teaching and learning of mathematics.
3. Design an interactive worksheet using either a spreadsheet or a presentation graphics programme. Use OpenOffice as your first choice. (MS Office or similar will be accepted). You should submit the file for you're your worksheet plus a short report (approx 300 words) explaining how this worksheet supports the learner's understanding. You may choose any topic from a secondary level mathematics course.
4. Produce a graph showing  $y = ax^2 + bx + c$  with a range of different values of a, b and c. Either use Graph or wxMaxima. Write a short report (300 words) explaining the variation in the graph as a, b and c vary.
5. Design an interactive worksheet using either wxMaxima or GeoGebra You should submit the file for you're your worksheet plus a short report (approx 300 words) explaining how this worksheet supports the learner's understanding. You may choose any topic from a secondary level mathematics course.

## Final Assessment

Each of the questions in the summative assessment is independent of the others.

To achieve at different levels (30%, 60%, 90%, 100%) you will need to:

1. 30% You will have produced different polygons using MSW Logo. 60% You will have created a successful word in MSW Logo which generates polygons from the two variables. 90% You will have generated a range of polygons using your code. 100% Your code will be efficient and use appropriate variables.
2. 30% You will have chosen a suitable example of ICT to support mathematics education and given some initial examples of school use. 60% You will have explained how the technology can be made available in your local circumstances. Also at this level you will have engaged with at least two software possibilities. 90% You will have additionally engaged with the teaching and learning advantages and included 2 hardware possibilities. 100% You will have completed the work with a thoughtful and critical view of the difficulties and opportunities.
3. 30% You will have created a computer file using a spreadsheet of presentation graphics programme which contains mathematical material. 60% Your file will be able to show a variety of different presentations of a mathematical idea. 90% Your file will be able to be changed dynamically e.g. by changing values in the spreadsheet or using hyperlinks in the presentation graphics programme. 100% Your file will additionally be neatly constructed and well suited for classroom use.
4. 30% You will have successfully produced the required graph for a small number of different cases. 60% You will have shown a systematic collection of cases and given an initial organised view of the variation. 90% Your collection of cases will be sufficient to give a full description of the variation in the graph as  $a$ ,  $b$  and  $c$  vary. 100% Your report will be mathematically concise and complete.
5. 30% You will have produced a GeoGebra or wxMaxima file illustrating a mathematical topic. 60% Your file will contain some instructions to the user how they can make changes to look at variation in your chosen mathematical topic. 90% Your file will guide the user through a sequence of changes to engage them with the full variability in your chosen topic. 100% Your file will additionally be accurate, concise and easy to use.

## XVII. References

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## **XVIII. Main Author of the Module**

Conceptual framework:

Dr. Salomon TCHAMENI NGAMO holds a Masters in Educational Administration and a PhD in Education from the University of Montreal in Canada. He specializes in pedagogical integration of ICT and distance learning. Research professional, trainer and consultant in the Interuniversity Research Centre on training and the teaching profession (CRIFPE) and Canada Research Chair on the integration of information and communications technology (ICT) of the Université de Montréal, he accompanies and provides technological support to Université de Montreal distance learning students of Master and PhD. Besides his research interests focus on the pedagogical integration of ICT, he is a regular member of the research team on the knowledge transfer (TC) and skills development process of the Université de Montréal (<http://www.equiperenard.ca/membres/salomon-tchameni-ngamo/>).

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### **Module author biography – Application in Mathematics**

Chris Olley was born in Kansas, USA, but brought up and educated in England. He graduated in Pure Mathematics at the University of Warwick in the UK. Chris began his career as a secondary school teacher in 1984. After two years of teaching in England, he took up a post at Iringa girl's school in the central highlands of Tanzania, where he spent two very happy and successful years teaching. A modest conversational Kiswahili is one of odd remnants of this time. After a two year return to England during which Chris completed his masters in education course at the Institute of Education, University of London, Chris set of again this time to teach the diploma in education course at kabala National Teacher's college in South eastern Uganda. He also ran a local In-service training programme in rural schools. Chris followed this by further work in English secondary schools leading up to a lengthy job heading the maths department in an inner London school.

During this time Chris also ran the secondary teacher training course for Goldsmiths College, University of London. In 2000, Chris went freelance, working on a range of educational projects, including public maths events, web sites and materials production. For the last three years, Chris has been a lecturer on the secondary maths teacher training postgraduate course (PGCE) at King's College, London, while keeping some time for freelance projects (such as the AVU).

Chris is married with two school aged children and lives in South East London.

### Module reviewer biography

Dr Jeanine N Mwambakana holds a MS Mathematical Technology (2001, USM, USA) and DTech Mathematical Technology, (2008, TUT, SA).

She is currently a senior lecturer at the University of Pretoria (UP) in the Department of Science, Mathematics, Technology Education (SMTE).

She has taught statistics, general Mathematics, Calculus, ODEs and PDEs.

She has supervised (and co-supervised 3) to completion five (5) Master degree students. Jeanine has developed a new module for BEd Hons students that will be offered for the first time this year on a blended format. She was also involved in a Professional Development project where 120 teachers were trained in alignment with the requirement of the new curriculum.

She is a member of the organising committee for the joint UP-UNISA workshop of mathematics of epidemiology that started in 2014 and ending in 2016.

She has published with colleagues seven (7) peer-reviewed journal articles and 4 peer-reviewed/refereed conference proceedings full papers.

Dr JN Mwambakana has presented several papers at National and International Conferences.

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