



ICT as Core and as Elective Subject: Issues to Consider

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Introduction

This paper has been developed by the Global e-Schools and Communities Initiative (GeSCI) to serve as a discussion paper to inform the introduction and implementation of Information Communication Technology (ICT) as a core and elective subject in pre-tertiary education.

In this paper, the term ICT includes computers, computer networking (the Internet and intranet), peripheral devices and multimedia, and the range of assistive technologies available for children with Special Educational Needs (NCCA, 2004a).

Background

Many developing countries aspire to becoming knowledge economies. The education sector is seen as the natural source for the creation of technological literacy and the creation of new technological skills. For new technologies like ICTs, the creation of technological literacy has meant the introduction of ICTs like computers into educational institutions and the introduction of computer literacy courses. Technology is increasing in importance in business and all other areas of people's lives to the extent that technological literacy will become a functional requirement for people's work, social, and personal lives. The creative use of ICT in education has the capacity to increase the quality of young people's schooling by enhancing teaching and learning. Part of the mission of educational institutions is to produce workforce-ready graduates who can, among other things, manipulate and analyze raw data, critically evaluate information, and operate hardware and software. This technological literacy imparts a very important set of vocational skills that will serve students well in the world of work.

As technological use, and particularly computer use, become more prevalent in society and the world of work, and new technologies constantly find their way into popular use,

it is necessary “for the curriculum to be dynamic and adapt appropriately to the introduction of new tools, while simultaneously keeping a focus on conceptual learning” (*Computer Science Curriculum for Schools: Model Curriculum and Teaching Material for K – 12 Indian Schools, 2007*)

Taught as either a discrete subject (elective e.g. Computer Science/Studies) or embedded within the curriculum (e.g. as core), ICT is regarded as a new ‘literacy’, alongside reading, writing and numeracy.

ICT as a core subject/ICT Literacy (across the curriculum)

ICT as a core subject across the curriculum is also referred to as ICT Literacy, the aim of which is to produce students/graduates who have operational knowledge and conceptual understanding of technology, and are able to use and manipulate productivity and communication tools with ease and an acceptable level of skill (The level of acceptability will be determined by the ICT competency standards to be set by each country).

ICT as a core subject is normally taught at all levels of the school education system in a spiral of increasingly more demanding knowledge and skills to be acquired in line with the student’s age and development.

The learning domains for ICT Literacy are (NCCA: 2004a):

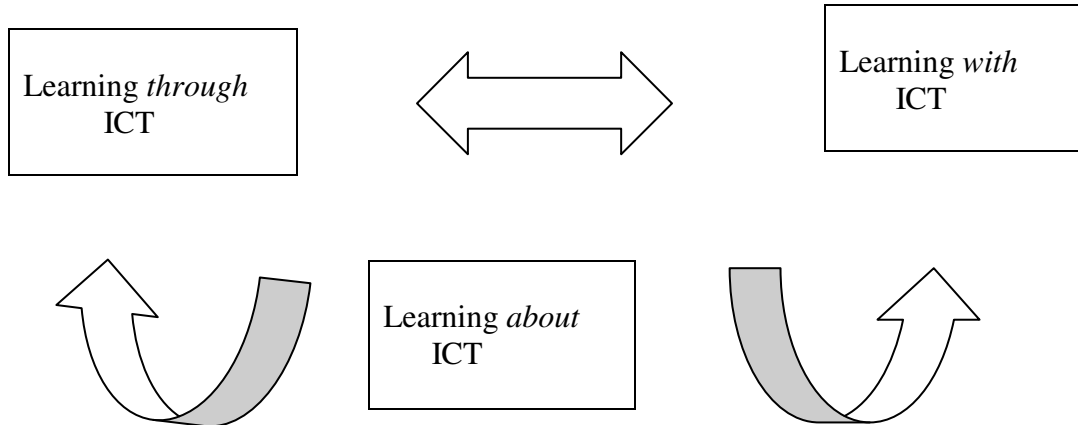
- Communicating, expressing creativity, enquiring and problem solving
- Using ICT productivity and communication tools
- Developing operational knowledge and concepts
- Developing critical awareness of the personal and societal impact of ICT.

The literature indicates that a coordinated developmental approach to the students’ developing ICT literacy will incorporate *learning about, with, and through, ICT*:

- *Learning about ICT*: students develop skills in, and knowledge of, the potential uses of ICT
- *Learning with ICT*: teachers and students use ICT resources to support the classroom curriculum
- *Learning through ICT*: teachers and students use ICT to learn in new ways that would not previously have been possible

Figure 1 (taken and adapted from NCCA: 2004a) provides a schematic view of this coordinated mutually supportive approach. The spiral nature of all learning is also evident in this approach when learning using ICT. At the same time as the student is learning *with* and *through* ICT, he/she is also learning more and more *about* ICT.

Fig. 1 Learning about, with, and through, ICT



Learning about ICT

Learning about ICT is not simply about the acquisition of ICT skills. It also concerns understanding new developments in ICT, their potential to afford new experiences, and the skill sets they require. In this way learning about ICT is more than initial skills training; rather, learning about ICT is ongoing throughout our lives. Learning about ICT also entails understanding the human, social, and ethical issues concerning ICT and learning *when* to use ICT, *what* ICT is most appropriate, and *how* to use it to support a learning situation or task. Successful use of ICT by both teachers and students is dependant on this basic understanding of *what it can do*.

Learning with ICT

Learning with ICT focuses on teaching and learning in a curriculum context using ICT. Teachers and students use ICT resources to support the classroom curriculum, for example, using tools such as word processing to create written materials, using presentation and authoring software to present projects, using drawing and painting software to enhance work in visual arts. In certain ways, learning with ICT may be perceived as a natural *integration* of ICT with existing classroom processes. Thus ICT can be used interchangeably with tried and trusted teaching and learning methodologies. Learning with ICT also supports learning, through the use of 'practice' type software to reinforce concepts already learned, or to access digital encyclopaedia or other resources. Thus, learning with ICT not only supports self directed learning by affording students enhanced opportunities to select individual paths to learning, but also can also make learning meaningful and contextualized.

Learning through ICT

Learning through ICT may automatically include learning with ICT, but it focuses on teachers' and students' use of ICT to engage with the curriculum in ways that would not previously have been possible without ICT. Learning through ICT results in more authentic learning experiences for teachers and students. Previously, students could access a certain level of resources and materials at first hand, but much classroom learning was achieved through vicarious experience. In cases where the real or actual experience is out of reach, ICT offers another dimension, which is virtual. For example, using the Internet, students in classrooms can now access live data from NASA, (which supports the curriculum in science) and have the same opportunities to analyse data as real scientists. Students can engage in virtual 'field trips' in space, back in time or within the human body. A group of students could meet the goals of their history curriculum/syllabus by engaging in local historical research using online databases and archive records, and create a web page or other artefacts as learning outcomes (NCCA:2004a).

In the study of ICT as a core subject for all, students will need to acquire the knowledge, skills, values and attitudes to use ICT to communicate, handle information, model and control. They will develop key ICT skills in a range of applications including: word processing, computer graphics, databases, spreadsheets, email, internet, presentations, video/animation and web authoring. Students learn ICT practical skills, but they also learn to consider wider issues such as adapting their work according to the audience, and they learn about the ethical issues as well as the dangers associated with technologies, e.g. internet safety. These skills and topics are normally the same over successive years of study, but are taught in a spiral of increasingly more challenging demands and in an age appropriate manner.

Some countries use the International Computer Driver's Licence (ICDL) programme (intermediate level) as a benchmark for achieving computer literacy and students leave senior high school with ICDL (intermediate level) certification.

A note of caution: For technologies, including computers to fulfill their promise, educators must establish environments that will support their optimal utilization *viz a vis* the development of higher order skills as the new technologies lend themselves to prompting reflection and discussion. Teachers who engage with ICT in the classroom have reported that ICT is more suited to support collaborative learning, active learning, enquiry etc. than traditional teaching pedagogies. Activities must be focused on problem solving and students must be involved in knowledge creation. The deployment of the computer as an electronic textbook or babysitter does not harness the power of the medium. Books and other learning materials should not be abandoned in favour of newer technologies. Like computers, books, maps, paint brushes, microscopes, and other non-technological tools are valuable real world tools that enhance and make learning possible. Multiple resources - technological and non-technological - must be used to address multiple learning styles and curricular goals.

Sufficient time needs to be allocated for the acquisition of ICT skills. As an example, the idea of deploying 20 computers for a high school of 700 students on the average will allow each student to have access to the computers only 2 hours a month. There needs to be enough equipment and adequately trained teachers/support to ensure that students actually acquire the skills set out in the curriculum. Timetabling for learning *about* ICT (ICT Literacy) would need to be negotiated within the curriculum and students need to have adequate access to the technologies (mostly computers in labs) to acquire the necessary competence, and opportunity to practice and use the technologies for other purposes (*with* and *through* ICT, e.g. doing projects, research). Learning *with/through* ICT does not require extra time on the timetable as activities and opportunities would be integrated in the subject teaching in schools where adequate numbers of the technologies are available.

ICT as elective subject in a programme in SHS

ICT as an elective subject is normally taught at the upper end of the school system (high/secondary school) in the form of Computer Science/Studies (CS) or Information Technology (IT) and is normally grouped with Business, Science or Creative, Technical and Vocational areas of specialisation in the curriculum. As such it is part of a programme/package and receives the time allocation for subjects in that programme and can be selected (as an elective) like other subjects in that programme in combination with other subjects from other programmes to meet the curricular requirements for the class/level. ICT as an elective subject (CS/IT) as part of a programme of studies will prepare students to enter the world of work with marketable skills and/or to pursue ICT/IT related studies at tertiary level.

The emphasis in these subjects is on understanding the concepts behind various computer-based activities, rather than just the usage skills of specific tools. In higher classes, there is exposure to learning more than one operating system or tool for performing a given activity. Computer Studies is a practical subject and the concepts to be taught must be seen to work in practical applications. Schools offering the Computer Science/ Information Technology package must assure that facilities and equipment are adequate for the students to be able to work as required by the syllabus. The focus on hands-on learning experiences will allow the students to test a variety of solutions, analyse results and make predictions.

Computer Science or Information Technology?

ICT as an elective subject in Senior High Schools (SHS) can be offered as Computer Science/Studies (CS) or Information Technology (IT). SC and IT have many common elements but they are distinctive subjects, each with their own thrust, and neither can fully substitute for the other (i.e. some SC topics overlap with IT, while some are completely different and are not relevant to an IT curriculum). Countries and schools therefore opt for the one or the other or both in their subject packages, depending on their needs and curricular objectives.

While IT is an applied field of study, driven by the practical benefits of its knowledge, CS has scientific and mathematical, as well as practical dimensions. Some of the practical dimensions of CS are shared with IT, such as working with text, graphics, sound, and video. But while IT concentrates on learning how to use and apply software as a tool, Computer Science is concerned with learning how these tools are designed. This latter concern exposes students to the scientific and mathematical theory that underlies the practice of computing. Therefore, any comprehensive K-12 CS curriculum will necessarily have topics that are distinct from those that normally appear in an IT curriculum (ACM K-12 Task Force Curriculum Committee, 2003)

Computer Science

The ACM K-12 Task Force Curriculum Committee (2003) definition is as follows:

Computer Science (CS) is the study of computers and algorithmic processes, including their principles, their hardware and software designs, their applications, and their impact on society.

It is generally believed that a fundamental understanding of CS enables students to be not just educated users of technology, but the innovators capable of using computers to improve the quality of life for everyone.

In a well-structured curriculum CS students learn logical reasoning, algorithmic thinking, design and structured problem solving—all concepts and skills that are valuable well beyond the CS classroom. Students gain awareness of the resources required to implement and deploy a solution and how to deal with real-world constraints. These skills are applicable in many contexts, from science and engineering to the humanities and business, and have already led to deeper understanding in many of these areas.

CS curricula in general have the following kinds of elements: programming, hardware design, networking and telecommunications, graphic design, databases and information retrieval, computer and data security, software design, programming languages, logic, programming paradigms, translation between levels of abstraction, artificial intelligence, the limits of computation (what computers *can't* do), applications in information technology and information systems, and social issues (Internet security, privacy, intellectual property, etc.).

When CS is taught as an elective examinable subject, the emphasis is on:

- learning of concepts associated with various tools, rather than just the usage skills of a specific tool (as is the case in ICT as core subject) and
- learning of more than one operating system/tool for doing a given task.

The Aga Khan University Examination Board (2004) states that the objectives of teaching CS are for students to:

- Understand the basic concepts, theories, principles and laws of Computer Science and their applications
- Develop mathematical manipulation skills for designing different language programmes in Computer Science
- Understand and appreciate the role of Information Technology in socio-economic and cultural development of society
- Develop skills for using and promoting Internet techniques
- Provide a sound and solid basis for further studies in Computer Science/Information Technology.

Information Technology

Information Technology (IT) is defined by the ACM K-12 Task Force Curriculum Committee (2003) as involving the proper use of technologies by which people manipulate and share information in its various forms—text, graphics, sound and video.

IT as a subject in high schools is normally designed to prepare students for the practical use of technology and to stimulate their interest in the use of computers. The course usually includes integrated career exposure/exploration components, which provide career awareness and prepare students for entry level positions. Depending on how the course is structured, students will gain the foundation for further technology training (either in the workplace or at tertiary/further education levels) and will be prepared for entry-level work experiences.

In most countries where IT is offered as a subject, it focuses on activities that deal with the solution of problems through logical thinking, information management and communication. As such, the subject will enable learners to understand the principles of computing through the use of current programming language, hardware and software, and how these apply to their daily lives, to the world of work and to their communities.

The following learning areas are normally covered by high school IT syllabuses:

- Hardware and system software, i.e. an understanding of hardware and the system software that is needed to make the hardware operational
- e-Communication – developing an understanding of electronic communications. This includes the legal, ethical, social, political and moral aspects of access to information and data protection
- Social and ethical issues - the reasons for using computers and the effects of their use across a range of application areas
- Programming and software development – the design, implementation, test and delivery of efficient and effective solutions to problem situations is studied. Thus object-orientated programming language, databases, spreadsheets, websites and their interconnectivity will be used in the design and implementation of solutions to specific real life problems.

Table 1 below provides an example of both Computer Science and Information Technology as part of the Creative, Technical and Vocational programme/package that can be offered in

combination with other subjects as required by the curriculum in the high school phase. Similar programmes/packages, containing either one or both Computer Science and Information Technology, exist for Commerce (Business), Humanities, Science in the usual combination with other subjects as required by the curriculum.

Table 1: Computer Studies/IT as elective subject in a programme

Creative, Technical and Vocational Package
Accounting
Art and Design
Business Studies
Child Development
Computer Studies
Design and Technology
Drama
Food and Nutrition
Information Technology
Music
Physical Education

Source: Cambridge International Examinations (CIE):
<http://www.cie.org.uk/qualifications/academic/middlesec/ice/syllabus>

The Dimension of Special Educational Needs (SEN) and Inclusive Education (IE)

In the Inclusive Education paradigm students with Special Educational Needs would also have to develop ICT Literacy (ICT as core across the curriculum), and use ICTs to overcome or compensate for their learning difficulties or disabilities. In order to look at the issue of developing ICT Literacy across the curriculum more holistically (learning *about*, *with* and *through* ICTs), it is necessary to look at how technology can be used for students with SEN.

Technology allows schools the opportunity to provide greater assistance to traditionally underserved populations of students. Assistive technology (AT) such as voice recognition systems, dynamic Braille displays, speech synthesisers, and talking books provide learning and communication alternatives for those who have developmental or physical disabilities. Research also shows that computer-mediated communication can ease the social isolation that may be experienced by those with disabilities. Computers have proved successful in increasing academic motivation and lessening anxiety among low ability students and learning disabled students, many of whom simply learn in a manner different from that practiced in a traditional, non-technological classroom (SEDL Technology Assistance Program: *Connecting Student Learning and Technology*)

One of the more salient findings in the general research on the use of ICT in education is the extent to which ICT can support the inclusion of students with Special Educational Needs. Research has shown that ICT can help students to overcome communication

difficulties, and to access the curriculum more fully, through using communication aids and appropriate assistive technology and software tailored to meet their needs. In some instances ICT offers perhaps the only way in which some students can make their thoughts and needs known and demonstrate their achievements.

Changes in our perceptions of SEN offer opportunities for more inclusive classrooms. Developments in learning theory, such as multiple intelligences and research on learning styles have led to a move away from a uni-dimensional view of how people learn, to a realisation that individual difference in learning capacities extends across the entire range of students. Rather than viewing some students as *able* and some as *less able*, there is an increasing awareness that *every* student brings an individual combination of strengths, needs, and interests to the classroom. In attempting to cater for the broad range of individual difference the teacher is encouraged to utilise a broad range of teaching strategies and approaches, as well as a variety of visual, audio and kinaesthetic learning resources.

ICT can support the provision of a differentiated curriculum to support individual needs as it affords *individual* access to more varied media, tools, and methods. For example, students who have difficulty with a print focused curriculum may have greater opportunities for learning, in an environment with greater access to audio and image related resources. Students with a visual impairment have increased access and learning opportunities through media such as talking books, descriptive videos, and screen reader software.

Assistive technologies which include a broad range of devices and technical aids can improve the quality of learning of students with disabilities. Students with physical disabilities may previously have been unable to access the curriculum because of communication or physical difficulties. Now, using a computer and a flexible range of assistive technologies, for example augmentative and alternative communication devices, both low tech and high tech, their experience of learning can be transformed. Classrooms which were previously inaccessible for many students with disabilities can now support inclusion for students who may require devices such as switches, mouse tracker balls and other peripherals to support access to the curriculum and learning resources. In such ways, ICT can support a broader spectrum of learning. Depending on the severity of the disability or learning difficulties, it might be necessary to offer differentiated syllabuses for ICT Literacy to SEN students (e.g. provide more time for the mastery of skills, adapted assessment formats)

Assessment

It is important that curriculum addresses the needs of the 21st century and assessment exhibits coherence with the curriculum. Learning has traditionally required students to be good consumers of information. Meeting the demands of the knowledge society will require shifting student learning to a higher gear from activities that use knowledge to activities that help students become information seekers, analysers, evaluators, innovative thinkers, problem solvers, decision makers, communicators, and creators of knowledge.

A wider range of assessment methods are necessary for such types of learning, while still maintaining the reliability of assessing in high stakes assessment environments

Assessment in education is about gathering, interpreting and using information about the processes and outcomes of learning. It takes different forms and can be used in a variety of ways, such as to test and certify achievement (e.g. Junior and Leaving Certificate), to determine the appropriate route for students to take through a differentiated curriculum or to identify specific areas of difficulty (or strength) for a given student.

Recent advances in our knowledge of how learning takes place and how learners make their way through classroom activities have led to new understandings of the importance of assessment in the promotion of learning (NCCA, 2004b). These new perspectives are having an impact across the curriculum as the focus in assessment activity begins to move from an emphasis on the assessment of learning to include assessment for learning - providing feedback how to improve their learning

Table 2 provides a summary of the differences between assessment *of* learning and assessment *for* learning:

Table 2: Differences between Assessment of learning and Assessment for learning

Assessment of learning	Assessment for learning
happens after the learning takes place	an integral part of the learning process
information is gathered by the teacher	information is shared with the learner
information is usually transformed into marks or grades	information is available on the quality of learning
comparison with the performance of others	comparison with aims and objectives is important
looks back on past learning	looks forward to the next stage of learning

(Source: NCCA, 2004c: *Assessment for Learning – Overview*, <http://www.ncca.ie/eng/index.asp?docID=332>)

ICT has the potential to make a significant contribution to new forms of assessment. In developing new curricula due consideration must be given to the potential and power of ICTs to deliver new ways of learning and to transform and match learning styles and assessment practices.

Teachers

Teachers play a critical role in the implementation of any change or introduction of any innovation in the educational system. The NCCA (2004) states that as gatekeeper of

his/her students' classroom learning, the teacher is a critical contributor to success in classroom learning - including learning with ICT. It follows logically that the teacher's own familiarity with ICT and confidence and competence levels in its use is a key determinant of the effective use of ICT in the classroom. ICT can also alleviate the administrative and planning burden for teachers in planning and managing lessons, resources, recording and assessment.

Teachers need to be adequately and appropriately trained through pre-service and in-service teacher education programmes to teach ICT Literacy. Some countries use the ICDL (or its equivalent) for teachers to acquire the necessary competence to understand and use ICTs confidently. Access to ongoing and appropriate ICT professional development is a prerequisite for *all* teachers if they are to improve their confidence and competence in using ICT to meet the needs of *all* their students.

Teachers expected to teach Computer Science/Information Technology at high school need to have had SC/IT training at tertiary level or to have had very intense and systematic in-service training to develop the conceptual understanding and advanced technical skills required to teach these subjects effectively.

Taking into account the age profile of teachers in Ghana as well as the number of graduates, it is reasonable to note that the majority of practising teachers did not receive pre-service training in the use of ICT. Teachers are often expected to teach ICTs under very difficult conditions (not enough resources) and if they encounter difficulties with ICT there is often very little assistance or support available to them. The rapidly changing nature of technology also renders much ICT professional development inadequate or out of date in a relatively short period of time. According to the NCCA (2004a) relying on one week workshops and seminars is not sufficient given the diversity of ICT and the rapid changes involved.

In order to achieve effective ICT Literacy and ICT as elective subject teaching, teacher education institutions will need to:

- Provide sufficient time for student teachers using computers for instructional purposes to develop confidence in using hardware and software
- Provide student teachers with computer education activities such as analysing material downloaded from the Internet, creating home pages for schools and facilitating communication between students
- Equip student teachers with the necessary skills to integrate ICTs (*learning with/through ICTs*) meaningfully into lessons (where equipment is available) and to appropriately use ICTs in/for assessment processes.

UNESCO developed ICT Competency Standards for Teachers which serve as a benchmark for formulating and evaluating teacher education programmes and use of ICT in teaching.

Barriers to the teaching of ICT (for both core and elective subjects)

In planning for introducing ICT as core and as elective subject, adequate consideration must be given to factors that will constrain or inhibit implementation. In planning to introduce ICT as core (literacy) or as elective subject, ways to deal with the barriers must be considered and addressed. The main barriers identified are:

- Insufficient deployment of relevant equipment
- Inadequate maintenance, support and security
- Insufficient time allocated for the acquisition of skills or to practice with/apply the skills acquired
- Lack of access for both teachers and students to appropriate technologies (hardware, software, and connectivity) due to costs, rapid rate of obsolescence, and location
- Teachers' lack of time to experiment with technologies and plan lessons using new methods that incorporate technology
- Teachers' lack of knowledge or understanding of best curricular uses of technology (what software to use, how to integrate it into the curriculum, and how to organise classroom activities), owing to insufficient training, support and models of best practice
- Teachers' lack of knowledge and support for resolving technical and logistical problems in the classroom.

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