13

Pedagogical Integration of Technology into Science, Technical and Vocational Education

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Introduction

Technology is an integral part of human lives and increasingly present in African societies. It has been introduced to varying degrees in all educational disciplines, especially in science, technical and vocational education. At the dawn of the twenty-first century, technology is becoming more vital to the society. Technology can be used to perpetuate a teacher-led, knowledge-based learning approach, or it can be used to help implement a student-centred, constructivist and progressive approach. Computers are also becoming more affordable and are indispensable to many people in their daily activities. Investing in technology, with proper training of teachers, provision of modern and quality equipment, and software in each classroom, would be a major gain in preparing students for the future. Improving teaching and learning is the key to integrating technology into the classroom. Technology integration is also very important because once a teacher is well prepared, he/she would be able to implement the use of technology across the curriculum. It is important to understand that technology is a tool for teaching and learning, and not a strategy. In other words, being proficient in the use of the technology tools does not guarantee success. However, teachers who integrate technology effectively can increase students' learning opportunities, efficiency, productivity and learning outcomes.

The integration of technology into an educational setting is, in many ways, like its integration into any business setting. Technology is a tool to improve productivity and practice, whether in an educational setting or in a business. Therefore, measures need to be available to assess effectiveness, even when some of the most significant effects can be difficult to measure. Technology integration in the classroom has

the potential to support important educational goals. Technology, it has been argued, helps change teacher-student relationships, encourages project-based learning styles, and supports the acquisition of skills such as 'higher order thinking', analysis and problem solving (Dockstader 2008). It is very important to recognize that pedagogical integration of technology is to better understand how the use of technology can improve the quality of teaching and learning.

What is Technology Integration?

Technology integration is the incorporation of technology resources and technology-based practices into the daily routines, work and management of schools (Dockstader 2008). It involves using computers effectively and efficiently in the general content areas such as mathematics, science, reading and social studies to allow students to learn how to apply computer skills and technology in meaningful ways. As a result, the curriculum drives the use of technology, not vice versa. Integrating technology goes far beyond using computers to supplement a lesson in the form of presentation or word processing software (Dockstader 2008). When teachers effectively integrate technology into their classroom practice, learners are empowered to be actively engaged in their learning. According to edutopia (Dockstader 2008), students who are instructed with technology are more likely to retain information and develop a deeper understanding of concepts.

Successful Technology Integration

The world is changing so fast today that with sufficient basic science and technology, nations can aspire to catch up with modern developments. The integration of educational technology will be a hollow achievement unless it is done properly and effectively. New technologies constitute not only a set of tools but also an environment – a space (cyberspace) – in which humans interact.

There are many successful stories of technology integration. Maslin and Nelson (2002) view technology as the enabler for students and educators to create significant projects collaboratively. Today's student needs to be literate across a variety of communication technologies (Merlkey, Schmidt and Allen 2001). Riley, Holleman and Roberts (2000) conclude that schools employing effective technology integration have shown positive results for both teachers and students. They report that teachers were better able to assist students in comprehending difficult concepts and better able to individualize instruction for students' needs. Also, Wepner and Tao (2002) discovered a common belief among teachers that computers were a valuable source of information, motivation and presentation. One of the participants in their study used technology to develop content knowledge and problem-solving skills, and participating teachers used multiple sources in teaching. Clark (2000) also reported that technology assisted teachers significantly in accomplishing routine tasks. As the enormous benefits of technology

were realized, it is also important to note that the incorporation of technology is not without complexities. The following section presents some challenges of technology integration.

Challenges of Technology Integration

The use of technology for the explicit purpose of integrating the school curricula often carries the implicit aim of introducing students to the concept of globalization. As a result, the conscientious educator confronts a number of challenges. For instance, the provision of instructional materials for use in schools today is faced with serious difficulties from various directions. Schoepp (2005) indicated that the act of integrating ICT into teaching and learning is a complex process and one that may encounter a number of difficulties. These difficulties, according to Schoepp, are known as barriers. A barrier is defined as any condition that makes it difficult make progress or achieve an objective (WordNet 1997, as cited in Schoepp 2005:2). According to Bingimlas (2009), the major barriers are lack of confidence, competenceand access to resources. Since confidence, competence and accessibility have been found to be the critical components of technology integration in schools, ICT resources, including software and hardware, effective professional development, sufficient time and technical support need to be provided to teachers. The presence of all components of technology increases the possibility of excellent integration of ICT in learning and teaching opportunities.

The most prominent difficulties in many developing and underdeveloped nations are found in lack of sufficient funds to procure all the essential materials needed and the lack of electricity to enable classroom teachers operate tools, if provided. In addition, the negative attitudes of many teachers in handling instructional materials constitute further problems. Other researchers indicated that integrating ICT is a gradual, reflective process for most teachers; it is also influenced by a complex mix of factors. For instance, in Kerr's (1991) study, participants indicated that incorporating technology into the practice allowed obvious and dramatic changes in classroom organization and management, yet changes in teacher pedagogical thinking were slow. However, Hennessy and Deaney (2004) indicate that a gradual but perceptible process of 'pedagogical evolution' appears to be taking place, involving both pupils and teachers developing new strategies and ways of thinking in response to new experiences and the lifting of existing constraints. Hennessy and Deaney (2004) also indicate that new approaches must be compatible with existing pedagogy and be perceived as meeting a need.

Innovation and adaptation are costly in terms of time; developing effective pedagogy around ICT involves significant input in terms of planning, preparation and follow-up of lessons (Cox, Webb, Abbott, Blakely, Beauchamp and Rhodes 2003). Other contextual factors which can act as barriers to technology integration include lack of confidence, experiences, trainings and access to reliable technology

resources (Dawes 2001). Loveless, DeVoog and Bohlin (2001) found that practice develops over time and this process is not automatically triggered by simply sharing information with colleagues. It entails developing ideas and trying them out, considering the principles and purposes that underpin activities in particular contexts, and critically reflecting on them.

Hennessy and Deaney (2004) identified the organizational factor, motivational factor, and pedagogical factor as the ones which variously influenced the processes of evolution over time, and dissemination of practice for the teachers.

- *Organizational Factor*: Extrinsic organizational factors or whole school characteristics were found to have the biggest motivating influence on both sustainability/development and dissemination of ICT-supported practice. Access to technology resources was the most frequently mentioned factor in this group. Teachers' comments highlighted the need for accessibility and flexibility of use over and above quantity of machines. In particular, provision of interactive whiteboards and data projectors has positive impacts on the development of practice, enabling teachers to model processes, using students' work to work more collaboratively with the whole class and 'have a dialogue while working' rather than merely 'giving them instructions'.
- *Motivational Factor*: Two internal or intrinsic factors, namely teachers' technical confidence and confidence in approach also played a key role, although they were linked twice as often to dissemination, and thus more to colleagues' confidence levels. The teachers involved in their study, while not being experts initially had subsequently used ICT regularly for three years and might therefore have developed their confidence to higher levels than colleagues that were just using it. Technology skills and experience, resistance to change, and teachers' age (younger teachers were construed as natural and innovative users of ICT) were also influential.
- *Pedagogical Factors*: According to Hennessy and Deaney (2004), all of the teachers and colleagues considered the practices they had developed to be largely successful in terms of enhancing pupils' learning (three times more often in relation to development than to dissemination). Pupil motivation was likewise an important factor concerning development and, to a lesser extent, dissemination. These findings resonate with other recent work concerning the critical impact of teacher beliefs about the benefits of ICT use for students in the classroom (e.g., Cox et al. 1991; Ruthven, Hennessy and Brindley 2005; Tearle 2004).

Furthermore, teachers exhibited a strong desire to develop effective practice which benefits pupil learning. Their skill and confidence in using technology and inclination towards the pedagogical approach were also contributory motivating factors, although barriers emerged where these were lacking. In both cases,

however, proactive support from more experienced colleagues (and 'seeing what was possible') offered mechanisms for facilitating take-up of new strategies. As stated by Hennessy and Deaney (2004), exploiting this support was, in turn, encouraged or constrained by organizational factors and a whole school culture which valued and promoted ongoing collegial activity. Also, it is important to look at learning theories related to technology integration because understanding the way that students learn (e.g. learning styles) should help in selecting relevant technologies for their learning activities to ensure they learn effectively.

Learning Theories related to Technology Integration

In reviewing the pedagogical use of technology, several learning theories and philosophies are involved. Three main theoretical schools or philosophical frameworks that are very popular and relevant in education are behaviourism, cognitivism and constructivism. Each of these schools of thought is still present in today's literature. These are presented below as explained by Sewall (2009). Also, another one that was added later by George Siemens and Stephen Downes is 'connectivism'.

Behaviourism

This theoretical framework was developed in the early 20th century with the animal learning experiments of Ivan Pavlov, Edward Thorndike, Edward C. Tolman, Clark L. Hull, B.F. Skinner and many others. Many psychologists used these theories to describe an experiment with human learning.

Cognitivism

Cognitive science has changed how educators view learning. Since the very beginning of the Cognitive Revolution of the 1960s and 1970s, learning theory has undergone a great deal of change. For instance, it includes research on how information is processed (in faculties such as perception, language, reasoning and emotion), represented, and transformed in a (human or other animal) nervous system or machine (e.g., computer). Cognitive science consists of multiple research disciplines, including psychology, artificial intelligence, philosophy, neuroscience, linguistics, anthropology, sociology and education. It spans many levels of analysis, from low-level learning and decision mechanisms to high-level logic and planning; from neural circuitry to modular brain organization (Wikipedia 2011).Much of the empirical framework of cognitivism was retained even though a new paradigm had begun. Cognitive theories look beyond behaviour to explain brain-based learning. Cognitivists consider how human memory works to promote learning.

After memory theories like the Atkinson-Shiffrin memory model and Baddeley's working memory model were established as a theoretical framework in Cognitive Psychology, new cognitive frameworks of learning began to emerge during the 1970s, 80s and 90s. It is important to note that Computer Science and

Information Technology have had a major influence on Cognitive Science theory. The cognitive concepts of working memory (formerly known as short-term memory and long-term memory) have been facilitated by research and technology from the field of Computer Science. Another major influence in the field of Cognitive Science is Noam Chomsky. Today, researchers are concentrating on topics like Cognitive Load and Information Processing Theory. This is beyond the scope of this chapter.

Constructivism

Constructivism is a learning theory or educational philosophy that many educators began to consider in the 1990s. One of the primary tenets of this philosophy is that learners construct their own meaning from new information as they interact with reality or other people with different perspectives. Constructivist learning environments require students to utilize their prior knowledge and experiences to formulate new, related, and/or adaptive concepts in learning. Under this framework, the role of the teacher becomes that of a facilitator, providing guidance so that learners can construct their own knowledge. Constructivist educators must make sure that the prior learning experiences are appropriate and related to the concepts being taught. According to Jonassen (1997), 'well-structured' learning environments are useful for novice learners and 'ill-structured' environments are only useful for more advanced learners. Educators utilizing technology when teaching with a constructivist perspective would be expected to choose technologies that reinforce prior learning perhaps in a problem-solving environment.

Connectivism

Connectivism is 'a learning theory for the digital age', and has been developed by George Siemens and Stephen Downes based on their analysis of the limitations of behaviourism, cognitivism and constructivism to explain the effect technology has had on how we live, how we communicate and how we learn. Donald G. Perrin, Executive Editor of the *International Journal of Instructional Technology and Distance Learning* says the theory 'combines relevant elements of many learning theories, social structures, and technology to create a powerful theoretical construct for learning in the digital age' (Wikipedia 2009b).

Different Types of Technology and their Educational Applications

Many different types of technology can be used for pedagogical integration of technology into science, technical and vocational education. Instructional materials include more conventional materials, such as the chalkboard, televisions, VCRs, overhead projectors, slide projectors and opaque projectors, as well as newer materials, such as the computer, various software applications, LCD projectors,

camcorders, digital cameras, scanners, the internet, satellite, interactive TV, audio and video conferencing, artificial intelligence, and so on.

Also, everything from video content and digital movie-making to laptop computing and handheld technologies have been used in classrooms, and new uses of technology such as podcasting, e-learning, internet are constantly emerging. Various technologies deliver different kinds of content and serve different purposes in the classroom. For example, technologies range from simple tool-based applications (such as word processors) to online repositories of scientific data and primary historical documents, to hand-held computers, closed-circuit television channels, and two-way distance learning classrooms.

Having a computer in the classroom is an asset to any teacher. With a computer in the classroom, teachers are able to manage the classroom affairs, demonstrate a new lesson, present new materials, illustrate how to use new programmes, and show new websites. Class website is a very effective way to display students' work. Once a web page is designed, teachers can post homework/assignments, students' work, famous quotes, trivia games, and much more. In this digital age, students know how to use the computer and navigate their ways through websites. The following are some other benefits of technology applications in the classroom. Technology:

- leads to enhancing a knowledge-level educational system;
- promotes higher-level thinking, independent learning, and life-long learning;
- improves education over what it would be without technology;
- enables easy access to course materials; instructors can post the course material or important information on a course website, which means that students can study at a time and location they prefer and can obtain the study material very quickly;
- improves student writing; it is convenient for students to edit their written work on word processors, which in turn improves the quality of their writing;
- enhances learning; different types of educational software are designed and developed to help students to learn specific subjects (e.g. pre-school software, computer simulators and graphics software).

Integrating into Education (Teaching and Learning)

With the advent of new technologies, a technology gap is increasing between teachers and students. To help bridge this gap, both students and teachers need to become competent in all that technology has provided for modern methods of teaching. In order to integrate technology effectively in teaching and learning, teachers must be capable of the following:

- designing and creating various instructional materials for learners;
- understanding design principles – how to create instructionally effective materials;
- understanding the types of materials to create to best meet-the-learner needs, and how they can utilize these materials in their teaching;
- understanding how to create materials from bulletin boards and transparencies to PowerPoint, Hyper Studio, and web-based materials;
- keeping up with emerging instructional materials and tools that are being developed and how these new materials might be useful to them as teachers.

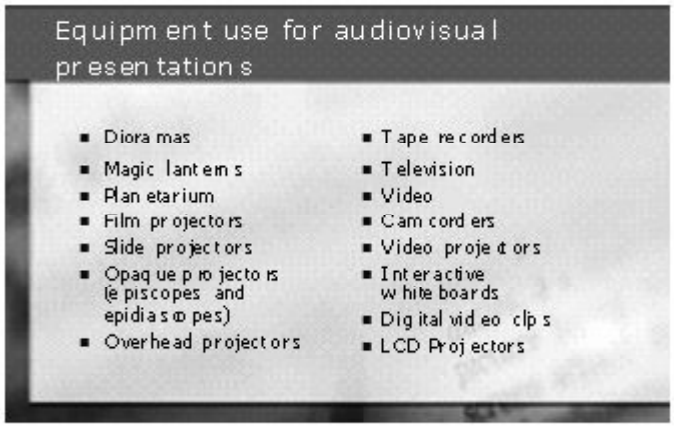
Development and Utilization of Instructional Materials

Whereas traditional learning tools include chalkboards or whiteboards, pencils, typewriters, and books, twenty-first century learning tools include traditional learning tools plus computers with high-speed internet, high-end graphics and instantly published audio and video tools. Modern methods of teaching make greater demands for the use of emerging instructional materials on the part of the teachers who are supposed to help the learners to understand certain concepts. A teacher's ability to produce and utilize equipment and materials for teaching and learning will depend, to a great extent, on his interaction with and continuous use of media for learning. Whenever such materials and equipment are used for teaching and learning, they are referred to as educational media. Educational media are a broad range of information-carrying resources that constitute an integral component of classroom teaching and learning, and are utilized in an instructional process, with the hope of facilitating effective and efficient communication in the teaching and learning process.

Educational media are classified into different groups by different people. Generally, educational media are categorized as audio media, visual media and audio-visual media.

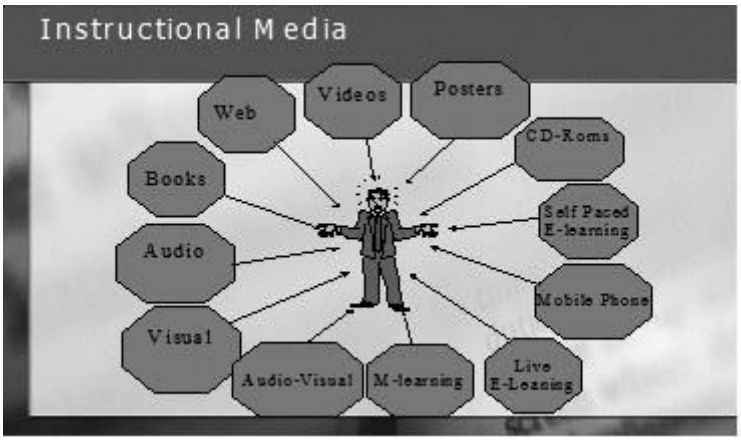
- Audio Media are teaching and learning devices that mostly appeal to the sense of hearing. They include telephone, records, public address system, tape recorder, talking drum and human voice;
- Visual Media are teaching and learning devices that mostly appeal to the sense of seeing only. They can be sub-categorized into projected and non-projected visuals. The projected visual requires electricity for projection, e.g. films, slides and transparencies. The non-projected ones do not need a light source. These include pictures, maps, globes, posters, realia, etc;
- Audio-Visual Media refers to those instructional materials which provide the students with the opportunity of seeing and hearing at the same time, e.g. instructional or education television, closed-circuit television, microcomputer (see the figures below).

Figure 13.1: Some Equipment Used for Audio-visual Presentations



Source: Clark (2000)

Figure 13.2: Some Instructional Media



Source: Clark (2000)

Functions of Instructional Media

There are several functions of instructional media. The most important functions are listed below:

- helps in focusing attention and motivating learners;
- lends support and authenticity to what the teacher says;
- makes learning real and concrete;
- makes individualization of instruction possible; and
- increases learning effectiveness.

Emerging Educational Media and their Applications

There is a proliferation of emerging educational tools such as E-Readers, mobile applications, nook and tablets. They are among a few of the latest communication learning devices used currently along with virtual and online training. These recent devises are used to locate resources to educate large numbers of students simultaneously, internationally. Snapshots of some of the common and emerging technologies are presented below.

Internet

The development of the internet has started a revolution in teaching and learning that is providing a new opportunity for delivering instruction through various media. Such a new revolution has been called several names – web-based learning, online instruction, virtual learning or e-learning. Recently, new terminologies such as m-learning, i-learning, u-learning, and new media have come on board. Regardless of the name given to it, this form of learning integrates online educational telecommuting activities into teaching and learning.

Mobile Learning

Mobile learning, or m-Learning, has different meanings for different communities. Although related to e-learning and distance education, it is distinct in its focus on learning across contexts and learning with mobile devices. One definition of mobile learning is: Any sort of learning that happens when the learner is not at a fixed, predetermined location, or learning that happens when the learner takes advantage of the learning opportunities offered by mobile technologies. In other words, mobile learning decreases the limitation of learning location with the mobility of general portable devices. The term covers: learning with portable technologies, where the focus is on the technology (which could be in a fixed location, such as a classroom); learning across contexts, where the focus is on the mobility of the learner, interacting with portable or fixed technology; and learning

in a mobile society, with a focus on how society and its institutions can accommodate and support the learning of an increasingly mobile population that is not satisfied with existing learning methodologies.

Some major ways to integrate communication devices into science are through: voice, short message service (SMS), internet, data transfer, and mobile instant messaging (MIM).

- *Voice* – The mobile phone allows a user to communicate with another user especially when students are in the field collecting data or at a construction site.
- *Short message service (SMS)* – This service allows individuals to send short messages, with a maximum of 160 characters, to other individuals or groups. It becomes applicable where students need to communicate in an environment where they cannot make noise.
- *Data Transfer* – Bluetooth is a technology that enables people to share data, such as music, videos and images wirelessly via their mobile phones, among other devices (Erasala and Yen 2002). It becomes important for sharing of information from students to their lecturers and from the lecturers to the students.
- *Mobile instant messaging (MIM)* – A large number of people prefer instant messaging (IM) to other electronic communication methods, such as e-mail (Marshall 2003). One of the attractive aspects of IM is the instantaneous transfer of messages between individuals and groups.

E-learning

E-learning (or sometimes Electronic Learning or eLearning) is a term which is commonly used, but does not have a common definition. Most frequently, it seems to be used for web-based distance education, with no face-to-face interaction. However, much broader definitions are also common. For example, it may include all types of technology-enhanced learning (TEL), where technology is used to support the learning process. Although pedagogy is usually not part of the definition, some authors do include it; for example, one of the definitions says e-learning is 'pedagogy empowered by digital technology'. It is important to mention that the term 'e-learning' is ambiguous. It is nearly impossible to define what it is, as it has different meanings to different people. Furthermore, it is often used interchangeably with various other related terms, such as distance learning, distributed learning, and electronic learning. The meaning of the term also seems to be dependent on the context in which it is used. In companies, it often refers to the strategies that use the company network to deliver training courses to employees. Lately in most universities, e-learning has been used to define a specific mode to attend a course or programme of study where the students rarely or never meet face-to-face, nor access on-campus educational facilities, because they study online.

Social Networking

A social network service focuses on building online communities of people who share interests and/or activities, or who like to explore the interests and activities of others. Most social network services are web-based and provide varieties of ways for users to interact, such as e-mailing and chatting. Social networking has provided new ways to communicate, share information, teach and learn. Social networking websites are being used regularly by millions of people around the world (Wikipedia 2009a). Abbitt (2007) states that there has been 'tremendous growth in the popularity of websites focusing on social activities and collaboration'; this would include online applications such as Facebook.

The main types of social networking services are those which contain category divisions (such as former school-year or classmates), means to connect with friends (usually with self-description pages) and a recommendation system linked to trust. Most popular social networks consist of Yahoo group, Facebook, MySpace, Twitter, LinkedIn, Nexopia, Bebo, Hi5, dol2day, Tagged, Xing, Orkut, Friendster, Multiply, Wretch, Xiaonei, Cyworld, Skyrock, etc. This list increases daily, but they all have one thing in common, and that is 'networking'.

Tertiary institutions are beginning to recognize the use of social networking tools to support teaching and learning. They are now realizing that these same tools can be used to create pedagogically sound learning environments for students. Academics have also examined the building of online communities that have dealt with different aspects of online community development in classroom environments. For instance, Abbitt (2007) used a Coldfusion system to allow students to add resources and have these rated by their peers. Roper (2008) utilized an asynchronous online discussion tool to allow students to participate in an online undergraduate labour/management relations' class while McElrath and McDowell (2008) examined Brown's theory of community building in their online distance education course. Although social networking tools are not designed for explicit learning targeted at education; nonetheless, they are tools that people use to organize information and understand the world and to learn. Educators and trainers should take advantage of the widespread availability of these tools – at no cost – to support teaching and learning.

Communication technologies are also categorized as asynchronous or synchronous. Asynchronous activities use technologies such as blogs, wikis and discussion boards. The idea here is that participants may engage in the exchange of ideas or information without the dependence of other participants' involvement at the same time. Electronic mail (Email) is also asynchronous in that mail can be sent or received without having both the participants' involvement at the same time. Synchronous activities, on the other hand, involve the exchange of ideas and information with one or more participants during the same period of time. A face-to-face discussion is an example of synchronous communication.

Synchronous activities occur with all participants joining in at once (e.g. online chat session or a virtual classroom or meeting). Within synchronous learning; learning and teaching take place in real time (same time) although the trainer and learners are physically separated from each other (place shift). Examples include:

- listening to a live radio broadcast or watching live a television broadcast;
- audio/video conferencing, internet telephony, online lectures, two-way live satellite broadcast.

One major characteristic of asynchronous learning is the fact that that the trainer prepares the courseware material before the course takes place and the learner is free to decide when he wants to study the courseware.

Examples include:

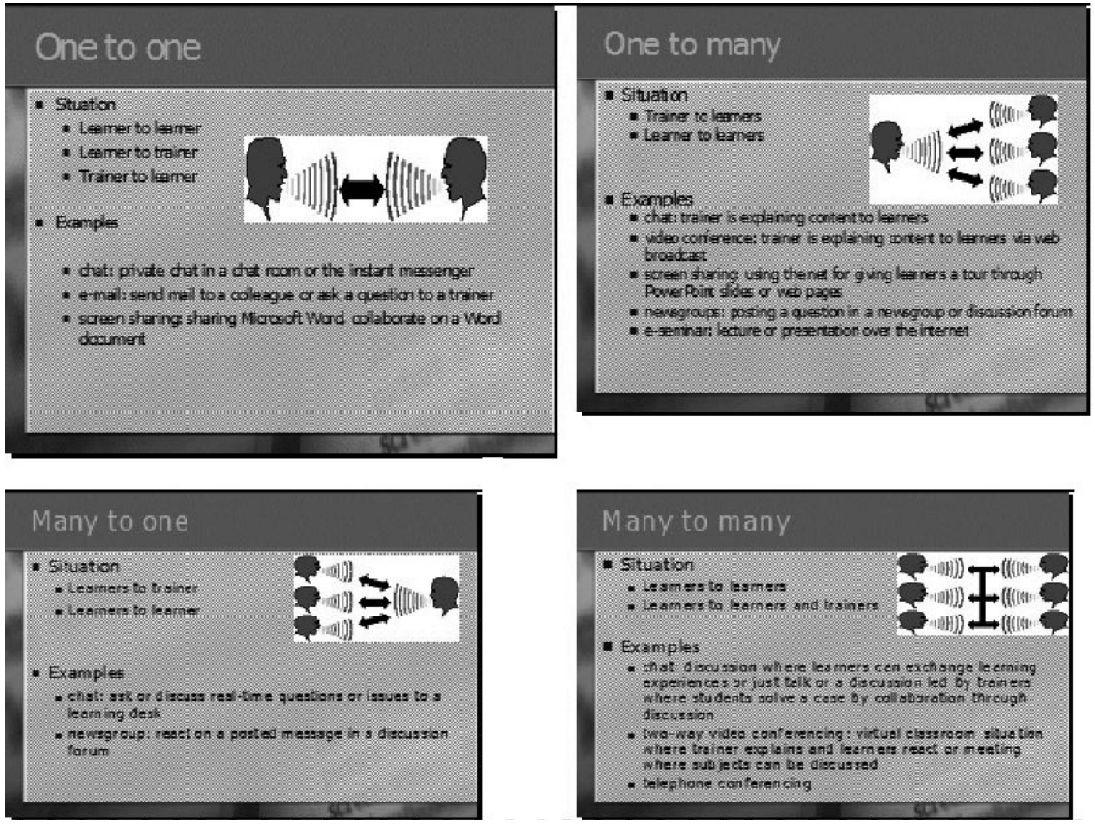
- self-paced courses taken via Internet or CD-Rom and videotaped classes;
- stored audio/video Web presentations or seminars, recorded audio tapes; and
- question and answer mentoring and e-mail messages.

Information and Communication Technologies

Although the use of information and communication technologies (ICT) is often limited to computer literacy and information retrieval by pupils and teachers, their effective pedagogical integration remains marginal. Information and communication technologies (ICT) is an umbrella term that covers all advanced technologies in manipulating and communicating information. The common usage of ICT is synonymous with the fact that IT or ICT encompasses all mediums of recording information (magnetic disk/tape, optical disks (CD/DVD), flash memory, etc. and, arguably, also paper records); technology for broadcasting information – radio, television; and technology for communicating through voice and sound or images – microphone, camera, loudspeaker, telephone and cellular phones. It includes the wide varieties of computing hardware (PCs, servers, mainframes and networked storage).

It has developed a personal hardware market that comprises mobile phones, personal devices, (MP3, MP4, MP5 and MP6) players, laptops, palmtops, etc. The full gamut of application software spans from the smallest home-developed spreadsheet to the largest enterprise packages and online software services. Similarly, the hardware and software needed to operate networks for transmission of information, again ranging from a home network to the largest global private networks operated by major commercial enterprises and, of course, the internet. 'ICT' makes technologies such as broadcasting and wireless mobile telecommunications more explicit. We distinguish different directions/ways to communicate:

Figure 13.3: Communication with Technology



Source: Clark (2000)

Graphics adapted from: Martin Molhanec (www.teipat.gr/socrates-ip2006/files/e-Learning.ppt).

192

Integrating Technology into Science

Without any doubt, science education has benefited most from technology. This can be proved by looking at many inventions and other activities – from the massive amount of interactive applications to technologies like probeware. Students have an even better chance than others to be involved with real science that engages them in scientific methods and the thrill of discovery.

The internet alone has been a transformative technology. There are varieties of resources that both teachers and students can take advantage of on the internet – from interactive activities to collaborative projects that connect classrooms around the world in scientific investigations. Timely content and information like weather s atellites and astronomical photography have made it a simple process to have the same access to information as professional meteorologists and astronomers.

Interactive applications have provided students with interactive activities to test and expand their knowledge of scientific principles, graphics to increase the motivation of users to attend prompt perception, aid recall and assist in the development of higher order thinking and concept formation and simulations to explain processes that are difficult to 'see' in static form. All these are possible with the aid of technology. The following websites (Knowledge Network Explorer 2004) consist of some examples of what has been done in the integration of technology into science. All the websites contain teacher resources, lesson plans, and activities for the students.

Froguts

http://www.froguts.com

It is a website where students can access gaming media, pathology and histology equipment, It can simplify laboratory activities and empower students with dynamic experiments.

DNA Interactive

http://www.dnai.org

It is a website where students can register free to join an online teaching community and create personalized web pages and use the Lesson Builder tool. The website also has an animated primer of 75 experiments that made modern genetics. The science behind each concept is explained by: animation, image gallery, video interviews, problem, biographies, and various links.

Genetic Learning Center

http://gslc.genetics.utah.edu

This centre is a science and health education programme located in the midst of the bioscience research at the University of Utah. Its mission is to make science easy for everyone to understand. It provides educational materials and programmes for global and local audiences.

HHMI Biointeractive

http://www.biointeractive.org

This website presents issues such as where and when did humans arise and what distinguishes humans from other species.

Visual Interpretation of the Periodic Table

http://www.chemsoc.org/viselements/index.htm

This website provides information on a natural affinity between iconography and chemistry.

Web-based Inquiry Science Environment (WISE)

http://wise.berkeley.edu

WISE is a simple, yet powerful learning environment where students examine real world evidence and analyze current scientific controversies.

Collaborative Projects

Students can collaborate with other students across the world through the Internet. In fact, creating a realistic, collaborative environment is the best way for students to experience the real world life of a scientist. Some of the websites below provide students some resources with information on collaborative connections with scientists and enable students to participate. There are many examples, but the one listed below is the one we visited at the time of our review of literature.

Voyage of the Odyssey

http://www.pbs.org/odyssey

The Voyage of the Odyssey is a five-year programme designed to gather the first ever baseline data on levels of synthetic contaminants throughout the world's oceans. It is dedicated to rigorous scientific research in conjunction with global education in order to improve people's appreciation for, and understanding of, the ocean environment and the creatures within it, and to contribute to the conservation of whales. The materials posted are advanced multimedia material offering a thematic, hands-on approach to understanding life in the seas.

Ask a Scientist

http://www.askascientist.org

Ask a Scientist connects one to some of the top scientists in the world, and each of them is connected to the Howard Hughes Medical Institute. This is a place one can ask questions about medicine, human biology, animals, biochemistry, microbiology, genetics or evolution.

NASA Quest

http://quest.arc.nasa.gov

NASA Quest Challenges are free web-based, interactive explorations designed to engage students in authentic scientific and engineering processes.

There are some websites that act as the home of several content databases that go beyond what students generally have access to in the traditional curriculum resources. Many of these contain not only text, but images and animations that provide opportunities for students to reinforce and extend their scientific knowledge. These include:

Planetary Photojournal
http://photojournal.jpl.nasa.gov/
Science World
http://scienceworld.wolfram.com/
Brainpop: Science
http://www.brainpop.com/science/seeall.weml

Biodiversity Hotspots
http://www.biodiversityhotspots.org
Also, the internet has also been the largest library of this age. Finding the best resources for each area of the content that teachers must teach to students can take a long time if one does not use existing resource directories. The best directories subdivide the resources into each content area, making it even easier to locate specific resources.
SCORE Science
http://scorescience.humboldt.k12.ca.us/

Blue Web'n: Science
http://www.kn.sbc.com/wired/bluewebn/contentarea.cfm?cid=11
ENC Online
http://www.enc.org
Frank Potter's Science Gems
http://www.sciencegems.com

Integrating Technology into Education

Integrating technology is what comes next after making the technology available and accessible. It is a goal-in-process, not an end state. The goal of perfect technology integration is inherently unreachable: technologies change and develop, students and teachers come and go – 'things change. It is the process by which people and their institutional setting adapt to the technology that matters most. The process of technology integration is one of continuous change, learning, and (hopefully) improvement. Developing a culture that embraces technology is also important to its successful integration. For example, sending important messages

by e-mail, or encouraging staff to use electronic calendars to schedule meetings, fosters a culture that accepts technology as 'natural' to the business of everyday work.

Conclusion

This chapter has submited that pedagogical approaches to using new technologies in education are being consolidated through the integration of ICT into science, vocational and technical subjects. The extent of sustainability, further development and dissemination of practice highlighted in the chapter indicates that the sustainability levels of investment in school ICT provision may be paying off. However, teachers and subject departments depend on adequate access to reliable resources (and technical support) if practice is to evolve. A favourable management outlook and development of ICT, as a school priority, in turn leads to soliciting further resources and expanding practice. Thus, the process is complex and iterative rather than linear. Individual teachers' confidence, skills and motivation towards using ICT develop in response to other contextual factors, including a supportive organizational culture. These 'internal' factors also play a critical role in the processes of both developing and disseminating new practice.

In terms of actual instruction, technology is an invaluable tool for providing active collaborative learning and assessment. While basic word-processing programmes allow students to become independent publishers of ideas and opinions, email provides opportunities for 'peer review' and group editing. More sophisticated interactive multimedia packages offer true inquiry-based learning, where students must construct and demonstrate solutions to a variety of in-class projects. This is not to suggest that technologies are used in reform to replace the role of the teacher; realistically, that would be both undesirable and impractical. Instead, the computer must be recognized as an effective teaching tool which assists the instructor or teacher. Software offer students individualized learning; while some students progress on a subject at their own pace, those who begin to fall behind can receive proper interpersonal attention from the instructor. The computer allows the teacher to concentrate on interaction and individualized assistance. In a sense, because computers have proved to be a successful tool of reform-minded schools and educators, they are now inextricably linked to the reform movement itself.

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