

# Technology integration in education in developing countries: Guidelines to policy makers<sup>1</sup>

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*Technology such as Information and Communication Technology (ICT) is a potent force in driving economic, social, political and educational reforms. Countries, particularly developing ones, cannot afford to stay passive to ICT if they are to compete and strive in the global economy. The health of the economy of any country, poor or rich, developed or developing, depends substantially on the level and quality of the education it provides to its workforce. Education reform is occurring throughout the world and one of the tenets of the reform is the introduction and integration of ICT in the education system. The successful integration of any technology, thus ICT, into the classroom warrants careful planning and depends largely on how well policy makers understand and appreciate the dynamics of such integration. This paper offers a set of guidelines to policy makers for the successful integration of ICT into the classroom.*

Technology integration, developing countries, policy makers,  
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## TECHNOLOGY, EDUCATION AND THE GLOBAL MARKET

Much has been said and reported about the impact of technology, especially computers, in education. Much research has been conducted throughout the world to evaluate the positive effects of technology on learning, and to investigate the kind of enhanced learning environment that technology provides in the classroom. In short, considerable resources have been invested to justify the place of technology in education, and many research studies have revealed the benefits and gains that can be achieved by students, teachers and administrators.

Integration of ICT in education has been a contentious issue. At one extreme, there are some who are not convinced that ICT will bring the pedagogical benefits that have been so much touted about (Cuban, 1986; McRobbie and Thomas, 1998; Oppenheimer, 1997; Peat and Franklin, 2003; Postman, 1990, 1993, 1995; Stoll, 1995, cited in Vestich, 1997). At the other extreme, advocates like Edison (cited in Saettler, 1990, p 98), Negroponte (1995), the co-founder of the Massachusetts Institute of Technology Media Lab, and Papert (1996) claim that technology will change the educational landscape forever and in ways that will engender a dramatic increase in the performance of learners. In between the two extremes, there are others who adopt a balanced approach. They are convinced that ICT, if properly integrated, has the potential to enhance the teaching and learning process (Apkan, 2002; Bork, 2003; Dwyer, Ringstaff, and Sandholtz, 1990; Kian-Sam Hong, Abang Ahmad Ridzuan and Ming-Koon Kuek, 2003; Lee and Dziuban, 2002; Thompson, 2003). If properly integrated, ICT-enabled education has the potential to promote the

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development of students' decision-making and problem solving skills, data processing skills, and communication capabilities (Whitworth and Berson, 2003).

Motivated by the prospect of greater economic, social, educational and technological gains, both developing and developed countries, are bringing about education reform, with a clear focus on ICT integration in education. Countries have been investing considerably in terms of money, expertise, resources and research to integrate technology in education as smoothly as possible so that the classroom environment is made more conducive for enhanced teaching and learning. Nations have recognised not only the positive effects of technology in education, but also the pivotal roles that it plays in securing jobs in the competitive job market of the 21st century. Prospective job applicants increasingly need to be computer-literate in order to qualify for job positions. Moreover, for countries to compete with each other in the global information-based and knowledge-based economy, they need a workforce that is skilled in the use of technology to gain the necessary competitive edge over one another. Hence, it is no longer a question of if technology should be integrated in the school setting, but a question of when and how to integrate technology so that it benefits all the parties concerned – students, teachers, administrators, parents and the community. Countries that fail to recognise and act according to the trends in new content and new methodologies in education and training may find it very hard to compete in the global economy (Christensen, 1997; Delannoy, 2000).

Few statistics are available from developing countries. Much research in the area of technology integration in education has been conducted in technologically advanced countries, but little in the so-called developing or third world countries. On the one hand, this implies that the former countries now possess a wealth of knowledge, skills, expertise, and the competitive edge that most of the latter countries do not possess. On the other hand, the latter countries can gain a lot by learning and adapting the 'ready-made' skills and expertise of their advanced counterparts, and they can do so with relatively less money. This means that developing countries and poorer nations do not require investing as much as their more developed counterparts have had to do. They can benefit immediately. Nevertheless, just like any development project, this technology integration in education will still require considerable investments and it has to be systematic and well planned.

This paper looks at how developing countries and poorer nations can adopt, adapt, and apply the knowledge gleaned by countries that have already embarked on the ICT integration bandwagon in their own educational systems. It is hoped that the insights put forward in this paper will enable such countries to make better plans on how to create their own pool of skilled and expert educational technologists. The paper first establishes a ground for technology integration in education; then, it highlights various ideas and insights on planning this integration process; and finally, it recommends what can be done in the context of developing and poorer nations, bearing in mind that many of them have very few or no computers in their schools and limited infrastructural, technological, and financial resources.

For the purpose of this document, technologically advanced countries and developed countries are regarded as synonymous, and developing and poorer countries are collectively referred to as developing countries unless explicitly stated otherwise. Also, policy makers refer to the people who are decision makers in education such as school principals, education superintendents, regional education directors and, district-level or state-level educational administrators. Also, unless stated otherwise, technology is used to include the computer system, Internet and World Wide Web, networks and communication devices, and software.

## JUSTIFICATION FOR ICT INTEGRATION IN EDUCATION

Technology in education should not be considered as a replacement for face-to-face instruction but rather as a support to “attain objectives that have not been attained efficiently otherwise: expanding access, promoting equality, improving the internal efficiency of educational systems, enhancing the quality of education, and preparing new and old generations for a technology-driven market place” (Haddad and Jurich, 2002, p. 47). Technology in education offers the following benefits to the educational community and the society:

- An enhanced learning environment for learners. Technology provides a motivating learning environment whereby learners are given the opportunity to be constructively engaged with instruction. Research has revealed that, if properly implemented, learners can reap the pedagogical benefits of technology in the classroom. Experts today increasingly advocate the implementation of the constructivist model of learning rather than of the traditional instructivist model (Clark and Sun, 1996; Means and Olsen, 1997; Williams, 2000).
- A powerful tool to supplement teachers’ instruction in classroom. If properly used by teachers, technology can foster more interest in learning on the part of students, and teachers can use it in the instruction of their respective subjects. Technology has the potential to make instruction easier, more challenging and motivating for teachers.
- An administrative tool for teachers and administrators. Apart from classroom instruction, teachers are also involved in class administrative duties such as student record keeping, lesson planning, preparing handouts, tutorials and slides, preparing exams papers, marking papers and recording of results, performing some type of statistical analyses on marks, and so on. Administrators are also involved in a variety of work that requires technology, such as the computation of school performance for a certain year, keeping of records of employees, and preparation of school budget.. Technology can therefore become an extremely useful tool in handling of a number of the administrative tasks for both teachers and administrators.
- Increased access to education and inclusive education in the school. Schools have had at heart the integration of all students regardless of their cultural, racial and socio-economic backgrounds, as well as their strengths and weaknesses in any area into an integrated school community. Technology has been recognised as providing a means of helping schools achieve this goal of promoting equal access to education. Also, it has the potential to offer increased access to education to students with disabilities.
- A communication platform. In the not so distant past, geographical distance was a major hurdle when it came to communicating with people around the world. Technology has changed that. Through networks and the Internet, it is now possible to communicate with anyone in the world. Technology has also presented schools with an excellent medium to share ideas and experiences. Students, teachers, and administrators can communicate, exchange knowledge and concerns, meet experts and peers, and share work in collaborative projects through the use of technology.
- A passport to employment and to gaining competitive edge in the global economy. Increasingly in developed and developing countries, job markets are demanding a computer literate workforce. In the not too distant future, knowledge and skills of computer use will become a basic requirement for securing a job and for a nation to compete for a share of the global market. Technology in education can prepare students now to integrate the world of work and competition tomorrow.

## PLANNING FOR TECHNOLOGY INTEGRATION IN EDUCATION

Just like any project, technology integration in educational settings requires an implementation plan. Without a needs-analysis, proper planning and management activities, projects are doomed to slow progress or outright failure. Levine (1998) emphasises the importance of having a plan that is based on real school needs and one that is realistic, achievable, and effective. The plan should be produced, not for the sole purpose of putting technology in the classroom but to reflect the real needs of schools in order to make effective technology deployment and to produce enhanced learning environments. The involvement of all stakeholders in the preparation and execution of the plan has been identified as a catalyst in the integration process.

Levine (1998) proposes the following the components of an effective technology integration plan in schools:

- Formulating a planning team
- Collecting and analysing data
- Formulating the visions, goals, and objectives
- Exploring available technology
- Determining training and staffing needs
- Determining a budget and funding sources
- Developing an action plan
- Implementing the plan
- Evaluation

Still relevant today is a three-phased approach to the process of systematic planning and implementation of computers in schools formulated by Cheever et al. (1986). The three phases are:

- **Strategic planning.** This involves establishing institutional goals at district/state level, identifying the necessary resources to achieve goals, planning the acquisition, deployment and disposition of the resources. Examples of strategic planning activities are the writing of long-term plan for the integration and use of computers in schools, and the appointment of citizens and committees to work towards funding acquisition.
- **Management control.** This is concerned with the actual acquisition of the necessary resources and planning their integration in the classroom to meet the institutional goals. Examples of management control activities are the formulation of instructional objectives of a certain subject at a certain grade level when computers are introduced to teach and learn that subject, and the development of school-level budgets for resource acquisition and staff development.
- **Operational control.** This has to do with the day-to-day usage of computers in the classroom. Examples of activities are the scheduling of computer access to teachers and students, and the computer usage policies.

Levine (1998) and Cheever et al. (1986) thus inform us how essential it is to plan at different levels based on real needs in order to increase the probability of getting the acceptance and support of all other stakeholders both philosophically and financially. Therefore, technology integration requires the preparation, implementation and evaluation of holistic plans at various levels – the classroom, school, district, state, and across the nation. It is important to ensure that these plans do not conflict with or diverge from each other. Rather, they should be compatible, integrative and synergistic.

## MORE INSIGHTS FROM A FEW CASES

### The Case of South Africa

Writing about educational reform in South Africa, Christensen (1997) proposes a two-pronged strategy for implementing technology-enhanced educational reform at the national level and at the global level internationally. He states that an economically developing country like South Africa faces two types of challenges – international and national. At the international level, it faces the same global market competition as economically advanced countries – a market that is increasingly being driven by information and knowledge instead of industries. Many schools in the developed countries are still using the teacher-centred model in classroom instruction as opposed to a collaborative and constructivist one that current education reforms recommend (Williams, 2000). Students in such schools are thus not being educated to enter the knowledge-based economy of the near future. The same situation applies also to developing countries. At the national level, South Africa faces a huge task, beginning with changing public and professional perceptions and ending with changing educational practice at grassroots levels.

Christensen (1997) recommends the use of the best combination of educational technologies to meet the national and international challenges. This combination will consist of low-cost, high-impact, mass-delivery approaches through radio, television, and printed text in order to meet the national challenge, and computers and the Internet to meet the international challenge. However, Christensen warns against the danger of promising too much or ignoring real limitations. Educational reform is a positive process but recommendations that are made should be realistic, feasible and dependent on the economic, social, and political situations of a country. A majority of developing countries, mostly the third world countries, face the same challenges and many of Christensen's recommendations apply to other developing countries as well.

### The Case of Mauritius

As part of its education reform, the Republic of Mauritius introduced ICT as a subject in 2003 into primary schools under the School IT Project (SITP) (Ministry of Education and Scientific Research [MOESR], 2002). In 2003, ICT teachers completed their initial training at the Mauritius Institute of Education and were subsequently posted in all the primary schools throughout the country (Jhurree et al., 2004). However, until now, there are no computer laboratories or adequate ICT resources in primary schools. A direct result of this situation is frustration among ICT teachers and a sense of disillusionment in the nation.

Lack of funding and inadequate planning have been postulated as two major obstacles to the implementation of the SITP project. Funding has always been a perennial hurdle in any project. However, by compounding it with politically-motivated promises, lack of political commitment (Kenny, 2001), and misjudgement of the massiveness and scale of the project by policy makers, the project was likely to suffer a setback.

The government has now revived the project by adopting what it calls the phased-implementation approach. Under this formula, around 50 computer laboratories would be set up each year in 50 primary schools instead of equipping all 284 primary schools at one time. This approach has been advanced as being more realistic and feasible. Undoubtedly, the amalgamation of achievable and realistic targets with firm commitment from authorities will move the technology integration project a step closer towards success.

### The Case of Warren County, USA

An evaluation study on the district's instructional and administrative use of technology in Warren County public schools, Kentucky, was conducted and recommendations were made thereafter in

how to integrate and deploy technology more effectively and efficiently in these schools (Clark and Sun, 1996). The following recommendations were made:

- The need for proper infrastructural support such as for proper hardware, software and, networks and Internet access, in order to provide the required logistical support to schools. Proper hardware can be obtained by either upgrading old machines or redeploying them to run software that requires little computing power, or by purchasing more powerful ones. Proper software should allow more exploration, collaboration and communication rather than the traditional drill-and-practice software (see also Means and Olsen, 1997).
- The improvement and expansion of professional development programs on the hands-on instructional use of technology in classroom. These programs need to be continuous and relevant to the needs to the teacher. Considerable authority should be given to schools in deciding the nature, scope, and frequency of the programs.
- The development of a district-wide technology plan focusing on the integration of technology in education to provide an enhanced learning environment.
- The investment of more effort by the district to inform teachers about software focusing on communication, application, and exploratory activities instead of tutorial activities.
- The provision of more technical support to teachers, both in how to handle the technology for administrative works and how to make pedagogical use of it in the classroom.
- The equipment of classrooms with computers so that teachers and students have easy access when they need them.

The study by Clark and Sun (1996) adds the following recommendations:

- District-supported 'group-buy' of computers by teachers and students for home use in order to reduce the incompatibility that may exist between school computers and home computers,
- The provision of assistance to teachers regarding training and support in the use of technology in instruction.

Though the Warren County had already integrated technology in the schools, the study was an effort to evaluate the impact or success of this integration. It showed the need to conduct evaluation exercises on a timely basis in order to determine the degree of success of implementation of any technology integration plan. This evaluation study also helped in identifying areas of strengths and weaknesses.

### **The Case of the State of Michigan, USA**

The concept paper on technology and educational reform produced by the Technology and Telecommunications Planning and Advisory Group (TTPAG, 1994) of the Department of Education of the state of Michigan in the United States discusses a five-year plan for the integration of technology in schools in its quest to reform education in the state of the Michigan. The Department of Education has recognised the role of technology in reforming education and in bringing positive change to the teaching-learning environment. The concept paper offers insights that are also applicable and useful to many developing countries. It proposes the following measures:

- The formulation of and adherence to an implementation plan. Like any project, technology integration needs to be properly planned and the plan needs to be adhered to and its implementation monitored. Without this, there will be little or no chance for successfully achieving the set goals.

- The creation of an information network in and among schools with access to the Internet.
- The creation of new technology-rich learning communities of teachers and students that (1) foster more active learning, (2) provide access to information, (3) enable teacher-student communication and collaboration irrespective of time, geography, age and ability, (4) transform the classroom into a global learning environment by providing links to the rest of the world, and (5) link homes, schools and society so that learning not only occurs in schools but anywhere and at anytime during the life of an individual.
- Opportunities for the professional development of in-service and pre-service teachers, parents, community members, and local boards of education in upgrading their technological skills.
- The allocation of adequate funding for the establishment of a state-wide informational and educational network and for staff development programs targeted to increase skills and competencies of school staff in its use of educational technologies.
- The development of a set of educational technology standards for the creation of a flexible technology-based learning environment that promotes and maintains full participation, open communication, and equal access. This ensures that users of technology such as teachers, students, administrators, and the community will be able to access it, and communicate with each other without having to worry about the changes in and differences among the technological platforms constituting the learning environments.
- Fostering a partnership among government, business, and educational institutions, such as schools and universities. This partnership involves all stakeholders concerned and would create a forum whereby they can collaborate constructively in the technology integration process.
- Uniform distribution of funds. A proper scheme for allocating funds needs to be established. This scheme must not only include one-time funding but continuous and recurring financial support.

Though the state of Michigan already had a number of technological capabilities and infrastructure, like a data network connected to the National Science Foundation NET (NSFNET), the National Research Network, and the Internet, the goal of the concept paper was to extend and improve these existing facilities to grant access to a wider community of learners in schools and community. This plan, despite dating back ten years, still offers strong propositions which apply to any country in the world.

### **Other Cases**

According to its ICT integration plan for education, Hong Kong has taken the following initiatives, among others, of (1) offering technical support on a contractual basis to schools, (2) opening school labs after school hours for students to increase access, (3) implementing a pilot scheme of demonstration schools with a view to establishing best practices in ICT education similar to countries such as Australia and Singapore, and (4) setting up a nationwide school network similar to countries such as Singapore, Australia, and Mauritius. It also lays much emphasis on issues of access and connectivity, teacher empowerment, curriculum and resource support, and community-wide culture that fosters more involvement and collaboration among school management, teachers, students, parents, the business sector and other community bodies (Education and Manpower Bureau, 2004). Furthermore, while the Malaysian Smart School Project plan (Ministry of Education of Malaysia, 1998) stipulates the setting up of a Teacher's Room resourced with Internet access, access to educational databases and professional networking

tools, the government of New Zealand emphasises the empowerment of not only teachers but school administrators as well in the use of ICT.

World Links, a project initiated by World Bank in 1997 to assist developing countries bridge the digital and knowledge divide and empower the youth, provides many interesting lessons (Hawkins, 2002). Technology integration programs have suffered failure because of (1) little or no professional development initiatives, (2) the absence of national policies on ICT education, and (3) the lack of community involvement. These mistakes were therefore not repeated in the World Link project and the author reports that the project was successful. Web-based tools and services such as emails and, web hosting, and wireless technologies have also been proposed. An alternative to wireless technologies can be the use of dedicated high-speed lease lines with a view to overcoming the barrier of using computers in school due to unreliable connections. It is also recommended that Ministries of Education establish close partnerships with telecommunications providers to show them the benefits of providing subsidised access to schools such as expanded client base and positive image.

With regard to technology and systemic educational reform in the US, Lane (n.d.) notes the following:

- Redefinition of the educational community, the roles and relationships between the partners in that community
- Restructuring of curriculum, instruction and assessment
- Redefinition of the structures and technologies of the school, recognising that it is also a player in the educational process
- Redefinition of where learning takes place and what it means to be 'educated'
- Time for teachers to learn to use technology, to experiment with its use and to create effective lesson plans that contribute to the learning needs of students
- Consistent access to a range of similar technologies at all levels of education for teachers and students, in schools, individual classrooms, libraries, home and the workplace
- Ongoing needs assessment

#### **POTENTIAL SOURCES OF FUNDING FOR TECHNOLOGY INTEGRATION IN EDUCATION**

On the issue of cost and financial mechanisms, there are various categories that need analysis in the calculation of financial investment. These include: (1) hardware, (2) software, (3) connectivity, ongoing maintenance and technical support including personnel, (4) professional development and training, (5) facilities, locale, and renovation, and (6) project management cost (Bakia, 2002). It would be suicidal not to consider all of these various categories of investments because they function in a holistic manner. If any one category receives more attention to the detriment of the others, the project could collapse.

Funding is an important ingredient to the successful integration of technology in the classroom. Cheever et al. (1986) identify six sources of funding. These are:

1. School budget: The first place to look for funds is the school's operating budget. However, due to limitations of this fund, large purchases of technological devices are difficult.
2. Bond issues: School districts also have capital budgets, apart from the operating budgets for schools, usually targeted toward the funding of major projects such as the construction of a new school and other facilities. Capital budgets can be obtained through floating bonds.



3. Educational collaborations: Through collaborative efforts among schools and other organisations, both local and foreign, funds can be raised and provided to schools. Also, school districts can purchase technological devices like computers and printers in bulk from a single vendor so as to reduce the purchasing costs. Through collaborative efforts, educational software can also be developed or purchased.
4. Federal or State Funds: If the government has a vision of improving education and integrating computers in education and if it is committed to this vision, then the task of getting government funding should also be explored.
5. Corporate Grants: Many wealthy companies receive tax deductions, along with societal recognition and customer market, for the help, in funds or other financially quantifiable terms, they give to institutions to achieve the latter's goals.
6. Private gifts: Financial support can also be obtained from private sources such as parents-teachers associations, civic groups or individuals or alumni, special fundraising events.

Added to this list could be international donor organisations such as USAID, World Bank, and UNESCO. These sources can be exploited by developing countries to obtain funds towards the equipment of schools with computers (Haddad and Jurich, 2002). Opening school computer laboratories after school hours to the community can also be a source of finance (Hawkins, 2002).

#### **SECURING THE COLLABORATION AND COMMITMENT OF MAJOR STAKEHOLDERS TO THE ICT INTEGRATION ENDEAVOUR**

There are a number of major stakeholders in ICT integration in schools. Three such stakeholders are teachers, school administration and parents. They form the cogs of the wheel that drives the ICT integration engine, and their involvement at the outset cannot be underestimated. Failing to take this into account may result in either slow or no integration.

Changing the attitudes of teachers toward ICT education is also crucial. Teachers are at the forefront when it comes to influencing the teaching-learning process inside the classroom. It is therefore important to change their attitude towards a computer-based learning environment. Miller (1988) suggests that school administrators should encourage teachers to develop a positive attitude about computers and to have minimum skills in using computers for educational purposes.

Administrators should be careful in the process of changing teacher attitudes. This process should be conducted so that teachers do not feel threatened in any way due to the introduction of computers in the classroom and such that they learn to appreciate the virtues of computers in education. They should be given positive accounts of how computers can make their teaching duties easier and more pleasing. Also, they should feel secure from the fear of job loss due to the integration of computers. They should be reassured that their jobs will not be threatened in any way by computers, and that computers will rather complement their classroom instruction.

Another step towards securing the trust and commitment of teachers to the ICT integration endeavour is their inclusion in the decision-making process alongside the policy makers as from the start (Cuban, 2001). Education reform has too often followed a top-down path whereby teachers have not been involved in decision-making. Decisions have been made for them by some higher authority without taking on board their opinions and suggestions. Teachers tend to feel that policy makers do not understand the classroom dynamics and hence they do not know what works and what does not at the grassroots level. Consequently, teachers tend to resist the implementation of such decisions. Therefore, involving teachers, and school administrators, and the community for that matter, maximises their sense of belonging to the integration process and hence their collaboration to the whole endeavour.

## **GUIDELINES FOR EDUCATIONAL ADMINISTRATORS AND POLICY MAKERS**

The reality in many developing countries is not a secret or an obscure reality. For instance, Africa is considered to be the poorest continent and it is overrun by a plethora of problems ranging from political instability and social unrest, to disease and poverty. It is also difficult to obtain figures to gauge the technological and digital divide between Africa and the rest of the world. Access to technology and ICT correlates with the economic health of a country (Haddad and Jurich, 2002). Many developing countries do not have the resources that other countries have. The major disparities lie in the following areas:

1. Vision of an education for the 21st century – many countries have little or no vision on the need to reform their education systems and their commitment to accommodate the challenges they will face in the global market economy of the 21st century (Christensen, 1997).
2. An economic reality – many countries do not have the financial means to support technology integration in schools. Also, educational reform in many nations is more rhetoric than a priority with, for example, some countries allocating much more of the budget to military ends than to education.
3. Knowledge, skills and expertise.
4. Infrastructure – many countries do not even have a proper physical school infrastructure, such as libraries, classroom furniture, electricity, and telephone lines.

Developing countries usually tend to be at the undesirable end of the digital divide spectrum. However, they cannot afford to stay passive and be left behind in race for better social, economic and education prospects. They face challenges at both national and international levels similar to what Christensen (1997) says about South Africa. His recommendations about the use of the best combination of educational technologies to meet the challenges are still valid nearly a decade later.

### **The Guidelines**

The list of guidelines that follows is neither exhaustive nor prescriptive. It is meant to be used for the establishment of priorities and goals regarding national policies on technology integration in education. Therefore, while some items in the list may be long-term milestones for some countries, other countries may look at them as intermediate or short-term goals. Countries may then need to establish their own priority lists based on what they can afford in the short-, intermediate- and long-terms.

- Establishment of a priority list. This is one of the first issues that needs to be dealt with at the outset. Social, economic, political, educational and technological disparities exist between and within developing countries. Likewise, there are differences in terms of electric supply, ICT and telecommunications infrastructure within and between these countries. National policies in ICT Education and a priority list need to be formulated accordingly. Countries have to establish first where they want to be and why in terms of ICT and ICT in education before considering how much money they have (Trucano and Hawkins, 2002). Asking what is to be achieved is the second type of question to ask. It will then be possible to know what kind of technology to put in place in schools. The context where ICT will be integrated is the next category for consideration as the cost will depend on the place of implementation. The ‘who’ and ‘when’ questions need answers also because implementation depends on whom it will affect and also the time frame for such implementation.
- Preparation of technology integration implementation plans. Implementation plans should be prepared at the strategic, management and operational levels, with clearly defined milestones

and schedules. Plans should be prepared by responsible and qualified persons in light of information gathered on real school needs, goals and objectives, availability of resources, training and staff development needs, and funds. If we are to learn from the case of Mauritius, the milestones should be realistic, achievable and effective. The effectiveness of the plans and milestones achievements should also be monitored and evaluated. Moreover, plans should be changed in light of the deliberations of the evaluation process.

- Involvement of all major stakeholders, such as teachers, schools administrators and parents at the outset in making decisions on ICT integration in education. Also, changing the attitudes of teachers toward such integration is important. Many teachers, both in developed and developing countries, are apprehensive about using computers for instructional purposes. Therefore, their attitudes need to be changed such that their collaboration and commitment are secured so as to achieve success in the integration process.
- Exploration of funding sources. Implementation costs can be very high. They include the cost of (1) hardware, (2) software, (3) connectivity, (4) ongoing maintenance and technical support including personnel, (5) professional development and training, (6) facilities, locale, and renovation, and (7) project management cost. Therefore, all possible sources of funding such as school budgets, bonds, educational collaborations, federal or state funds, corporate grants, private gifts, and donor organisations should be explored. Opening school computer laboratories after school hours to the community can also be a source of finance.
- Trying out of the technology-enhanced education project on a pilot basis. Even the best designed models that have been successful in one context may not work elsewhere. Conducting a pilot run of the project in some schools may help to identify and correct problematic areas before more investment is done (Tinio, 2003).
- Setting up of adequate school technological infrastructure. An important milestone for countries, both developing and developed, is to equip their schools with computers and associated accessories and tools such as appropriate educational software, printers, scanners, and multimedia systems in laboratories, and if the budget allows, classrooms also. A teacher's room with Internet access can also be set up. Schools should plan to provide school access to the Internet, preferably through school Intranets. Many pedagogically sound educational software packages for exploration, collaboration, and communication exist on the Internet and they can be downloaded freely or for little cost. The use of dedicated Internet connection lines increases the speed of access to resources outside the schools. However, both dial-up phone line connections and dedicated Internet connections are rather expensive and not affordable by many schools. This problem is exacerbated by the fact that many developing countries have inadequate telecommunications facilities, and this may present an obstacle to the provision of Internet access. Wireless technologies can be an alternative to dial-up or fixed line connections. However, it should be borne in mind that while the telecommunication systems remains inadequate and are not easily available to school and homes, and while the cost of using these systems remain high and unaffordable by users, the great potential offered by the networks and the Internet as an educational tool will not be achieved. All stakeholders, including government and parents, need to make every effort towards providing adequate network access to schools. Computer laboratories and/or computer-resourced classrooms need to be properly designed to house the various technology-based devices including access points to the Internet and/or the school Intranet.
- Identification of a priority list of staff training needs. Teachers, librarians, and administrative staff need to be trained, though teachers may need much more training than others. Due to limited funds, time and replacement staff, it is important to establish training-needs lists ordered according to priorities. These lists may be done on a timely basis. Thereafter, plans

must be devised so as to allow teachers and other staff to receive appropriate training. Training can be conducted either by professional organisations or by staff within the same school or other schools through workshops.

- Synchronisation of training with infrastructure. To maximise and strengthen the transfer of learned skills to the classroom, the time gap between training and actual classroom integration should be small, immediately if possible. The opportunity of putting into practice immediately what has been learned during training is more likely to increase the skills and confidence of teachers. To this end, the necessary infrastructure in terms of classrooms, computer labs, and other related ICT logistics should already be in place by the time teachers complete their training.
- Use of best combination of educational technologies in the form of low-cost, high-impact, mass-delivery technologies such as TV, radio, and printed text. This can be an interesting option in the face of financial hurdles for the purchase of computers, related peripherals and appropriate software. For TV- and radio-based projects, broadcasting stations could air educational programs either freely or at little cost (Haddad and Jurich, 2002).
- Conduct of frequent, needs-based, timely and hands-on staff training in the following areas:
  - For all staff*
    - How to handle and feel at ease with technology
    - How to do administrative tasks using technology
  - For teachers*
    - How to integrate technology in the classroom and make use of it in the teaching of subject matter
    - How to manage the technology-based learning environment with limited computers
    - How to assess learning outcomes of students as a result of using technology in addition to traditional classroom instruction
    - How to look for and evaluate educational software and integrate it in the classroom
- Identification of teacher training institutions. In order to train teachers, and other school staff, in how to integrate technology effectively and efficiently in their classroom teaching and for administrative purposes, the appropriate training institutions need to be identified and their collaboration secured.
- Gradual integration of technology into classroom instruction. It is not technology that revolutionises education, but rather the way in which it is used by teachers and students. It is not advisable to change current classroom practices of teachers abruptly without giving them enough time to get used to the presence and utilisation of technology as an instructional aid. For teachers to adopt technology as an instructional aid, they need to experience some degree of success with it. This experience will motivate them to make further and more effective instructional use. The transition from non-computer based instruction to an engaging computer-based learning environment should be gradual, smooth and well planned. Through subsequent training conducted in a timely fashion and support available in schools (such as mentors, school inspectors, and support from school administration) and outside schools (such as information, resources, and technical support), teachers will be able to make increasing instructional use of computers in the classroom. They will be able to move from little to highly learner-engaging instructional use of computers.
- Provision of easy access to technology to all teachers and students. Computers should preferably be located in classrooms instead of computer laboratories so that users can access them throughout the school day. However, it may be very expensive to equip all classrooms with computers, let alone having a single well-equipped laboratory. Developing countries

should aim at putting as much technology as possible in computer laboratories first, then gradually equipping classrooms as and when budgets allow.

- Implementation of an outcome-based assessment. The assessment of students' performance should be more on what they can do instead of how much time they have spent during learning. Performance assessment should aim at evaluating the performance of the student in the new technology-based learning environment where learning has been taking place by exploration, collaboration, and communication. Assessment should aim at evaluating the number of learning objectives attained, instead of rating one student with respect to another through written examinations.
- Provision of technical support to schools. Schools require the necessary technical support to successfully implement technology in education. Schools will need to (1) maintain and repair their technological devices, (2) provide some degree of support to teachers within the school building so as to train them in how to use technology in their classroom instruction, and (3) provide adequate support to teachers and administrative staffs within the school so as to train them in the use of technologies for administrative and communication purposes. Maintenance can consume from 30 to 50 per cent of initial investment in hardware and software (Moses, 2002). This aspect of integration cannot be underestimated. As a solution, district-level and/or school-level technology coordinators can be appointed and given computer maintenance and staff training responsibilities. Technical support can also be obtained from other schools, and teacher-training institutions can provide expert level advice in new educational software packages and their use in the classroom. The idea is for schools not to wait for formal training programs in order to equip teachers and administrative staff with the necessary knowledge and skills to make effective use of technology, but they should explore other possibilities as well.
- Appraisal and motivation of teachers. Appraising, motivating and giving due recognition to teachers for their work of integrating technology in classroom can be important. Teachers not only need to be professionally supported, but emotionally as well. By giving them managerial and peer support for their effort of technology integration in instruction, and by giving them their due recognition by praising them for their work, teachers will be more motivated and willing to further explore the pedagogical potential of technology-based classroom instruction (Sammons, 1994). A staff-appraisal scheme can be developed and implemented to reward teachers according to their effort, dedication and success in applying technology to enhance the learning environment.
- Recycling and redeployment of older machines. Computer recycling is an ecologically sound alternative to the purchase of new PCs (Haddad and Jurich, 2002). Many schools can only afford a limited number of powerful, multimedia, and up-to-date computers. However, older computers can be acquired, either by purchase or donation from public and private institutions, and they can be redeployed in schools. These machines can run educational software that does not require advanced technological features. There are several places from where these old machines can be acquired, for example, (1) local, regional and national government offices, (2) private industry which in turn can be motivated through tax breaks or other financial incentives, (3) computer stores, and (4) private households that want to dispose or donate their PCs (Thomas, 2002).
- Creation and subsequent computerisation of the school library. Students and teachers need access to curriculum materials as conveniently and easily as possible. This can be achieved by having computerised libraries in schools. However, many schools in developing countries have few or no library facilities. Hence, the setting up of libraries in schools is an important priority for educational administrators. Moreover, schools that already possess libraries can start computerising them. Computerisation will handle such activities as curriculum materials

recording, cataloguing, indexing, searching and, connecting to other electronic educational resources. Therefore, the library will not only be a place of putting low-cost, high impact print medium, but will also provide fast and easy access to curriculum materials to teachers and students, it will also ease the job of librarians and library technicians.

- Technology standards for compatibility and software licenses. To prevent incompatible technology between schools and home, schools and districts can adopt common technological platforms such as common computer systems, like PC or Macs, and common networking technologies, like TCP/IP. Licensing issues will also have to be sorted out even in the case of acquiring older PCs (Thomas, 2002).
- Setting up of an information and educational network linking schools and other educational organisations together. African SchoolNet organisations are good examples (Issacs, 2002) such as the SchoolNet Cameroon, SchoolNet South Africa and SchoolNet Namibia. SchoolNet Africa is another example of an educational network but of a far wider span than just a single country. The establishment of such networks can foster more cooperation, communication and collaborative efforts among educational institutions. This endeavour consumes considerable resources in terms of money, effort, planning and monitoring, and many developing countries may find this difficult to implement. However, a long-term goal for schools in developing countries could be the creation of such networks.
- Partnership with corporate organisations and higher education institutions. The initial and/or continued support, in the form funding and technical support, for technology integration is bound to be a major problem to be faced by schools in many developing countries. Thus, looking for alternative means of support is advisable. Such alternative means can come from higher education institutions and corporate organisations in the form of funding, technical and technological expertise, computers and other technological devices that can be obtained either as donations or purchased in bulks. These institutions can also be very good sources for acquiring older machines.
- Establish links with other institutions within the country or with other countries. Through those links, knowledge, expertise, experience can be shared across schools. Students will have the opportunity to indulge in more collaborative work and, individual and group project works as well. They will be able to contact peers, teachers and experts in their subject areas and other areas of interest. Collaboration is an important factor in determining the success of ICT integration projects (Haddad and Jurich, 2002). For instance, this can be achieved by (1) adapting existing materials produced elsewhere to local contexts, (2) dividing the integration work among participating institutions and countries and thus sharing the expenses, and (3) sharing resources such as allowing access to users beyond school hours for a fee or other relevant support.
- Support teachers and students in purchasing computers. School-supported, district-supported and/or government-supported purchases of computers by teachers and students can increase technological-platform compatibility and familiarity with the technology. To reduce incompatibility between computers in schools and at home, the schools, local authorities and the government can provide support for teachers and students in terms of finance or partnership deals with computer sales companies.
- Equipment of community centres with technology for increased access to students. For schools that cannot afford a computer lab, community centres can be used as a place to provide wider access to technology. Equipping these centres can provide the opportunity for students, teachers, and the community to learn about and with technology.

- Correspondence between the workplace, students' access and use of technology. Students learn better when they evolved in a learning environment that closely reflects the workplace in both the types of activities and the types of technological resources. Many developing countries may find it hard to implement this correspondence. However, a long-term milestone could be the provision of authentic learning situations which could be achieved by matching the workplace to the classroom.
- Creation of relevant legal frameworks. ICT has the ability to go beyond national barriers to reach international legal frameworks. Therefore, required laws and regulations can serve as facilitators in the promotion of easy and equal access to ICT and at the same time as watchdogs to deter unethical, illicit and illegal use of ICT. Deregulation against monopolies by government or private organisation, accreditation and certification especially in the era of e-learning, and the protection of intellectual property rights (Haddad and Jurich, 2002) are a few areas where legal frameworks are required.

Equipping schools with computers can be very expensive for many developing countries. Although computers have become cheaper in recent years, they still remain expensive and unaffordable to many. However, in the face of change and the shift towards technology integration in schools, developing countries must start equipping schools with computers. A student-computer ratio of one-to-one could be very desirable, but surely unattainable even for developed countries. Developing countries should, however, put enough computers in schools that allow, at least, for group activities on the part of students and enough hands-on practice to all the students. However, one important lesson to remember is that technology by itself does not enhance the teaching-learning process and environment (Levine, 1998). It is the effective and efficient use of technology along with effective teaching strategies and a classroom environment conducive to learning that will bring about a positive change.

## CONCLUSIONS

On the issue of technology integration in education, there are considerable disparities between developed and developing countries. Developed countries have more resources, knowledge, skills and experience than developing countries. However, developed nations suffer from many of the same challenges and concerns as developing nations, though to different extents. They suffer from the same concerns of teacher apprehension and motivation, and lack of appropriate educational software and technical support, and the same challenges of providing adequate teacher training, of taking care of infrastructural inadequacies, and implementing learner-centred instruction and proper assessment procedures in schools. Much can be learned, however, from what developed countries have done to deal with their technology integration problems, and much can be applied to developing countries. This paper has advanced a list of guidelines intended for educational administrators and policy makers. Stakeholders should not treat the list as prescriptive, but more as suggestions that will help them produce realistic, achievable and effective implementation plans at district, school and classroom levels based on a priority list. Developing countries should establish a list of priorities based on their needs, specificities and capabilities, and then apply appropriate guidelines to execute and evaluate their plans. However, high in the priority list should be the conduct of needs-analysis and establishment of goals, the securing of funds, procurement of ICT infrastructure, the training of teachers, providing adequate support to schools and teachers, and involving major stakeholders in the decision making process. All this should be cemented by a firm commitment by the authorities and a constant evaluation and management of the implementation process.

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