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Information and Communication Technologies (ICT) in Medical Education and Practice : the Major Challenges.

Summary

This paper identifies four major challenges in raising physician awareness about the benefits of using ICT in education, training and practice. The first of these challenges is to better prepare future physicians for the changing patterns of behaviour of patients, increasingly more sophisticated regarding the use of the internet to learn more about their disease condition(s). The second challenge is to educate physicians in the multiple benefits of using ICT to improve health care delivery and understand the organization and processes of the health care system.

The third challenge is to motivate students to critically use ICT to search, find and use appropriate information that enhances learning and development. This challenge additionally requires ICT literacy as a mandatory skill for all medical students. The final challenge is to change medical teaching/learning practices. The evidence demonstrates how ICT stimulates innovation in teaching practice and prepares physicians to use ICT for their academic and practice needs.

Major Themes:
ICT with regard to medical education is in an early stage of development. Rather than being reactive to ICT innovation and development, the author delineates ways in which ICT can be adapted and used to improve education and practice standards.

It is also evident that widespread population access to the internet has begun to change patient behaviours in terms of knowledge of disease and ability to engage with the physician practitioner in partnership concerning health care decision making. Moreover, virtual reality technologies have the potential to improve both educational and health care practice.

A case is made that there is a lack of scientific research in this area. Medical educators seem to be more concerned with devising and implementing innovations rather than systematically studying and assessing them.

Best Practices and Innovations:
The e-learning approach to education, training and practice represents the future of initial and continuous medical education. Virtual resources and network communities, simulations and 3D animations are being used to (a) conduct more diagnoses at a distance, (b) assist in long procedures, (c)

follow up with high risk patients at home, (d) rural health care delivery, (e) delegated nursing care and (f) sharing information and skills among practitioners. The use of hand held devices have enabled personalized care by facilitating people to adopt preventive lifestyles and are increasingly being used to transmit patient information and provide better patient follow up.

Full Text

Abstract

This literature review addresses the main effects and challenges in using information and communications technologies (ICT) in medical education and practice. The first challenge is to better prepare future physicians for the changing behaviours of patients, who are increasingly Internet-savvy and who sometimes appear to know more about their diseases than their physicians. The second challenge, which is closely linked to the first, is to raise awareness among physicians in training of the many benefits of using ICT, to improve not only the quality of interventions and health care delivery, but, from a broader perspective, the organization of the health care system itself. The third challenge is to motivate medical students to use ICT to find information, learn and develop. It is proposed that informational literacy should be a mandatory skill for all medical students. The e-learning mode of training is also addressed. Although under-employed in most medical faculties, it represents the future of initial and continuous medical training. Virtual resources and communities, simulations and 3D animations are also discussed. The fourth and final challenge is to change medical teaching practices.

Description of Search Strategy

In our review, we used 78 references. We searched both the UofM library as well as the following databases: Medline and Premedline (2000-June 2008), EMBASE (2000-May 2008), Web of Science (all years), Information Sciences Abstracts (2000-May 2008), Library Information Sciences Abstracts (2000-May 2008), AACE (2002-2008), ERIC (2000-2008). We used mainly ICT, Medical Education and Medical Practice as keywords.

Introduction:

This paper reviews the main impacts and challenges in using information and communication technologies (ICT) in the practice and teaching of medicine. When considering the impact of technologies on fields such as medicine, the first images that come to mind are advanced techniques and highly sophisticated machines. However, few are aware that ICT have also changed the ways in which medicine is practiced and taught. As Fieschi (1) explains, although ICT have assumed an important role in medicine in the last 25 years, the effectiveness of medical teaching and practice in Western societies has been brought into

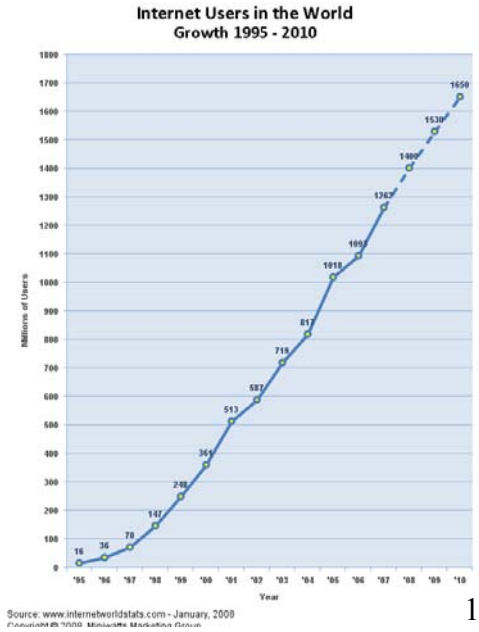

Figure 1:
Growth in number of Internet users in the World.[1]

question, and some say it is in crisis. On the one hand, *"Biological and surgical techniques were developed and extensively used and, on the other hand, medicine was fragmented into numerous sub-specialties as medical knowledge improved. As a result, the costs of medical procedures increased considerably, the quality of patient/physician relationships was tarnished and, in addition, iatrogenic [i.e. inadvertently caused by a medical professional] risks were not and have not yet been fully controlled"* (1).

In 2008, the Internet celebrated 39 years of existence. Originally the province of the army and a handful of American universities, a few short years later it has become an indispensible, everyday tool for people on every continent. The number of Internet users in the world has catapulted from 16 million in 1995[12] to over 1407 million en 2008[13] (Figure 1). In the words of Kofi Annan, speaking at the World Summit on the Information Society, "A technological revolution is transforming society in a profound way. If harnessed and directed properly, information and communication technologies (ICT) have the potential to improve all aspects of our social, economic and cultural life." Originally conceived as efficient means to distribute information and communications, ICT have rapidly been appropriated by all manner of professional circles, including medical practitioners and students.

With the introduction of ICT, everything changes – our ways of living, learning, working and socializing. And the pace of societal change has accelerated with the recent arrival of Web 2.0, with interfaces that enable Internet users to interact with Web pages and other users. Unlike users of the fledgling Internet, which consisted mainly of static Web pages, users of Web 2.0 are Web *protagonists*, or principle actors who input site content and keep peers abreast of new developments. With Web 2.0, citizens in every country can create their own destinies and actively contribute to the technological world. According to *Time Magazine*, the invention of YouTube in 2006 exemplifies the advances made by Web 2.0. In the medical field, over 84,000 animations and conference extracts are featured on the Web, for example, a demonstration of how the heart works (Figure 2).

Figure 2 :
Animation du site YouTube.com.

In the opinion of Heath, Luff and Svensson (2), one of the key developments in health care in the last 25 years is the incursion of information and communications technologies (ICT). These

[12] Source : IDC (http://www.idc.com/)
[13] Source : Internet World Stats (http://www.internetworldstats.com)

authors feel that ICT wield a wide range of impacts on medical practice, patients' experiences and health-care management, to name only a few.

The first challenge: to prepare physicians for the changing behaviours of Internet-savvy patients:

Several studies have found that one of the most important impacts of ICT on medical education is that tomorrow's physicians must be well prepared to cope with changing patient behaviours. Research has shown that patients' habits have changed significantly in recent years. Not only do they use ICT to better understand medical issues, but they also use networking to inform each other, rate their doctors, question medical procedures and launch malpractice suits. For Duvvuri and Jianhong (3), ICT have definitively transformed the physician-patient relationship, which implies a new kind of training for tomorrow's medical practitioners. Fieschi (1) and Denef, Lebrun and Donckels (4) go so far as to claim that patients are far ahead of doctors in their use of the Internet to learn about medical developments, and they are sometimes better informed on their illnesses. *"With the omnipresence of the Internet in homes and the growing presence of public virtual portals such as Healthgate and Medecinenet.com, increasing numbers of patients are consulting their doctors after having navigated the Web"* (5). [translated]
The literature also reveals new possibilities for physician-patient relationships, particularly when patients are isolated or away from hospital settings, such as elderly persons (see Magnusson et al., 6), or chronic disease sufferers. According to Lucas (7), by using ICT, patients *"can link with others, again using the Internet and mobile telephone networks, to share information, seek advice […]."*

With the advent of the Internet, medical knowledge is no longer the prerogative of health-care experts. A kind of democratization of scientific and medical knowledge has come about, which profoundly affects the traditional relationship between the patient, who used to be relatively ignorant, and the physician, who used to be the fount of wisdom.
This relational shift between physician and patient means that, on the one hand, medical practices have been increasingly called into question, and on the other, the status of the medical profession has been profoundly shaken (8).

Willmer (9) points out that, despite the realignment of the doctor-patient relationship, the increasing use of ICT by patients and medical practitioners alike improves the quality of health care delivery in the end. Some, like the European Commission, appear to have embraced this new patient attitude, viewing it as a way to make people more accountable for their health. Thus, better informed patients are usually more inclined to get involved in health management. *"They want to be part of the health decision process and are increasingly requesting access to the data contained in their medical records"* (1). Gatzoulis and Iakovidis (10) discuss *"citizen-centered care,"* which requires greater patient involvement at all levels of medical practice (prevention, diagnosis, treatment and follow-up.) The arrival of ICT has caused a paradigm shift in medical practice and teaching. Greater importance has been placed on information sharing, akin to what Fieschi (1) calls *patient empowerment*. Therefore, ICT should not be perceived as a nuisance, as many doctors do, but rather as a way to get patients more involved in managing their health. Moreover, as Broom (8) explains, *"It is argued that the ways in which these specialists are adapting to the Internet and the Internet user should be viewed as strategic responses, rather*

than reflecting a breakdown in their authority or status."
In countries where most people have Internet access, as in North America, where about 73% of households are connected, this new patient attitude is changing the practice of medicine, and it poses serious challenges to the ways that initial and continuous medical training are handled.

The second challenge: to raise awareness among physicians in training of the benefits of using ICT:

The exponential rise of ICT in our society, far from being a nuisance factor in medical practice and instruction, has many potential benefits for patients and doctors in the areas of health-care organization and management.

Benefits for the quality of interventions and health-care delivery:

Along with challenges to the physician-patient relationship, this technological shift brings many benefits. For instance, using ICT, patients can readily interact with health-care experts without having to leave home. Stretcher (11) describes the benefits of software systems that can "analyze" medical situations. He also demonstrates the utility of interfaces that enable patients to communicate directly with an online health-care specialist, 24/7. He particularly stresses the benefits of these systems for patients who, *"because of stress, pain, or the cancer treatment itself, have irregular sleeping habits"* (11). Medem Inc. (http://www.medem.com), a cybercompany that provides web-based physician-patient communications services, uses a similar interface so that patients can *consult* a physician on line at all hours. As Norman and colleagues (12) point out, the rapidly developing capacity of interactive technologies to store and transmit data multiplies the possibilities for physician-patient interaction. Although physicians have had access to statistical databases for just a short time, they can now consult continuously updated data in just a few clicks of the mouse. They can also communicate with their patients (and even "see" them), get more detailed information first-hand and provide better treatment. For these reasons, the field of telemedicine, or practicing various aspects of medicine (prevention, diagnosis, treatment and follow-up) at a distance, has become increasingly common in both initial and continuous medical training (13). In fact, telemedicine is gaining ground in the health-care systems of many industrialized countries, including Canada, the United States, Great Britain, Germany, France and Norway (14).

The HERMES project (15) in Europe is one such initiative. Telemedicine can be used to make diagnoses at a distance, to assist other surgeons in complicated operations, and to follow up high-risk patients in their own homes (16). According to Suarez (16), telemedicine also facilitates centralized pathology services, rural health-care delivery, delegated nursing care, and the provision of health-care in hostile or unusual circumstances. For Ganapathy (14), a major advantage of telemedicine is that it enables diverse experts around the world to share their opinions in a few seconds and find the best solution to a particular problem. Ganapathy (14) also suggests that specialists will soon go farther to diagnose their patients: "*Like most other professionals, the telespecialist of the future will offer advice from home without having to travel long distances to a hospital. Junior hospital staff currently depend on advice received by telephone, which has considerable limitations. Soon, using telemedicine, the senior consultant*

can evaluate the patient and the investigations from outside the hospital and make a correct decision. The patient's needs cannot wait for the next day's 'rounds.'" (14).

In addition, as Suarez (16) explains, telemedicine enables occasional or continuous training to be offered to hospital health-care specialists, who would otherwise have to leave the workplace. In the view of Sargeant (17), telemedicine has become a highly sophisticated tool with a convincingly demonstrated efficiency. For instance, it is a particularly effective way to teach surgery. In addition, virtual telemedicine environments that integrate the Internet and videoconferencing allow not only real-time consultations with other specialists (see Loke Jennifer, 18), but also, and most importantly, continuous follow-up during surgical procedures when interns are assigned to isolated regions or foreign countries.

These systems increasingly require physicians in the 21st century to acquire technopedagogical skills as part of their university training to effectively fulfill their roles as medical healers (5). Raising awareness among future medical practitioners of these innovative methods should be part of the basic training program for all physicians.
Finally, as Strecher (11) points out, the use of ICT for preventive purposes is relatively limited, and it is still primarily used for treatment. According to him, this is not surprising, and it should be viewed by practitioners as a welcome challenge. The use of preventive services should also be promoted as a way to motivate citizens to be more accountable for their health management.

Benefits of improved health care organization

In the words of Lucas (7), *"[t]here is a growing consensus that the impact of ICT on health systems will be substantial or even revolutionary […]."* Although this point is not directly linked to medical teaching, it is important to mention that several authors have underscored the benefits of ICT for health care organization. Oh and colleagues (20) extensively discuss the concept of *eHealth*, which refers to the application of information and communications technologies in the health sector, from purely administrative to health care delivery, or alternatively, as healthcare practice that is supported by electronic processes and communication. Among the many benefits of ICT in health care systems, Haux (21) and Duvvuri and Jianhong (3) note that ICT are incomparable for providing access to a vast store of information about the patient in the form of a digital file. This electronically available information facilitates follow-up, teleconsultation of the patient's file, and patient education so that patients can learn more about their condition. Duvvuri and Jianhong (3), Ganapathy (14), Bulterman (22) and Fieschi (1) place particular emphasis on the potential of health telemanagment for prevention, diagnostics and follow-up on chronic diseases. For example, ICT allow decisions to be made *"once the parameters delivered at home have been analyzed"* (1). And the Internet will only make this easier in future, which will undoubtedly contribute to the growth of distance health-care delivery. Finally, there are a growing number of handheld devices that support new and promising applications. *"The work done so far has demonstrated the potential of these platforms to enable personalized care by empowering people to adopt a preventive lifestyle with an emphasis on early diagnosis"* (10). As reported by Norman and colleagues (12), these handheld devices are being used increasingly to transmit patient information and provide better patient follow-up. For example, many portable devices are equipped with sensors that automatically send a range of patient information to the health-care specialist, with no effort on the patient's part, so that physicians can make better

diagnoses and take action as needed. It would appear required for medical training programs to raise awareness among medical students of the various benefits of ICT so that they can use them to advantage when they eventually join medical organizations (23, 1).

Haux (21) argues that ICT enable health-care specialists to organize health care delivery better, more easily and more systematically, and that this advances the *"quality and efficiency of patient care,"* among other things. The technology explosion also has the potential to promote better rationalization of resources (14, 24). For Fieschi (1) and Haux (21), the changes that ICT has wrought in health care organizations and medical practice have led to a more macroscopic vision of the patient's file through the transformation from a hospital information system to a more inclusive health care information system that belongs to all citizens.

The third challenge: to motivate physicians in training to use ICT to find information, learn and develop:

Several studies have noted the shortcomings of medical faculties in terms of integrating ICT into initial and continuous medical training. Suarez (16) found relatively little initiation to ICT applied to health care in most initial medical training programs. However, according to many researchers (see 25, 23, 26, 27), ITC should be a mandatory component in initial and continuous medical training. On the one hand, ICT are omnipresent in the workplace, and on the other hand, they are vital for health-care professionals to update their knowledge in a field where that knowledge is constantly evolving. Some authors, such as Harden (28), suggest two main technologies to apply to medical training: e-learning and simulators. Others consider virtual 3D animations one of the most promising innovations in medical education (see 29). Researchers such as Valcke and De Wever (23) and Fieschi (1) mention that knowing how to access online resources and *informational literacy* (30) should be required competencies in initial medical training.

The importance of informational literacy:

Given the vast amount of resources available on the Internet, the concept of informational literacy has received much attention, particularly in the medical field. Informational literacy is defined as knowledge and mastery of a variety of technical tools that facilitate access to information (Web sites, databases, etc.) in order to find solutions to problems that arise (see 30). Kwankam (31) sums up the importance of informational literacy as follows: *"ICT has become indispensable to health workers, as the volume and complexity of knowledge and information have outstripped the ability of health professionals to function optimally without the support of information management tools."* Results of the studies by Kisilowska (32) and Bennett et al. (33) illustrate the importance for future physicians to develop informational literacy. Their findings indicate that the greatest problems facing physicians who seek information on the Internet are the phenomenal quantity of facts that are available, on the one hand, and on the other, the difficulty of finding more specific facts on certain topics.
Informational literacy is all the more necessary for the physicians of tomorrow, who will work in an environment of ever advancing knowledge. *"En médecine, on n'apprend plus uniquement du professeur et du livre. Internet est maintenant pour beaucoup la première source d'accès à la*

connaissance […]" [In medicine, learning is not transmitted by professors or books alone. The Internet has become the primary source of knowledge] (5). Thus, ICT are already providing solutions to the growing need for information and knowledge sharing by today's and tomorrow's physicians. Most importantly, ICT allow physicians to stay better informed and to more easily communicate with each other. A study by Bennett and colleagues (33) conducted on 3,347 physicians shows that almost all had Internet access, and that most considered the Internet important for improving the quality of care they provided to their patients. The most frequent use by far was seeking information (on the latest research or a particular disease or problem presented by a patient).

Virtual resources:

There are many resources that specifically target health care professionals. Mattheos and colleagues (34) attempted to organize these into categories. First, there are tutorials and other applications for computer-assisted learning (CD-ROMs, instructional Web sites, etc.). To illustrate, Nosek, Cohen and colleagues (35) set up an instructional Web site targeting students in the fields of genetics and cancer (http://casemed.case.edu/cancergenetics). Black and Smith's (36) initiative also demonstrates how online tutorials can foster better learning. However, as pointed out by Letterie (37) and Valcke and Wever (23), few studies have compared the benefits of computer-assisted learning to more traditional methods. The idea here is not to denigrate the inherent advantages of using ICT, but rather to underscore the lack of research in this area. It appears that medical educators are more concerned with implementing innovations than with systematically assessing them.

Mattheos et al. (34) report on the large number of medical databases available, the most popular being Medline. These platforms allow medical professionals to rapidly find the information they need. According to Kwankam (31), the essential advantage of these systems and databases is that they can offset *"the mind's limited capacity to sift through large quantities of health facts and identify those items that bear directly on a given situation."*
There are also many games designed to motivate students to absorb medical lore. Although few studies have addressed this area, Valcke and De Wever (23) point out the enormous educational potential of these tools, as they confront learners with complicated situations where they have to apply their theoretical knowledge, come up with hypotheses (usually diagnoses) and test them. Immediate feedback is then provided. Sargeant (17) provides support for this argument, contending that *"computer-mediated multi-media instruction and the Internet can effectively link learners to learning materials and information resources, to each other, and to instructors."*
Several authors have enumerated the advantages of interactive online learning systems. Chan and Dovchin (38) highlighted the benefits for medical training in so-called developing countries. Others conclude that these systems will wield a significant impact on the abilities of tomorrow's physicians to generate hypotheses (see 39) develop critical capacities (see 40, 41), develop *reflective practice* and the provision thereof (see 42), develop metacognitive strategies (see 43), and refine their diagnoses of clinical cases (44). Some authors see in these systems benefits for university educators, such as improving their abilities to assess interns (45). Others contend that medical faculties could make greater use of these systems in their recruitment strategies (46).

The studies by Charlin and colleagues (47, 48) found that physicians in training could develop clinical reasoning through the use of interactive ICT applications. Charlin and colleagues (48) set up an online Script Concordance test to assess the clinical reasoning of medical practitioners, residents and students in uncertain situations. Participants were asked to handle complicated or poorly structured problems that required clinical reasoning and the mobilization of a sound knowledge base. Their responses were then compared to those of a variety of experts in the field. The literature generally confirms the effectiveness of ICT-supported assessment tools and systems, particularly for active learning (49, 23).

Finally, a number of specialized Web sites are dedicated to research data. As argued by Karsenti (5), it is important to make available to learners a wide variety of informative sources, and medical training should actively promote this. The Web also contains many sites of medical training institutions that have encouraged access to a wide range of medical information, such as the Tufts University School of Medicine in Boston (www.tufts.edu/med/), the University of Nebraska Medical Center (www.unmc.edu), Stanford University (summit.stanford.edu/cqi/), *l'Université catholique de Louvain* (www.md.ucl.ac.be/luc/netlinks.htm) and *l'Université Bordeaux II* (www.apprentoile.u-bordeaux2.fr/default.htm) (see 5). These sites also facilitate interuniversity collaboration in medical teaching (see 17). For Fieschi (1), the availability of high-quality content on the Internet is a vital factor for initial and continuous training in the medical field.

Note also that an increasing number of scientific references are available on the Internet, and many circumvent copyright issues. Thus, initiatives such as PLoS and BioMed Central are willing to share medical knowledge with all comers. Along with movements such as the *Directory of Open Access Journals* (which currently indexes over 3,000 journals) and more flexible copyright systems such as the *Creative Commons* and *Science Commons* licenses, these initiatives facilitate access to and sharing of vast quantities of resources via the Internet.
The literature reports on many indexed digital directory sites containing highly useful *learning repositories* (50). These learning repositories allow educators to quickly retrieve all kinds of useful pedagogical materials. One of the most extensive learning object repertories is MERLOT (http://www.merlot.org/), which stands for *Multimedia Educational Resource for Learning and Online Teaching.* A free resource that imposes no copyright conditions, it was created mainly for university educators and students. Among other things, it offers peer reviewed teaching materials: animations, lesson plans, assessment methods, etc. However, as rightly pointed out by Valcke and De Wever (23), no scientific assessment of the effectiveness of such resources has been published to date.

Virtual communities:

CD-ROMs, databases and Web sites are important resources for medical training. However, they usually offer limited user-interface interaction. Several studies have shown that adding the capacity to communicate and input content engenders positive outcomes, particularly in medical education (see 23, 51). Besides making hard-to-access resources readily available, information and communications technologies facilitate knowledge sharing and networking between physicians in training and practitioners. In the view of Fillion-Carrière and Harvey (24), ICT foster greater information exchange between researchers and practitioners. They render the

literature much more accessible and they simplify communications and knowledge sharing between professionals.

There are many virtual communities of professionals who are interested in particular topics and who regularly communicate through the Internet. Meanwhile, blogs have sprouted everywhere. These are individual, regularly updated sites that allow anyone interested to read and respond to posted messages. For example, *scienceroll.com*, *clinicalcases.org*, *healthcarebloglaw.blogspot.com* and *askdrwiki.com*, all award-winning sites, receive millions of visitors. These sites target medical students as well as practitioners. Such resources allow the exchange of best practices, best sites, recent discoveries and the latest cures, in the aim of improving medical practice. Zobis and colleagues (52) reported the positive effects of an experiment conducted at the Mayo Medical School. A virtual community was created to facilitate exchanges between medical students and between teams of educators and the students. These specialized sites are not only a way to keep abreast of the exponential growth of information in the medical field, but also a way to mobilize individual and collective skills to find solutions to health problems (31).

Other popular tools are the *discussion list* and the *electronic distribution list.* Discussion lists are usually dedicated to small groups because they allow exchanges between members. A study by De Wever, Van Winckel and Valcke (25) found that knowledge building, which is a higher-level process than reflection or the development of critical thought, is fostered by the use of electronic discussion groups in medical study programs. Distribution lists address larger groups, as they are used uniquely to transmit information and do not enable members to exchange views. According to Castel and colleagues (53) these lists *"have also been shown to be very useful in bringing information that is otherwise inaccessible to professionals working in less well-developed settings […]."*

E-learning:

As explained by Muirhead (54), Harden (28), Jones et al. (55) and Chryssafidou and Arvanitis (56), one of the key challenges facing medical faculties is to introduce e-learning into initial and continuous training programs. The literature reports on the many inherent advantages of e-learning, with flexibility the most often cited. Users of e-learning can proceed at their own pace, wherever they happen to be, and usually in the way that best suits them (see 57). Kunnath (58), Heywood et al. (59), Relan and Krasne (60), Seelinger and Frush (61), and Haigh (62) also cite as advantages in the medical field the transmission of high-quality content, support for continuous and post-graduate education, and multiple possibilities for communicating while learning. Broader communication is another key advantage of e-learning. Castel and colleagues (53) explain that *"with further outreach than conventional distance learning, and taking advantage of interactivity among students and teachers in a virtual community and hypertext and hypermedia facilities, e-learning has become a useful and widely accepted tool for […] training and continuous professional development programmes."* Nevertheless, although the benefits of collaborating with ICT have been extensively exploited in other contexts (see for example the studies by Henri and Lundgren-Cayroll, 63), they are still under-employed in medical pedagogy (23). For instance, very little research has investigated whether this form of collaboration fosters

decision-making in medical practice. One such study was conducted by Lu and Lajoie (64). The same holds true for videoconferencing in medical education, an area that has been extensively documented in other settings: *"There is a lack of literature and formal studies on the use and effects of videoconferencing to enhance real-time synchronous delivery"* (65).

As Harden (28) argues, although it is difficult to accurately predict the forms that e-learning will take in future, it seems inevitable that medical students will be increasingly required to learn on line. Moreover, studies conducted long before 2002 have shown that medical students are ready for distance learning (see Akinyemi, 66). It appears undeniable that e-learning is the wave of the future in medical pedagogy, despite the many problems to be surmounted and the evident lack of documentation or assessment of past experiences (see Karsenti, 5).

Virtual simulators:

As reported by Harden (28), the use of simulators has grown tremendously in the medical field in recent years. They are as effective in education as they are in practical training. Virtual simulators have been used primarily to reduce medical error (see, 67). The experiment conducted by Doiron and Isaac (68) demonstrates how simulation can reduce the medical errors of physicians in training. Using an online game, the authors reproduced an emergency room where learners had to make rapid decisions as they tried to stabilize patients and make diagnoses. Virtual simulators represent a paradigm shift in medical education, and virtual reality is expected to play a key role in initial and continuous training in future. Again according to Harden (28), simulations facilitate learning *"through the provision of: effective feedback, repetitive practice, a range of difficulty, multiple learning strategies, clinical variation, a controlled learning environment, and individualised learning."* In Canada, ICT are used to improve and personalize teaching methods and clinical skills, which when delivered in the traditional way, can sometimes compromise the patient's well-being (24).
The literature on virtual simulators documents the clear advantages of using ICT in medical training (see 69, 70). However, as pointed out by Valcke and De Wever (23), this is particularly true when (a) neophytes are trained in the use of ICT and (b) use of the virtual simulator is not limited by lack of technological skills. Hence the importance of introducing physicians in training to these innovations at the initial training stage.

3D animations on the Web:

Graphic representation of information appears to be central to the acquisition of medical knowledge (see 23). For some years now, medical faculties and other medical organizations have constructed extensive image banks to help specialists better understand a variety of medical issues. The literature shows that online images foster knowledge acquisition in a variety of scientific fields (see 71, 72). In the medical field, studies have shown the importance of incorporating advanced graphic representations, particularly in e-learning, when the educator is not available to comment on the image (see 23). Three-dimensional animations, commonly called 3D animations, are examples of advanced graphic representations. They have the advantage of facilitating knowledge acquisition through a realistic three-dimensional visualization, which is superior to the traditional two-dimensional image. When these pedagogical resources are available on the Internet, learners and educators have the flexibility to

watch them at any time, in any place, as long as they are connected to the Internet. John (29) explains that 3D representations are particularly useful for anatomy classes, and they have shown a clearly demonstrable impact on learning, although it is evident that such resources must be used in combination with other types of pedagogical support, such as video clips, textbooks, etc. John (29) reports that many assessments have shown the effectiveness of this pedagogical strategy. Thus, increasing numbers of medical faculties are using three-dimensional animations on the Web in initial training, for example, at *l'Université de Lyon I* in France. They have pushed the envelope even further by conducting an experiment in which educators and students can manipulate the animation, i.e. *move* it, *pivot* it, or *change its position*, at least virtually, to improve the presentation. Although their results have not yet been published in a scientific journal, the reactions of the students who participated in the experiment and were able to *move* the organs and bones of the virtual human being using a Wii remote (a.k.a. Wiimote) raise interesting possibilities for the future.[14] In addition, as John (29) contends, the emergence of new standards and a very active user community augurs well for the future of 3D Web applications for initial and continuous medical training.

The Fourth challenge: to change medical pedagogy practices:

A further challenge inherent to the use of ICT in medication education is how to implement this innovation into medical pedagogy in universities and hospitals. There are many references and publications on the issues to consider in the broader area of integrating ICT into university teaching (see for example 19, 73). The literature on university teaching reveals a sort of Cornelian dilemma facing university educators (i.e. a lose / lose situation): should the content (teaching method) be adapted to the vehicle (technology), or should the vehicle be adapted to the content? (24). In fact, researchers in university pedagogy generally feel that pedagogy should be the main priority and that technology should be adapted to it. Nevertheless, recent studies have shown that pedagogy can evolve when it comes into contact with new technologies. In certain circumstances, therefore, and for specific uses, ICT can be catalysts for change in university pedagogy. The study by Nosek, Wang et al. (74) shows how technologies can be used to spur innovation in teaching practices. The authors worked with professors of very large classes who wanted to help their students engage in more active learning. The use of televoters by the participants during lecture classes fostered active learning and increased students' motivation. In addition, their results show improved performance by medical students (in their official exams) after participating in the study. Some authors wonder whether ICT can really change physicians' practices on the ground and the behaviours of patients towards their diseases, which would promote improved quality of care and disease prevention (see 4). Ward and Moule (75) suggest that physicians could improve their practice by employing ICT during their practical training so they would know how to use ICT for their academic needs, to communicate with university supervisors, and to improve patient care delivery during their internships. Some go further by proposing an online management system for the training curriculum (see 76).
Other researchers (77) feel that use of the e-portfolio would inspire physicians in training to use ICT not only to learn, but also to showcase their accomplishments. Thus, e-portfolios are increasingly being used not only for university training, but in medical practice as well. According to many sources, they are also a creative and effective means to organize, summarize, present and share information for medical teaching and learning, and for personal and

[14] Details of the experiment are provided at: http://www.univ-lyon1.fr/1205315796141/0/fiche___actualite/&RH=PRAC_ACT-SER

professional development. According to Lewis and Baker (77), the use of the e-portfolio can incite the use of ICT in medical practice.

Conclusion:

This literature review presents the main challenges of using information and communication technologies in medical education and practice. The first challenge is to better prepare medical students for the changing behaviours of patients, who are increasingly connected to the Internet and sometimes better informed on their disease than their physician. In North America, where the vast majority of households have Internet access, this new patient attitude will transform the practice of medicine, and physicians of the future must be prepared for the new reality. For the practitioner, the idea is not to limit the information to which the patient has access, but rather to use these new skills as leverage to make patients more accountable for their health. The term *patient empowerment* is increasingly used in the literature, but, as Haux (21) points out, *"Patient empowerment is still in [its] early stages."*

The second challenge, closely tied to the first, is to raise awareness among physicians in training of the many benefits of ICT for improving the quality of interventions and care provided to patients, and for better organizing the health-care system. The exponential rise of ICT in all societies, far from being considered a nuisance in medical teaching and practice, should instead be perceived as a significant advantage that could improve the physician-patient relationship as well as the quality of health care delivery. The examples of telemedicine and virtual communities of practitioners are only a few of the many benefits of ICT for improving the quality of medical practice. Lucas (7) explains that ICT wield a major impact on the health-care system. It would therefore appear necessary to introduce medical students to these changes now so they can take advantage of them later to improve the quality of health care delivery.

Motivating medical students to use ICT to find information, learn and develop is the third challenge. The focus here is on informational literacy, which is considered a mandatory skill in the training of all physicians. The issue of e-learning is also addressed, because although this teaching mode is not very widespread in medical faculties, it represents the future of initial and continuous medical training. The role of virtual simulators, 3D animations, and virtual and community resources as important innovations in medical education is briefly discussed. It is essential to instruct physicians in training in their use and the impacts on medical practice.

Changing practices of medical pedagogy is the fourth and final challenge addressed in the literature. The massive incursion of technologies in our societies influences the habits of not only patients, but also physicians in training. Medical teaching practices must adapt accordingly. The idea is not to place pedagogy and technology in opposition, as many have done (see 24), but rather to adapt technologies to pedagogical needs, while being mindful of the innovate effects of technologies on teaching practices.

We must reiterate that the challenges engendered by ICT in medical education and practice are still under-documented scientifically (23, 78). As noted by Lau and Bates (65), lack of detailed methods, small sample sizes (e.g., the study by Nakamura & Lajoie (39), where only 16 participants were studied) and the specificity of the technologies examined make it impossible to generalize results from the few studies conducted. Letterie (37) and Valcke and De Wever (23) go further by deploring the absence of studies that clearly demonstrate the benefits of learning with ICT: *"There are no comparative studies [...] that demonstrate a clear-cut advantage. […] In addition to descriptive studies, more evaluative studies of ICT tools are required, focusing on the efficiency and the impact on students' learning."*

As mentioned above, it is not a matter of calling into question the many inherent advantages of ICT, but rather of noting with disapproval the lack of scientific research in this area. It appears that medical education stakeholders are more concerned with implementing innovations than systematically assessing them.

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