

Section 2.2

Potential of information technology in dental education

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Keywords

computer-assisted instruction; dental education; implementation; information technology.

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Codes in respect of declaration of conflict of interest:

nci: declared no conflict of interest with
 commercial company in past 2 years
 nd: no declaration made

Accepted: 23 September 2007

Abstract

The use of information technology (IT) in dentistry is far ranging. In order to produce a working document for the dental educator, this paper focuses on those methods where IT can assist in the education and competence development of dental students and dentists (e.g. e-learning, distance learning, simulations and computer-based assessment). Web pages and other information-gathering devices have become an essential part of our daily life, as they provide extensive information on all aspects of our society. This is mirrored in dental education where there are many different tools available, as listed in this report. IT offers added value to traditional teaching methods and examples are provided. In spite of the continuing debate on the learning effectiveness of e-learning applications, students request such approaches as an adjunct to the traditional delivery of learning materials. Faculty require support to enable them to effectively use the technology to the benefit of their students. This support should be provided by the institution and it is suggested that, where possible, institutions should appoint an e-learning champion with good interpersonal skills to support and encourage faculty change. From a global perspective, all students and faculty should have access to e-learning tools. This report encourages open access to e-learning material, platforms and programs. The quality of such learning materials must have well defined learning objectives and involve peer review to ensure content validity, accuracy, currency, the use of evidence-based data and the use of best practices. To ensure that the developers' intellectual rights are protected, the original content needs to be secure from unauthorized changes. Strategies and recommendations on how to improve the quality of e-learning are outlined. In the area of assessment, traditional examination schemes can be enriched by IT, whilst the Internet can provide many innovative

approaches. Future trends in IT will evolve around improved uptake and access facilitated by the technology (hardware and software). The use of Web 2.0 shows considerable promise and this may have implications on a global level. For example, the one-laptop-per-child project is the best example of what Web 2.0 can do: minimal use of hardware to maximize use of the Internet structure. In essence, simple technology can overcome many of the barriers to learning. IT will always remain exciting, as it is always changing and the users, whether dental students, educators or patients are like chameleons adapting to the ever-changing landscape.

Introductory parameters

What is our definition of information technology (IT) as related to dentistry?

The group discussed the instructional applications of IT in undergraduate and postgraduate dental education. This includes all possible ways where IT can assist in the education and competence development of dental students and dentists (e.g. e-learning, distance learning, simulations, computer-based assessment). Furthermore, the group identified that there is another dimension of IT within dentistry which is how IT can assist the dentist in professional practice (e.g. patient management software, digital X-ray, etc.). This dimension was not within the primary focus of the group.

Terminology

What are the terms that will be employed and what is their working definition?

From a pedagogic point of view, what is described as computer-assisted instruction (CAI), computer-assisted learning (CAL) or e-learning is a wide array of instructional methodologies and tools (1). Learning is the process that takes place from the student's perspective as a result of instructional strategies. Therefore, it is important to define from the start that the main focus of the group relied on instructional strategies and tools. The group reviews the existing IT-based instructional tools and methodologies and evaluated the impact of these tools on student learning. Finally, the group endeavoured to suggest recommendations on how dental education could profit from IT, based on existing evidence and best practice.

The terms biomedical and dental informatics as well as information science are very wide (2). This working group focused on some specific areas within the educational process and avoided general terms and used defined terminology. For example, CAI (3) and IT (technology and media for the collection, classification, storage, retrieval and dissemination of information) are two terms that define our working area.

Which IT-related activities are to be identified?

The group identified the following main areas of IT application in relation to dental education:

1. Teleconference applications (audio/videoconference, Web-based or not).

2. Standalone CAL applications (CD-ROMs, didactic Web pages, in general applications that limit interaction between user and interface).
3. Simulations (Web-based or not) Simulation of skills, decision making, authentic scenarios, virtual patients, etc.
4. e-learning platforms (Web-based collaborative learning environments, learning content management software, virtual learning environments, etc.).
5. Consumer electronics and related new technologies (i-Pod, mobile telephones, palm pilots, etc.).
6. Administration and learning management systems (managing the logistics of the learning process, tracking and documentation of progress).
7. Tools for the retrieval and management of information (Web-based databases such as Medline, reference management software, etc.).
8. Computer-based assessment (tools and strategies for the use of IT in the student assessment).

The above-mentioned tools and technologies are represented in scientific literature to a variable extent. The group felt that a thorough investigation of each of these technologies would be beyond the scope of this report. Therefore, the group discussed strategic issues in relation to the implementation and benefits of IT in dental education.

Reviewing the existing evidence – best practices

Why IT?

As society is changing, our education methods cannot remain static but must be dynamic and responsive to the wider social environment. Our society is information driven. Web pages and other information-gathering devices have become an essential part of our daily lives, as they provide extensive information on all aspects of living. Problems arise regarding how to cope with, categorize, remember, file, etc., the increasing mass of information. In response, industry is providing faster, smaller devices with increasing memory capacity and greater possibilities with regard to information gathering and communication.

A whole generation has grown up with IT (4, 5) and the Internet is a very significant facility. It has become an essential part of daily lives both in society and in education. The term Net Gen (net generation) has been used to describe young people with the following characteristics: digitally literate, connected, immediate, experiential, social, team-workers, structure, visual and kinaesthetic, interactive and experiencing

(5). As information volume increases exponentially, there is a growing need to critically assess the information, digest it and file it in order to avoid 'system' overload. Furthermore, information should be available for re-accessing and sharing amongst students and peers. The diversity of learning needs amongst students requires the matching of methodological approaches to education; often independent of time and place.

Specific educational applications

There are particular IT tools available for dental education. The following is a general classification, as it appears in the existing literature (6, 7) and was discussed in the last Global Conference (8, 9).

For foundational knowledge acquisition (theoretical)

9. Tools for the retrieval and management of information (Web-based databases such as PubMed, reference management software, etc.).
10. Standalone CAI applications (CD-ROMs, didactic web pages, in general applications that limit interaction between user and interface).
11. e-learning platforms (Web-based collaborative learning environments, learning content management software, virtual learning environments, etc.).
12. Consumer electronics and related new technologies (i-Pod, mobile telephones, palm pilots, etc.).

For acquisition of skills (pre-clinical and clinical)

13. Simulations, web-based or not, two-(2D) or three-dimensional (3D) simulation of skills, decision making, authentic scenarios, virtual patients, etc.

For patient care and decision making

14. Tools for the retrieval and management of information (Web-based databases such as PubMed, reference management software, etc.).
15. Teleconference applications (audio/videoconference, Web-based or not).

For formative and summative assessment

16. Administration and learning management systems (managing the logistics of the learning process, tracking and documentation of progress).
17. Computer-based assessment (tools and strategies for the use of IT in student assessment).
18. Computer-based reflective logs, diaries, portfolios, etc.

For information sharing

19. Teleconference applications (audio/videoconference, Web-based or not), collaborative working environments, file share applications).

e-learning platforms

Early in the e-learning era, content management systems were developed which were Web-based. In their simplest form, subjects for discussion could be created for a threaded discussion amongst those having access to the site. Today there are more than 100 learning management systems (LMS) available, including commercial (Blackboard, First Class, Luvit, etc.) and several shareware or freeware (Moodle) platforms. All these programs have more or less the same functions. It is primarily the design of the interface between the software and the user that varies. Typically a modern LMS should contain the following functions:

1. A main page which can be edited by the administrator of the e-learning session.
2. A calendar, a notice board for short messages.
3. A forum for subject discussions.
4. A member list.
5. An email list.
6. A function for uploading documents.
7. A link list.
8. A literature list.
9. A chat function.
10. Options for audio and video conference, as well as an option for online lectures.

The complexity of the commercial LMS is often high and there is a potential risk that the user may get lost amongst all the functions available in the software. Therefore the teachers should be able to design the functions of a given content learning system and keep the interface for the user as simple as possible.

The added value of IT in comparison to traditional teaching methods and tools

Information technology applications can provide significant advantages in many areas of dental education:

Access issues

1. IT-based courses can reach groups that would otherwise be unreachable by conventional educational methods (remote practitioners, part-time faculty, outreach clinics).
2. Sharing of resources by the faculties of schools (for example, lack of basic sciences teachers).
3. Standards of technologies allow easy sharing.
4. Some schools lack resources (space, faculty, teaching rooms in the dental school), but students still have the latest technology (Internet access, mobile phones, etc.).
5. Information retrieval, critical evaluation of resources.

Student-centred

1. Individualization of the curriculum and often the assessment process.
2. Attendance, independent of time and place.
3. The 'YouTube' model: empowers student to create educational content, logs of their own activities or projects, to share it with peers and receive feedback.

Simulations

1. 2D or 3D simulations, visual and more realistic.
2. Haptic (feedback).
3. Decision-making simulations (virtual patients) for the improvement of clinical decision-making skills.
4. Video for training – cognitive (anatomy, surgical techniques) – brings virtual patients into the pre-clinical lab, allowing students to view clinical material in advance.

Decision support

1. Support students and dentists through quickly providing relevant information at chairside.

How to implement quality assurance with both content and structure of electronic learning environment

Quality assurance of electronic-based learning products includes the learning effectiveness of the product, usefulness to faculty and students, the quality of the content and its technical quality (10–12).

Learning effectiveness

Existing research points out that e-learning applications can be at least as effective as conventional instruction alternatives (6, 13). Furthermore, there are specific learning scenarios where e-learning applications are reported to present specific advantages (7). A significant advantage of e-learning material is that it is easily updated, as new information and potential improvements become known.

Usefulness to faculty and students

Many members of faculty are not comfortable using new technology (14). Support needs to be provided to encourage them to effectively use technology to its fullest extent. This can be achieved through faculty knowledgeable/comfortable with technology to serve as mentors to their colleagues. Where possible, institutions should appoint an e-learning champion with good interpersonal skills to support and encourage faculty change.

In order for all students and faculty members from developing and developed countries to have access to e-learning tools, this group encourages open access to e-learning material, platforms and programmes. To ensure that e-learning tools can be easily accessible, their developers need to use metadata standards, so that automatic search machines (robots) can effectively find and classify the necessary information.

Programmes should track the use of e-learning tools so that the faculty members involved in the development can gain recognition in their home institution and be globally acknowledged. Effective strategies that can be employed locally include making the use of e-learning part of the faculty members evaluation process, and the promotion and tenure process for those whose primary duty is teaching. To monitor students' perception of the e-learning tools, feedback can be gathered via rating scales, with

the ratings being posted and made accessible to others. In order to simplify distribution, lower costs of education, it is necessary to guarantee that e-learning tools will be widely available to facilitate the use of the World Wide Web.

Content quality

Peer review is a way to ensure content validity, accuracy, currency, the use of evidence-based data, and the use of best practices. Some examples of peer review e-learning materials can be found at MedEd Portal (15). Additionally, faculty at other schools around the world should be able to rate materials. The developers can then use this feedback to improve the materials available for use around the world.

Technical quality

In order to ensure that the developers' intellectual rights are protected, the original content needs to be secure from unauthorized changes. The Congress encourages the use of registering e-learning materials with the Creative Commons for international copyright protection (16). Ease of use is paramount for all e-learning tools. The system should be easy, technically, for students and faculty. They should use established standards for technical quality and pilot-test each product to find and resolve navigation and other interface issues.

Students and faculty should be able to use e-learning tools in any location. There needs to be a balance between security that protects the original content and open access.

Recommendations as to how the IT tools and strategies might be used to improve the quality of the following

Instructional methodologies and learning outcome

The 'learning outcome', although being in the focus of educational research in the past decade, has proved to be a rather elusive term. Especially in the early years of CAL, the learning outcome of computer-based instruction was repeatedly compared with that of traditional teaching with mainly evaluation of subjective parameters. From a macroscopic point of view, learning constitutes a real change taking place in the knowledge, skills and attitudes of the students. It should be possible to evaluate objectively this change, i.e. the outcome of the learning process. However, the elements that constitute this 'learning outcome' proved to be very difficult to define and even more difficult to evaluate.

Therefore, educational research is currently moving away from summative terms such as 'learning outcome' or 'learning effectiveness' to focus mainly on more concrete 'objectives'. These objectives can be identified in the area of motor skills and competences, in the cognitive area (skills, attitudes, competences), meta-cognitive area (self-assessment) or in the administrative area of the learning process (time consumption, cost/effectiveness, flexibility, etc.). Achievement of these predetermined objectives might constitute a successful learning process and therefore a positive outcome.

Information technology can aid in many ways the achievement of such objectives, both the learning objectives as well as these of an administrative nature.

Information technology should be used to:

1. Enrich instructional interaction.
2. Allow flexibility of structures and support individual learning paths.
3. Support the building of association and development of networks.
4. Enable reflection, self- and peer-assessment.
5. Promote the development of life-long learning attitudes.
6. Encourage active learning, collaborative and peer learning.
7. Support face-to-face teaching through blended learning environments.

To secure effectiveness and efficiency, implementation of IT instruction should include:

1. Existing research evidence and best practices.
2. Faculty development programmes.
3. Students' active involvement.
4. Global collaborations in the development and sharing of content and methods.
5. A modular philosophy of development, which allows easy, sharing, update and redesign of the content.
6. Platform independence in terms of technology, which would allow for maximal applicability of the content.

The implementation of IT instruction can be jeopardized by:

1. Overcomplexity of the educational software (LMS), which may confuse and discourage the users.
2. Inflexible platforms which do not allow enough teacher control over the instructional methodology and content delivery.
3. Lack of a support team, including IT specialists and knowledgeable project management.
4. Lack of an effective IT infrastructure. The use of IT will be improved by the presence of wireless connections, high-speed connections and access to computers on/off campus.

Assessment

The modern healthcare environment requires that professionals are continuously developing their competence in all areas relevant to their expertise. Any curriculum in healthcare education must educate professionals who are not only competent in clinical procedures but also are prepared to adopt a practice of life-long learning. This reality must consequently be reflected in the assessment process. With the help of IT and the Internet, classical assessment schemes can be enriched, whilst innovative assessment can be constructed. With the help of IT, assessment can focus on flexibility, independence of specific instructional approaches and interdisciplinary applicability.

For example, the ability to self-assess one's own competence is a crucial skill for all health professionals. The Internet has been shown to be an appropriate tool to facilitate training in self-assessment ability (17, 18).

Information technology could contribute to assessment schemes through:

1. Simplifying the logistics of the examination process.
2. Enhancing interaction during the assessment process, both human-to-human but also programmed interaction with Internet database-driven applications.

3. Supporting self- and peer-assessment scenarios.
4. Supporting reflective modes of assessment such as diaries and portfolios.
5. Facilitating distance learning environments and independent Internet-based training.
6. Enriching traditional assessment schemes with quick and easy access to information and documents.

Potential of a global perspective

According to the report from the WHO Consultative Meeting 'New Approaches in Oral Health Training and Education in Africa', which was held in Cape Town, South Africa in April 2002, half of today's higher education students live in developing countries and their education systems are under great strain. The problems facing higher education in developing countries have their roots in the lack of resources. Far less is spent per student in developing countries than in developed countries. Over 80% of the funding is spent on personnel and student costs, leaving little for building maintenance or research. Academic staffs are often under-qualified, lack motivation and are poorly rewarded. Many students with poor primary and secondary schooling are under-prepared for higher education studies. Buildings and libraries are often inadequate and scientific equipment cannot be used because of lack of supplies (19).

Using IT in education could help improve and relieve some of the strain imposed on educational systems in the developing world. We can all agree that the ultimate aim of learning and teaching is to produce a creative thinker. Using IT in the education process can help us achieve this. IT will increasingly be used in dental education to build career technology skills, improve information-gathering skills and opportunities, expand learning opportunities, increase communications between teachers and students, and encourage more active and collaborative learning (20).

For many, the Internet has become an integral part of everyday life (21). Unfortunately, according to the above-mentioned WHO report (19), the Internet is accessible to only 3% of the world's population. It is unknown what the exact percentages are for dental students and dentists who have access to the Internet. According to surveys investigating the use of Internet and IT amongst undergraduate dental students in Chile, UK, Jordan and Turkey, most respondents admitted to not fully using Information communication technology (ICT) for learning purposes or to search information relevant to their studies of profession (22–25). Virtanen and Nieminen reported that 80% of students in Finland used Medline (26).

There are a number of limitations in the use of IT in dental education and lifelong learning in both developing and developed countries. These include the cost and availability of software and hardware in both the home and university environment, together with low computer literacy and resistance to change of the teaching staff and students (27). The cost of subscription to access electronic journals constitutes another barrier.

How to change the global perspective

1. High development and software costs could be partly overcome through the Open Source initiative (28).

2. Open access to electronic resources (29), which means free and unlimited access to scientific knowledge and innovation, might allow developing countries to equally participate in scientific progress through IT at both an institutional and individual level.

3. Rationalization of the copyright process should empower teachers worldwide to use available resources more effectively.

4. Full library access and computer availability need to be taken into consideration and prioritized as aims of development cooperation. The International Federation of Dental Education Associations (IFDEA) could undertake a leading role in collecting quality content, archiving and then making it available to a worldwide audience of dental educators and students'.

5. Investing in the educators should also be a priority. Educating a small number of influential educators in the use and benefits of affordable learning technology, might accelerate progress and decrease resistance.

6. Interactive e-tutorials via VoIP (Voice Over Internet Protocol)-type programs, might constitute a cost-effective tool for sharing educational content.

7. The OLPC (30) programme is a great example of what simple technology can do when combined with internet resources.

The future

It is difficult to predict, but often fun, to identify current trends and upcoming changes in IT and its use in society which will have an impact in educational settings. The Internet, and its use as a communication tool, has undergone unpredictable changes but it is possible to undertake some 'crystal ball gazing' of what might happen.

Uptake and access of IT

The uptake of existing technology will continue to increase. The technologies and strategies we use for this generation during their education will eventually cause a shift in the information-seeking and learning behaviours of the lifelong learner. The general public relies more and more on the Internet for oral health-related information and this will be seen when our patients attend for consultation and care. Consequently, in the near future online information will have a significant role in shaping patients' perceptions and uptake of professional care (31). Although general computer literacy will be widespread, dental students will need thorough training in the educational use of the Internet and IT. In particular, students will have to search for and evaluate information, then use it in a sensible but caring way with their patients. They will have to inform their patients and colleagues on the quality of on-line resources.

Technology, hardware

The merging of consumer electronics (computers, mobile phones, organizers, multimedia players, etc.) into multipurpose devices, in combination with the expansion of wireless networks, will increase accessibility. There will be greater potential to develop flexible instruments which will provide more opportunities to deliver educational material. Miniaturization will continue and this will lead to the further development of inex-

pensive portable means of hardware. New media carriers of educational content will emerge with an emphasis on portability, quick search and access to content and 'custom-made' delivery of content.

Technology, software

There will be a move towards advanced 'intelligent' software (artificial intelligence, semantic networks, database-driven applications with built-in abilities to 'learn' from users). This will allow a more effective use of learning resources and an increased number of 'custom made' educational environments. The software will determine what learning materials the learner requires and these will be 'pushed' to students.

Methodologies – paradigm

Emphasis will be placed on increasing student involvement and making them responsible for their own learning. This will lead to a seamless transition from undergraduate to postgraduate education. The early interaction with IT and its ability to facilitate scholarship will prepare future graduates for lifelong learning. Dental educators will be forced to consider the use of the Internet to strengthen their educational programme and to communicate with their students.

Web 2.0

The impact of Web 2.0 (32) technology and social interactions on the Web are increasing and allowing people to collaborate at various levels. The use of learning communities on the Internet [open source projects, blogs, sharing platforms (Wikis), podcasts, videos, bookmarking, page customization] are exciting developments which captivate students' interest. Harnessing such interest and bringing it into dental education will be a future challenge for all academics. Such social networking applications are system-operating independent. That is, one only needs an Internet browser to have access. This is vital for teaching environments, where all students have different hardware, software and operating systems (Linux, Windows or Mac). This may have implications on a global level: the OLPC programme is the best example of what Web 2.0 can do: minimal use of our own hardware and maximal use of the Internet structure. In essence, simple technology is required to overcome the barriers.

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