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Information and communication technology, mobile devices, and medical education

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Abstract

Introduction*:* Information and communication technologies (ICT) are practical and highly available tools that combined with the vast amount of knowledge available in the web have several implications in everyday life, including education. In medical education, ICTs allow physicians to update their knowledge and remember basic information within the reach of current mobile devices. However, few authors have studied ICTs as preparation tools for medical education and, to the best of our knowledge, none has been reported for medical students in Mexico.

Methodology: To assess the use of mobile devices as ICTs with medical education purposes, we distributed a questionnaire through an online survey management system to all the medical students (n=215) from a private university in Mexico City, and 83% agreed to participate in the study. We developed the questionnaire based on previous surveys and adapted it to the particular conditions of the university.

Results*:* All participants reported possession of an electronic mobile device and 95% of them use it regularly for learning purposes. Regardless of the school year, the most frequent usage given to these devices was the search and reading of medical articles and pharmacologic information, use of medical calculators, and taking notes.

We observed that as the students advanced in school year there was a reduction in the use of electronic devices with an inverse correlation between higher career levels and the use of electronic devices. According to the students, the main barriers towards using mobile devices for learning purposes were both the lack of access to the internet and of permission from the professor to use them.

Conclusion*:* Most medical students use mobile devices for learning purposes, but usage changes during the course of their education. It is convenient to encourage the use of

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mobile devices and development of ICT skills as tools for educational purposes rather than banning their use in schools and hospitals.

Kew words: information and communication technology (ICT), electronic devices, mobile devices, medical education

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Introduction

The high-speed information and knowledge development of our current society makes the use of electronic resources and devices an essential skill for the medical profession (Ward et al., 2001) for both learning and updating medical knowledge (Romanov & Aarnio, 2006; Sclafani, Tirrell & Franko, 2013; Eggermont, Bloemendaal & van Baalen, 2013; Friederichs, Marschall & Weissenstein, 2014). In the last two decades, thousands of scientific articles have been consulted as sources of new knowledge needed in medical education (Samuel et al., 2004; Bravo, 2014). As a consequence, those in charge of medical education worldwide are interested in knowing student's information and communication technologies (ICT) skills during their basic and clinical training (Fan, Radford & Fabian, 2016).

In this regard, Samuel and colleagues in Tanzania (Samuel et al., 2004) reported the perception of inferior performance compared to other students of medical schools from developed countries; their 92 students surveyed attributed that perception to the lack of ICT, mainly personal computers. Another study in Malaysia (Lim, Wong & Lim, 2005), where the students had computers both personal and at the university, reported that 53% of their students claimed to use them for educational purposes with varying times, half of the students used computers between 1-2 hours, 6.5% between 3-6 hours, and 3.4% more than 6 hours per day. However, the authors did not explore the use of these technologies as a means of accessing medical information.

Other authors such as Hye Won Jang y Kyong-Jee Kim (Jang & Kim, 2014) have been interested in the use of videos as an ICT learning strategy; the authors evaluated the impact of a series of videos designed to respond favorably to the Objective Structured Clinical Examination (OSCE) among students from 34 Korean universities. After

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watching the videos, the exam was applied and the students were asked for their opinion on its usefulness to solve the examination. Almost all the students who answered the survey (91.9%) agreed with the usefulness of the videos. It is important to mention that one third of the participants watched the videos on mobile devices, and considered it the most accessible way to do so. However, they also pointed out the difficulty to interact with these devices and software. More recently, improved applications for clinical practice of both physicians and medical students have been developed for computers as well as mobile devices. In 2014, Boruff and Sotrie (Boruff & Storie, 2014) evaluated the appropriateness of Canadian libraries to facilitate the interaction between the members of their universities, students and teachers, with the availability and accessibility of information collections as well as the reliability of the information obtained. In general, they found that doctors, both in training and teachers, had no problem accessing collections but ignored the most reliable sources of information and had limited access to quality or authenticated databases.

A current challenge is to facilitate access to reliable sources of medical information in both universities and health care clinics. To our knowledge, there are no studies in Mexico on the accessibility of medical information and communication technologies for medical students despite the high frequency of access to these tools in medical schools. In contrast to what has been studied by other authors who have focused their studies to basic applications of computers or to the distraction generated by this type of technologies (Kir et al., 2004; Maroof, Parashar & Bansal, 2012; Ayatollahi et al., 2014; Nalliah & Allareddy, 2014), the aim of our study was to analyze the specific use of information and communication technologies as learning tools in medical education, avoiding on purpose its possible use for entertainment or distraction, as well as its

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mobile accessibility at the learning centers of the students, either at the university or hospital.

Materials and methods

An observational, cross-sectional, descriptive and prolective study was carried out during the period of January-March 2016. All medical students from a private medical school were invited to participate in the study. Since all students had mobile devices, the survey was created using an online survey platform (https://www.surveymonkey.com/). Participation was only excluded for students enrolled in the sixth year of medical school as they were located in rural areas doing their social service assignment, where access to internet could be limited and could generate a selection bias.

Questionnaire construction. The questionnaire (available at https://osf.io/tnx4d/) consisted of 36 *Open-ended* and *Multiple choice* questions. It was divided into 3 sections: general information, information technology in the school, and information technology in the hospitals (4, 22 and 10 questions, respectively). Finally, the mandatory thirty-sixth question referred to the informed consent for the research use of the information provided by each participant. Some questions allowed more than one answer. The questionnaire was constructed for our purposes considering some questions from similar surveys conducted in other countries (Cheston, Flickinger & Chisolm, 2013; Boruff & Storie, 2014; Farooq & White, 2014; Nalliah & Allareddy, 2014). The clarity and content of the questionnaire was reviewed by three professors not involved in the project. The questionnaire was distributed through an online survey management system with the institutional e-mails from all the students enrolled in the school year of 2016 (n= 215). From the invitation date the page remained open for two months. Access

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was restricted to one response per device. The participant could make changes at any time until the answers were sent, and then the participation was recorded. To encourage participation, the groups were informed on the importance of the study and, for motivation, the response rate of each school grade was reported.

Ethical aspects. The project was approved by the research and ethics committee of the medical school. At all times, the anonymity of the participants was protected by requesting only information on age, gender and year. Individual participation was ensured by restricting access to the device key.

Statistical analysis. The information collected was redirected to a database available in the same software. From there, it was transferred to a commercial database for further analysis. For each of the qualitative variables the findings were summarized in simple and relative frequencies in percentage. To maintain anonymity of the participants, the analysis was carried out based only on the school year and the place of the academic activities. The mean and its standard deviation were obtained for the qualitative variables.

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Results

Of all the medical students enrolled in 2016, 83% participated in the online survey (180/215). The distribution of participants according to school year is shown in Table 1. Participation was higher for second- and fourth-year medical students and lower for first and fifth-year medical students. The mean age for both men and women was 21 years, with no differences between school years.

Use of electronic devices for information and communication technology: All students reported owning at least one type of electronic device. All of them had a smartphone, 82.8% (149/180) a laptop, and 98% an electronic tablet.

Use of information technology: 95% of medical students reported using their devices for learning purposes (improving comprehension, memory, and school performance), while only 5% denied using their devices for those purposes. Due to the observed similarity by gender ($p = 0.77$; Table 1), the use of ICTs was compared only by school year and according to the places where they attended classes. Table 2 shows the use of electronic devices on campus according to the school year. Our data revealed that the main use of these devices is for taking notes, especially for the first four school years, followed by reading medical articles or e-books in more than 80% of students, regardless of the school year. The search for information on drugs and medical update platforms queries increased from the second school year. Enquiry of medical practice guidelines was more common among third- and fourth-year medical students (clinical courses), followed by searches for differential diagnoses. Likewise, there was an increase in the use of medical calculator applications for clinical conditions, which were rarely used in the first two years, but not in the last three years. Finally, ICT use as a means of

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communication within the university campus was reported by about 50% of the students.

Use of electronic devices in hospitals was also analyzed (Table 3) and revealed that the main purpose was to search medical update platforms. This use increased significantly over the clinical years. This was followed by the reading of articles or books, with articles being more consulted in the last two years, but without significant difference. Taking of notes with electronic devices increased in the third and fourth years, and sharply reduced in the fifth year (medical internship). The search for drug information, although remaining high (> 66%), was no longer as high as in the time spent in the university campus (> 90%). Searches for clinical practice guidelines was greater in advanced school years specially when a network was available at the hospitals. The communication's use of electronic devices remained stable over the years and in equal proportion as when they are in or outside the university campus.

Duration of use of electronic devices for educational purposes. Table 4 summarizes the proportion of students who invest less than 24 hours, from 24 to 72 hours, and more than 72 hours per week in learning with the support of their electronic devices. With the exception of third-year students, they usually access their devices for less than 24 hours per week, especially during the fifth year. In their third school year, just over half of the students used their devices between 24 to 72 hours. The duration above 72 hours was observed in fourth-year students, although the difference was not statistically significant.

Barriers to the use of electronic devices. The barriers were different for the university campus and the hospital headquarters (Table 5). According to the students, the main limitations in the university campus were the instability of the internet connection,

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followed by the lack of authorization from the professors, being in areas where there was no network signal or it was restricted to a not-provided password, as well as the lack of time for their consultation. All of the students (180/180) referred to difficulties on the use of electronic devices at the university campus.

On the other hand, the main limitations to the use of electronic devices in hospitals were the absence of networks or the refusal of the authorities to provide the access codes, and the non-authorization by the professors. Other less mentioned limitations were not knowing if they had the resources or how to access them, the little time available and connection instability. The least common limitation reported was not knowing how to use some platforms provided by the hospitals. Overall, 85% of the students (153/180) referred to difficulties on the use of electronic devices at the hospitals.

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Table 1. Demographic characteristics by gender of the students participating in the online survey (n=180)

Variable		Males n=88	Females n=92	All n=180
School year*				
	1st	14 (51.9%)	13 (48.1%)	27 (9%)
	2nd	19 (42.2%)	26 (57.8%)	45 (25%)
	3rd	21 (46.7%)	24 (53.3%)	45 (25%)
	4th	24 (54.5%)	20 (45.5%)	44 (24.5%)
	5th	10 (56.6%)	9 (47.4%)	19 (10.5%)
Age in years**				
	Mean ± 1 SD	21 ± 1.7	21 ± 1.8	21 ± 1.8

*Pearson's chi-square test 1.6, df=4, p= 0.79; **Student t test -0.28, df=178, p=0.77

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Table 2. Use of electronic devices per school year in the university campus

Laptop, computer, smartphone or tablet was used for…	Medical school year					p-value**	
	1st n= 15	2nd n= 38	3rd n= 39	4th n= 42	5th n= 11	X^2-P	X^2-T
taking notes	86.7%	94.7%	94.9%	95.2%	54.5%	**0.0004**	0.10
reading articles or medical books	86.7%	97.4%	97.4%	95.2%	81.8%	0.16	0.69
drugs information search	66.7%	94.7%	97.4%	97.6%	90.9%	**0.0008**	**0.01**
search for information platforms	53.3%	92.1%	92.3%	92.9%	90.9%	**0.006**	**0.008**
search clinical practice guidelines	46.7%	52.6%	74.4%	88.1%	54.5%	**0.002**	**0.005**
communication	46.7%	52.6%	56.4%	50%	45.5%	0.94	0.89
medical calculations	6.7%	42.1%	79.5%	78.6%	81.8%	**0.0017**	**0.005**
differential diagnoses search	0%	44.7%	35.9%	57.1%	9.1%	**0.0001**	0.31

** X^2-P, Pearson's chi-square test; X^2-T, Trend chi-square test

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Table 3. Medical student use of electronic devices in hospitals by school year*

Laptop, computer, smartphone or tablet was used for…	Medical school year				p-value**	
	2nd n= 21	3rd n= 37	4th n= 35	5th n= 9	X^2-P	X^2-T
search for information platforms	76.2%	73%	88.6%	88.9%	**0.04**	0.09
reading articles or medical books	76.2%	81.1%	74.3%	88.9%	0.76	0.80
taking of notes	66.7%	89.2%	82.9%	44.4%	**0.01**	0.57
drugs information search	66.7%	86.5%	88.6%	88.9%	0.24	0.14
medical calculations	57.1%	81.1%	82.9%	66.7%	0.11	0.21
search clinical practice guidelines	52.4%	70.3%	85.7%	88.9%	**0.03**	**0.004**
differential diagnoses search	47.6%	35.1%	51.4%	11.1%	0.12	0.47
communication	42.9%	48.6%	37.1%	55.6%	0.59	0.92

*This question allowed more than one answer
** X^2-P, Pearson's chi-square test; X^2-T, Trend chi-square test

***The reported use of electronic devices for study purposes in the hospital was almost 60% (102/180)

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Table 4. Frequency of use of electronic devices for learning purposes

Frequency (Hours/week)	Medical school year					Total n=154	p-values**	
	1st n= 16	2nd n= 40	3rd n= 41	4th n= 43	5th n= 14		X^2-P	X^2-T
<24 h	56.2%	52.5%	39%	58.1%	85.7%	83 (53.9%)	**0.04**	**0.04**
24 – 72 h	37.5%	37.5%	53.7%	25.6%	7.1%	55 (35.7%)	**0.01**	
>72 h	6.2%	10%	7.3%	16.3%	7.1%	16 (10.4%)	0.64	

*85.5% of the participants (514/180) responded to this question
** X^2-P, Pearson's chi-square test; X^2-T, Trend chi-square test

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Table 5. Obstacles to access electronic information sources in medical learning settings

	University campus n= 180*		Hospitals n= 153**		
Barriers	N	%	N	%	*p-value***
Technical problems with the connection	63	35%	23	15%	***<0.001***
No network or access key	43	23.9%	108	70.6%	***<0.001***
Lack of knowledge on the use of resources	43	23.9%	8	5.2%	***<0.001***
Lack of time	20	11.1%	36	23.5%	***0.004***
Unawareness of available resources	42	23.3%	34	22.2%	*0.84*
Not authorized use by the professor	47	26.1%	42	27.5%	*0.87*

** Pearson's chi-square test with Yates's continuity correction

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Discussion

The data obtained by this strategy support the notion of a broad use of electronic devices in medical learning settings from both professors and students. Also, we observed a transition in its use from the basic sciences to the clinical courses. In the former, use of ICTs was mainly directed to drug information searches; in the clinical courses, to clinical practice guidelines searches; and in the fifth-year acting internship, to medical calculators (resolution of formulas of indicators such as "glomerular filtration" or "calculation of body surface", among others). Taking notes with the support of electronic devices remained a common activity throughout the medical school. One observation that caught our attention was the decrease of searches for clinical practice guidelines in more advanced students (fifth-year acting interns). A possible explanation of this decrease could be the increased experience and knowledge acquired during the previous school years.

A previous study (Boruff & Storie, 2014) also reported that drug information searches, use of medical calculators, and taking notes were among the main activities and reasons for using electronic devices. In addition, the authors observed a reduction on the consultation of these digital sources by medical professionals with respect to students and residents, which could be associated with the generational learning gap of these technological devices. Although we did not evaluate the use of electronic devices from professors, given the student-reported barrier (carried-out by the professors) to use these devices, we could also expect that these professors do not consult these digital sources as well. In either case, it is possible that future professors reverse this situation as former medical students and active users of ICTs for learning purposes. Although this was an exploratory study, medical students reported that the lack of authorization from

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teachers was a barrier for the exploitation of ICTs. The students referred that usually this limitation of the use of electronic devices occurs during the direct attention of the patients, probably and appropriately to avoid the perception of a distant communication from students towards patients; on some occasions, it also occurred during class.

Worldwide use of electronic devices is promoted as useful tools for both clinical learning activities and patient care support, especially in developed countries (Cheston, Flickinger & Chisolm, 2013; Farooq & White, 2014). This support is driven by the immediate and accurate information availability with the aim of solving problems and doubts during the treatment of a patient. As a result, several applications or "apps" available for smartphones, tablets or laptops have been developed to support information query and decision making by physicians. However, barriers to take advantage of these ICTs may arise when those apps are unknown or ignorance about their use in teaching and clinical practice. In this regard, Boruff y Sotrie (Boruff & Storie, 2014) reported that although the main limitation to access information is the absence of internet in clinics and hospitals, ignorance of resources was the second barrier for its use. In addition, the authors found that the lack of training could lead to the search for unreliable information; therefore, they recommend to access only approved medical information. To address this issue, we consider that a directed incorporation of ICTs supported by both institution and professors would improve usability of these resources as medical learning tools, the quality of patient care and even counteract the ludic use of electronic devices, at least in medical settings.

Although this was an exploratory study, medical students reported that the lack of authorization from teachers was a barrier for the exploitation of ICTs.

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Possibly, this is the result of a negative perception of the use of electronic devices, instead of consider them as useful resources for learning and medical purposes. In many occasions, when the search for information is necessary and beneficial, its utility can overlap the lack of support or permission (Masters & Al-Rawahi, 2012).

In this study we also found that use of electronic devices was more frequent in the university campus, probably as a result of network connections availability, in contrast to the clinical or hospital areas, where students experienced difficulties to access Internet or use their devices. This connectivity failure at the university campus was a technical barrier, possibly due to high demand, while the lack of time was a personal barrier sometimes related as a reason for not using ICTs, even though the resource was available. Time was also reported previously as a substantial factor for not accessing electronic information sources (Boruff & Storie, 2014). This variable is even shorter in clinical settings, where we believe that usability could be increased during patient rounds if they were accompanied by evidence-based medicine questions for the patient's care, while being supervised by the professors, such as dose consultation, review of studies, calculations of scales or laboratory results, calculations of diagnostic probabilities based on the likelihood ratios obtained in laboratory studies, among others.

In addition to the absence of internet connection in several clinical settings, other common barriers reported by the students include the refusal to concede the internet access codes as well as the risk of thefts. The implementation of computer rooms in clinical settings could avoid these barriers; they are common and increasing in medical libraries from developed countries (Bravo, 2014).

An important aspect about this survey is the recognition that information about new educational techniques based on the interaction of students with digital information

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sources is still scarce. Problem-based learning methods as well as simulators or algorithms, through apps or programs, would allow both professors and students, achieve a meaningful learning of the medical topics to be fulfilled. A recent study found a great interest among students and professors to incorporate these tools for learning and teaching, respectively; however, its adoption is affected by the age and occupation of the professors, the scarce training in their use in addition to the institutional policy about its incorporation (Fan, Radford & Fabian, 2016).

The aim of this study was to explore the use of information and communication technologies during the training of medical students. We consider that among its main strengths were the high participation (> 80%) as well as its reliability, since the information was anonymous and without repercussion in the qualification of the participants. However, several limitations must be addressed. Although our results could be similar in other universities, both on the university campus and in clinical settings, it is possible that they have already solved them. On the other hand, the questionnaire was mainly designed to answer closed questions; more studies are necessary for a more detailed analysis.

We do not know if there are already medical programs in our country designed for the use of electronic devices and ICTs in teaching-learning processes. For the moment, we believe that training in their use may improve the learning process of the future physicians in benefit of patient care

Conclusions

Most medical students surveyed from a private medical school located in Mexico City own at least one electronic device and use them for learning purposes in both the university and medical settings. During their career, the use of ICTs transit from

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theoretical information queries to the search for medical guides and articles, and finally, to medical calculators. Main reported barriers to its use included accessibility to internet connection (real or imposed) and available time. The incorporation of these devices and medical applications will depend on the consent of professors when employed as teaching-learning tools, and with its support from institutional programs and medical settings.

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References

Ayatollahi A., Ayatollahi J., Ayatollahi F., Ayatollahi R., Shahcheraghi SH. 2014. Computer and Internet use among Undergraduate Medical Students in Iran. *Pakistan journal of medical sciences quarterly* 30:1054–1058.

Boruff JT., Storie D. 2014. Mobile devices in medicine: a survey of how medical students, residents, and faculty use smartphones and other mobile devices to find information. *Journal of the Medical Library Association: JMLA* 102:22–30.

Bravo LE. 2014. From printing to Scielo and Pubmed Central. *Colombia medica* 45:5–6.

Cheston CC., Flickinger TE., Chisolm MS. 2013. Social media use in medical education: a systematic review. *Academic medicine: journal of the Association of American Medical Colleges* 88:893–901.

Eggermont S., Bloemendaal PM., van Baalen JM. 2013. E-learning any time any place anywhere on mobile devices. *Perspectives on medical education*. DOI: 10.1007/s40037-013-0045-4.

Fan S., Radford J., Fabian D. 2016. A mixed-method research to investigate the adoption of mobile devices and Web2.0 technologies among medical students and educators. *BMC medical informatics and decision making* 16. DOI: 10.1186/s12911-016-0283-6.

Farooq A., White J. 2014. #Nomoretextbooks? The impact of rapid communications technologies on medical education. *Canadian journal of surgery. Journal canadien de chirurgie* 57:E119–20.

Friederichs H., Marschall B., Weissenstein A. 2014. Practicing evidence based medicine at the bedside: a randomized controlled pilot study in undergraduate

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medical students assessing the practicality of tablets, smartphones, and computers in clinical life. *BMC medical informatics and decision making* 14:113.

Jang HW., Kim K-J. 2014. Use of online clinical videos for clinical skills training for medical students: benefits and challenges. *BMC medical education* 14:56.

Kir T., Ogur R., Kilic S., Tekbas OF., Hasde M. 2004. How Medical Students Use the Computer and Internet at a Turkish Military Medical School. *Military medicine* 169:976–979.

Lim TA., Wong WH., Lim KY. 2005. Perceived skill and utilisation of information technology in medical education among final year medical students, Universiti Putra Malaysia. *The Medical journal of Malaysia* 60:432–440.

Maroof KA., Parashar P., Bansal R. 2012. How are our medical students using the computer and internet? A study from a medical college of north India. *Nigerian medical journal: journal of the Nigeria Medical Association* 53:89–93.

Masters K., Al-Rawahi Z. 2012. The use of mobile learning by 6th-year medical students in a minimally-supported environment. *International Journal of Medical Education* 3:92–97.

Nalliah RP., Allareddy V. 2014. Students distracted by electronic devices perform at the same level as those who are focused on the lecture. *PeerJ* 2:e572.

Romanov K., Aarnio M. 2006. A survey of the use of electronic scientific information resources among medical and dental students. *BMC medical education* 6. DOI: 10.1186/1472-6920-6-28.

Samuel M., Coombes JC., Miranda JJ., Melvin R., Young EJW., Azarmina P. 2004. Assessing computer skills in Tanzanian medical students: an elective experience. *BMC public health* 4:37.

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Sclafani J., Tirrell TF., Franko OI. 2013. Mobile tablet use among academic physicians and trainees. *Journal of medical systems* 37:9903.

Ward JPT., Gordon J., Field MJ., Lehmann HP. 2001. Communication and information technology in medical education. *The Lancet* 357:792–796.