ORIGINAL ARTICLE

Importance of Infrastructure and Learners Readiness for Administration of Electronic Learning in Undergraduate Medical Education

Malihe Hasanzadeh[1,*], Parviz Marouzi[2], Reza Asadi[3], Fatemeh Zoubin[4], Mohammad Naser Shafiee-Jafarabadi[5],

[1] Department of Gynecology and Oncology, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, IRAN

[2] Department of Biostatistics and Epidemiology, school of health, Mashhad University of Medical Sciences, Mashhad, IRAN

[3] Toxicology Research Center, Mashhad University of Medical Sciences, Mashhad, IRAN

[4] Department of Linguistics, Mashhad University of Medical Sciences, Mashhad, IRAN

[5] Mashhad University of Medical Sciences, Mashhad, IRAN

*woman health research center, mashhad university of medicasl sciences, Mashhad, Iran.

Tel/Fax: +9835118012477
Emali: hasanzademofradm@mums.ac.ir

Background: A combination of teaching modalities instead of a single method may enhance learning. The purpose of the current study was to evaluate the effectiveness of integrating e-learning modules into the syllabi of clinical contents from different clinical majors at different levels.

Methods: A total of 108 undergraduate students enrolled from various clinical majors, and participated via using sub-syllabi from gynaecology courses in classroom-based sessions and e-learning modules. All students were proposed to attend pre- and post-test sessions in addition to training. Prior to being admitted to the study, all participants filled out a questionnaire regarding their attitude toward, and desire to participate in, e-learning.

Results: Mean exam grades increased significantly in 3 items including Abnormal uterine bleeding (from 1.28± 1.11 pretest to 2.3±1.11 post-test), Breast masses and malignancies (from 2.61±1.3 pretest to 3.9±1.11 post-test) and Gestational trophoblastic Neoplasia (from 1.12±1.04 pre-test to 3.58±0.76 post-test).

Discussion: The Results dramatically demonstrated that access to suitable infrastructure and students' readiness are crucial perquisites for e-learning and without them, lack of collaboration and engagement of the learners significantly diminish effectiveness and usability of the learning material, despite high quality content provided within suitable environment.

Keywords: Electronic Enhanced Learning, Gynecology Training, Interactive Learning, Educational Interventions

اهمیت مناسب بودن زیرساختها و آمادگی فراگیران در اجرای برنامه های آموزش الکترونیکی در آموزش پزشکی

زمینه و هدف: ترکیب مدل های آموزشی بهتر از یک روش برای یادگیری بهتر هستند. هدف این مطالعه بررسی کارایی ادغام آموزش مجازی با برنامه درسی رایج بالینی در رشته های تحصیلی مختلف بود.

روش: در مجموع ۱۰۸ دانشجوی در رشته های مختلف بالینی وارد این مطالعه شدند. این دانشجویان چندسرفصل زنان و مامایی را به دو صورت حضوری و مجازی آموزش دیدند. همه دانشجویان در پیش و پس آزمونهایی نیز شرکت کردند. همچنین کلیه نمونه ها پرسشنامه ای را نیز در خصوص نگرش خود درباره آموزش مجازی پیش از ورود به مطالعه تکمیل کردند.

نتایج: میانگین نمرات آزمونها در سه سر فصل خونریزی غیرطبیعی رحم (از ۱.۲۸± ۱.۱۱ پیش آزمون به ۲.۳± ۱.۱۱) ، توده ها و بدخیمی های پستان (از ۲.۶۱± ۱.۳ در پیش آزمون به ۳.۹± ۱.۱۱) و بدخیمی های تروفوبلاستیک (از ۱.۱۲± ۱.۰۴ به ۳.۵۸±۰.۷)

نتیجه گیری: نتایج به طور مؤثری نشان داد که دسترسی به زیرساختهای مناسب و امادگی دانشجویان نیازهای أساسی آموزشهای مجازی هستند و بدون آنها نباید متوقع همکاری و درگیر شدن فراگیران در فرایند آموزشی بود. حتی اگر محتوای آموزشی بسیار سطح بالا و با کیفیت تهیه شده باشد.

واژه های کلیدی: آموزش مجازی، آموزش زنان و زایمان، آموزش های تعاملی، مداخلات آموزشی

الأهمیه وجود ارضیه مناسبه وجهوزیه المتعلمین فی مجال اجراء برامج التعلیم الالکترونی فی التعلیم الطبی

التمهید و الهدف: إن دمج عدة أسالیب تعلیمیه افضل من استعمال اسلوب واحد فی مجال التعلم.

إن الهدف من هذه الدراسه هو تبیین تأثیر دمج التعلیم المجازی مع البرامج المعتاده الدراسیه فی التعلیم السریری فی الکلیات المختلفه .

الأسلوب: تمت الدراسه علی ۱۰۸ من طلاب الکلیات المختلفه . تم تدریس جمیع الطلاب عدد من الفصول من درس الطب النسائی و الولاده علی اسلوبین الحضوری والمجازی. اشترک جمیع الطلاب فی اختبارات قبل التعلیم و بعد التعلیم . تم تکمیل استمارات من قبل الطلاب فی مجال رؤیتهم تجاه التعلیم المجازی قل الدخول فی الدراسه .

النتائج: کانت النتائج فی الفصول الثلاثه، النزیف الغیر طبیعی فی الرحم من (۱.۲۸+۱.۱۱۱ قبل الاختبار الی ۲.۳+۱.۱۱)، الاورام و خبائث الثدی من (۲.۶۱+۱.۳ قبل اختبار الی ۳.۹+۱.۱۱) و خبائث التروفوبلاستیك من (۱.۱۲+۱.۰٤ الی ۳.۵۸+۰.۷) .

الإستنتاج: اشارت النتائج الی أن وجود ارضیه مناسبه و جهوزیه المتعلمین من اهم احتیاجات التعلیم المجازی و لایجب ان نتوقع بدون هذه الموارد ان یکون تجاوب من قبل المتعلمین فی مجال التعلیم حتی لو کان المتحوی التعلیمی ذو قیمه عالیه.

الکلمات الرئیسیه: التعلیم المجازی، تعلیم النسایی و الولاده ، التعالیم التعامليه ، المداخلات التعلیمیه .

طبی تعلیم میں الکٹرانیک وسائل کے استعمال کے لئے مناسب انفرا اسٹرکچر اور طلباء کی آمادگی کی اہمیت

بیک گراونڈ: تعلیم کوبہتر بنانے کے لئے متعدد تعلیمی روشوں کو ملاک کر کام کرنے سے بہتر نتائج حاصل ہوتے ہیں۔ اس تحقیق کا ھدف کلینیکل کورس کی تعلیم کے ساتھ ساتھ آنلائین تعلیم کے اثرات کا جائزہ لینا ہے۔ یہ تحقیق مختلف موضوعات کو شامل ہے۔

روش: اس تحقیق میں مجموعی طور سے ایک سو آٹھ طلباء کو شامل کیا گیا۔ ان طلباء نے گائیناکالوجی اور میڈوائفری کے کورس کی تعلیم کلاس میں اور آن لائین حاصل کی تھی۔ ان طلباء نے امتحان سے پہلے اور بعد میں کلاسوں میں شرکت کی تھی۔ اس کے علاوہ تحقیق سے قبل انہوں نے آن لائین تعلیم کےبارے میں سوالنامے کا مطالعہ بھی کرلیا تھا۔

نتیجےوسفارش: اس تحقیق سے معلوم ہوتا ہے کہ مناسب انفرا اسٹرکچر اور طلباء کی آمادگي آن لائین تعلیم کے لئے نہایت ضروری ہے اور اس کے بغیر ان سے بہتر تعاون کی امید رکھنا بے سود ہے گرچہ نصاب کو بہت کی معیاری طریقے سے ہی کیوں نہ تیار کیا گیا ہو۔

کلیدی الفاظ: آن لائین تعلیم ، گائنا کالوجیسٹ۔

INTRODUCTION

Conceptual knowledge is a big part of the syllabi received by medical and paramedical students almost everywhere. However, the greater part of such material is taught in the classroom, away from a clinical setting. The achievement of learning objectives in both undergraduate and postgraduate medical education can be obtained by a combination of modalities, including electronic learning. In order for the teaching and acquisition of this content to be effective, it should be integrated with clinical activities. Integrating teaching clinical course material into a clinical setting is not easy, and risks distracting from service delivery and being enough of a practical challenge for tutors and students (1, 2). Aside from these issues, clinical teachers are always busy and complain about the need to attend class as their reason for repetitive content, particularly in developing countries that academic clinicians are likely to visit a large number of patients daily in university clinics, as well as, attending to other academic affairs (3, 4).

In 2006, Mashhad University of Medical Sciences (hereafter "the University") installed an open-source, web-based learning content management software (LCMS) for student courses (5, 6). Meanwhile, some research projects had to assess the usability and applicability of this new modality of education and see if it produced better learning.

In order to address the lack of time and capacity to deliver clinical teaching "on the go," we developed an integrated e-learning course on gynaecology for asynchronous learning through self-directed training for undergraduate medical trainees. Its feasibility was trialled by students from different majors, including medicine and bachelor and master of midwifery, in a before-and-after study. To assess the applicability of equivalent content between the traditional lecture mode and e-learning, we determined the effect of teaching sub-syllabi of basic concepts of a gynaecology course on a participant's knowledge, using two modes of e-learning and lectures by a single instructor.

METHODS

From May to September 2010, we conducted a controlled trial to compare the clinically integrated e-learning gynaecology course to a lecture-based course, and three groups of students who studied different majors enrolled. This trial was undertaken in three teaching groups by a single instructor. The participants in the trial were second year medical students (externs) and master and bachelor midwifery students. All trainees consented to be part of the trial. After obtaining approval from the University, which granted us permission to undertake the trial and funded it, the study was conducted in the University's hospital.

As soon as consent was obtained, all participants filled out a questionnaire about e-learning and their attitude about online courses. All students in the current study enrolled into two phases of teaching methods: in Phase 1 they received two sessions of standard classroom-based stand-alone teaching in a course on abnormal uterine bleeding and breast masses and malignancies (control intervention), and in Phase 2 all former students received five e-learning modules with equivalent content concerning ovary malignancies and molar pregnancies (experimental group, see Table 1).

The development of the electronic contents of the course was previously performed by the same tutor recording a narration of her lectures and combined with PowerPoint slides, using trial version 6 of the Camtasia Studio software, which after preparation was uploaded to the University's LCMS under Sharable Content Object Reference Model (SCORM) standards developed from Atutor (6, 7). The course plan, learning objectives, and material contents, including PowerPoint presentation slides, were presented online and in the classroom. The seven sub-syllabi used in this study were assessed by the tutor according to student scores in previous course rotations; it was determined that the conceptual knowledge of students about the content was approximately at the same level, which was confirmed by an analysis of means of pre-test scores, using a Freidman test.

At the beginning and end of each online or classroom syllabus, students were asked to reply five multiple choice questions (MCQ) related to the session's content. Questions on pre- and post-assessments were different. For the traditional phase, the teaching was delivered by the lecturer over two sessions, consisting of one hour for each topic, followed by a question-and-answer period.

Table 1. Frequency of attendance of participants in training and pre and post assessment of seven syllabuses of current study

Modality of training	Title of sub-syllabus	Number of participants in pre- test (%)	Number of participants in post-test (%)
Lecture	Abnormal uterine bleeding	106	90
	Breast masses and malignancies	57	55
e-Learning	Germ Cell tumors	79	105
	Stromal ovarian Tumors	56	52
	Epithelial ovarian tumors	40	40
	Molar pregnancies	40	40
	Gestational trophoblastic Neoplasia	40	39

Meanwhile, unlimited access to the e-learning materials via a University LCMS website was granted for a period of four weeks (8). Each participant was given a login username and password, and their activities were monitored on a weekly basis to ensure compliance with the trial protocol. The logged activities including visits to web pages, the visit duration for each page, and answering pre- and post-session assessments. To facilitate the download of multimedia slides for those with lower connection speeds, the resolution (800x600 pixels) and moderate-to-low audio quality (8-16 kilobytes per second) was used for the production of the multimedia content, done in a SWF format. For each PowerPoint slide, a separate multimedia file was created to reduce waiting time, and the files were regularly arranged based on the learning objectives for each module, in the tree order of the electronic module. Students in the e-learning phase could use navigation buttons to move forward or backward. Participants also could use the hierarchy tree in the side menu to jump between content. The media control buttons were active for flash files, enabling the user to pause and replay the material.

Online assessment questions were chosen from a question repository prepared for each section, and were randomly offered to the students; however, during post-test assessments, the content was inaccessible. Prior to beginning each course, students filled in a questionnaire about electronic learning, and their aspirations for participating in the study were evaluated and recorded.

Data Collection

All participants answered MCQs to assess course knowledge before accessing the e-learning materials, prior to the start of the teaching sessions. After completing each online module, the participants answered MCQs relevant to that module. The MCQs were parallel to the learning objectives of the modules, in order to assure content validity. As with the e-learning phase, students in the lecture sections were asked to answer MCQs about the related lectures, both before and after the lectures. The participants who did not fully complete the course content or did not answer the pre- or post-test quizzes were excluded from the study.

Analysis

Responses to the pre- and post-test MCQs were scored, and comparisons between the e-learning and the standalone groups were made. Missing data were not imputed and analyses were restricted only to those participants who fully answered both pre- and post-test MCQs for all seven assessments.

For data analysis, the Social Package for Statistics Software (SPSS) Version 11.5 was used. A comparison of mean grades for pre- and post-course quizzes measured the variation between pre- and post-course grades; the grades were measured one by one and compared. As the assessment of the normality of measurements revealed no normal distribution, nonparametric tests were used for these measurements. The differences in mean scores for pre- and post-course assessments were determined by a Friedman test, and the degree of variation in pre- and post-course quizzes was presented in a box plot diagram and interpreted.

RESULTS

Out of a total of 108 undergraduate and postgraduate trainees—93 (86.1%) female and 15 (13.9%) male, with a mean age of 23.36±2.59 years—completed the questionnaire about electronic learning and participated in several teaching sessions. This was the first time using an e-learning integrated course for the majority of participants (90, 83.3%). The students replied to pre- and post-course MCQs on the e-learning (intervention) modules and on the standard classroom teaching (control) sessions for seven sessions, with various subject headings for a gynaecology course (two lecture and five e-learning sessions). During the study, 50 (47.3%) participants did not fully complete the assessments and were excluded from the trial (Table 2). The reasons for not completing the assessments included not having access to a computer, being volunteer learners, having a lack of commitment to cooperate with researchers, and being unfamiliar with electronic learning. A total of 58 (53.7%) students fully completed the course assessments and returned all seven pre- and post-course assessments for both phases, and their grades were entered into the data analysis.

Mean exam grades for pre- and post-course tests from e-learning sessions were 1.2 and 2.3 out of a possible 5 for the AUB session) ($P<0.001$) and 2.6 and 3.9 for the breast mumps session ($P=0.031$), respectively. Mean exam grades for pre- and post-course tests for five e-learning sessions were 1.05 and 4.1 out of a possible 5 for the Germ cell malignancies session ($P=0.46$), 0.82 and 3.5 for the Stromal tumours session ($P=0.158$), 1.6 and 4.4 for the epithelial cell tumours session ($P=0.854$), 2.7 and 4.9 for the molar pregnancies session ($P=0.207$), and 1.1 and 3.5 for the Gestational trophoblastic neoplasia session ($P<0.001$), respectively. Post- course assessment scores

Table 2. Expressed desire of students of different majors for e-learning

Major	Eager to have e-learning course				
	Very much	Much	Little	Very little	Total
Bachelor of midwifery	1	5	25	8	39
Master of midwifery	0	2	6	0	8
medicine	9	24	15	3	51
Total	10	31	46	11	98

Table 3. Mean scores of pre and post tests and mean of variation

	Pre test score Mean (SD)	Post test score Mean (SD)	Mean of variation in pre and Post tests scores
Abnormal uterine bleeding	1.28 (1.11)	2.3 (1.11)	2.17
Breast masses and malignancies	2.61 (1.3)	3.9 (1.11)	2.72
Germ Cell tumors	1.05 (1.27)	4.1 (1.19)	5.12
Stromal ovarian Tumors	0.82 (0.87)	3.5 (0.99)	4.97
Epithelial ovarian tumors	1.62 (0.89)	4.45 (0.71)	4.71
Molar pregnancies	2.75 (1.29)	4.92 (0.26)	3.99
Gestational trophoblastic Neoplasia	1.12 (1.04)	3.58 (0.76)	4.33

were improved for both groups compared to baseline scores (Table 3); in some sub-syllabi there was significant difference between the mean pre- and post-course test scores.

About 50 students from majors, except for medical students, did not fully participate in the pre- and post-course quizzes, and their scores were subsequently excluded from the study. The frequency of attendance for students from the different majors in the pre- and post-assessment periods is demonstrated in Table 1. Of the 108 students who filled out the questionnaire on electronic learning, an evaluation of items including their overall intention to use, and desire for, electronic learning demonstrated a significant difference between majors and intentions to utilise electronic learning: medical students and bachelors and masters of midwifery had 1, 0, and 9 express *very high*; 5, 2, and 24 for *somewhat interested*; 25, 6, and 15 for *somewhat uninterested*; and 8, 0, and 3 had *very little* desire to utilise electronic learning, respectively ($P<0.001$, $X^2=26.4$).

DISCUSSION

The current study demonstrated that learners' readiness is more than important in case of new modalities of education. In this study knowledge improved significantly for some participants that remained until the end but that it was not possible to measured for others; generally speaking, however, both trainees who completed the course and the tutor(s) who taught the course found the e-learning course to be acceptable if initially had been agreed or ready for it. Otherwise, those who claimed it is not suitable failed to continue the learning process and lead to high rate of drop-out.

The baseline and post-course scores were generally the same for both groups, and both methods of teaching have been to some extent effective in increasing conceptual knowledge; this finding is parallel to other studies (3). Students, who finished the course, achieved similar scores for overall knowledge gain after both the e-learning and lecture phases. This raises the opportunity of delivering some elements of curriculum through e-learning to some major disciplines, replacing the traditional lecture-based method without legitimate concern of knowledge loss, when the initial evaluation showed learners' readiness for this new modality of learning. This approach will decrease education expenses and increase the feasibility and flexibility of learners in clinical settings and increases the collaboration rate of appropriately selected learners. So any concerns in learners should be understood and controlled before commencing new method of education (1).

Few studies have examined the effectiveness of computer-based teaching of medical content compared to standard lecture-based approaches in developing countries, and while our study is confirmed by findings from similar studies in developed countries, one major flag is raised. Our trial merits concern, as we implemented a modified design from previous studies and enrolled participants from different majors (4, 9-12). In Iran, according to national higher-education regulations, high school graduates are intended to participate in a nation-wide comprehensive exam and, according to overall rankings, can select majors from a large group of government-run, tuition-free universities. Additionally, regarding social interests and income, medicine is of the most requested and welcomed majors for natural science students. Due to the highly competitive nature of this exam, and considering the restricted positions in medicine, the most talented students are able to achieve acceptable ranks in the discipline: students accepted into medical schools will be, after seven continuous years of study, granted an MD degree. Accordingly, many of these students are selected from families higher up the socioeconomic ladder that have better access to computers and internet and, more so than students from other majors in the study, were familiar with information technology and the internet.

As mentioned above, one of the strategies of the study was to enrol the same number of participants from different majors; unfortunately, students from majors other than medicine were uncooperative and were excluded from the trial. However, this notion is parallel to their attitudes about e-learning, and there were a significant relationship between majors and overall intentions to pursue e-learning ($P<0.001$, $x^2=26.4$, see Table 2). This notion was reinforced by low or decreased commitments to attend pre-

and post-course quizzes, confirming the necessity of readiness for students using novel learning methods, prior to installation and implementation (13). The data presented in Table 1 reveal the degree of disagreement expressed by students from excluded majors, in clear accordance with their attendance for pre- and post-course quizzes.

This is a particular concern with current educational research. Additionally, the enrolment of the same participants in both phases and inability to blind selection of participants and the teacher can cause concern in educational research expressed by other studies (3). To cover this limitation, another researcher not aware of which sub-syllabi have been enrolled online or lecture-based was responsible to analyze and interprets recorded data. To cover the difference returned by variations in baseline knowledge and learning abilities, the same groups of learners enrolled in the study but, in order to overcome variations of content in different phases, first attempted topics selected from a single course (malignancies and neoplasm of gynaecology), and, second, internally compared scores for pre- and post-course quizzes for each sub-syllabus.

It seems that just well-structured and managed e-learning classrooms are at least as effective as traditional lectures in developing and developed countries, particularly when used in blended mode (14). Although conceptual knowledge gained via online sessions will be practiced in clinical settings, this method does raise some concerns about the effectiveness of the learning, it seems that its flexibility and feasibility will cover this limitation (1). E-learning resources enable users to learn when and where they want, and for medical professionals working many different shifts, this approach is likely to provide them with better opportunities to learn whenever they are able (1,3).

E-learning can play various roles in medical education, including virtual environments or patients, medical simulations, and hospital information systems with integrated learning materials and tele-consultation (15-19).

Basic, simple electronic training programs are already effective when designed appropriately and offered to users ready for this modality of learning. The current study clearly reveals that, when two groups of students present varied interests in electronic learning, this belief clearly has an effect on their further participation in the learning process, and may even completely interrupt it. In conclusion, there was a significant difference in replies to the quizzes between the two groups in the study.

Subsequently, it seems that before instalment of any e-learning course, attention to some issues is important:

1.Learners' skills: The learners' ability to work with computer and internet and/or any other skills necessary for them to participate in the course. For example providing a course in non-native language to students' weak in it. Will decrease learning despite provision of a high quality learning content.

2.Technological aspects: the used technology is very important, when this technology can not be supported or provided suitably, the effectiveness decrease, for example when the online large-size multimedia content is provided to students who don't have access to broadband internet, should not expect high collaboration rate.

3.Learners learning styles: various kinds of interactions and instructional designs, and the context of the learning environments is available now, but it is important to know learners preferences and styles for learning and adopt the modalities of education based on this information (20).

Besides, medical training in Iran is currently encountering great challenges of employment, as well as an excess presence of professionals in large cities; in restricted rural and smaller cities or deprived areas, it is imperative that the challenges of providing high-quality teaching syllabi for future health professionals in changing environments be met. The benefits of an e-learning approach to teaching should be considered as a viable way to overcome these challenges, as it can support a wide range of learning activities, which are readily accessible and can be tailor-made to meet specific learning objectives.

REFERENCES

1. Choules AP. The use of elearning in medical education: A review of the current situation. Postgrad Med J 2007; 83(978): 212-16.
2. Andrews PV, Schwarz J, Helme RD. Students can learn medicine with computers: Evaluation of an interactive computer learning package in geriatric medicine. Med J Australia 1992; 157: 693-5.
3. Hadley J, Kulier R, Zamora J, Coppus SF, Weinbrenner S. Effectiveness of an e-learning course in evidence-based medicine for foundation (internship) training. J R Soc Med 2010; 103(7): 288-94.
4. Adanu R, Adu-Sarkodie Y, Opare-Sem O, Nkyekyer K, Donkor P, Lawson A, et al. Electronic learning and open educational resources in the health sciences in Ghana. Ghana Med J 2010; 44(4): 159-62.
5. Assadi R, Mirkhani A. Atutor software and medical education: Experience of using an open source learning software. International journal on new trends in education and their implications 2011; 2(1): 15-20.
6. Atutor official website. [cited 2011]. Available from: URL; http://www.Atutor.ca.
7. TechSmith Camtasia Screen Recorder Software. [cited 2011]. Available from: URL; http://www.techsmith.com/download/camtasia
8. Mashhad University of Medical Sciences virtual learning environment. [cited 2011]. Available from: URL; http://lms.mums.ac.ir
9. Al-Shehri AM. E-learning in Saudi Arabia: To E or not to E, that is the question. J Fam Commun Med 2010; 17(3): 147-50.
10. Walsh K, Rutherford A, Richardson J. E-learning: Are learners improving their practice as a result of their learning? Educ Prim Care 2011; 22(1): 40-2.
11. Smeekens AE, Broekhuijsen-van Henten DM, Sittig JS, Russel IM, Ten Cate OT. Successful e-learning program on the detection of child abuse in emergency departments: A randomized controlled trial. Arch Dis Child 2011; 96(4): 330-4.
12. Diessl S, Verburg FA, Hoernlein A, Schumann M, Luster M, Reiners C, et al. Evaluation of an internet-based e-learning module to introduce nuclear medicine to medical students: A feasibility study. Nucl Med Commun 2010; 31(12): 1063-7.
13. Eslaminejad T, Masood M, Ngah NA. Assessment of instructors' readiness for implementing e-learning in continuing

medical education in Iran. Med Teach 2010; 32(10): e407-12.
14. Gormley GJ, Collins K, Boohan M, Bickle IC, Stevenson M. Is there a place for e-learning in clinical skills? A survey of undergraduate medical students' experiences and attitudes. Med Teach 2009; 31(1): e6-12.
15. Hurmusiadis V, Rhode K, Schaeffter T, Sherman K. Virtual arthroscopy trainer for minimally invasive surgery. Stud Health Technol Inform 2011; 163: 236-8.
16. Bogdan CM, Popovici DM. Information system analysis of an e-learning system used for dental restorations simulation. Comput Methods Programs Biomed 2012; 107(3): 357-66.
17. Wildhaber RA, Verrey F, Wenger RH. A graphical simulation software for instruction in cardiovascular mechanics physiology. Biomed Eng Online 2011; 10(1): 8.
18. Jimenez A. E-learning supports EHR implementations. In addition to meaningful use, we need to define meaningful training. Health Manag Technol 2010; 31(11): 22-3.
19. Hoffman K, Dempsey J, Levett-Jones T, Noble D, Hickey N, Jeong S, et al. The design and implementation of an Interactive Computerized Decision Support Framework (ICDSF) as a strategy to improve nursing students. Nurse Educ Today 2010; 31(6): 587-94.
20. Sandars J, Lafferty N. Twelve tips on usability testing to develop effective e-learning in medical education. Med Teach 2010; 32(12): 956-60.