e-Learning Initiatives in Radiology Education at Undergraduate Level

In this article, we present a summary of our recent study in which we investigated, using a well-established training evaluation system, the outcomes of the incorporation of e-learning in radiology at the undergraduate level. Our data show that there is an increasing use of highly interactive self-directed e-learning courses. In the majority of cases a positive response is reported as far as student satisfaction and outcome are concerned. The e-learning initiatives included interactive games, audience response systems and a wide range of customized tools designed to address individual learner needs.

Radiology education is a mandatory component in the medical curriculum and is introduced in some form or another in almost every medical undergraduate year. In most European countries, the year in which most radiology is taught to undergraduate medical students is during their fourth year of medical training [2]. A lesser amount of radiology content is taught in the third and fifth year and only a relatively minor amount of initial radiology training is given in the first year of the medical course. The importance of radiology in medicine and of radiology training has been highlighted in recent surveys [3-5]. Training in radiology is of course essential for doctors who plan to specialize in radiology and for future radiographers but it is also important to teach radiology to all junior doctors. This is simply because of the central role of radiology in modern medicine which means that even junior doctors must have a deep enough experience of radiology so as to ensure they don’t miss any critical features in the radiological images they will inevitably meet in their clinical practices.

Because of the importance of radiology in medicine, modern technologies for teaching the subject are increasingly gaining prominence in radiology education. In our study [1] we found that the incorporation of advanced technological methods such as e-learning procedures in the radiology educational system led to an improvement in the skills and knowledge of medical students.

In our study which evaluated the learning outcomes in undergraduate radiology education, four databases were searched, namely (1) PubMed Central, (2) MEDLINE, (3) Embase and (4) Eric between the years January 2003 to December 2013 to identify reports on the use of e-Learning in undergraduate radiology education. We found 130 papers in total and extracted 30 studies which met our criteria of radiology education at the undergraduate level. These thirty studies were then categorized according to study design in medical research. A total of 13 papers involved experimental studies, 11 were observational and 6 studies were simply reports.

The training evaluation model used to evaluate the learning outcomes presented in the experimental and observational studies was the well-established Kirkpatrick’s four level learning model [6]. The six descriptive reports did not report any level of learning outcome.

Out of the remaining twenty four studies, 19 satisfied the learner satisfaction level and 15 studies satisfied the learning outcome level but no study reported satisfaction of practical change level and health outcome level. The reason for the absence of outcome measures with respect to performance improvement in clinical practice and patient healthcare is believed to be due to the difficulty in measuring these levels in medical education as retrospective assessments of e-learning interventions may not be able to assess these measures [7]. A change in education environment may not have a sudden impact on change in practice or health outcome [8] but clinical competencies and performances are highly affected by learning environments [9]. The evaluation of published literature helped us in identification of those precious learning environments that ultimately aid in change in practice or health outcomes.

The authors
Saad Zafar PhD and Saima Safdar are at Riphah Institute of Systems Engineering, Riphah International University, Sector I-14, 46000, Islamabad, Pakistan.
Emails:
1. saad.zafar@riphah.edu.pk;
2. saima.safdar@riphah.edu.pk
UNDERGRADUATE YEAR AND RADIOLOGY SUBFIELDS

The selected studies were categorized into radiology subfields along with the identification of the year in which the related e-learning intervention was offered. The studies were broadly divided into three main categories:

1. Interventional,
2. Diagnostic and
3. Medical Radiation.

The most prevalent category found in the radiology undergraduate education was diagnostic radiology (n=26) which was further subdivided into 6 more categories as shown in Figure 1. The data extraction showed that the focus of the e-learning initiatives within diagnostic radiology was to improve the interpretational skills of radiology in students along with the learning of imaging techniques, radiation protection and safety related issues. The coverage of reported studies related to diagnostic radiology is spread across all years of education (1-5 years). There were three reported studies related to radiation protection that covered radiology education in 2nd, 4th and 5th years. We found only one study covering interventional radiology which was given in the 4th year of education.

E-LEARNING INITIATIVES

The studies that satisfied the learner satisfaction level were categorized according to the reported e-learning interventions (web-based, blended, online, computer-based and audience response system based learning). The most prevalent intervention found in the undergraduate education...
Radiology education was web-based learning interventions followed by blended learning environments and computer-based learning. The ease of access and presentation of ideas using a wide range of multimedia objects is the prime reason for designing web-based learning interventions. The selected studies in this group reported on use of various web-based tools, web modules integrated into Learning Management Systems (LMS), web tutorials (both interactive and non-interactive) and use of web-based customized Picture Archiving and Communication Systems (PAC). In [10] 75% of students showed satisfaction with the use of web-based video tutorials in understanding the concepts of interventional radiology procedures while 87% of the students rated Dynamic Quiz Bank [11] as a useful tool in radiology education. A Radiation Protection (RP) web-based module was rated good by 81% of the students but the preference in this case was given to clinical attachments and educational material as compared to e-learning tool [7].

Blended learning involves the blending of traditional classroom based teaching with other form of e-learning interventions. The use of blended learning in undergraduate radiology education [12] may be underestimated because of the difficulty in evaluating blending learning outcomes [13]. The studies that used the blended learning environments incorporated the use of the CaseTrain tool [14] with classroom learning for the nuclear medicine discipline, the use of video sequences for solving oral radiological cases on discussion forums [13] and the use of learning management system k-MED for nuclear medicine and radiotherapy education. All these blended learning environments were rated highly effective for undergraduate radiology education. A special form of computer supported collaborative learning has been observed in solving and discussing radiological cases [15] in which student's response was neutral.

Computer-based learning has been used in radiology education for a very long time and can potentially produce significant results if used appropriately. The digital hot seat method [16] for solving radiological cases and the Virtual Learning Object VLO [17] for Cephalometric Radiography (CEPH learning) were rated as being good by 100% and 83% of the students respectively. As far as regular online learning systems are concerned they were also found to be beneficial [18] in limited situations where only basic radiology topics are to be covered. The usefulness of virtual lectures through EMERAM (Aplicación Multimedia para la Enseñanza de Radiología a Alumnos de Medicina) was high for learning general radiology [19]. The use of Audience Response System (ARS), 12vote, for radiology education was reported in [20], and was rated 4.2 on a five point Likert-scale in terms of its usability by students. The use of ARS may be low in radiology because of its intense imaging nature. Overall, all the e-learning interventions used in radiology education at undergraduate level received positive response from students. Figure 2 summarizes the count of all e-Learning initiatives found in the thirty studies.

**LEARNING OUTCOMES**

Table 1 summarizes the significance of the interventions in radiology education according to the outcomes achieved [1]. A total of 15 studies satisfied the Kirkpatrick’s learning outcome. The most effective e-learning intervention in enhancing knowledge and skills in radiology education at undergraduate level was blended learning as all four blended learning related studies [8, 14, 21, 22] showed significant learning outcomes. These four blended learning related studies reported improvement in knowledge and skills in nuclear medicine, oral radiology, diagnosing imaging procedures (CT, MRI, ultrasound, neuroradiology, etc.) and case-based radiology in undergraduate students. The second most effective e-learning intervention found in enhancing the learning outcomes of radiology education was online/virtual learning environments [19, 23]. It is noteworthy that online learning showed significant learning outcomes when only basic radiology topics were involved. On the other hand, web-based learning was found to be significant in only 60% of the time in enhancing the learning outcomes in undergraduate radiology education. The web-based video tutorial for MR arthrography [10], Online Electronic Information Skills (OEIS) intervention in the area of radiography [24], and Radiation Protection (PR) module in delivering radiation protection
New aspects arising in the field of radiology education include the increase in the use of blended learning environments (involving the commercial and non-commercial learning management systems, PACS and case-based learning management systems), emergence of audience response systems (even though the radiology is of an intense imaging nature). Other aspects whose use is on the increase include, development of customized tools (LVO, EMERAM, k-MED, RP module, video tools etc); the emergence of highly interactive educational games (Breast Cancer Detective), the use of video lectures in interventional radiology; the replacement of problem-based learning with case-based learning [25]; the development of customized PACs and the replacement of traditional classroom based lectures with virtual/online lectures [1].

TABLE 1. Most significant e-learning interventions in radiology education as determined by Kirkpatrick’s method of evaluating training programs.

D I EU R O P E

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REFERENCES


