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Integrating of scenario-based simulation into radiology education to improve critical thinking skills

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Introduction: For many years, conventional radiographic films have been used for radiology education. Nevertheless, advances in imaging modalities, image quality, and the number of images produced by various methods have seen a move toward digital formats. Certainly, a patient's case has a significant value in medical education; it can transfer theoretical knowledge to real experiences. The aim of this study is to evaluate the value of scenario-based simulations in radiology education and their impact on professional learning outcomes.

Materials and methods: Patient scenarios were collected and converted to digital teaching files, each supported by clinical history, anatomy illustration, as well as medical and radiological investigation. The scenarios were presented online to radiology professionals for 6 months. At the end of the study, the scenarios were evaluated regarding design, content, and their role in improving critical thinking.

Results: Twenty-two scenarios were published online covering various radiology areas. Two hundred and thirty-eight radiology professionals were invited, and 84% participated in the evaluation process. Each participant completed an average of 13 scenarios with an approximate time of 23 minutes for each. The majority of participants agreed or strongly agreed that the scenarios were well designed (94%), were appropriate to their level of knowledge (70%), and helped them in critical thinking and in understanding similar cases (79%).

Conclusion: The integration of scenario-based simulations in radiology education led to a positive impact on learning outcomes, formative interactive learning, and filling the gap between theory and practice. Moreover, it promoted critical thinking skills and allowed radiology professionals to demonstrate their knowledge of similar cases.

Keywords: radiology education, scenario-based simulations, digital teaching files, critical thinking

Introduction

Simulation is defined as the act of representing an actual situation or incident by a virtual environment that has a similar appearance or outward qualities.[1] Gaba[2] described simulation as a technique that is used to amplify real experiences with guided experiences that evoke the strong aspects of the real world in an interactive manner. The implementation of scenario-based simulations as a teaching method in medical education is widely accepted and is growing in academic and clinical settings. They have contributed to improving patient safety and communication, reducing medical errors and instruction time, and enhancing clinical experiences for students and staff.[3] The scenario-based simulations compared to traditional educational methods have the ability to shape the learner professional outlook; they can allow them to refine

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their practice skills and apply what they learn in theoretical courses. In addition to this, the professionals will have the opportunity to provide a formative feedback to improve learner's clinical skills.

Dutra (2013) studied the implementation of case studies in nursing education; the results showed that case studies can serve as a resource for faculty in developing creative strategies and enhancing learning experiences.[4] Similarly, Cant (2009) showed that simulation is an effective teaching and learning method, has advantages over other teaching methods, and enables nurses to apply their knowledge in real-life practice.[5] Moreover, simulation can be used for continuing medical education to provide hands-on experiences and can positively affect clinical practice.[6] In radiology, the use of simulation in a digital teaching library and as e-learning resources has been shown to improve learning and reporting skills.[7]

Education in radiology consists of an accumulation of experiences shared as teaching clinical cases. Demonstrating clinical cases plays a significant role in positively linking the gap between academic knowledge and professional practice, what is taught or learned and what is practiced. Simulations are able to bring the field to the classroom as well as take the classroom into the field. The traditional method of radiology education relies on a bulk collection of available patient X-ray films from images.[7] However, efficient and creative radiology teaching requires the development of a wide range of theoretical knowledge and practical technical skills that include appropriate proper practice methods, optimal image production, and interpretation.

The scenario-based method of teaching is interactive and considered essential to optimal learning.[5] The use of scenario-based education as a teaching method provides a model of how to think professionally about a problem. Learners learn critical thinking skills, how to use theoretical concepts to illuminate practical circumstances, and apply the knowledge to actual and similar cases in the future and to effectively link their clinical experiences to solve issues.[8] It also helps to learn how to think productively about the clinical experiences, which enhances their ability to learn from their experiences. A radiologic case study contributes to teaching other various topics such as ethics, medical law, and data collection from patients and physicians. A case study allows clear thinking of the diagnostic methods of the clinical problem, the radiographic procedures, and radiographic image analysis.[9] Moreover, it helps to reflect on expert-based knowledge as well as create and use the new skills.

A well-developed scenario should provide a model of how the faculty thinks about actual clinical problems. Learners should learn how to develop their thinking strategies to apply similar approaches to a problem. Scenarios help to learn how to identify issues and think as a professional. Case studies are valuable to instructors since they allow to draw many conclusions, some of which the instructor may not have considered. Scenarios can be a way of framing problems and analyzing experiences.[10] However, they can also be a stressful "double-edged sword"; the stress can interfere with performance.[5] The fact that they can encourage involvement by other audience members is another positive attribute.[10,11] The instructor can experience an intense but rewarding role and, depending on his skills, can help in various degrees to set an agenda and direct their learning, which can significantly enhance their educational experience.[12] An experienced instructor can choose from many images to show depending on the questions raised by the students. Many instructors prefer to use radiographic images as part of their teaching methods; images are worth a thousand words, and drawing or using a strip and graphical depictions can be valuable. Radiographic images have a significant role in interactive medical learning; it would be unfortunate to lose this valuable advantage.

A radiology scenario case consists of depicting films or digital images, reports, and pathological findings of patient cases that help to learn how to utilize medical images to develop their knowledge and practice. Scenario-based radiology teaching is designed to stimulate conversational dialog regarding imaging, which enables the integration of different image sources into a coherent knowledge base. The scenario should elicit questions that allow the student to think about similar problems from another point of view such as "What if we used a 16 multislice instead of a conventional CT scan". Such questions might come up in a practical knowledge discussion. It encourages the learners to apply a particular piece of knowledge to other knowledge that they might not have. It also allows to remember and apply it in new and unfamiliar settings.[13] The faculty, especially in radiology, should take advantage of the digital revolution in teaching through a comprehensive vision of it is meaning. They should look closely at the innovative tools at their disposal to find ground-breaking ways to enhance teaching.

The goal of the simulation is to take advantage of the standard functioning of health care units as a virtual reality and build a knowledge base of cases and data for teaching and research purposes.[14] However, scenario-based simulation is a challenge but could encourage participants to articulate answers that exhibit profound reasoning rather than delivering simple tidbits of knowledge. Despite its drawbacks, scenario-based simulation education can encourage learners to develop deeper thinking skills and to eloquently communicate their

responses. One potential drawback of simulation implementation in education is the expense of personnel and equipment. The maintenance and training of such equipment as well as maintaining the latest updated are costly. The scenario-based simulation requires low students-to-faculty ratio, which increases the time and costs.[15]

To provide radiology students and professionals with structured radiology education in the form of scenario-based simulations, this study introduced a web-based radiology educational tool called scenario case simulation (SCS). This article describes our experience in developing and integrating SCS into the radiology curriculum to measure its effectiveness and potential benefits in knowledge and skill acquisition as well as in critical thinking. Utilization of simulation in continuous medical education has a potential for changing traditional teaching and learning methodologies for health professionals.[6]

Materials and methods

This study was conducted at the Medical Diagnostic Imaging Department of the College of Health Sciences at the University of Sharjah and was approved by the Ethics Committee of the University of Sharjah. The study was self-funded by the authors. The aim of this study is to evaluate the value of scenario-based simulations in radiology education and their impact on professional learning outcomes.

The scenarios were based on the guidelines of the Alliance of Medical Student Educators in Radiology (AMSER)®. These guidelines were utilized to help develop standardized medical student radiology curricula.

This study's case selection was based on the ability to apply the theories to a practical framework, demonstrate the ability to analyze and evaluate the case. We allow the participants to use their knowledge, test it, and give their feedback about their learning experiences, which are clearly shown in the quiz and discussion section of the case study. The online case study was designed to be able to support the full process of case preparation from image acquisition, through image editing and case annotation to the structured organization of cases and secure image archiving. The database is easily accessible to participants either within the hospital, institute, or home, "Anytime and Anywhere". The scenario is user-friendly and quick and requires minimal training to be able to use it effectively. The scenario was designed to be compatible with a variety of different image formats and allowed direct transfer of images, upload digital image communication in medicine (DICOM), JPEG, and videos. Searching for a different scenario according to the learner interest was designed through a simple searching method using the keyword or advanced methods using various anatomical and pathological conditions.

The scenarios were described in a format that allowed participants to follow simulated patients through both the clinical and imaging stages of their disease and concomitant complications. The primary purpose of case selection is that it should cover a broad range of imaging modalities and have complete patient data. All cases were reviewed by faculty members and clinicians in the specialty before final publishing.

Each scenario consisted of clinical information, including patient history, laboratory investigations, biopsy, etc. (Figure 1). The case literature includes interactive illustrations of anatomy, physiology, and pathology supported by various radiographic imaging modalities for the current patient (Figure 2).

Patient written informed consent was deemed exempt according to the university of Sharjah because the radiographic images were treated as anonymous after removing all patient and hospital information to ensure confidentiality and patient privacy. The progression of the cases and the radiologic examinations illustrate the role of radiological investigations in the diagnosis of these cases.

Figure 3 shows an example of the user interaction features, which consisted of discussion and multiple-choice questions to stimulate interactive learning, outcomes measurement, and decision-making processes. The scenario was converted to digital format and published online at a website prepared for this purpose and made available to the public (www.uospacs.com).

The stakeholders of this study were radiology professionals involved in the radiology education such as radiographers, radiologists, and radiology residents. To evaluate the impact of this educational methodology, sufficient time was provided to the participant to move through the scenarios. The online digital teaching files database was made available to them for 6 months. Next, participants were asked to perform online evaluations using a 5-point Likert-type rating scale (Table 1). In addition, they were asked to comment on their overall experience. The survey was administered and reviewed by expert faculty members, six radiologists, and six supervisory radiographers. The necessary corrections were made to ensure that the results helped evaluate and improve the project. Corrections ensure the realistic and workable of the questions in terms of ambiguities and difficulty and recording of the time taken to complete and decide whether it is reasonable. The questionnaire was uploaded to the online survey site "www.surveymonkey.com" and a link was provided to the participants. After they completed the questionnaire, the results were collected, stored, and analyzed. The feedback was used to recuperate, modernize, and revise the scenarios as necessary.

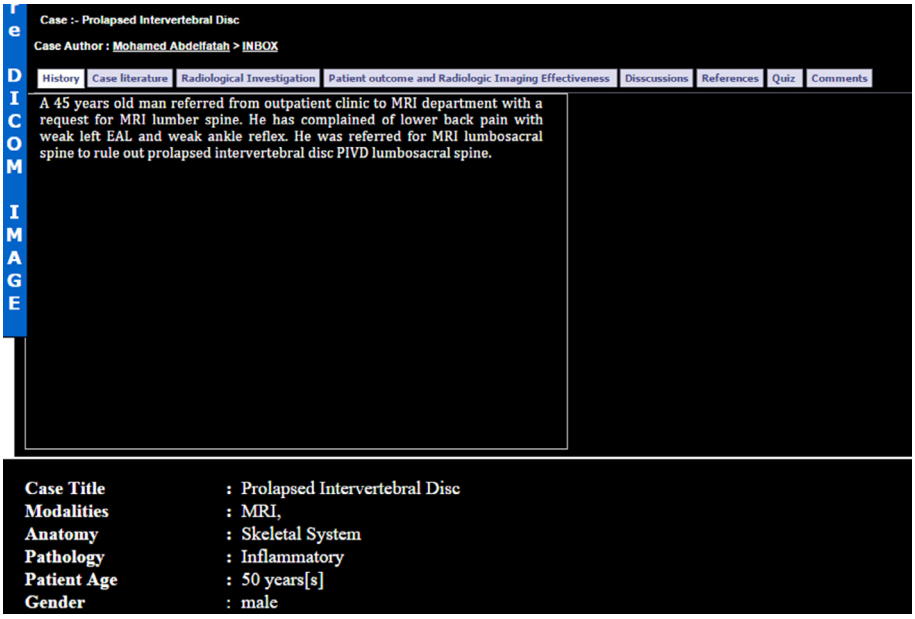

Figure 1 Incorporating scenario-based simulation in radiology education.
Notes: The first page of the case showing clinical history; case literature "anatomy and physiology, anatomy radiographic anatomy and pathology"; radiologic investigation "procedures, reports"; patient outcomes and radiological imaging effectiveness; and discussions.
Abbreviations: MRI, magnetic resonance imaging; PIVD, prolapsed intervertebral disc; EAL, extensor anterior muscle.

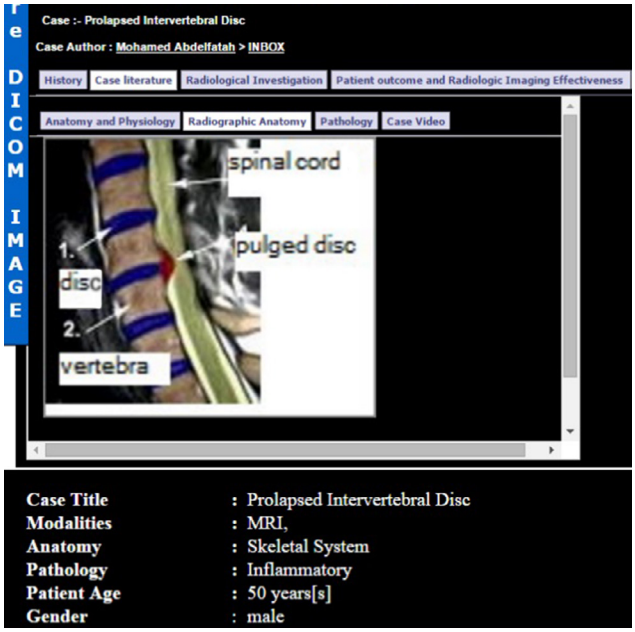

Figure 2 Interactive illustrations of anatomy and physiology.
Abbreviation: MRI, magnetic resonance imaging.

Results

Three faculty members were selected and produced 22 simulated scenario cases. The cases covered skeletal, respiratory, abdominal, urinary, cardiovascular, and central nervous system radiology.

The number of participants was 238; the invitations were sent by email and through direct meetings. The research group prepared leaflets and a manual to explain the concept and to facilitate the use of the material. The survey was administrated over a period of 6 months. The responses included 200 complete questionnaires, which was 84% of the invited population. Each participant completed an average of 13 scenarios. The website recorded a mean time of 23 minutes to review each scenario.

Most participants (94%) agreed that the design of the scenario-based simulation was good and attracted them to study. They evaluated the content and material of each scenario. They rated the information provided in each part of the scenario as to how it helped them understand the scenario, and 70% of

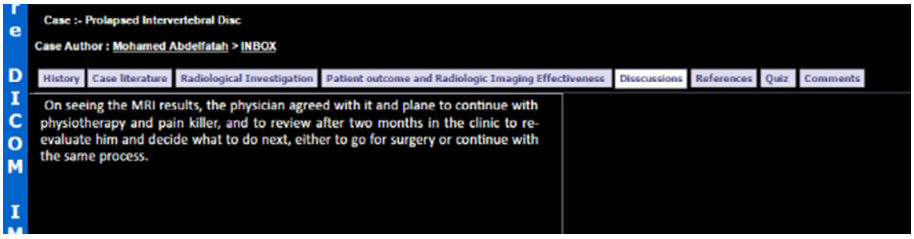

Figure 3 User interaction features "discussions, quiz, and comments".
Abbreviation: MRI, magnetic resonance imaging.

Table 1 Survey questions

Survey used to evaluate the scenario-based simulation cases using a 5-point Likert-type rating scale (1= strongly disagree, 5= strongly agree) (administered via surveymonkey.com)
Answer options
1. The scenario design was good and attracted me to study
2. The information presented in the scenario was appropriate to my level of knowledge
3. The scenario helped improved my critical thinking
4. The scenario length was appropriate
5. Comments

the participants agreed that the information presented in the scenario was appropriate to their level of knowledge. One of the essential aspects of each case was critical thinking. Critical thinking skills have been defined as the use of theoretical concepts to solve a practical problem and how to apply that knowledge to similar future cases, as well as to effectively apply clinical experience to solving issues. The scenario should help professionals to learn how to think productively about their clinical experience. Seventy-nine percent of participants noted that the scenarios helped them use their critical thinking skills to understand similar cases. Most participants (75%) agreed that each scenario length was appropriate, which was reflected by the 23 minutes required to review each scenario.

Participant comments were useful and reflected the advantages of each scenario; they claimed that they enjoyed the learning process and how the information provided could help them in actual situations that they might encounter in their daily clinical practice. A few examples:

> I enjoyed learning from cases, which appeal to the universal delight in a good story.

> I have become more and more convinced of the importance of good examples stories – in the presentation of the ideas.

The evaluation of the SCS provided an important part of the future maturity of the project; it empowered us to amend the text, images, and design to enhance the educational experience.

Discussion

Feedback from participants indicated that scenario-based simulations promoted learning and critical thinking, which could have a positive impact on professional learning outcomes. It enriched their interest in learning via an interactive, online, and case-based format. The study confirmed that scenario-based simulations were a valid method of education. The literature has reported that computer-assisted learning has had a positive impact on radiology education and has led to significant improvements in learning methodologies.[15] Most participants (94%) reported that the scenario case design was interactive. This design proved to be superior regarding its effect on transferring knowledge than more traditional educational methods such as stations or clinical seminars.[16,17]

The content of the scenario-based simulation was intended to ensure fulfillment of specific learning outcomes, and 89% of the participants agreed that it was an effective teaching resource for instructors since the information obtained corroborated the recent literature. Chetlen et al[18] stated that simulations should explain the concept of a case and provide accurate comparisons between the initial physician diagnosis and the final radiologist's report. The participants claimed that scenario-based simulations provided useful resources that were appropriate to the level of training.[15]

Radiology professionals are increasingly required to be critical thinkers in their practices. Examining, synthesizing, assessing, and then responding quickly to a patient's needs should be increasingly developed and improved through radiology education.[5] Seventy-nine percent of the participants agreed that the scenario-based simulations promoted a greater level of critical thinking.[3,4,8] Jamkar et al[19] argued that scenario-based simulations help develop critical thinking and are effective and superior to traditional instructional approaches. Traditional approaches using lecture-based instruction are often content driven and give little attention to problem-solving, collaborative learning, and lifelong learning skills. Moreover, they do not promote practical applications of knowledge and critical thinking skills.[19] Conversely, Chorney and Lewis[15] have stated that teaching radiology using scenario-based simulations can have advantages regarding learning imaging management and interpretive skills.

Scenario-based simulations are not intended to replace traditional learning or teaching methods, as no single teaching method can achieve all learning outcomes. Thus, different teaching approaches and activities can only enrich the learning experience. Moreover, a multifaceted approach can motivate learners to study more and engage in research and professional development. The scenario can be an effective tool to improve the required training hours before practicing experiences, helping in the shaping of the professional outlook.[20] It may be useful to include the structured simulation as a part of clinical practice experiences to fulfill program objectives and goal. Faculty can develop experiences, which focus on specific skills acquisition such as communication, techniques, and merging of different imaging modalities on one topic. During training and practice, medical knowledge improved, but it is necessary to investigate and determine the patient outcome[21]; post-simulation training assessment and feedback appear

to be the best way to demonstrate various possible options and it will improve confidence and skills.

Future prospective and limitations

Future goals of this study are to design an intelligent mobile application that allows users to view, share, and build on their experiences in a clinical setting. The limited financial resources of this study restricted the authors in their development of a DICOM web viewer to be integrated into the website.

Conclusion

Support for the value of patient scenarios in education is likely to increase. However, one concern is the rapid growth in technology, which requires teaching new and changing materials on an ongoing basis. Interactive scenarios for radiology professionals should be complemented by text-based knowledge and through the use of interactive images to explore the findings in literature reviews, as well as for pathology findings supported by radiographic images using different modalities. The interaction between professionals and the sharing of experiences, opinions, and exchange of information adds value to the learning process. Finally, the SCS module should be dynamic, easy to edit, retrieve, and update. The instructor should also be able to expand the module to include other radiologic imaging techniques.

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Disclosure

The authors report no conflicts of interest in this work.

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