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Introducing online continuing education in radiology for general practitioners

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Abstract The aim of this study was to determine whether e-learning as a new teaching methodology was acceptable for general practitioners in continuous education courses of radiology. Generally, these courses are face-to-face with the corresponding time and place limitations. To overcome these limitations, we transformed one of these courses to an online one evaluating its acceptance. The course was about thorax radiology and it was delivered to 249 participants. The experiment was carried out in two phases: Phase 1, as a pilot testing with 12 general practitioners (G1), and Phase 2, with 149 general practitioners (G2), 12 radiologists (G3) and 76 medical residents (G4). All participants evaluated the course design, the delivering e-learning platform, and the course contents using a five-point Likert scale (satisfaction level from 1 to 5). Collected data was analysed using t, Mann-Whitney U and Kruskal-Wallis tests. In Phase 1, the rounded scores of all questions except one surpassed 3.5. In Phase 2, all the rounded scores surpassed 4.0 indicating that a total agreement on all items was achieved. All collected impressions indicate the high acceptance of the proposed methodology.

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1 Introduction

Continuous medical education (CME) is defined by the International Association for Medical Education as any activity that is intended to maintain, develop or increase the knowledge, skills, and professional performance and relationships that a physician uses to provide services for patients, the public, or the profession. CME is mandatory in the majority of medical centres where offered courses vary according to institution needs or practitioners' demands, amongst others.

Currently, in our country there is a special interest on radiology courses for general practitioners and medical residents. Medical imaging has greatly evolved to become an indispensable tool for medical professionals in the diagnostic process. Therefore, courses to refresh and introduce radiology concepts, and also to learn how to use radiology in a proper and responsible way are required [17, 38]. To tackle these issues, teaching units from our centres offer radiology courses on different topics. All of them are delivered face-to-face, which limits participation due to time and place restrictions. To overcome these limitations, we decided to transform one of the courses to an online version to measure its acceptance with the idea of using it as a new teaching methodology.

E-learning focuses on the use of computer and network technologies to enhance teaching and learning, while preserving or improving the interactivity of face-to-face learning. Over the last few years, it has gained great importance at all educational levels from primary school to universities [9, 10, 15, 18]. In radiology education, different e-learning tools have been proposed; for a review see [3, 4] and [43]. To use this methodology, the challenge is how to design and implement courses that motivate teachers and learners to participate.

The aim of this study is to describe how we have transformed a face-to-face course in an online one in order to determine whether e-learning as a new teaching methodology is acceptable for general practitioners in continuous education courses of radiology.

2 Online courses in radiology

One of the main decisions when designing an online course is the selection of the e-learning platform. To select it, we have considered teachers and learners requirements with the purpose of increasing learners' participation in the courses. In our context, course teachers are generally radiologists who are used to face-to-face classes. They prepare case-based classes either by using their own cases or by using examples from different image repositories. They consider practice fundamental to accumulate experience. Therefore, their main

challenge is the translation of face-to-face material to online contents which can support user interaction in order to simulate practice [14, 37].

Focusing on learners, we considered the principles pointed by [6, 29, 30, 32, 37] related to the theory of learning for adults. Adults are results-oriented, show a great need to know, and are autonomous and self-directed. They have a lot of life experiences and knowledge as a basis, and they have a need for connecting this basis with the learning content. Adults are relevancy-oriented and generally practical, and show a high motivation to learn when they can get new information which can help them to solve significant problems in their lives/work. We believe that a course where case studies were presented as practical cases (with radiological images that can be interacted by the users) would be a suitable strategy to meet these principles [16].

To create and deliver the course, we evaluated some of the main state-of-the-art e-learning platforms that fitted our purpose, such as *MyPACS.net* [40], *KICLA* [34], *ELERA* [13], *Radiology ExamWeb* [25], *COMPARE Radiology* [12], *RadStax* [8], *USRC* [5] and *RadEd* [41]. Although other platforms could have been used, we selected RadEd since it provides functionalities to create theory material and exercises using images with which the user can interact. Moreover, it provides functionalities for automatic correction with feedback to the learner. In addition, we selected a course of thorax radiology to carry out our study. More details of the delivering platform and the course are given in the next section.

3 Material and methods

3.1 The Radiological Education platform (RadEd)

RadEd [41] is a web-based e-learning platform designed to complement teaching and learning of subjects that require the interaction with radiological images. It is available for PC, tablets and smartphones and it is multilingual. It allows the creation of modules (or courses) grouped by topics which can contain different levels of sections and subsections. These items can contain theory and exercises. There are different types of exercises, such as test, identification of regions and labelling, which can be corrected online using the corresponding correction strategy integrated in the same platform. The platform provides specific editors for teachers to create theory material and exercises, and functionalities to control learners' work and visualise their progression with respect to other learners of the course, amongst others. For more details, see [41].

3.2 A course on thorax radiology

A radiologist with more than 20 years of experience both diagnosing and teaching prepared the online course. He used his own presentation slides and also a set of cases which he uses in his face-to-face classes. He translated all this

Table 1 Topics of the thorax radiology course

Topic	Theory pages	Exercises
How to read a thorax X-ray	5	13
Lateral X-ray	7	11
Anatomical concepts	10	6
Hila and fissures	4	7
Errors due to bad technique	3	8
Evolution	1	10

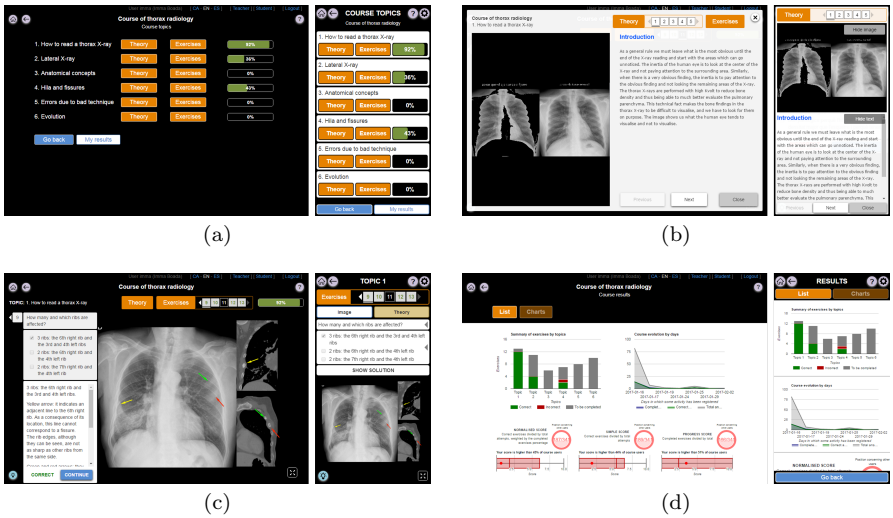

Fig. 1 Screenshots of the PC and smartphone versions of the course: (a) Course contents with the topics, the buttons to access theory and exercises, and the progress bar indicating the percentage of exercises that have been solved; (b) A theory page with the buttons to navigate to other pages and access the related exercises; (c) An example of one of the exercises of the course; and (d) Some statistics of learner progress such as number of exercises solved per day, number of correct exercises per topic, and position of the participant with respect to other members of the course

material to online contents using the theory and exercise editors of the RadEd platform. By using the editor options, he assigned help messages and feedback to the exercises to guide the learners. It was not required to prepare the material from scratch. The course topics and some screenshots of the platform are presented in Table 1 and Fig. 1, respectively.

3.3 Participants

Test participants are 249 subjects classified in four groups: G1, with 12 general practitioners who participated only in the pilot testing; G2, with 149 general practitioners; G3, with 12 radiologists from the radiology department of the Hospital Josep Trueta of Girona; and G4, with 76 medical residents. The

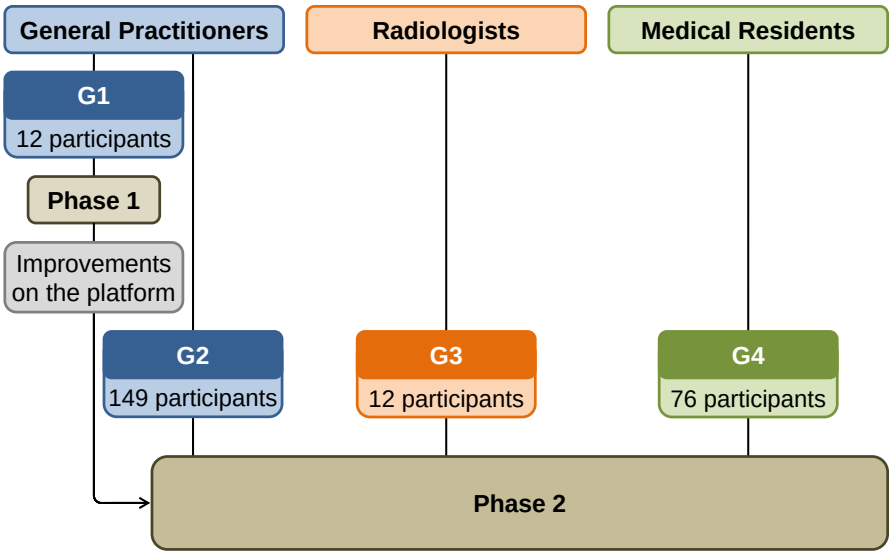

Fig. 2 Diagram of the participants divided by groups and phases

participants, recruited from different hospitals and medical residencies of our region, were asked to perform the course voluntarily. Those who agreed were all accepted, so there were no exclusion criteria. The experiment in which they have participated has been conducted according to the Declaration of Helsinki principles.

3.4 Experimental design

Our experiment has been done in two phases (see Fig. 2). To test the course, Phase 1 was delivered to G1 members. They had access to the course for 15 days, and after completing 80% of the course they filled the questionnaire presented in Table 2. To answer, Likert scale (1 = total disagreement, to 5 = total agreement) was used [26]. In this phase, some errors were detected and corrected. Afterwards, Phase 2 started with subjects from G2, G3 and G4. Again, participants had 15 days to access the course, and when 80% of it was completed they filled the same questionnaire.

3.5 Statistical analysis

To evaluate if the opinion of the course improved between Phase 1 and Phase 2 a Mann-Whitney U test has been performed. Using Phase 2 data, depending on the number of categories of independent variables, t-test and Kruskal-Wallis test were used to identify significant differences by gender, age, type of participant, attended online courses and usefulness of the smartphone version of

Table 2 Participants questionnaire filled when 80% of the course was completed

General Information
Age How many online courses have you participated in, aside from this one? [0, 1 to 3, > 3] Which device have you used preferentially to take the course? [Computer, Tablet, Others] Do you think that the smartphone version of the platform is useful? [Yes, No]
Global Evaluation (1 = Totally disagree, to 5 = Totally agree)
(Q01) Globally, I favourably evaluate the course (Q02) I would recommend this teaching methodology to my teammates
Usability (1 = Totally disagree, to 5 = Totally agree)
(Q03) It was easy for me to interact with images (Q04) It was easy for me to access and navigate through the content pages (Q05) It was easy for me to access and navigate through the exercises (Q06) It was easy for me to identify each icon with its function
Contents (1 = Totally disagree, to 5 = Totally agree)
(Q07) The topics in which the course was structured are appropriate (Q08) The course contents met my expectations (Q09) The balance between exercises and content was appropriate (Q10) Participating in this activity will allow me to improve elements of my daily work
Open questions (1 = Totally disagree, to 5 = Totally agree)
Aspects that you would suggest to improve this teaching methodology Positive aspects of this teaching methodology that you would emphasise Topics or issues on which I would like to take a course

the platform. Age has been transformed to a 3-categorical variable (25 to 34, 35 to 49 and 50 to 64). In all stages, we used the software R [31], which is a free software environment for statistical computing and graphics.

4 Results

4.1 Participants profiles

Phase 1 of the experiment was performed by 12 voluntary participants with an average age of 42 years old and a standard deviation of 7.87. The characteristics of Phase 2 participants are shown in Table 3. We only considered those participants who answered the survey (184 out of 237), and from these ones, those who provided all the information, thus reducing the sample from 184 to 146 participants, since 38 participants did not provide their age. When analysing the usefulness of the smartphone version, and also the online courses previously attended by the participants, the sample is reduced to 145, since some participants did not provide this information. Note that approximately two thirds of Phase 2 participants are interested in the smartphone version of the platform (56% of general practitioners, 71% of medical residents, and

Table 3 Characteristics of Phase 2 participants

		Age		
		mean	sd[a]	n[b]
	Female	36.02	9.95	108
	Male	42.00	12.73	38
Type of participant	General practitioners	44.19	9.23	84
	Medical residents	28.14	5.32	57
	Radiologists	34.00	5.70	5
Usefulness of smartphone version	Yes	36.27	10.51	92
	No	40.09	11.49	53
Online courses previously attended	Many (more than 3)	40.45	9.92	77
	None	30.00	6.55	36
	Few (between 1 and 3)	39.38	13.63	32

[a] Standard deviation
[b] Number of participants

100% of radiologists), being the non-interested group the oldest one [39]. We can also observe that more than half of the subjects have participated in many online courses, while the rest is divided in those that have participated in none or few courses.

4.2 Questionnaire results

Looking at Table 4, we can see that in Phase 1 the rounded scores of all questions of the test except Q03 surpassed 3.5 on a five-point Likert scale, while in Phase 2 all of them surpassed 4.0. Questions Q03 and Q05, related to usability of the delivery platform, have significant differences (p-value < 0.05), and Q02, Q07 and Q08 have nearly significant differences ($0.05 <$ p-value < 0.1). Therefore, the improvements introduced after Phase 1 have enhanced the course.

Focusing on Phase 2 scores, represented in Table 5, we can see that there are no significant differences in the scores by gender, frequency of online courses previously attended, and usefulness of the smartphone version. This means that the users, independently of their previous participation in online courses, feel comfortable with the teaching methodology. Considering age and type of participant, only question Q03 presents significant differences (p-value < 0.05).

Regarding the open questions that participants filled in the last block of the questionnaire, and focusing only on the answers related to the proposed methodology and the course contents, we divided them in three groups:

1. *Aspects that they would suggest to improve the teaching methodology.* Quite a few users said the course was too short, and that they expected more exercises. Other aspects they found improvable were the solving process of

Table 4 Differences in the scores between Phase 1 and Phase 2, and p-values

		mean	sd[a]	Mann-Whitney U
Q01	Phase 1	4.17	0.83	0.27
	Phase 2	4.42	0.69	
Q02	Phase 1	3.92	1.08	**0.07**
	Phase 2	4.43	0.73	
Q03	Phase 1	2.83	1.40	**0.005**
	Phase 2	3.95	1.04	
Q04	Phase 1	4.67	0.49	0.75
	Phase 2	4.68	0.54	
Q05	Phase 1	3.82	1.17	**0.03**
	Phase 2	4.49	0.75	
Q06	Phase 1	3.83	1.19	0.14
	Phase 2	4.30	0.82	
Q07	Phase 1	3.92	0.79	**0.07**
	Phase 2	4.31	0.77	
Q08	Phase 1	3.67	0.98	**0.07**
	Phase 2	4.16	0.85	
Q09	Phase 1	3.92	0.90	0.12
	Phase 2	4.28	0.83	
Q10	Phase 1	4.25	0.75	0.57
	Phase 2	4.34	0.80	

[a] Standard deviation

Table 5 Phase 2 scores taking into account gender, age, type of participant, frequency of online courses previously attended, and usefulness of smartphone version

	Gender	Age	Type of participant	Online courses previously attended	Usefulness of smartphone version
	t-test	Kruskal-Wallis	Kruskal-Wallis	Kruskal-Wallis	t-test
Q01	0.65	0.96	0.20	0.99	0.19
Q02	0.59	0.98	0.62	0.93	0.21
Q03	0.42	**0.04**	**0.03**	0.70	0.34
Q04	0.54	0.68	0.82	0.88	0.38
Q05	0.45	0.16	0.22	0.40	0.09
Q06	0.12	0.08	0.34	0.61	0.08
Q07	0.91	0.76	0.12	0.60	0.55
Q08	0.44	0.39	0.06	0.68	0.40
Q09	0.68	0.60	0.07	0.71	0.69
Q10	0.86	0.51	0.19	0.56	0.34

some exercises that require image interaction, the possibility to download the theory contents, the ability to organise the practical cases from less to high complexity, and informing about the length of the course. Related to the course contents, they wanted to delve into the patterns and differential diagnosis; they expected more paediatric images, a topic about lung parenchyma, and more practice in finding lesions over the images; and they suggested changing the order of the topics to study first the anatomy, while adding more radiographs to the first topic.

2. *Positive aspects of the teaching methodology that they would emphasise.* They highlighted the ability to take the course at any time and from anywhere; the possibility of interacting with the material to explore and select parts of the radiological images; the value of the feedback after solving the exercises to help understanding where the user has made a mistake; the good quality of the images and the well-structured information; the practical, image-based and light contents; the usefulness for the users' daily work; the good relationship between theory and exercises; and the fast learning and the maintenance of knowledge.
3. *Topics or issues on which they would like to take a course.* Participants requested and suggested many different topics, such as abdominal radiology, paediatric radiology, bone radiology, lumbar radiology, and ultrasound. However, a lot of participants requested the same course, but with more practical cases.

5 Discussion

Radiology concerns almost all medical specialities and continuing radiological education is required to maintain competence and learn about new advances in this field. With this purpose, experts on the topic prepare courses which are usually delivered face-to-face. Due to limited resources related to time and teaching staff, special attention has to be paid when designing these courses [14, 35]. Amongst the different issues that need to be considered when preparing them, we have mainly focused on: (i) how to motivate learners' participation; (ii) how to reduce the teacher workload when preparing courses; and (iii) how to support different devices to deliver the course. These issues are fundamental to extend the use of this experienced methodology to future courses.

Focusing on learners' side, Collins [7] evaluated education techniques for lifelong learning and described the application of ten principles of adult learning to radiological education. Amongst these principles, she remarks that adults learn best when they are active participants in the learning process and that they learn more effectively when appropriate feedback is given. Furthermore, adults tend to be problem-centred learners and learn best through practical applications of what they have learned. In the context of medical education, the impact of practical case-based methodologies has been very well studied and different studies demonstrated their positive impact

on learners [11, 27, 42]. They have also been studied in the field of radiology, where case-based e-learning is pointed out as one of the most promising approaches [28]. Therefore, a good strategy would be the creation of online case-based courses which support user interaction in order to simulate practice. We have designed such a course, focused on thorax radiology, and it has been very well accepted by both the experienced and non-experienced users. These results confirm Collins' principles.

As for the workload required to prepare the courses, we want to exploit the current material from face-to-face courses to avoid preparing online courses from scratch, since we are aware of teachers' time restrictions. To tackle this problem, it is very important to consider the functionalities provided by a platform before its selection. In [20], the uses of technology in the context of radiology education are presented, and in [3, 4] multiple online radiology resources which offer case-based learning experiences are described. From the experience of carrying out our course, we have realised that image interaction has been one of the most valued functionalities. Although it needs further evaluation, we have found that the time required for the teacher to prepare the course was less than what he expected, since the majority of tasks that have to be done are repetitive, such as uploading images and copying the learning material from the face-to-face course, which is already prepared, and pasting it in the e-learning platform. Teachers are usually expert radiologists who have a great knowledge about the topic, but they do not know how to make the online experience attractive for learners. For this reason, the possibility of easily transforming face-to-face cases into online exercises was greatly appreciated. From this experience, we have also detected the importance of pedagogical support to guide teachers in questions such as the number of attempts that have to be assigned to an exercise, when to return feedback, and when to send help messages.

Finally, regarding the supporting technology, the course was also offered in a mobile version for smartphones and tablets, and despite the fact that most of the participants stated that this version would be useful, only 10 of them took advantage of it. Although the use of such technologies is widespread, even amongst the medical practitioners, and mainly amongst the residents [22, 23], they are not the preferred tool to diagnose due to the limitations they have regarding the screen size [1, 33]. Some studies have demonstrated that they have some advantages with respect to the mobility, but when it comes to diagnosing they still cannot compete with a PC [36], and they are only kept for diagnosis during emergency [2, 19]. In [24], the recommended requirements for diagnosis devices are defined, and smartphones and tablets do not meet them. In our case, then, this conclusion has been made clear.

5.1 Strengths and limitations

From the results of the participants and the comments of the open questions, we consider that the proposed teaching methodology has been widely accepted,

and that it could be a suitable tool for increasing the participation of medical practitioners with regard to continuing medical education courses. Moreover, if we take into account the Kirkpatrick model [21], we can clearly conclude that level 1 of this model has been achieved, since participants found the training favourable, engaging and relevant to their jobs. Indeed, from Q10 of the questionnaire (average score of 4.34), related to the improvement of the participants' daily work, we can consider that participants will apply what they learned during training when they are back on the job, so that levels 2 and 3 have also been achieved. With respect to level 4, related to the outcomes as a result of the training, it is difficult to measure in our context, since it requires a further evaluation where several parameters need to be considered, and not only the background on radiology. Judging by the scores of the participants, we also consider that the pilot testing of the experiment was useful to correct errors and improve the learners' e-learning experience.

Although it falls out of the scope of our study, and despite the difficulty of measuring it, we think that it would be interesting to complement the evaluation of the acceptance of the proposed methodology with an analysis of how acquired knowledge is translated into practice. However, determining whether the participants are applying radiology in a more accurate and precise way is difficult, since although the course may affect their decisions, other factors can also be taken into account. In a similar way, our study lacks a previous evaluation to measure the acquired knowledge before and after the course. To tackle this problem we are preparing new cases for the course that will be presented as a pre-test. It would also be interesting to include a comparison with a control group that carries out the same course face-to-face, but this comparison is of little importance to our study since we are more interested in how the users feel with an online environment. As for the use of different supporting technologies, we find as a limitation the inability to analyse the difference between the questionnaire results, which conclude that the smartphone version is useful, and the real use of this version, which has been rather low. To find out the reason, a specific question should have been added in the questionnaire. Finally, regarding the teacher workload, a more exhaustive evaluation is needed considering more courses, more teacher profiles and more e-learning platforms.

6 Conclusions

The aim of this study was to evaluate the acceptance of an online teaching methodology as a substitute for face-to-face continuous education courses in radiology. An online environment is useful to motivate participants to enrol in CME courses. The feedback we have received by implementing a thorax radiology course is highly favourable, and the main conclusion is that participants feel comfortable with this format because it removes time and place restrictions and includes interactivity. Participation with respect to face-to-face courses is also increased. Therefore, the use of this online methodology is more engaging

and it can be considered as an appropriate substitute for face-to-face courses, since it favours the participation in CME courses and, consequently, it helps the medical professionals to maintain and increase their knowledge.

Compliance with ethical standards

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Conflict of interest

The authors declare that they have no conflicts of interest.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent

Informed consent was obtained from all individual participants included in the study.

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