Learner's perception, knowledge and behaviour assessment within a breast imaging E-Learning course for radiographers

Inês C. Moreira[a,b,c,d], Isabel Ramos[a,b], Sandra Rua Ventura[c,e], Pedro Pereira Rodrigues[a,d]

[a] *Alameda Prof. Hernâni Monteiro, Faculty of Medicine of University of Porto, 4200-319, Porto, Portugal*
[b] *Alameda Prof. Hernâni Monteiro, S. João Hospital Center, 4200-319, Porto, Portugal*
[c] *Rua Dr. António Bernardino de Almeida, 400, School of Health - Polytechnic Institute of Porto, 4200-072, Porto, Portugal*
[d] *Rua Dr. Plácido da Costa, s/n, Centre for Health Technology and Services Research, 4200-450, Porto, Portugal*
[e] *Rua Dr. António Bernardino de Almeida, 400, Center for Rehabilitation Research (CIR), 4200-072, Porto, Portugal*

A B S T R A C T

Purpose: E- learning has been revealed as an a useful tool among continuing education within health profes-sionals, namely for radiographers or radiologic technologists. Therefore like traditional learning, this teaching approach needs continuous evaluation in order to validate its effectiveness and impact. Kirkpatrick's model has been widely used for this purpose by health information management instructors. Our aim was to assess an E-learning Course on Breast Imaging for radiographers based on the first three levels of Kirkpatrick's framework: reaction, learning and behaviour.
Methods and materials: An E- learning course was developed for radiographers in order to provide an easy-to-understand, succinct and current overview in breast imaging, namely mammography technique and image in-terpretation. The program structure were built based on the guidelines proposed by the European Society of Breast Cancer Specialists (EUSOMA). Learner's satisfaction was assessed through a questionnaire and Knowledge gain was assessed using pre- and post- testing. After 6 months of complying the course, the learners were contacted through a questionnaire in order to give feedback on whether their behaviour changed in workplace. *Results:* Two editions of the breast imaging course were performed by 64 learners. In general, 97% of the learners stated that the program content was very good and excellent, all learners considered the content was delivered in a very good or excellent way. High percentages of learners stated to be satisfied with the distribution of the content among each module (94%) and 86% of learners stated that your level of dedication was high or very high. Concerning improvement of knowledge, we found an evolution of 4 percentual points between pre and post-tests ($p = 0{,}001$). The learners have identified two main changes on their practice, the first one related with patient care, improving communications and positioning skills and the second one related with image interpretation, improving the image processing and analyses. *Conclusion:* These global results show that e- learning can provide statistically relevant knowledge gains in Radiographers. This course is an important contribution to the improvement of mammography education, im-pacting on the development of students' and radiographers' skills.

Keywords: Mammography; Breast neoplasm; Continuing education; Distance learning; Kirkpatrick framework; Breast imaging; Teaching and assessment

1. Introduction

Continuing medical education has been highly recommended by international entities in order to improve the performance and routine work of health professionals, including radiographers or radiologic technologists [1–3]. In regards to breast imaging, the radiographer has a key role performing mammographic examinations. Also, mammography is currently considered the best imaging technique for breast cancer screening and the most effective tool for early detection of this disease [4,5]. The European Federation of Radiographer Societies (ERFS) sets out that undergraduated students shall acquire a broad knowledge base in mammography [6]. Thus, education and training programmes are demanded to radiographers in order to improve their professional competences. Food and Drug Administration (FDA) and the European Society of Breast Cancer Specialists – EUSOMA - established that to be able to work in mammography settings, radiographers

must have professional certification and at least 40 h of mammography specific training [3,7].

For mammography certification a few training programmes can be found, for example the NHS Breast screening program (NHSBSP) developed in 2000, which provides a framework for radiographers to develop their performance in all areas inside senology or breast medicine, with specific training centers and associated universities [2]. The Australian Institute of Radiography (AIR) has a professional accreditation program that ensures the necessary training competences to work in mammography in the country. In addition, since 1999 this institution offer a programme that promotes continuing professional education, the Continuing Professional Development (CPD), in order to help the "benefit practitioners, their patients and the public through a better educated, better trained and more proficient workforce" [8]. In Portugal, undergraduate students get a general knowledge base in mammography and can currently practice without meet minimal mammography requirements. In addition, radiology curricula and training programmes differs from one educational institution to another. A study conducted by Strøm et al. [9] showed that in five European countries (Portugal included) the short period allocated to mammography, for both the theoretical component and practical training, in degree's curriculum and the lack of material resources were the main limitations in mammography education impacting on the development of students' skills. In response to these educational limitations, E-learning approach can play an important role.

E-Learning, or learning through the internet, has been revealed to be a useful tool to specific training and continuing education within health professionals [10–14]. Several advantages of this teaching methodology and assessment approach are recognised, comparing to traditional learning methods. The ability to learn at any time from any location, without having to travel or spend time away from work and cost-savings are some examples. This individualised learning approach allows to skip information that learners already know and move on to less familiar topics, besides providing learning delivery and activities. Using E-learning, educators can achieve a great possibility of easily and quickly update content [10]. Several studies demonstrate that radiographers are very receptive to this learning method [15–17].

Therefore like traditional learning, this teaching approach needs continuous evaluation in order to validate its effectiveness and impact [8], [12]. The model of Kirkpatrick's framework is one of the best evaluation methods and widely used by health information management instructors [10,19,20]. Kirkpatrick's model stresses training evaluation on four levels: reaction (level 1), learning (level 2), behaviour (level 3), and results i.e. impact on organization (level 4) [18]. The popularity of this model for training programs evaluation can be found in several studies, including those related with health care workers [20–22]. Each level presents an order of steps to evaluate educational programmes. Reaction level evaluates the approach of the student towards the course, the participants perceptions. Learning level measures the acquired knowledge a student has achieved by joining the course. Behaviour level points out whether the participants are really employing what they have acquired during the programme. Finally, results level measures how appropriately the major aim of the education is attained (organizational effectiveness).

There are several recommended tools to assess the effectiveness and relevance of the E-learning materials [23,24]. For learner perception and satisfaction (Level 1 of Kirkpatrick's Evaluation Model) some tools included programme evaluation sheets, interviews, learners' comments throughout the training and the course's ability to keep learner's engagement [25–27]. To assess whether learner's knowledge and/or skills are improved by the E-learning programme (Level 2 of Kirkpatrick's Evaluation Model), evaluation methods includes from self-assessment to team assessment, such as individual pre and post-training tests for comparisons [15,28]. Individual pre and post-surveys, interviews, observations or feedbacks can be used to assess whether the new achievements have been transferred back to the clinical practice or not (Level 3 of Kirkpatrick's Evaluation Model). This evaluation is typically performed three to six months after learning, and should be done in the workplace, requiring a more elaborate plan than levels 1 and 2 of Kirkpatrick's Evaluation Model [29]. Finally, to assess the impact on the organization (Level 4 of Kirkpatrick's Evaluation Model) the definition of outcomes needs to be very clear. This evaluation is considered the most difficult to perform, since many topics aren't easy to quantify [18].

Recognising that it is important to demonstrate the outcomes of substantial investments in health worker training, as well as considering the lack of material resources in mammography for radiographers in Portugal, an E-learning Course on Breast Imaging was developed [15] and further evaluated.

2. Aim

Our aim was to evaluate an E-learning Course on Breast Imaging for radiographers based on the first three levels of Kirkpatrick's framework: reaction, learning and behaviour.

3. Materials and methods

An online certified course for radiographers was developed and assessed in order to promote and improve basic knowledge in breast imaging, namely about mammography technique and interpretation.

3.1. The course

We developed a four week program course offered through the Moodle® platform of the Faculty of Medicine of the University of Porto (FMUP). This course was awarded with 1 ECTS (i.e. equivalent to 27 h of full-time study) and was accredited by the Scientific Council of the Faculty.

Two editions of our course had been available, the first between 9th October and 3rd November of 2016 and the second between 11th February and 18th March of 2017. The course was announced at FMUP's website[1], by email and also on social networks, such as Facebook and LinkedIn. Qualified radiographers, final year undergraduate students in Radiography and other healthcare professionals were able to apply to the course and they were selected according to the University admission requirements for student selection. During the procedure, decisions on admission to the University were made on academic graduation in Radiography (40%), professional experience (40%) namely in mammography, and post-graduated formation (20%). The course were limited to 30–35 participants (30 participants for the first edition and 35 for the second edition). All participants admitted have signed a declaration of honour (Appendix 1) to attend the course.

The contents of this E-learning course were based on the guidelines proposed by the European Society of Breast Cancer Specialists (EUSOMA) [7]. The materials were designed by two experienced professors and reviewed by two radiologists with expertise in breast imaging. The course was structured in three modules (Table 1), and at the end of each module, exercises were given and designed to improve learning of the various topics. Formative assessment strategies have been used to improve teaching and learning simultaneously.

The modules included online lectures, reading texts, exercises and online assignments, available sequentially. Each module comprise two mandatory lectures, being the second one available one week after the first one. The lectures were built using the software Articulate Story Line®, and it was promoted an interactive environment where learners could listen and visualize text, images, clinical cases, lecturers, suggested articles and also videos. Each lecture session typically take around 30–40 minutes to complete.

[1] URL: https://sigarra.up.pt/fmup/pt/cur_geral.cur_view?pv_ano_lectivo=2016&pv_curso_id=11681&pv_origem=CAND&pv_tipo_cur_sigla=UFC

Table 1
Course's main contents.

Structure	Contents
1. Introduction (1 hour)	
2. Breast anatomy (8 hours)	Breast localisation and surface anatomy Breast tissues constitution Radiological anatomy Patterns of breast tissues Breast lesions localisation Exercise
3. Techniques & Positioning in Mammography (8 hours)	Mammography history Technical aspects of equipment and new technologies Technical quality control Positioning techniques and indications for standard and additional views Radiological protection Exercise
4. Semiotics in Mammography (8 hours)	BI-RADS classification Pathology of benign and malignant lesions Mammography findings Clinical cases Exercise
5. One synchronous session (1 hour)	
6. Final summative test (1 hour)	

Using a video, the course goals and the agenda was introduced to the learners. This kickoff event intended to motivate the participants and provide an overview of the activities and methods used through the course.

Besides asynchronous sessions, the course included one hour synchronous session promoted by two experienced professors, allowing learners to share experiences and answer questions about the topics of each module. In addition, a forum to share opinions and discuss some related topics was provided to the participants. The course features alongside the study design are depicted in Fig. 1.

At the end of the course, learners have to perform online a final summative test under time control, which was been scheduled one week after the end of the last module. The test included 25 multiple choice questions, 5 short answer questions and 2 mammography case studies. In this course, to reduce student bias, the final test have been rated by two professors. The course certificate were awarded only when learners successfully complete the formative assessments performed along the activities and on the final test (graded on a 0–20 scale with passing grade of 10/20).

3.2. Perception, knowledge and behaviour assessment

According to the Kirkpatrick's Evaluation Model and the suggested tools to assess the effectiveness and relevance of the e-Learning materials, learner satisfaction was assessed through a questionnaire one week after the final test. Then, Knowledge gain was assessed using pre- and post-tests, corresponding the post-test to the final summative test performed at the end of the course.

Finally, 6 months after complying the course, learners were contacted through an online questionnaire in order to give feedback whether their behaviour changed in workplace. The online approach was considered to be the best option considering the ability to reach to all learners including those that where from another countries. This questionnaire included 24 questions requiring a 5-point Likert scale, considering the following topics: patient call and preparation (Q1-Q5), technique and positioning (Q6-Q11), analysis and image processing (Q12-Q18), final procedures (Q19-Q20) and quality control (Q21-Q24). The questionnaire was designed accordingly to related literature [30]. All questions were asked to performed to obtain an answer according to what was their each behaviour before and after the course.

3.3. Statistical analysis

Normality was tested with the Kolmogorov-Smirnov test (total sample) and the Shapiro-Wilk test (for each edition group of learners), beyond the visual analysis of histograms.

The sample was described by median, 25 and 75 percentiles (P25; P75).

Homogeneity between the two groups was assessed using the Mann-Whitney *U* test for continuous variables and Fisher's exact test for nominal variables.

To analyze possible relations between variables it was used the Pearson's correlation coefficient for continuous variables and Spearman's correlation coefficient for discrete variables.

To compare possible gain in knowledge, paired-sample Wilcoxon test was conducted through the variables "pre-test" and "post-test", using a 20-point grading scale, being the lowest 0 points and the highest 20 points; then, the variable "improvement" was created in order to give the difference between pre and post-test grades.

We considered a significance level of 0,05, and the analysis was carried out in IBM SPSS Statistics software, version 24.0.

4. Results

The following results are organized around the main levels of the Kirkpatrick's framework: reaction, learning and behaviour, and include comparisons between participants enrolled in both editions of the E-Learning Courses on Breast Imaging.

4.1. Sample description

The two editions of the course was attended by 64 learners: 30 (46%) learners in the first edition, and 34 (54%) in the second. As shown in Table 2, the participants' demographic characteristics are in general comparable.

Most of the learners were 56 active workers (n = 56, 87%), 5 (8%) unemployed radiographers and 3 (5%) final year undergraduate students in Radiography. The unemployed radiographer's were recently graduated in Radiography and looking for their first job. At the beginning of our Course, the final year students already had a previous knowledge (theoretical) in mammography.

Considering residence, learners were mostly from Portugal (n = 60; 94%), but there were also four radiographers from Angola, Belgium, Brazil and United Kingdom.

Regarding how did they know about the course, most learners (n = 29, 45%) heard about it on social networks, 20 (31%) heard from other colleagues, 5 (8%) heard from e-mail, and 10 (16%) heard from other ways, e.g. the Faculty website.

The median age of learners was 29 years old (P25 = 25; P75 = 33), being the oldest person 50 years old and the youngest 22. Overall, 1 (2%) had bachelor degree, 49 (77%) had degree in Radiography and 11 (17%) had a master's degree. The median professional experience was 5 years (P25 = 1; P75 = 10), ranging from 0 years (students) to 24 years of work practice. Considering variables "Age" and "Years of profession", and according to respective medians, categorization was performed as follow: "age < 29 years", "age > 29 years", " < 5years profession" and " > 5years of profession", respectively.

4.2. Learner satisfaction

All learners answered the satisfaction questionnaire at the end of the course (before students perception of the rating final test results).

Firstly, the learners were questioned how their knowledge on breast imaging was before and after the course: before the course 33 (52%) learners considered insufficient and basic, and 31 (48%) considered moderate and advanced. After the course, 2 (3%) learners considered their knowledge basic and the remaining 62 (97%) considered

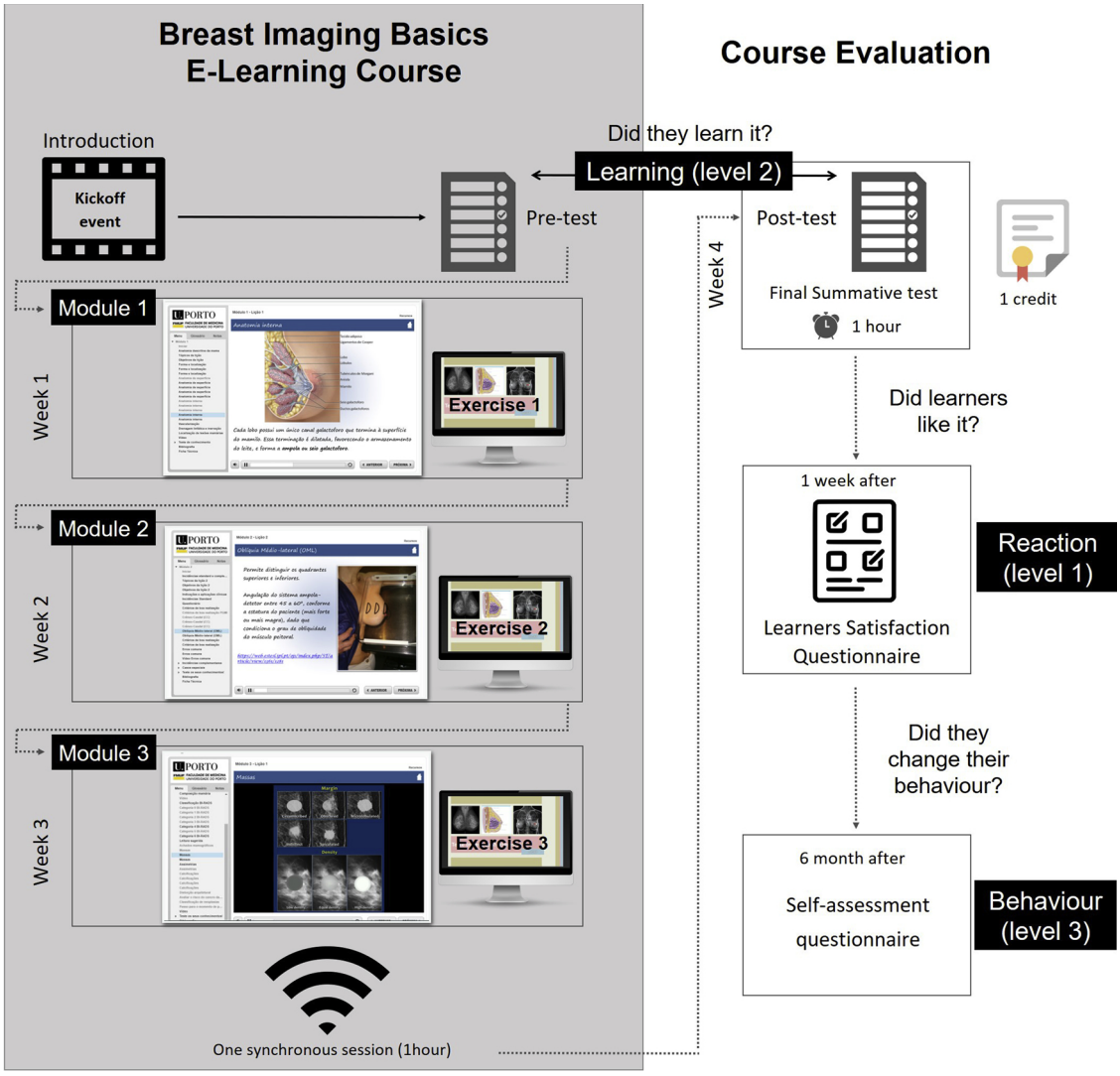

Fig. 1. Breast Imaging E-learning Course features and its assessment method.

moderate and advanced ($p < 0{,}001$). These results are depicted in Fig. 2.

Then, learners were asked about the content of the course. As shown in Fig. 3, 62 (97%) learners stated that the content was very good and excellent, all learners considered the content was transmitted in a very good and excellent way, and 60 (94%) considered the distribution of the content in each module was very good and excellent.

Regarding your dedication level during the course, 55 (86%) learners stated to be high and very high (Fig. 4).

At the end of the satisfaction questionnaire, learners were invited to write general comments about the course and to suggest future improvements. Most of learners (n = 37; 58%) enhanced the opportunity to update concepts and skills in order to improve their performance. In addition, some learners enjoyed the structure of the course (n = 11; 17%), and also the advantage to be an E-learning course with specific benefits (n = 11; 17%).

Learners perceptions regarding how the course can be improved include more exercises (n = 10; 16,%), more clinical cases (n = 6; 9%), more time between the modules for retaining concepts and learning (n = 10; 16%), more contents about breast pathology (n = 3; 5%), more lectures and references (n = 2;3%), more images (n = 6; 9%). Also, 13 learners (20%) suggested the course should have more contents about other imaging techniques beyond mammography, such as digital breast tomosynthesis and dual-energy contrast enhanced digital mammography. Two learners (3%) also suggested to include training sessions. The remaining twelve (19%) learners did not give improvement suggestions.

Finally, 100% of learners would recommend the course to other colleagues.

4.3. Knowledge gain

Of the participants enrolled, 54 (84,3%) answered to the pre-test. The median grade achieved by learners was 13 points (P25 = 10; P75 = 13), in 20-point grading scale. All learners performed the post-test, i.e. the final examination at the end of the course, achieving a median grade of 16 points (14;17). Among the 54 learners answering to the pre and the post-test an improvement of 4 (0,58; 7,0) percentual points pp ($p < 0{,}001$) was achieved. Forty four subjects (81%) revealed positive differences between post and pre-tests, which means those participants improved their knowledge (Fig. 5; Table 2). Considering the age stratum, we can observe that younger subjects had a higher improvement then the oldest ones (5 vs 2,67; $p = 0{,}032$). Regarding their professional experience, learners with less 5 years of profession had a higher improvement than learners with more years of profession (5 vs 2,67; $p = 0{,}041$).

Table 2
Sample's description, pre and post-tests results and comparison between stratus. The variable "improvement" represents the difference between the pre and post-test grade, in percentual points (pp). Acronyms and symbols: Med – Median; P25 – Percentile 25; P75 – Percentile 75; *- Fisher's exact test; Δ - Mann Whitney's test;† Wilcoxon's test.

	First edition n = 30	Second edition n = 34	Total n = 64	*p*	*Age < 29y n = 35*	*Age > 29y n = 29*	*p*	*< 5y profession n = 34*	*> 5y profession n = 30*	*p*
Age, Med (P25; P75)	31 (26;33)	28 (25;31)	29 (25; 33)	0165$^{\Delta}$	26 (24;28)	33 (31;37)		26 (24;28)	33 (31;35)	< 0001 $^{\Delta}$
Sex, n(%)										
Male	1 (3)	1 (3)	2 (3)	092	0	2 (7)	0201*	0	2 (7)	0216*
Female	29 (97)	33 (97)	62 (97)	9*	35 (100)	27 (93)		34 (100)	28 (93)	
Academic qualifications n (%)										
Student	0	3 (9)	(5)	0116*	2 (6)	1 (3)	1*	1 (3)	0	0116*
Bachelor	0	1 (3)	1 (2)		0	1 (3)		1 (3)	0	
Degree	21 (70)	28 (82)	49 (77)		27 (77)	22 (76)		25 (74)	24 (80)	
Master	9 (30)	2 (6)	11 (17)		6 (17)	5 (17)		5 (15)	6 (20)	
Years of profession, Med (P25; P75)	7 (2;11)	4 (1;9)	5 (1; 10)	0071 $^{\Delta}$	2 (1;4)	11 (7;13)	< 0001 $^{\Delta}$	1 (1;3)	11 (8;12)	
Pre-test grade, Med (P25; P75)	133 (10;13) n = 28	10 (7;14) n = 26	13 (10;13) n = 54	0,091$^{\Delta}$	10 (667; 133) n = 33	133 (10;16,67) n = 21	0062 $^{\Delta}$	10 (6.67;133) n = 30	133 (10;16,67) n = 24	0065 $^{\Delta}$
Post-test grade, Med, (P25; P75)	160 (14;17) n = 30	16 (14;17) n = 34	16 (14;17) n = 64	0,513$^{\Delta}$	16 (15;17) n = 35	15 (125;17) n = 29	0,030 $^{\Delta}$	16 (15;17) n = 34	155 (1375;17) n = 30	0214 $^{\Delta}$
Improvement, Med (P25; P75)	367 (033; 5.67)	550 (233; 8.0)	4 (058; 7,0)	0117$^{\Delta}$	5 (317;733)	267 (233;583)	0032 $^{\Delta}$	5 (342;749)	267 (141;591)	0041 $^{\Delta}$
p (pre-test vs post-test)	n = 28 0001†	n = 26 < 0001†	n = 54 < 0001†		n = 33 < 0001†	n = 21 0,049†		n = 30 < 0001†	n = 24 0,016†	

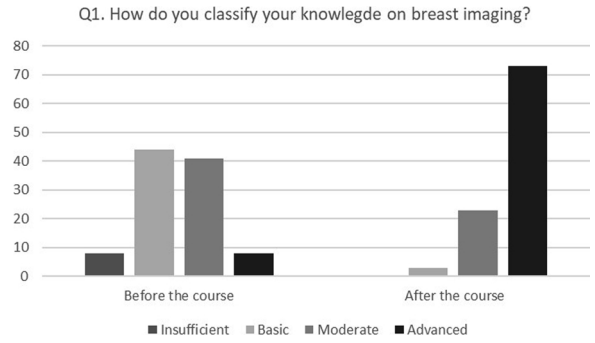

Fig. 2. First question of the satisfaction questionnaire. The results are exposed by percentages.

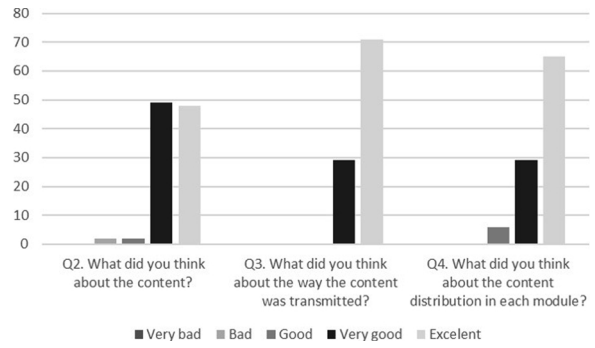

Fig. 3. Second, third and fourth questions of the satisfaction questionnaire. Results are exposed by percentages.

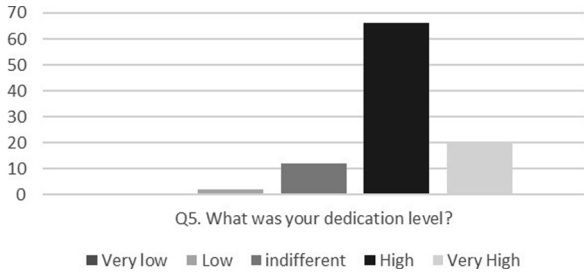

Fig. 4. Fifth question of the satisfaction questionnaire. Results are exposed in percentages.

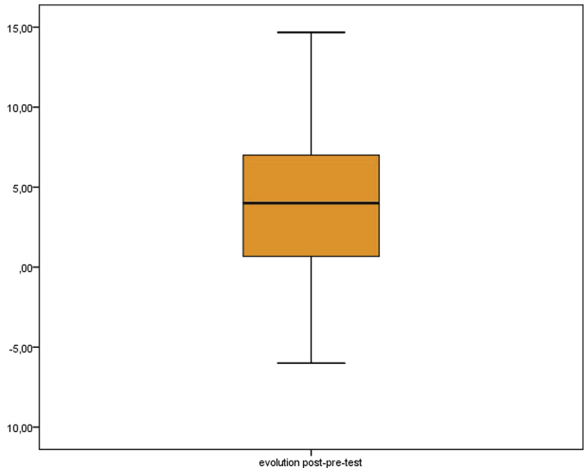

Fig. 5. Boxplot showing 'improvement' (Median 4 (P25 = 058; P75 = 7,0), i.e. the differences between post and pre-tests grades. We can observe that at least 75% (specifically 81%) revealed positive differences (p < 0001).

4.4. Behaviour

After six months complying the course, only 43 (67,2%) subjects answered the self-assessment behaviour questionnaire. Self-reported differences in behaviour were identified between before and after complying the course (Table 3). Regarding patient call and preparation (Q1-Q5, Fig. 6), learners consider to be more able to answer questions that the patient could have (Q4). However, their ability to hear the patient and use of active listening was self-reported to be the behaviour that least changed.

Regarding mammography technique and positioning (Q6-Q11, Fig. 7), learners think to be more able togged best positioning techniques in order to get all the quality criteria (Q6), to select the radiation

Table 3
Self-assessment behaviour questionnaire results. The results are exposed in a five-point Likert-scale, n (%).Acronyms and symbols: P25 – Percentile 25; P75 – Percentile 75; †- Wilcoxon's test.

	1	2	3	4	5	Median (P25; P75)	*p*
Q1. I pay attention to the way I perform the initial questionnaire							
Before the course	0	0	8 (17)	17 (40)	18 (42)	4 (4;5)	< 0,001†
After the course	0	0	1 (2)	7 (16)	35 (81)	5 (5;5)	
Q2. I pay attention to previous exams							
Before the course	1 (2)	0	9 (21)	18 (42)	15 (35)	4 (4;5)	< 0,001†
After the course	0	0	2 (5)	7 (16)	34 (79)	5 (5;5)	
Q3. I explain all the procedure to the patient (importance of compression and positioning)							
Before the course	1 (2)	0	3 (7)	20 (47)	19 (44)	4 (4;5)	< 0,001†
After the course	0	0	0	8 (19)	35 (81)	5 (5;5)	
Q4. I am able to answer questions patient could have							
Before the course	1 (2)	1 (2)	6 (14)	25 (58)	10 (23)	4 (4;4)	< 0,001†
After the course	0	0	0	6 (14)	37 (86)	5 (5;5)	
Q5. I am able to hear the patient and and practice active listening							
Before the course	0	0	2 (5)	13 (30)	28 (65)	5 (4;5)	0,004†
After the course	0	0	1 (2)	5 (12)	37 (86)	5 (5;5)	
Q6. I am able to positioning in order to get all the quality criteria							
Before the course	0	0	5 (12)	28 (65)	10 (23)	4 (4;4)	
After the course	0	0	0	10 (23)	33 (77)	5 (5;5)	< 0,001†
Q7. I am able to maintain the communication during all the procedure with patient							
Before the course	0	0	3 (7)	20 (47)	20 (47)	4 (4;5)	< 0,001†
After the course	0	0	1 (2)	7 (16)	35 (81)	5 (5;5)	
Q8. I am able to apply compression adequately							
Before the course	0	0	4 (9)	23 (54)	16 (37)	4 (4;5)	< 0,001†
After the course	0	0	1 (2)	11 (17)	31 (48)	5 (4;5)	
Q9. I am able to verify if patient is comfortable							
Before the course	0	0	3 (7)	18 (42)	22 (51)	5 (4;5)	0,001†
After the course	0	0	0	10 (16)	33 (52)	5 (5;5)	
Q10. I am able to select the exposition parameters adequately							
Before the course	0	0	7 (16)	27 (63)	9 (21)	4 (4;4)	< 0,001†
After the course	0	0	1 (2)	10 (23)	32 (74)	5 (4;5)	
Q11. I am able to use the ALARA principle efficiently							
Before the course	0	0	4 (9)	21 (49)	18 (42)	4 (4;5)	< 0,001†
After the course	0	0	1 (2)	10 (23)	32 (74)	5 (4;5)	
Q12. I am able to produce accurate images							
Before the course	0	0	5 (12)	21 (49)	17 (40)	4 (4;5)	< 0,001†
After the course	0	0	0	4 (9)	39 (91)	5 (5;5)	
Q13. I am able to evaluate the image quality according to clinical information							
Before the course	0	0	10 (23)	24 (56)	9 (21)	5 (5;5)	< 0,001†
After the course	0	0	2 (5)	7 (16)	34 (79)	5 (5;5)	
Q14. I am able to check all the quality criteria							
Before the course	0	0	6 (14)	27 (42)	10 (16)	4 (4;4)	< 0.001†
After the course	0	0	0	2 (5)	41 (95)	5 (5;5)	
Q15. I can identify artefacts							
Before the course	1 (2)	0	3 (5)	26 (31)	13 (30)	4 (4;5)	< 0.001†
After the course	0	0	0	6 (14)	37 (86)	5 (5;5)	
Q16. I am able to assess the necessity of repeating images							
Before the course	0	0	10 (23)	19 (44)	14 (33)	4 (4;5)	< 0,001†
After the course	0	0	1 (2)	6 (14)	36 (84)	5 (5;5)	
Q17. I am able to assess the necessity of performing additional views							
Before the course	0	0	13 (30)	22 (51)	8 (19)	4 (4;4)	< 0,001†
After the course	0	0	0	12 (28)	31 (72)	5 (5;5)	
Q18. I am able to optimize image quality							
Before the course	0	0	7 (16)	28 (65)	8 (19)	4 (4;4)	< 0,001†
After the course	0	0	1 (2)	11 (27)	31 (72)	5 (4;5)	
Q19. I can assess the emotional status of the patient after the procedure							
Before the course	0	0	4 (9)	18 (42)	21 (49)	4 (4;5)	< 0,001†
After the course	0	0	1 (2)	7 (16)	35 (81)	5 (5;5)	
Q20. I remember the patient the importance of performing mammography							
Before the course	0	0	7 (16)	18 (42)	18 (42)	4 (4;5)	< 0,001†
After the course	0	0	1 (2)	7 (16)	35 (81)	5 (5;5)	
Q21. I perform calibration of equipment							
Before the course	0	0	9 (21)	18 (42)	16 (37)	4 (4;5)	< 0,001†
After the course	0	0	5 (12)	10 (23)	28 (65)	5 (5;5)	
Q22. I perform quality control							
Before the course	2 (5)	0	15 (35)	12 (28)	14 (33)	4 (4;5)	0,002†
After the course	2 (5)	0	10 (23)	9 (21)	22 (51)	5 (5;5)	
Q23. I can detect problems in equipment							
Before the course	0	0	11 (26)	19 (44)	13 (30)	4 (3;5)	0,004†
After the course	0	0	4 (9)	19 (44)	20 (47)	4 (4;5)	
Q24. I am able to propose improvements							
Before the course	0	0	14 (33)	22 (51)	7 (16)	4 (3;4)	< 0,001†
After the course	0	0	3 (7)	21 (49)	19 (44)	4 (4; 5)	

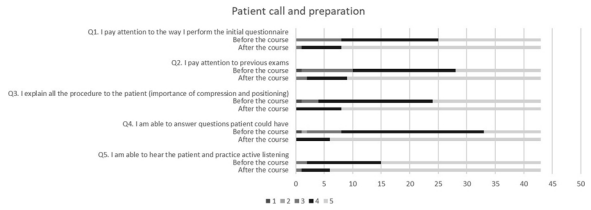

Fig. 6. Self-assessment behaviour questionnaire - Patient call and preparation (Q1-Q5). Results are presented by number of learners, and by five-point Likert-scale, where 1: strongly disagree and 5: strongly agree.

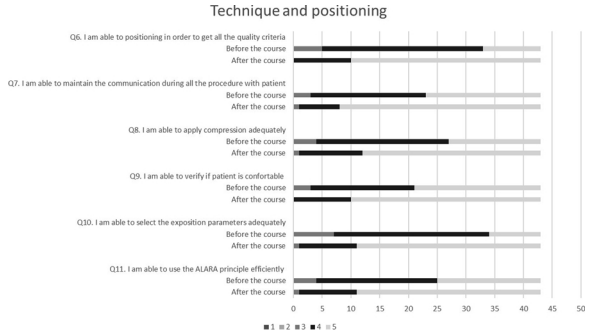

Fig. 7. Self-assessment behaviour questionnaire - Technique and positioning (Q6-Q11). Results are presented by number of learners, and by five-point Likert-scale, where 1: strongly disagree and 5: strongly agree.

exposure and dose parameters (Q10) and to maintain the communication with patient during all the procedure (Q7). The capacity to apply compression adequately (Q8), to verify if patient is comfortable (Q9) and to use the ALARA (As-Low-As-Reasonably-Achievable) principle efficiently (Q11) were the attitudes that less changed.

Concerning image analysis and processing (Q12-Q18, Fig. 8), learners think to be more able to optimize image quality (Q18), check all the quality criteria (Q14), evaluate the image quality according to the clinical information (Q13), identify artefacts (Q15), evaluate the necessity of repeat images (Q16) or to perform additional views (Q17).

As for items Final procedures (Q19-Q20, Fig. 9) and Quality control (Q21-Q24, Fig. 10), learners consider to be capable to assess the emotional status of patient (Q19) and to remember the importance of mammography (Q20). Furthermore, they can perform quality control (Q21 and Q22), detect problems in equipment (Q23) and are able to suggest improvements (Q24). Although, these attitudes were not so enhanced after the course. Concerning age and years of profession stratus, results were comparable showing only in Q23 that older and more experienced subjects did not change their performance ($p = 0{,}059$).

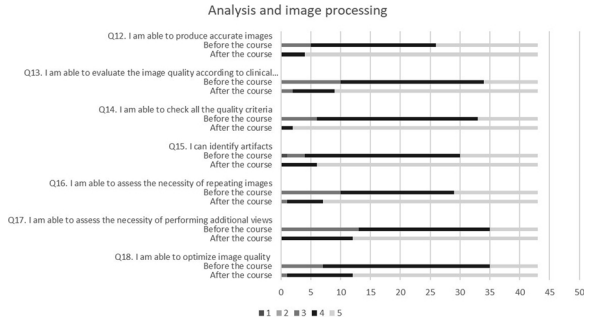

Fig. 8. Self-assessment behaviour questionnaire - Analysis and imaging processing (Q12-Q18). Results are presented by number of learners, and by five-point Likert-scale, where 1: strongly disagree and 5: strongly agree.

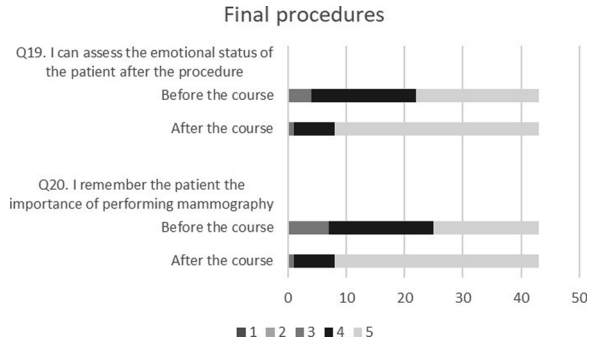

Fig. 9. Self-assessment behaviour questionnaire - Final procedures (Q19-Q20). Results are presented by number of learners, and by five-point Likert-scale, where 1: strongly disagree and 5: strongly agree.

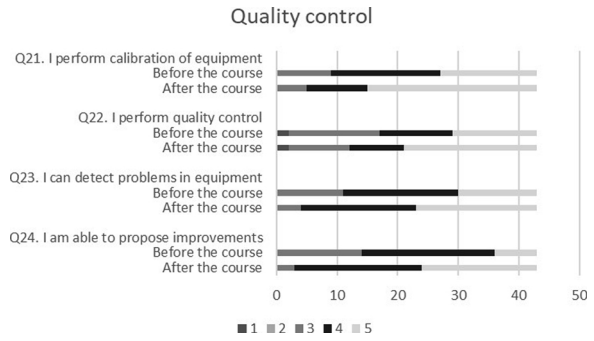

Fig. 10. Self-assessment behaviour questionnaire - Quality control (Q21-Q24). Results are presented by number of learners, and by five-point Likert-scale, where 1: strongly disagree and 5: strongly agree.

5. Discussion

We strongly believe that E-learning is a good option for continuing education, and this course has been well seek by Portuguese radiographers, since that *numerus clausus* were fulfilled for both editions. According to Strøm et al. [9] the level of emphasis on the acquisition of mammography knowledge, skills and competences of the undergraduate courses in Radiography curriculum differs from one country to another and for both the theoretical component and practical training. For this reason, continuing education and training programmes are demanded by international entities. To the best of our knowledge, our E-learning Course is innovative, contributing to the Portuguese continuing education programmes, as we did not find any similar course.

The high interest for E-learning teaching courses among Portuguese radiographers is in accordance to related literature [16,17]. Nowadays, these healthcare professionals are highly interested in acquiring professional training and continuous education among all countries. In Australia, researchers found that 94% of the Australian radiographers that collaborated in their study use the Internet as a resource for self-learning [17]. Additionally, these radiographers showed to be receptive to new technologies and training. In Denmark, a study conducted by Johansen and Brodersen [16] showed that the Danish radiographers are able to upgrade their skills.

Regarding the first question of the satisfaction questionnaire, which one we consider to be a good indicator of the learning process in this E-Learning course, 97% of the learners considered their knowledge advanced after the course, when compared with those that considered to have moderate and advanced learning before the course. This is consistent with the knowledge gain results, where we found an improvement of 4pp.

Regarding age and years of profession stratum, our statistical analysis demonstrate a higher improvement in younger subjects and also in subjects with less professional experience. These results can traduce a

higher motivation for continuing education for those who are starting the professional career. Nevertheless, oldest participants got better results in pre-test note when compared with younger participants (13,3 vs 10; $p = 0{,}062$), and same results were observed among more experienced subjects (13,3 vs 10; $p = 0{,}065$); post-test grades were tough similar (15 vs 16; $p = 0{,}03$ / 15,5 vs 16; $p = 0{,}214$). The authors observed a strong association between the variables "age" and "years of experience": after analysing the relation between them, a correlation of 0,852 ($p < 0{,}001$) was found, which actually corresponds to an almost perfect positive correlation.

Although the low response rate of the self-assessment behaviour questionnaire after six month, a good perception about how learners changed some attitudes and behaviours within their work routine after complying the course was provided. Major findings include a self-reported change of behaviour of radiographers in three main tasks: analysis and image processing, technique and positioning and patient call and preparation. Although, all questions that were answered by learners presented statistically significant differences, a less self-reported change of behaviour was perceived by subjects regarding communication with patient (Q1, Q3, Q5), patient comfort (Q9), to realize if the compression is adequate (Q8), and to be capable to use the ALARA principle (Q11). Also, both issues Final procedures and Quality control were the self-reported behaviours that less changed. Authors assume these were expectable results, since learners already have either a degree in Radiography or at least they had already completed 3 years of the degree (students were attending the last year of the 4 years degree).

An important result of our study is that radiographers are more capable to answer questions that the patient could have (Q4), highlighting the knowledge improvement achieved after complying this course. Besides technical issues, the radiographer is usually the first professional to be consulted by women in primary health care needs, at the time of breast cancer screening, and therefore he should be able to answer questions about the examination and the implications of its results, if the patient asks. For this reason, learning outcomes of this course will benefit patients through radiographers with improved knowledge, namely on patient safety, dose, time of imaging, less repeated images, less anxiety and better image quality assurance.

The self-assessment behaviour questionnaire used in this study was adapted from literature [30], demanding future work towards the validation for the Portuguese language and target group. However, this study suggests that the development and use of online courses should continue for radiographers. In addition, a new English-translated edition, with new contents suggested by our participants, such as breast digital tomosynthesis and dual-energy contrast enhanced is in working process. Moreover, other breast imaging methods will be considered, namely quantitative imaging techniques. Further effort is needed to improve overall contents or even to provide to learners a free e-book to be downloaded after performing the course, to be easily use at the clinical settings.

Two participants suggested to add training sessions, thus transforming this E-learning course into a blended learning course. For instance, blended learning is an education program (formal or non-formal) that combines online digital media with traditional classroom methods. In addition, blended learning bring more efficient knowledge as reported in some literature [31–33]. Also, it is reasonable to assume that the management of hands-on training sessions with learners from many different places including other countries needs further efforts for both learners and educational providers.

The assessment of Level 4 of Kirkpatrick's Evaluation Model is a high challenge according to [34,35]. Since it is more difficult and time-consuming to assess this level, it demands a further analysis on the way this task will be done in the future in this course.

Limitations of this study need to be considered. First, the limited sample size that affects the generalization of the results, and the limited implementation time, as the learners have their own agenda and priorities. In particular, regarding the knowledge gain, it should be stressed that since the majority of learners not answering to the pre-test belongs to the eldery and > 5 years profession groups. According to the better improvement results observed in young learners, this course would be in the future focused on this target group and their needs and to tailor a more personalised approach.

Given the way the survey was designed, we could not enforce an anonymous querying, which could have overestimated the satisfaction rating. However, given that no direct implications came, to the participants, from the results of this test, we believe that this overestimation might have been slight and, thus, might have had limited relevance in the overall conclusions of our work.

Another limitation of this course is that, hands-on mammography positioning training for learners wasn't provided as recommended by FDA and EUSOMA for professional certification. Moreover, we are aware about the importance of retraining and repetitive testing for quality assurance in breast cancer screening purpose.

Concerning the evaluation strategy, we also faced the risk of a slight bias because we did not control if learners resorted to external sources in order to provide correct answers to the final test. Notwithstanding, all participants have signed a declaration of honour to perform the course in the correct and honest manner. As future work, it would be interesting to conduct additional assessments to demonstrate effective consolidation of knowledge gain and retention.

Third, the success of a Kirkpatrick Level 3 evaluation largely depends on the design of the evaluation. In our study, a post-test survey have been administered to participant which might offer biased estimates of their self-assessed behaviour. However, the feedback provided can often lead to improvements in the course programme and the transfer of learning and to the identification of further training needs. Although limitations on reliability/ validity of data gathered, the self-report questionnaires still continue to be a popular methodology in behavioural science because of their utility and cost, in particular for distance learning evaluation.

Finally, we are aware about the need to be familiar with the online teaching programmes and assessment tools limitations. Although, online approaches were found to be the best choice namely for radiographers coming from different places or even different countries.

Our global results show that e-learning can provide statistically relevant knowledge gains in Radiographers. In view of these findings, our E-learning Course on Breast Imaging provides an important contribution for the improvement of mammography education in Portugal, impacting on the development of student's and radiographer's skills.

Thus, this study highlights the role of continuous education models in order to obtain a good quality performance in mammography.

Conflict of interest

The article is not under consideration for publication elsewhere, and the authors declare having no conflict of interest. All the authors have made a significant contribution to this manuscript and have approved the final article thus meeting the criteria for authorship. Also, all those entitled to authorship are listed as authors.

Acknowledgements

This article was supported by ERDF (European Regional Development Fund) through the operation POCI-01-0145-FEDER-007746 funded by the Programa Operacional Competitividade e Internacionalização – COMPETE2020 and by National Funds through FCT - Fundação para a Ciência e a Tecnologia within CINTESIS, R&D Unit (reference UID/IC/4255/2013). We would like to thank to Faculty of Medicine of University of Porto for hosting the eLearning course.

References

[1] A. C. R. P. Guidelines, "Mammography Accreditation Program Requirements," Program, pp. 1–22.

[2] J. Caseldine, et al., Quality Assurance Guidelines for Radiographers, Publication No 30, (2000).

[3] Food and Drug Administration, The Mammography Quality Standards Act Final Regulations : Preparing for MQSA Inspections ; Final Guidance for Industry and FDA, (2001).

[4] S. Misra, N.L. Solomon, F.L. Moffat, L.G. Koniaris, Screening criteria for breast Cancer, Adv. Surg. 44 (September (1)) (2010) 87–100.

[5] M. O'Mahony, et al., Interventions for raising breast cancer awareness in women, Cochrane Database Syst. Rev. (February (2)) (2017).

[6] E. F. of R. Societ, European Federation of Rradiographer Societies. European Qualifications Framework (EQF): Benchmarking Document: Radiographers, Utrech (2014).

[7] L. Cataliotti, et al., Guidelines on the standards for the training of specialised health professionals dealing with breast cancer, Eur. J. Cancer 43 (March (4)) (2007) 660–675.

[8] Australian Institute of Radiography, "Continuing Professional Development (CPD)," 2011. [Online]. Available: http://www.air.asn.au/cpd.php.

[9] B. Strøm, et al., Challenges in mammography education and training today: the perspectives of radiography teachers/mentors and students in five European countries, Radiography 24 (1) (2018) 41–46.

[10] A. Pinto, L. Brunese, F. Pinto, C. Acampora, L. Romano, E-learning and education in radiology, Eur. J. Radiol. 78 (June (3)) (2011) 368–371.

[11] C.M. Stark, M.L. Graham-Kiefer, C.M. Devine, J.S. Dollahite, C.M. Olson, Online course increases nutrition professionals' knowledge, skills, and self-efficacy in using an ecological approach to prevent childhood obesity, J. Nutr. Educ. Behav. 43 (5) (2011) 316–322.

[12] C. Docherty, D. Hoy, H. Topp, K. Trinder, E-learning techniques supporting problem based learning in clinical simulation, Int. J. Med. Inform. 74 (August (7–8)) (2005) 527–533.

[13] E. Nkenke, et al., Acceptance of technology-enhanced learning for a theoretical radiological science course: a randomized controlled trial, BMC Med. Educ. 12 (Jan) (2012) 18.

[14] H.S. Chumley-Jones, A. Dobbie, C.L. Alford, Web-based learning: sound educational method or hype? A review of the evaluation literature, Acad. Med. 77 (October Suppl. (10)) (2002) S86–93.

[15] I.C. Moreira, S.R. Ventura, I. Ramos, P.P. Rodrigues, Development and assessment of an e-learning course on breast imaging for radiographers: A stratified randomized controlled trial, J. Med. Internet Res. 17 (1) (2015) e3.

[16] L.W. Johansen, J. Brodersen, Reading screening mammograms–attitudes among radiologists and radiographers about skill mix, Eur. J. Radiol. 80 (December (3)) (2011) e325–30.

[17] M. Shanahan, Radiographers and the internet: an Australian perspective, Radiol. Technol. 81 (3) (2010) 223–232.

[18] G.M. Alliger, Ea. Janak, Kirkpatrick's levels of training criteira: thirty years later, Pers. Psychol. 42 (June (2)) (1989) 331–342.

[19] K.A. Moreau, Medical Teacher Has the New Kirkpatrick Generation Built a Better Hammer for Our Evaluation Toolbox? Has the New Kirkpatrick Generation Built a Better Hammer for Our Evaluation Toolbox? (2017).

[20] D.N. Rouse, Employing Kirkpatrick's evaluation framework to determine the effectiveness of health information management courses and programs, Perspect. Health Inf. Manag. 8 (Spring) (2011) 1c.

[21] S.R. Patel, Using instructional design, analyze, design, develop, implement, and evaluate, to develop e-Learning modules to disseminate supported employment for community behavioural health treatment programs in New York State, Front. Public Health vol. 6, (May) (2018).

[22] S.E. Bond, et al., Evaluating the Effect of a Web-Based E-Learning Tool for Health Professional Education on Clinical Vancomycin Use: Comparative Study, JMIR Med. Educ. 4 (February (1)) (2018) e5.

[23] W. Horton, V.A. Alexandria, Evaluating E-learning, (2001).

[24] V. Aitken, S. Tabakov, Evaluation of the e-Learning material developed by EMERALD and EMIT for diagnostic imaging and radiotherapy, Med. Eng. Phys. 27 (September (7)) (2005) 633–639.

[25] Y. Wang, Assessment of learner satisfaction with asynchronous electronic learning systems, Inf. Manag. 41 (2003) 75–86.

[26] E.V. Bloomquist, N. Ajkay, S. Patil, A.E. Collett, T.G. Frazier, A.V. Barrio, A randomized prospective comparison of patient-assessed satisfaction and clinical outcomes with radioactive seed localization versus wire localization, Breast J. 22 (2) (2016) 151–157.

[27] I.C. Moreira, S.R. Ventura, I. Ramos, P.P. Rodrigues, Learner's satisfaction within a breast imaging E-learning course for radiographers, Proc. CBMS 2013 - 26th IEEE Int. Symp. Comput. Med. Syst. (2013), pp. 215–220.

[28] C. Zhu, Student Satisfaction, Performance, and Knowledge Construction in Online 15 (2012), pp. 127–136.

[29] K. Campbell, V. Taylor, S. Douglas, Effectiveness of online Cancer education for nurses and allied health professionals; a systematic review using kirkpatrick evaluation framework, J. Cancer Educ. (December) (2017).

[30] B.T. Andersson, L. Christensson, B. Fridlund, A. Broström, Development and psychometric evaluation of the radiographers' competence scale, Open J. Nurs. 2 (June) (2012) 85–96.

[31] S. Zafar, S. Safdar, A.N. Zafar, Evaluation of use of e-Learning in undergraduate radiology education: a review, Eur. J. Radiol. 83 (December (12)) (2014) 2277–2287.

[32] A.H. Mahnken, M. Baumann, M. Meister, V. Schmitt, M.R. Fischer, Blended learning in radiology: is self-determined learning really more effective? Eur. J. Radiol. 78 (June (3)) (2011) 384–387.

[33] J.G. Ruiz, M.J. Mintzer, R.M. Leipzig, The impact of E-learning in medical education, Acad. Med. 81 (March (3)) (2006) 207–212.

[34] L. Zirn, et al., Design and evaluation of an IPE module at the beginning of professional training in medicine, nursing, and physiotherapy, GMS J. Med. Educ. 33 (2) (2016) Doc24.

[35] C. Pehrson, J. Sorensen, I. Amer-Wåhlin, Evaluation and impact of cardiotocography training programmes: a systematic review, BJOG An Int. J. Obstet. Gynaecol. 118 (July (8)) (2011) 926–935.