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Development and assessment of an eLearning course on senology for radiographers: a stratified randomised controlled trial

Sílvia Inês de Castro Moreira

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SET|2012

«My world will always be yours, and yours will always be ours.»

To my fiancée, Paulo.

Acknowlegdements

"As we express our gratitude, we must never forget that the highest appreciation is not to utter words, but to live by them."
John F. Kennedy

I am extremely grateful to all that participated in this thesis:

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It is a great pleasure to thank everyone who helped me write my dissertation successfully. Thank you all!

Context

Being graduated in Radiology in 2006 at *Escola Superior de Tecnologia da Saúde do Porto* (ESTSP), Politécnico do Porto, and working at the Breast Centre of *Centro Hospitalar S. João, EPE* and at ESTSP, as well as being part of the Breast Research Group at the *Instituto Nacional de Engenharia de Software e Computadores* (INESC), the author started in 2010 a master's degree in Medical Informatics at *Faculdade de Medicina do Porto, Universidade do Porto*.

Due to specific training needs in senology within the professional context, and due to the necessity of sharing knowledge with other colleagues, the author took the opportunity to develop an easy-to-use eLearning environment course, combining her two professional components of radiographer and teaching.

In addition, during her academic journey, the author was involved in the following publications:

- Inês C. Moreira, Igor Amaral, Inês Domingues, António Cardoso, Maria João Cardoso, Jaime S. Cardoso. *INbreast: Toward a Full-field Digital Mammographic Database*. Academic Radiology, Volume 19, Issue 2, February 2012, Pages 236-248;

- Moreira I. C., Bacelar-Silva G. and Pereira Rodrigues P. February 2012. Compliance of Publicly available mammographic databases with established case selection and anotation requirements. In *Proceedings of the International Conference on Health Informatics*, pages 337-340;

- Travassos C., C. Moreira I., Ferreira P. and Bacelar-Silva G. February 2012. Security and Privacy in European EHRs - Should Portugal Follow Denmark and Sweden's Examples? In *Proceedings of the International Conference on Health Informatics*, pages 354-357.

Abstract

Breast cancer is a serious public health problem, and screening is a critical tool to combat the mortality rate of the disease. Mammography technique is considered the best imaging examination for this screening and the radiographer plays a crucial role in this process. For this, the radiographer must be properly prepared and should therefore be subject to specific training and continuing education. Therefore, there should be training programmes, and eLearning has been revealed a useful tool and an alternative to the traditional education method.

The objectives of this work include the knowledge promotion and understanding of all aspects related to the breast illness and patient care required to radiographers. To achieve this, we proposed to develop an easy-to-use course in eLearning environment and assess about its efficacy, effectiveness and the users' satisfaction, according to evaluation levels 1 and 2 from Kirkpatrick's framework. A randomised controlled trial was performed with radiographers and radiology students, using as instruments individual satisfaction questionnaires and pre and post-knowledge tests for further comparisons, respectively. Intention-to-treat and per-protocol analysis were considered in the statistical analysis.

As result, a total of 54 participants were included in the intervention group (20 students and 34 radiographers) and 53 in the control group (19 students and 34 radiographers). The intention-to-treat analysis showed a mean improvement of 21 percentual points (pp) in the intervention group, compared with 4 pp in the control group ($p<0.001$). Radiographers clearly improved with the intervention (23pp *vs* 4pp.; $p=0.004$). Although the effect was not clear in students (18pp *vs* 5pp; $p=0.098$), we found differences in post-test results between intervention and control (88% *vs* 63%; $p=0.003$) whereas such difference was absent in pre-test (63% *vs* 63%; $p=0.106$). Therefore, an additional per-protocol analysis was applied to reduce the influence of lost to follow-up individuals, which resulted in a higher effect (26pp *vs* 2pp; $p<0.001$),

both in students (25pp *vs* 3pp; p=0.004) and radiographers (27pp *vs* 2pp; p<0.001). Regarding effectiveness, the majority of participants (81%) in the intervention group agreed to take the course, although 9% of them did not attend the full course. Considering users' satisfaction, 85% are satisfied with the eLearning system and 88% consider that the system is successful.

The students that performed the course have improved their knowledge, although the participants who did not attend the course had also some improvement. This result could be explained because some students can achieve more knowledge by self-learning or that there was interest from students in the control group in learning more after performing the pre-test. Regarding the radiographers, the positive evolution observed after the course performance reveals the importance of continuing education throughout their working lives. The per-protocol analysis enhances the influence of the course, revealing a notorious effect on the students' group. Real effect is probably in between the two analysis.

As the main finding we consider the improvement of knowledge on senology that the eLearning course provided to radiographers. The course is efficacious, especially for radiographers, which highlights the need for continuing education, foreseeing also eLearning as an increasingly viable alternative to the traditional method. The course is also effective, since only 10% of the learners dropped out during its performance. Moreover, the course showed to have a great level of satisfaction, mainly at the level of interface and contents topics.

Regarding the future work, the ultimate goal may be to proceed to an overall improvement and accreditation of the course, realize a nationwide study in the same way that this project was developed and in a more challenging long-term perspective, to explore the evaluation of the course towards levels 3 and 4 of the Kirkpatrick's platform, studying the efficiency and costs aspects.

Keywords: Breast cancer, mammography, radiographer, evaluation, eLearning.

Resumo

O cancro da mama é um grave problema de saúde pública, constituindo-se a implementação de programas de rastreio uma ferramenta fundamental para combater a taxa de mortalidade da doença. Devido às suas características, a mamografia é considerado o melhor exame imagiológico para este tipo de rastreio. O Técnico de Radiologia tem, neste processo, um papel crucial, por meio de inúmeras funções para as quais deve estar devidamente preparado, devendo por isso ser submetido a formação específica. Entre os diversos programas de formação existentes, o *eLearning* tem-se evidenciado como uma ferramenta muito útil, alternativa ao método tradicional.

No contexto deste trabalho foi desenvolvido um curso em ambiente *eLearning* e sujeito à avaliação da eficácia, efetividade e satisfação do utilizador, de acordo com a plataforma de avaliação de Kirkpatrick. Neste sentido, foi realizado um estudo randomizado controlado, onde os participantes foram técnicos de radiologia e estudantes de radiologia e os recursos utilizados foram ferramentas de avaliação tais como pré e pós-testes e um questionário de avaliação da satisfação do utilizador.

Como resultado, globalmente foram obtidos 54 participantes no grupo de intervenção (20 estudantes e 34 técnicos de radiologia) e 53 no grupo de controlo (19 estudantes e 34 técnicos de radiologia). De acordo com a análise estatística *intention-to-treat,* no geral observou-se uma melhoria de 21 pontos percentuais (pp) no grupo de intervenção, em comparação com 4pp no grupo de controlo (p<0.001). Os técnicos de radiologia apresentaram uma clara melhoria no grupo de intervenção (23pp *vs* 4pp; p=0.004). Apesar do efeito não ter sido claro nos estudantes (18pp *vs* 5pp; p=0.098), encontraram-se diferenças nos resultados do pós-teste entre os grupos de intervenção e controlo (88% *vs* 63%; p=0.003), não existindo diferenças nos resultados do pré-teste (63% *vs* 63%; p=0.106). Por conseguinte, foi realizada uma análise por protocolo que revelou um aumento do efeito do curso (26pp *vs* 2pp; p<0.001), tanto nos estudantes (25pp *vs* 3pp; p=0.004) como nos técnicos (27pp *vs* 2pp; p<0.001).

Em relação à efetividade, 81% dos participantes aceitaram fazer o curso e 9% não fizeram o curso na sua totalidade. Em relação à satisfação dos utilizadores, 85% revelaram-se bastante satisfeitos com o curso e 88% consideraram o curso bem-sucedido.

O facto de os estudantes no grupo de intervenção não terem tido uma evolução no conhecimento que seja estatisticamente significativa, prender-se-á com o facto de os estudantes desenvolverem uma melhor autoaprendizagem, e aqueles que fizeram parte do grupo de controlo terem desenvolvido algum interesse pela área após terem feito o pré-teste procurando depois por sua iniciativa aumentar o seu conhecimento. Em relação aos técnicos de radiologia, a evolução positiva realça a importância da educação contínua no âmbito profissional. A análise por protocolo realçou a influência do curso nos resultados, revelando efeito no grupo dos estudantes.

Como principal resultado, consideramos a melhoria do conhecimento na área da Senologia que o curso proporcionou aos técnicos. O estudo provou que o curso é eficaz, especialmente para os técnicos, realçando desta forma a formação contínua e o *eLearning* enquanto uma viável alternativa ao método tradicional. Para além da eficácia, este estudo provou também que o curso é efetivo e tem alto grau de satisfação por parte do utilizador, principalmente a nível de interface e de conteúdo. Em relação a trabalho futuro, o grande objetivo será proceder a uma melhoria global do curso e à respetiva creditação. Seria interessante alargar este estudo randomizado controlado ao âmbito nacional. Numa perspetiva mais arrojada e a longo prazo, seria importante também avaliar o curso segundo os níveis 3 e 4 da plataforma de Kirkpatrick, de forma a estudar a sua eficiência.

Palavras-chave: Cancro da mama, mamografia, técnico de radiologia, avaliação, eLearning.

«Learning is finding out what you already know. Doing is demonstrating that you know it. Teach is reminding others that they know just as well as you. You are all learners, doers, teachers.»
Richard Bach

Contents

List of abbreviations and acronyms

ACR	American College of Radiology
AIR	Australian Institute of Radiography
BIRADS	Breast Imaging Report and Data System
CI	Confidence Interval
CHSJ	Centro Hospitalar S. João, E.P.E
CSS	Cascading Style Sheets
CT	Computed Tomography
EUSOMA	European Society of Breast Cancer Specialists
FDA	Food and Drug Administration
FFDM	Full Field Digital Mammography
FTP	File Transfer Protocol
HTML	HyperText Markup Language
HSJ	Hospital S. João, E.P.E
IT	Information Technology
Md	Median
MRI	Magnetic Resonance Imaging
PHP	Hypertext Preprocessor
pp	Percentual points
P_{25}	Percentile 25
P_{75}	Percentile 75
RCT	Randomised Control Trial
UK	United Kingdom
US	Ultrassound
USA	United States of America
XML	Extensible Markup Language
μ	Average

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1. Introduction

This initial chapter comprises a global approach of this thesis, and outlines the research problem and question, the objectives purposed, its structure and the contributions that this work can bring to the scientific research.

1.1. Research problem

Breast cancer has become a serious public health problem worldwide, being responsible for about 1500 deaths in Portugal each year. Therefore, screening programmes are crucial to reduce this mortality rate, and mammography technique is currently considered the best imaging method for breast cancer screening and the most effective tool for early detection of this disease.

The radiographer has a key role in the performance of mammographic examinations, and is therefore responsible for a set of functions and processes that require a more specific knowledge in the area of senology. Beyond radiation exposure, positioning techniques and technical aspects of X-ray equipment, the organisation of a breast cancer screening programme, the management of breast disease and treatment options, as well as the image quality assurance and interpretation are a few examples of other important topics that can be lead to a good professional performance.

Education and training programmes are crucial so that these professionals can improve their professional skills. Besides this educational need it is worth mentioning several others, like the availability of learning resources and a greater convergence of information, without interference in the work routine. Another inherent element is the cost related to the training, such as travel expenses, lodging, and registration fees for events, including congresses or conferences.

In this perspective, distance learning (eLearning) has emerged in this area to meet these needs and therefore provide new skills and new knowledge to health

professionals at a lower cost and without requiring a high degree of computer knowledge.

1.2 Research question

In the context abovementioned, the research question for this work is whether an eLearning system improves the knowledge of radiographers and radiology students on senology.

1.3 Objectives

The objectives of this work include the knowledge promotion and understanding of all aspects related to the breast illness and patient care required to radiographers. To achieve this, we proposed:

- To develop an easy-to-use course in eLearning environment;
- Assess about its efficacy and effectiveness;
- Assess about the satisfaction of users.

1.4 Thesis structure

The thesis is organised in seven chapters and outlined as follows:

- Chapter two – presents basic senology concepts, the relevance of mammography as the best imaging technique for breast cancer screening and the radiographer role in this process;
- Chapter three – describes the eLearning as the new trend of education as well as its advantages and disadvantages;
- Chapter four – presents the study design and implementation;
- Chapter five – reports the results of the implementation;
- Chapter six – discusses the results attained and some research limitations of this work;
- Chapter seven – presents the main findings and proposes some recommendations and directions of future work.

1.5. Research contributions

This work provides a new easy-to-use eLearning course, thus contributing to the senology teaching, emphasising the continuing education and professional development in this way.

Also, it fills the lack of randomised control trials in the evaluation systems, assessing about its efficacy and effectiveness. In addition, research articles are being prepared for submission.

2. Basic concepts of senology

Senology is defined as a multidisciplinary science that studies the human breast and related pathology. This medicine field covers all topics related to prevention, diagnosis, prognosis and treatment of breast pathology, which implies the involvement of various specialities of the healthcare area, such as surgery, radiology, pathology, genetics, psychology, nuclear medicine, oncology, radiation therapy and nursing (Alto Comissariado da Saúde, 2009). It has become an increasingly important area within research community due to the high incidence of breast cancer and its mortality rate, particularly in western countries.

2.1 Breast cancer

In 2008, breast cancer was the most common cause of cancer-related death in women worldwide (Boyle P, 2008). Even before, in 2004 breast cancer alone was responsible for approximately 519 million deaths, comprising 16% of all cancer incidences among women (World Health Organization, 2009). In Portugal, breast cancer related mortality incidence reaches 1500 women every year. It is estimated that one in every 10 women will develop breast cancer at any time in her life. In the Europe Union breast cancer is responsible for one in every six deaths from cancer in women (Eurostat, 2009; Jemal *et al.*, 2011).

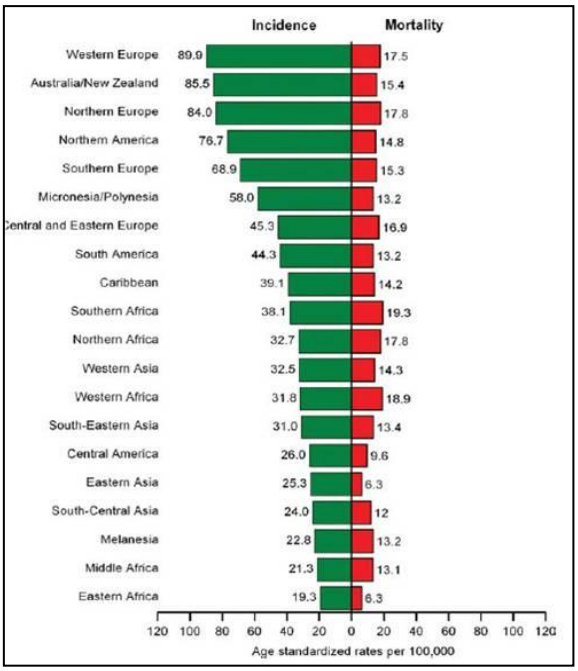

Figure 1: Incidence and mortality rates of breast cancer around the world. Western and Northern Europe, Australia and USA are the ones that have a higher incidence of the disease, as opposed areas like Asia and Africa. On the other hand, places such as Southern and Western Africa have a higher mortality rate. The factors that contribute to this variation are related to socio-economical lifestyles as well as the type of resources for early detection of the disease that are provided in each location.
Source: Jemal, A. *et al.*, 2011.

Although the statistics aforementioned look devastating (Figure 1), there has been a reduction of mortality rate in developed countries such as the United States of America, Canada, United Kingdom (UK) and Denmark, in association with organised screening programs and proper treatment. On the other hand, in other countries such as Brazil, the increased incidence rate has been accompanied by an increase in mortality, which can be mainly attributed to a later diagnosis and further treatment (Philippe Autier & Mathieu Boniol, 2008; Jemal *et al.*, 2011).

In this context, advanced techniques that lead to breast cancer early detection and diagnosis are essential to decrease its associated mortality rate. Considering the Eurostat recommendation (2009), all countries should have

screening programmes to deal with this illness. Mammography technique is currently considered the best imaging method for breast cancer screening and the most effective tool for early detection of this disease (Misra *et al.*, 2010).

Screening mammographic examinations are performed on asymptomatic women in order to detect early and clinically unsuspected lesions. In the United States of America, the age range at which mass screening mammography is generally recommended is between 40 and 74 years old, every two years, although recently state organisations were debating the possibility of changing the lower age limit to 50 years (Lee *et al.* 2010). According to European guidelines on quality assurance in mammography, the screening should be performed every two years in women aged 50 to 69 years. However, despite broad consensus of having a breast cancer screening, these programs differ depending on each country, its policies, economy, population and higher or lower incidence rates of the disease in the corresponding country. For example, in France the screening applies to women between 50 and 74 years old, and in Malta screening is performed every three years (L. von Karsa *et al.*, 2008; Ponti & Psaila, 2010; Perry *et al.*, 2006; Misra *et al.*, 2010).

Regarding Portugal, the screening mammography is organised by the *Liga Portuguesa Contra o Cancro* institution, which invites every two years women with ages between 45 and 69 years old (in Azores the range is extended up to 74 years) who are enrolled in the National Health Service. The doubtful cases are recalled for a better diagnosis and are sent to the hospital if needed (Liga Portuguesa Contra o Cancro, 2009).

Specially, in women with genetic mutations or with a significant family history of breast cancer, screening should start usually 10 years earlier than the age of diagnosis of the youngest relative (although never before 25 years old) (Lee *et al.*, 2010).

Breast cancer in men is extremely rare; it corresponds to 30% of the cases in which the disease is inherited and is less than 1% of all cancers that affect humans. It affects most commonly people at the age of 65 and it is rarely bilateral (Lee *et al.,* 2010; U. Fischer & Luftner-Nager, 2008).

Although there are screening programmes already implemented all over the world, the anxiety motivated by the possibility of existence of the disease and the existence of known cases of breast cancer by the patient lead to some specialists believing that screening should start earlier and/or carry out the breast evaluation annually. For this reason, concerning women under 40 years, although is not considered screening, the first intended exam is the ultrasound

(US), since mammography for this age group has lower sensitivity and specificity (Misra *et al.*, 2010; Lee *et al.*, 2010).

Besides mammography there are other imaging techniques for breast diagnosis, including US and Magnetic Resonance Imaging (MRI). Breast lesion biopsy should preferably be guided by US, but when the lesion is not visible it is recommended that the biopsy should be guided by X-ray or MRI (Alto Comissariado da Saúde, 2009; Lee *et al.*, 2010).

The treatment options include surgery, chemotherapy, radiotherapy and hormonal therapy. The proper treatment choice depends on the stage of the disease, the type of tumour and the general health status of the patient (Perry *et al.*, 2006; Alto Comissariado da Saúde, 2009).

2.2 Mammography

Due to its sensitivity and specificity (66% and 94%, respectively (FMUP, 2004; Kavanagh *et al.* 2000)), through spatial resolution and performance features such as breast compression, mammography can detect lesions with less than 1cm, no palpable or visible in other imaging methods, such as US (Mahesh, 2004). It is less costly when compared to other types of imaging techniques (e.g. MRI) (Schueler *et al.*, 2008; Lee *et al.*, 2010). For these reasons, mammography is currently considered the best imaging technique for breast cancer screening and therefore the most effective tool to early detection of this disease. It is a way of reducing the mortality of the disease and thus increasing the treatment options (Lee *et al.,* 2010; Misra *et al.,* 2010; N. M. Perry, 2001).

Mammography technique comprises the radiographic acquisition of two views or projections for each breast: the craniocaudal (CC) view, which is a 'head-to-feet' view, and a mediolateral oblique (MLO) view, which is a side-view (Figure 2) (Misra *et al.*, 2010). The images can be recorded on x-ray film, such as a film-screen mammogram, or in digital format, such as a digital mammography (Full Field Digital Mammography – FFDM – and Computed Radiography) (Karellas, 2006; Mahesh, 2004). Some breast screening programmes, such as the National Health Service (NHS) of England encompass a single MLO view of each breast (Ponti & Psaila, 2010).

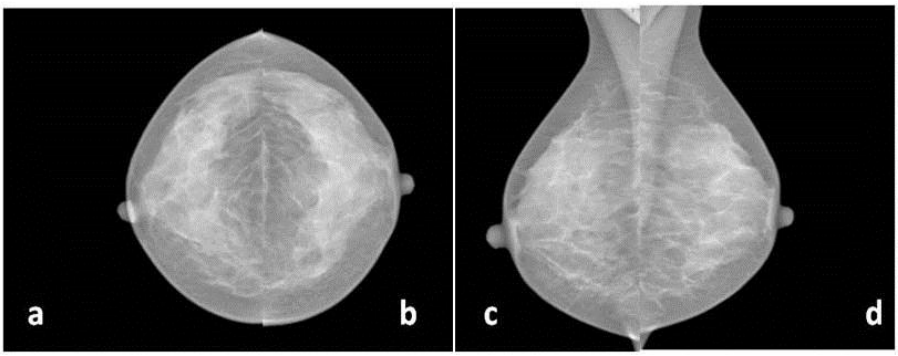

Figure 2: Mammogram examples: (a) CC view of the right breast; (b) CC view of the left breast; (c) MLO view of the right breast; (d) MLO view of the left breast.
Source: Breast Centre, *Hospital S. João* (HSJ), 2009.

Besides screening, mammography is also used in diagnosis and intervention, and subsequent follow-up of benign and malign lesions. In this kind of situations other type of X-ray projections are performed in order to clarify the lesion description. Also the mammography equipment allows the use of a stereotaxic device, which allows performing the biopsy and the localization of impalpable lesions which are going to be removed by surgery and are only visible on X-ray. Mammography also provides the radiography of chirurgical breast specimen, in order to confirm the total resection of the lesion (Mahesh, 2004).

Mammography shows the morphological aspects of the breast, such as the anatomical structures and all the breast tissues, namely glandular, fibrous and adipose tissues. However, there is one major problem concerning breast radiography: these three types of tissue have similar density among them (there is no bone tissue or air to provide high contrast). The relative density of the breast is primarily affected by the inherent characteristics of the patient, by their hormonal status, age and pregnancy (Williams *et al.,* 1995; U. Fischer & Luftner-Nager, 2008). Generally speaking, and according to the American College of Radiology (ACR, 2003), a mammogram can be classified into one of four existing standard patterns as the relative amounts of fibro-glandular tissue as opposed to fatty tissue (Figure 3): fat (less dense), fat-fibrous, fibro-glandular and glandular (denser) (ACR1 to ACR4).

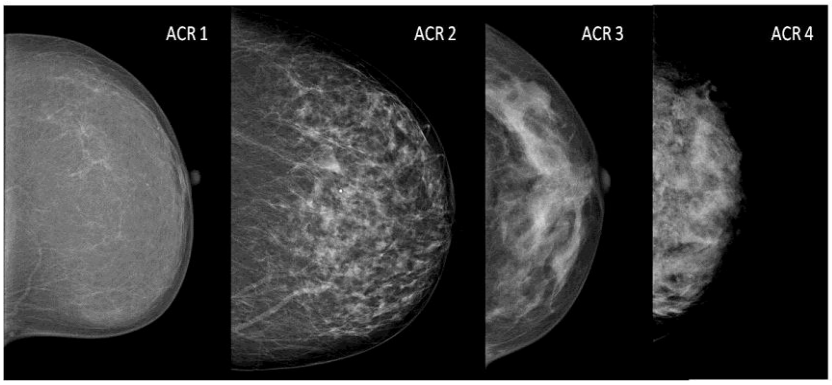

Figure 3: Standard patterns of breast tissue, according to the ACR.
Source: Breast Centre, HSJ, 2010.

With the increase density of the breast it becomes more difficult to detect pathology due to the overlapping tissues effect, being also harder to make a correct diagnosis, which decreases the sensitivity and specificity of the exam. Usually this type of pattern is found in younger women; in this case the first advised exam is US, as previously described. To contest this decline in the quality of the diagnostic examination, several improvements such as in the image acquisition - as FFDM-, in the material composition of the equipment and in the technical parameters and automatic exposure have been upgraded in order to create a better visualization of dense breast tissue (Karellas, 2006).

Tomossynthesis, another recent mammographic progress, is a tomographic application of digital mammography. It includes a three-dimensional imaging technology that involves the acquisition of images from a stationary compressed breast at multiple angles during a short scan. The individual images are then reconstructed into a series of thin high-resolution slices that can be displayed individually or in a dynamic 'cine mode'. The aim of this technique is to reduce or eliminate the tissue overlapping effect thus detecting lesions with more sensitivity (Figure 4) (Park *et al.,* 2007).

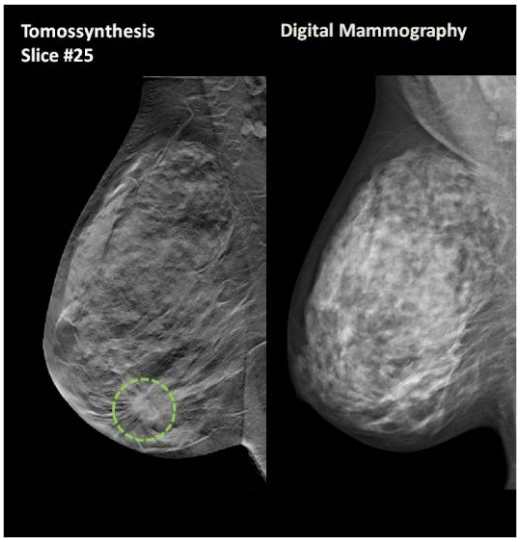

Figure 4: Comparison between tomosynthesis and digital mammography in detecting a breast nodule in ACR3 pattern tissue. The biopsy diagnosed carcinoma.
Source: Images gently provided by Siemens SA.

One limitation of the mammographic technique is the X-ray exposure, with all the implications of ionising radiation (Fazel *et al.,* 2009), thus it cannot be performed in pregnant women (only in absolutely necessary cases, with adequate X-ray shield protection). However, within the others radiological techniques the mammography is the one which has the lowest radiation exposure and its equipment is particularly directed to breast only (Mahesh, 2004; Fazel *et al.,* 2009).

2.3 Radiographer role

Successful mammography depends on the performance of the equipment, the expertise of the radiology technologist and the cooperation of the woman. The skills of the radiographer and various factors associated with the woman undergoing the examination affect the quality of the mammogram. These include the composition and size of the breast and the stature of the woman as well as her physical and psychological attributes (Van Goethem *et al.,* 2003; Caseldine *et al.,* 2000; Food and Drug Administration, 2001).

The radiology technologist - or radiographer, according to the European Society of Breast Cancer Specialists (EUSOMA) - has an important role in the performance of mammographic examinations, and therefore several

requirements related to this knowledge field must be taken into account, beyond the radiation exposure, the positioning techniques and the equipment used. Image quality assurance and interpretation of mammographic images, additional imaging techniques and the localization and biopsy techniques for impalpable lesions are other important issues for a good professional performance (Cataliotti *et al.,* 2007; Perry, 2001; Caseldine *et al.,* 2000).

The radiographer is part of a multidisciplinary team, whether in screening or in diagnosis and intervention environment, making him be aware of the clinical information as well as previous breast exams of the patient. Also, it is important that the radiographer establishes a direct contact with the radiologist in order to transmit relevant information and therefore guide and contribute to a proper diagnosis. The radiographer is also responsible for the availability and accessibility of images (Cataliotti *et al.*, 2007; Perry, 2001).

Beyond these 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. Moreover, the correct understanding of Senology concepts such as breast cancer statistics and family history, and the knowledge of breast disease symptoms and treatment options are also important. Also the examination demands a fair degree of sensitivity of the radiographer, since this is an exam that causes great anxiety for most women (Cataliotti *et al.*, 2007; Van Goethem *et al.,* 2003).

This role extension is needed in order to fulfil the ultimate goal of decreasing the mortality rate of breast cancer and thus improving the health care needs (Caseldine *et al.*, 2000; Perry *et al.*, 2006).

2.4 The need for continuing education

In order to improve their professional competences, education and training programmes are demanded for radiographers. Both Food and Drug Administration (FDA) and EUSOMA declare that to work in mammography radiographers must have professional certification and at least 40 hours of mammography specific training (Cataliotti *et al.*, 2007; Food and Drug Administration, 2001).

For senology there are training programmes, 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, with specific training centres and associated universities (Caseldine *et al.,* 2000) . The Australian Institute of Radiography (AIR) has a professional accreditation program that ensures the necessary training to work as a health professional in the country. In addition, since 1999 the same institution has 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" (AIR, 2011).

In general, there is a large interest of these professionals in acquiring professional training and continuous education. Shanahan (2010) found that 94% of the Australian radiographers that collaborated in the study use the Internet as a resource for self-learning. Additionally, these radiographers showed to be receptive to new technologies and training. In Denmark, Johansen & Brodersen (2011) described the Danish radiographers to be able to upgrade their skills and get the role extension described above.

According to Norman *et al.* (2004), continuing education is defined as the systematic maintenance, improvement and expansion of knowledge skills and personal qualities in order to perform professional duties throughout his working life. With this educational need, not only for health professionals but also for health students, education and training programmes are required (Schrader & Kldiashvili, 2008). In this field, other concerns must be taken into account, namely available learning resources, the inherent costs for obtaining professional training, such as travel, lodging expenses and registration fees for events or conferences. In addition, it must be considered the time spent out of the work, which represents an important factor in the decision process so as to obtain knowledge and training in the health area, for both students and professionals (Ruiz *et al.,* 2006). Therefore, Masys (2002) claimed that is increasingly necessary that these professionals are aware and familiar with Information Technology (IT) so that they are in 'constant' continuing education.

3. The eLearning system in higher education and professional world

With the continuous technology development and global spread of computer networks, in particular the Internet, new challenges emerge constantly in several areas, namely in education. Increasingly the education relies on computer resources to attract students through the multimedia integration and interactivity, providing equal or even better results in the knowledge dissemination and skills development when compared to the traditional classroom learning method (Sun *et al.,* 2008).

The eLearning or 'learning through the Internet' has emerged in the 1960s and has become a promising alternative to the traditional face-to-face method, helping not only the students but also professionals to move towards a vision of lifelong and continuous learning (Liao & Hsieh, 2011). Regarding Healthcare sector, the continuing education is necessary in order to obtain the highest performance possible from professionals and thus providing better healthcare services (A. Pinto *et al.,* 2011). The National Health Service University (NHSU) identified eLearning as a central strategic delivery mechanism for all its professionals (Childs *et al.,* 2005).

ELearning has then become one of the fastest-moving trends and aims to provide a configurable infrastructure which integrates learning material, tools and services. Moreover, the unique goal is to create and deliver training or educational content in a quick, effective, and economical way, without requiring too much IT knowledge. Besides, it gives the learner the opportunity of to manage his own learning materials from the information resources. This concept fits the constructivist learning theory, where learners search out and create their own knowledge bases (Ruiz *et al.,* 2006; R. D. Johnson *et al.,* 2008).

3.1 ELearning concepts

The "eLearning" expression can also be portrayed by e-learning, online learning, web-based learning (WBL), distributed learning, computer-assisted instruction or internet-based learning. Nowadays, all these expressions mean the same: the use of Internet technologies to deliver a broad array of solutions that enhance knowledge and performance, with a strong pedagogical effect (Ruiz *et al.*, 2006; McKimm *et al.*, 2003).

Creating an eLearning system requires the development of four main components:

1. A "digital learning object" which is defined as a collection of digital contents organised in an ordered way, based on an educational objective. Some examples include lessons, modules, tutorials and case-based learning;
2. "Content management" is needed in order to make the teaching material available to learners in a continuous way. Some examples include storing, updating, delivery and maintenance of the software;
3. "Content delivery" is defined as the way the information is transmitted; it can be either synchronous or asynchronous. Synchronous delivery is related to real-time, where the information is received by all elearners at the same time, and provide the opportunity to contact instantaneously the teacher and other colleagues, e.g. through videoconferencing and chat forums; this require the presence of the elearner at the course at some specific date and time. Meanwhile, asynchronous delivery transmits a self-instruction and learning, offering the learner the opportunity to take his learning in an adaptive and personalised way; it does not require the presence at any specific instance; the teacher and learner communicate using e-mail or feedback technologies, but not in real time;
4. Standardisation has become an increasing need for the creation of new eLearning materials, in order to support the compatibility and usability of the system across the various computer systems, facilitating the widespread use of it (Ruiz *et al.*, 2006; McKimm *et al.*, 2003).

3.2 Technology and tools

Several online courses are currently being offered. With the looming development of Information Technology, there is much software that can be used to implement eLearning systems, and offer many alternatives of multimedia and interactive teaching solutions.

ELearning Web sites, email, blogs with education material, Wiki (a type of web-site that allows users to easily edit and change its content, and thus features the collaborative creation of content by several authors), discussion forums (providing communication between the elearners and the teacher) and Learning Management Systems (LMS) appear, in order to plan, organise and access a specific learning process (A. Pinto *et al.*, 2011; a Pinto *et al.,* 2008; McKimm *et al.*, 2003). Among the various LMS, there is the Moodle (*Modular object oriented dynamic learning environment)* platform, which is considered the most appropriate LMS for the implementation of eLearning courses (A. Pinto *et al.,* 2011; McKimm *et al.,* 2003; Núñez *et al.,* 2011). Such technologies are valuable tools for collaboration, interactivity, simulation, and self-testing.

3.3 Benefits and barriers

There are various references in literature about the benefits and barriers of eLearning (McKimm *et al.,* 2003; Ruiz *et al.,* 2006; Wutoh *et al.,* 2004). The potential advantages are related to:

- The ability to learn at any time from any location without having to travel or spend time away from work;
- Cost-savings – beyond medical literature there is strong evidence that eLearning can result in significant cost-savings, sometimes higher than 50%, compared with traditional face-to-face learning. Savings are related to reduced instructor training time, travel and labour costs, reduced institutional infrastructure, and the possibility of expanding programmes with new educational technologies;
- An individualised approach that allow learners to skip information they already know and move on to less familiar issues;
- Learning delivery which increases the accessibility to information, and ease of distribution (internet technologies allow the widespread distribution of digital content to many users simultaneously anytime and anywhere);

- The possibility of easily and quickly update content (updating electronic content is easier than updating printed material).

Childs *et al.* (2005) stated that the institution, administrators and learners find that multimedia eLearning enhances both teaching and learning. A multimedia approach, which supports individual learning styles, may lead to increased comprehension of the teaching contents. Moreover, outcomes assessment should be included in the eLearning system design to determine whether learning has occurred.

On the other hand, in literature there are some negative comments concerning barriers to use eLearning techniques, such as time constraints and ease of use (Baumlin *et al.,* 2000; Komolpis & Johnson, 2002; Pinto *et al.,* 2008). Childs *et al.*, (2005) presented a systematic review that include a compilation of all the barriers found in literature concerning eLearning systems, for students and health professionals, and suggested some adequate solutions. These are described in Tables 1, 2 and 3.

Table 1: Organisational and economical barriers related to eLearning. Source: Childs *et al.,* 2005.

Issue	Barrier	Solution
Organisational	• Time is needed to develop eLearning programs and to evaluate material; • No dedicated time for this purpose is made available; • Learners ask for the time consuming nature of eLearning, and how to manage their time properly; • Learners needed advice on organizing eLearning tasks.	• ELearning needs to be integrated into all aspects of the institution and into the curriculum; • At the trainer level the collaboration between content, pedagogy and technology must be ensured; • Need of incentives for trainers; • Trainers need time to master the technology, to convert materials and to prepare teaching sessions; • Learners need flexible eLearning that can suit their individual work-life balance.
Economical	• There is a need for cost effectiveness/cost benefit evidence; • Learners are concerned about the costs of courses and the requirements needed; • If learners are required to pay then sufficient materials need to be provided to justify it.	• Evidence for the true costs of eLearning and associated cost-effectiveness and cost benefits; • Cheap or free courses and materials, although paying up front may contribute to a higher involvement of the learner in the outcome of the contents.

Table 2: Barriers of eLearning relative to hardware, software and support issues. Source: Childs *et al.,* 2005.

Issue	Barrier	Solution
Hardware and Software	• Costs, specially concerning software licenses; • Lack of, or inadequate, technology at both work and home, e.g. computers, printers, applications, internet access, access speed; • Technology can be poorly concerning transportability and compatibility problems; • Learners experience technical and practical problems with hardware and software.	• National approach of delivery channels and broadband strategy; • Appropriate location of equipment; • Suggestions on effective use of specific items of hardware should be available; • Hardware needs to be reliable; • Learners need an easy access to computers, and to be comfortable in using them; • Evaluation and feedback of the equipment and software.
Support	• Lack of technical support staff; • Lack of suitable support materials; • Learners may need support from their trainer the needed feedback may be lacking; • Hardware and software support can be costly.	• Continuous technical support; • Quick solutions to technological problems; • Access to technical expertise; • Trainers need to provide support for learners, including information, guidance and feedback.

Table 3: Pedagogical, phychological and skills barriers in eLearning. Source: Childs *et al.,* 2005; Clark, 2002.

Issue	Barrier	Solution
Pedagogical	• Some eLearning packages have poor quality, and are inappropriate or insufficient for the task; • Creation of myths including: it is a passing fad; it is only for knowledge acquisition; it is ineffective and inefficient; 'the lonely learner'; 'the redundant teacher'; 'technology is king'; 'an unrealistic dream'.	• Standardisation; • Integration into the curriculum; • Regular evaluation and feedback; • Accreditation and outcomes should be equivalent to traditional methods; • Demystifying the myths by evaluating effectiveness and efficiency.
Psychological	• Resistance to change; • "Technophobia" (lack of IT confidence); • Negative views of the value of eLearning • Preference for personal contact; • How to motivate trainers to undertake eLearning.	• A blended approach mixing face-to-face with eLearning methods; • Trainers need to provide a safe environment for failure; • Learners can learn from mistakes in an informal atmosphere; • Integration into the curriculum.
Skills	• Trainers lack appropriate skills and need training; • Learners need skill training in computers use and the Internet.	• Promote training in IT skills, eLearning techniques and management skills; • Establish a policy so learners can take either a basic computer literacy course or demonstrate computer skills as requirement for admission to the eLearning course; • Develop user friendly interfaces.

3.4 Evaluation: related literature

The potential eLearning advantages described above may not translate into significant improvements in educational outcomes (Chumley-Jones *et al.*, 2002). So, as with any new implementation project, eLearning needs to be justified by its effectiveness and relevance. This evaluation requires the students' participation and the professionals involved in the training and the education programmes (Wutoh *et al.,* 2004).

An evaluation should help making the learning experience more efficient and effective and its feedback is used to improve the system. Before conducting an evaluation it is important to define what is going to be investigated and how this is going to be achieved (Horton, 2001). Crompton (1992) suggested a checklist to plan the evaluation procedure in order to fulfil all the requirements of its process (see Table 4).

Table 4: Evaluation Checklist. Source: (Aitken & Tabakov, 2005; Crompton, 1992).

Who? (Know your target audience)	Who is the evaluation for?
What? (Understand what is to be evaluated)	Process Outcome Combination of both Purpose
Why? (Rational for evaluation)	To improve quality To determine if aims are fulfiled To prove accountability
When? (Timing – being ready to start)	Have you defined a question? Will the findings have any effect? Benefits outweigh costs
How? (Choosing an appropriate technique)	Questionnaires Interviews Confidence logs Observations Student profiles Pre-tests and post-tests Inventory learning checklists

One of the best methods considered in literature to evaluate a learning system is the framework developed by Kirkpatrick (Alliger & Janak, 1989). It consists of four categories from level 1 - the easiest and least resource-intensive - to level 4 - the most difficult and expensive. Moving from level 1 to 4, the evaluation process becomes more difficult and time-consuming, although it provides information of increasingly significant results. Each successive level of evaluation stays upon of the previous level.

The four levels are outlined in Table 5 and described below.

- **Level 1: Reaction**. This can be the easiest assessment but also reveals the importance and impact that the eLearning system could have. This level measures how learners react to learning, gaining knowledge about whether the learners enjoyed the training and if it was relevant to their work. In fact, positive learner's reactions do not ensure that objectives are met, but negative reactions guarantee a less successful transfer of knowledge and skills, and reduce the possibility of learning. Evaluation tools for this level include programme evaluation sheets, interviews, learners' comments throughout the training and the course's ability to keep learner's interest (Aitken & Tabakov, 2005; Horton, 2001);
- **Level 2: Learning.** At this level is assessed whether learner's knowledge and/or skills are changed by the eLearning programme. Evaluation methods range from self-assessment to team assessment; examples include individual pre and post-training tests for comparisons, assessment of action based learning such as work-based projects and role-plays, and observations and feedback from peers, managers and instructors. Ruiz *et al.* (2006) stated that the best evaluation method at this level is to conduct an experimental study, in which the learners are divided into two similar subgroups. Prior to the intervention (the eLearning system), both subgroups can be tested on the topics of interest during a pre-test, performing equally. Then only one of the subgroups, the experimental one, is subject to the intervention. After that, both subgroups are retested with a post-test. If the experimental group now performs better than the control group, the eLearning system can be identified as the cause of the improvement;
- **Level 3: Behaviour.** At this level, the question whether the training has been transferred back to the job or not is trying to be answered. This evaluation is typically performed three to six months after

learning, and must be done in the workplace, requiring a more elaborate plan than levels 1 and 2. Some evaluation tools used at this level include individual pre and post-tests or surveys, interviews, observations and feedbacks from others, and focus groups to gather information and share knowledge. Evaluating level 3 can be difficult because it must be conducted months after the training has been completed. This highlights the importance of planning an evaluation strategy when planning the course (Horton, 2001; Tseng *et al.,* 2011);

- **Level 4: Impact on organization.** This evaluation measures the success of the programme regarding the outcomes of the organisation and provides the increased production, sales, quality and less cost. The most difficult evaluation to perform is the one in this level. The possibility to compare the increase in sales with the training cost and the calculation of a bottom-line return on investment are two fairly good examples. Unfortunately, many topics are not that easy to quantify.

Table 5: Kirkpatrick's plataform. Source: Aitken & Tabakov, 2005; Alliger & Janak, 1989.

Level	Measurement focus	Questions addressed
• Reaction	Learners' perception	What did trainees think of this training?
• Learning	Knowledge/skills gained	Was there an increase in knowledge or skill level?
• Behaviour	Worksite implementation	Is new knowledge/skill being used on the job?
• Results	Impact on organization	What effect did the training have on the organization?

Wutoh *et al.* (2004) and Chumley-Jodes *et al.* (2002) performed a literature review about eLearning evaluation in medical, dental and nursing education, and the latter categorized the studies in four evaluation domains: knowledge gains, attitudes, efficiency and costs. These authors described all the study designs reported in each article found, including the type of intervention and assessment, as well as the corresponding results. An overwhelming number of these studies were conducted among students, for the reason that they have supposedly more time to participate than professionals (Wutoh *et al.*, 2004). Ruiz *et al.* (2006), stated that these evaluations and comparison studies have

limitations, especially because the variability of the research design and the evaluation tools used, resulting in inconsistent results for many outcomes.

Concerning knowledge gains, the most common research design was the pre and post-tests self controlled study, with multiple-choice test scores, which results showed significant improvements after WBL intervention; there were also semi experimental and randomised controlled trials (RCTs) whose WBL intervention was given to a group while the other group had no intervention or, on the other way, had traditional training, such as classroom or a combination of WBL and traditional learning. Generally, authors found that WBL is superior to no education method (as in Stark *et al.*, 2011), but equivalent to traditional education method (as in Nkenke *et al.*,2012); alternatively, WBL proved to be more effective when combined with traditional learning (as in Núñez *et al.,* 2011), although there are three studies that found no differences in exam scores (Perryer *et al.,* 2000; AJ *et al.,* 2001; Komolpis & R. a Johnson, 2002). Nkenke *et al.* (2012) and Mahnken *et al.* (2011) recognised that eLearning should be a contribution and a complement for education and not a replacement for face-to-face learning.

Regarding learner's attitudes, there is a strong evidence that learners prefer WBL to other educational methods – in Ludlow & Platin (2000) 71% of students preferred WBL - and claim for higher user's satisfaction. The specifications of an eLearning system for user's satisfaction evaluation related to web technology are: accessibility, navigation (specially downloads speed) and attractiveness (Sun *et al.,* 2008).

There are very few studies about efficiency and costs of eLearning programmes. Bell *et al.* (2000) performed a RCT to compare eLearning to text-based learning and reported that learners achieved equivalent test scores with shorter time using WBL contents. On the other hand, Komolpis & Johnson (2002) through a RCT did not find differences between mean test times between conventional and web-based groups. Regarding costs, Cimino *et al.* (1995) resumed that the printing and distribution of educational materials is less costly than creating and disseminating e-learning content; however they assumed that hardware, software and other equipment were available and they did not consider study design costs. There is a need to determine whether lower distribution costs offset the costs of technical support, and whether eLearning systems saves or costs money in terms of faculty time (Chumley-Jones *et al.*, 2002).

Both authors admitted that there is no evidence that students learn more from WBL than traditional learning, but they can learn more effectively and

WBL combined with traditional learning is the best way to obtain better gain knowledge. They also refer that is crucial to have more RCTs in order to get more strong evidence, especially in the efficiency and costs domains.

4. Study design and methodology

In order to promote a better knowledge about senology and Mammography, and according to the recent learning and educational trends described in the previous chapters, an asynchronous eLearning system was developed specifically to radiographers and health professionals who get in touch with this area.

The course was intended to be evaluated for its efficacy and effectiveness, according to evaluation levels 1 and 2 from Kirkpatrick's framework (Alliger & Janak, 1989), through a RCT, using as instruments individual satisfaction questionnaires and pre and post-knowledge tests for further comparisons, respectively.

4.1 Target population

The target population in this study was radiographers and radiology students. The radiographers who were contacted work at public health institutions that perform breast cancer screening and diagnosis, surrounding the Porto's city area. The students are attending the 3rd and 4th years of the radiology course, enrolled in the present academic year (2011-2012), students at the *Escola Superior de Tecnologia da Saúde do Porto*, who already had mammography training.

4.2 Sampling strategy and recruitment

The sample was stratified by "professional status" – students and radiographers. The public institutions in Porto's city area were filtered from a

list of radiology public institutions of Porto's metropolitan area that was obtained from a Portuguese source, namely *Administração Regional de Saúde do Norte* website, a National Health Service institution.

The target population described above was invited to participate in the study, through their email contact.

In respect to radiographers, in order to obtain the email contact of each individual, it was asked individually, by telephone or email to each public institution, since a public list of radiographers it is not available. It was requested to the Coordinator' radiographers the permission to ask the email contacts of the radiographers. In the event of failure to contact each one of them, it was suggested that the Coordinator could disseminate the study and everyone who was interested in participating was invited to provide the email contact.

Regarding students, email contacts were obtained through their personal records, available at *Secretaria Online*, an online framework which gathers information about all students and professors from the institution.

4.3 Randomisation

After the sample strategy, it was asked to radiographers and students to perform the pre-test.

Randomisation was performed with the number of elements in each group who accepted and effectively took the pre-test. Therefore, 50% of the elements of each group were randomly selected and contacted to participate in the intervention. Randomisation was performed using IBM SPSS Statistics® software, version 17.0. The remaining sample was subsequently contacted to participate in a second test.

4.4 Implementation

It was sent an email with a diagnostic test concerning Mammography and Breast Cancer to those who have been contacted. This diagnostic test corresponds to the pre-test. For instance, if there is no response within seven days from the request for collaboration, another attempt is made, by sending a second email with a new request, and then after seven days a third one is sent if there is still no response. Finally, after seven days have elapsed from the date of

the third e-mail and a reply is not received, the individual participants under discussion are not included in the study.

After 21 days, the sampling was randomly divided into two groups. The intervention group is contacted in order to perform the online course, and a similar process to pre-test enrolment occurred; after 21 days if there is no response the individual under discussion was not allocated to intervention. A private access of 20 days period was defined to those that accepted to perform the course in an asynchronous way, through an individual login and password. After this time it was given a final assessment test to be answered within 5 days.

On the other hand, the control group is contacted after 41 days to make another diagnostic test. Those who were not allocated to intervention and those who did not conclude the course were requested to perform the post-test, thus following the intention-to-treat analysis. The study design is shown trough a diagram in Figure 5.

It was given individual code identification to each participant to further comparison between pre and post-tests. The same code was used to access the online course as username, for those who were allocated to intervention. It was asked to all participants to answer in honest manner, without consulting external sources.

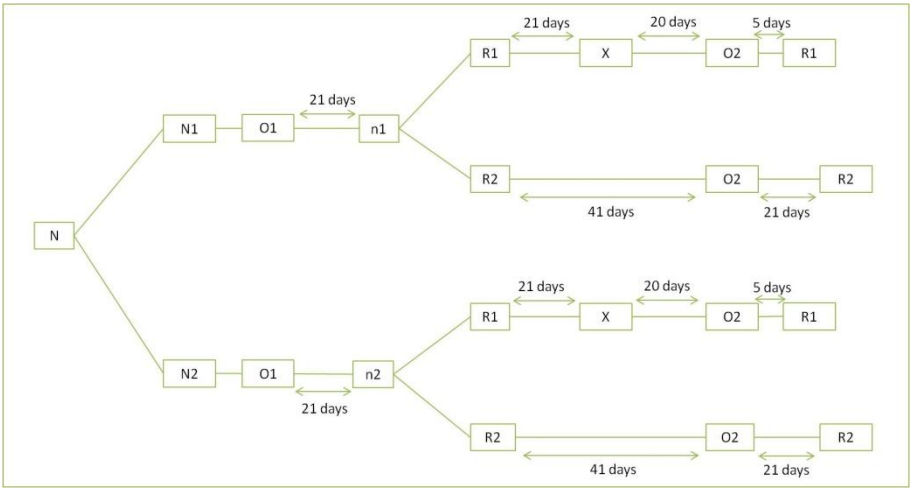

Figure 5: Study design: randomisation and implementation. The interval days that are shown correspond to the maximum period for each phase.

Captions: N: Total participants assessed; N1: Radiographers assessed; N2: Students assessed; O1: pre-test; n1: technologist enrolled; n2: students enrolled; R1: randomised intervention group; R2: randomised control group; X: intervention; O2: post-test.

4.5 Pre and post-tests

Each test was structured with eight different multiple-choice questions related to the course modules: the first two questions were related to the anatomy and physiology of the breast, the third and fourth questions addressed breast cancer and multidisciplinary approach, the fifth and sixth questions concerned breast pathology and the last two questions were related to radiological technique.

All the questions were different and had the same level of difficulty. To ensure this condition, a pilot study was made and described below. The technology that was used to provide this evaluation tool to the individuals was GoogleDocs®, a free web-based office suite and data storage service offered by Google.

4.5.1 Pilot study

A convenience sample of eight radiographers agreed to participate in a pilot study to ensure that all questions presented in pre and post tests had the same level of difficulty. It was asked to all participants to answer in a honest manner, without consulting external sources.

This study comprised two phases; in the first step four individuals received one test, and the other four received the other test. The random delivery of the tests was accomplished, highlighting the independence of the questionnaires in relation to be the first or the second test to be answered. Then, in a second step, when an individual submitted the answers 24 hours later, the other test was sent. This pilot study was made between 18th February and the 1st March 2012.

The focus of the data analysis was to determine whether there was a significant difference between the questions presented in the first and the second tests. For this observation, we used paired Wilcoxon tests to compare the number of incorrect answers of each individual between the first and the second test. As the questions are organised by themes, related to the modules of the course, the tests were also organised for each set of questions. The statistical analysis was performed using IBM SPSS Statistics® software version 17.0, and the considered significance level was 5%.

4.5.2 Final format

Through the data analysis, we can conclude that there are no differences among the modules in one test and the other: module 1 (p=0.083), module 2 (p=0.096), module 3 (p=1.000) and module 4 (p=0.317). However, some questions and multiple choices were readjusted in order to make them clearer.

Also, a question concerning the definition of specificity was decided to be kept in the two tests, replacing a question in one of the tests. This option was because 86% of the individuals did not answer correctly and therefore it can be an indicator of knowledge increase due to the intervention.

The tests also included questions about demographic information such as age, gender, academic qualifications, years of professional experience and routine mammography, and it was also assessed the need for continuing education as well as the receptivity of eLearning programmes in any topic of professional interest.

The final pre and post-tests can be seen in Appendix 1.

4.6 The Course description

4.6.1 Course's characteristics

The course was developed between October 2011 and January 2012 and was written in Portuguese language. The instructions for conducting the course were available on the website, along with a glossary, and it was structured into four modules, taking in consideration the following topics described in Table 6.

The presentation of the contents comprised text, images, videos and presentations using Prezy®, a free web-based presentation software. Diagnostic images were collected directly from the Breast Centre at the *Centro Hospitalar S. João, EPE* (CHSJ)[1], accordingly with the proper authorisation from the Breast Centre medical chairman and the Radiology Department chairman. The contents were reviewed by specialists from the proper institution.

The images appear anonymised and isolated only in the context of the course, to illustrate examples of various types of mammographic patterns of breast tissue and benign and malignant lesions, without any association with data from patients who can identify them.

[1] Previoulsy known as *Hospital S. João* (until April 2011).

Table 6: Course's main contents.

Module	Contents
1. Breast anatomy and physiology of breast	Breast localisation and superficial anatomy; Breast tissues constitution; Radiological anatomy; Patterns of breast tissues; Breast lesions localisation.
2. Breast cancer: multidisciplinary approach	Breast cancer statistics; Breast cancer screening: Mammography; Breast cancer signs and symptoms; BI-RADS classification; Additional imaging techniques; Breast cancer management and treatment options.
3. Breast pathology	Pathology of benign and malignant lesions; Male breast cancer.
4. Mammography: technical approach	Mammography history; Technical aspects of equipment and new technologies; Technical quality control; Positioning techniques and indications for standard and additional views; Localisation and biopsy techniques for non-palpable lesions; Radiographer role

At the end of each module, a table with the main key-points and a formative test of six multiple-choice questions for self-assessment were presented. The correct answers were immediately available after submitting the test. At the end, a final summative assessment corresponding to post-test was sent by email and was available during a five-day period.

The course was designed to be performed asynchronously, with a 20 days period available. The learner could observe his evolution learning during the course through a status bar, in order to make his self-learning. After the approval course, a certificate was sent to the learners.

4.6.2 Website learning development

The website was developed in Netbeans® version 8.0, using several technologies such as Hypertext Preprocessor (PHP), HyperText Markup Language (HTML), JavaScript, Cascading Style Sheets (CSS) and Extensible Markup Language (XML). It was hosted on the server of the *Faculdade de*

Medicina da Universidade do Porto, and its content was transferred by File Transfer Protocol (FTP). Regarding website security, it was guaranteed through an authentication mechanism with username and password.

The data of the eLearners, as well as their evolution during the course and the answers given in the intermediate tests were recorded in XML files. The user through a progress bar that updates dynamically could consult this evolution at any time. The intermediate tests allowed immediate consultation of its results shortly after its performance. In addition, all references were made available through direct links inserted on the corresponding page.

The user was only allowed to click in a new page of the course if he had already consulted the immediately preceding page. This check led to a progressive way of the course performance, thus being an essential point for a correct learning. The forward or backward options to any page already consulted were however allowed.

4.7 Assessment of outcomes

The course was intended to be evaluated as described below.

4.7.1 Main outcomes

For the purpose of evaluating the course for its efficacy (level 2 from Kirkpatrick's framework), the primary outcome under study was the evolution in the knowledge observed between pre-test and post-test for those who were allocated to intervention, through the assessment of the percentage of correct answers in each test and further comparison with the control group.

In order to assess the learner's perception (level 1) a satisfaction questionnaire was given to participants who performed the course; for instance, to assess its effectiveness it was observed the number of participants who discontinued the intervention.

4.7.2 User's satisfaction questionnaire

There are many studies in literature about user's satisfaction in eLearning systems, and therefore there are several user satisfaction questionnaires. One of the most cited in literature is the one performed by Wang (2003), who considered four factors to fulfil the eLearner satisfaction measurement – content, learner interface, personalization and learning community.

The satisfaction instrument developed by Wang consists in 26 items related to the abovementioned factors, using a seven-point Likert-type scale, with anchors ranging from "strongly disagree" to "strongly agree". The latter two questions reflect the two global measures related with overall satisfaction and success of the eLearning system. The questionnaire was shown as a reliability (Cronbach alpha) of 0.95 (Wang, 2003; Chen *et al.*, 2011).

For our study purpose and considering the inexistence of a questionnaire in Portuguese language, a bilingual expert translator carried out the translation of the questionnaire proposed by Wang. In addition, it was asked if participants had already any eLearning experience before, and if it was related to health area. The original questionnaire and corresponding translation can be found in Appendix II and III, respectively.

4.7.3 Statistical analysis

The statistical analysis was performed according to the intention-to-treat condition, involving all the participants allocated to intervention whether they have not agreed to take part or even have not completed the whole course.

To test the normality of the sample, Kolmogorov-Smirnov test (Marsaglia *et al.*, 2003) was used for the total sample and subsequently the Shapiro-Wilk test (Shapiro & Wilk, 1965) to each group analysis, beyond the visual analysis of histograms with normal curve.

To describe the sample it was used measures of central tendency, as the average (μ) for the variable "evolution" and the median (Md) for the others; and dispersion, such as confidence intervals (CI) and percentiles 25 and 75 (P_{25} and P_{75}), respectively.

To analyse possible relations between variables it was used the Pearson's correlation coefficient for continuous variables (Rodgers & Nicewander, 1988) and Spearman's correlation coefficient for discrete variables (Corder & Foreman, 2009).

To compare possible gain in knowledge between pre-test and post-test (corresponding to the percentage of correct answers) inside each group a paired analysis was conducted through the variable "evolution", which is the difference between pre and post-test percentage of correct answers.

For the two groups' comparison, in order to verify the homogeneity between them, it was used the following analysis:

- The Mann-Whitney U test for independent samples (Kruskal, 1957) to verify the homogeneity between the groups;

- The Student's t-test for means for independent samples (Fisher Box, 1987) for the variable "evolution";
- The Chi-square test (Corder & Foreman, 2009) to examine the association between nominal variables. One of the conditions to use this test is that each cell does not provide the expected frequencies below one and more than 20% are expected frequencies lower than 5. When this is not possible, we used Fisher's exact test (Fisher, 1922). The variables were categorized into two values, when necessary.

For all this statistical analysis, we considered a significance level of 5%, and it was used the IBM SPSS Statistics® software, version 17.0.

5. Results from the course's evaluation

The course was created and revised between October 2011 and January 2012. The implementation of the study took place between the 7th March and the 31st May, and the contacts have been obtained between the February 1st and the 7th March. Globally were obtained 120 contacts from the radiographers and 70 from the students, resulting in a total sample of 190 individuals.

Following the same principle of the pilot study described in the previous chapter, the delivery of tests was made randomly. After performing the pre-test, we are left with 68 radiographers and 39 students, for a total of 107 individuals enrolled. These individuals were then randomised, getting a total of 54 in the intervention group (20 students and 34 radiographers) and 53 in the control group (19 students and 34 radiographers). The average of time spent (measured in days) between the answers obtained from the tests and the course's performance, can be observed in Figure 6.

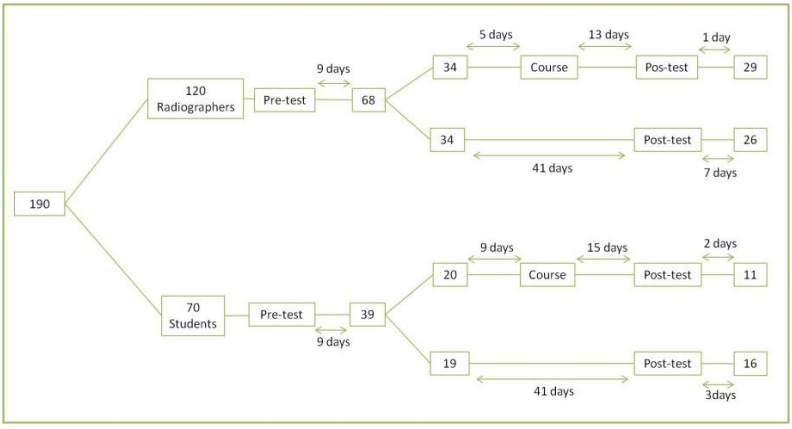

Figure 6: Study design and post-implementation. The time-interval in days that is shown corresponds to the average period of each phase.

Seven students that were allocated to the intervention group did not answer to the invitation to take the course and thereby were considered "lost to follow-up". On the other hand, two students agreed to take the course but did not finish it, being then considered "discontinued Intervention". Regarding radiographers, there are three "lost to follow-up" and two "discontinued Intervention." In the control group, there are three students and eight radiographers who have not performed the post-test and then considered "lost to follow-up". These and other dropouts are explained in Figure 7.

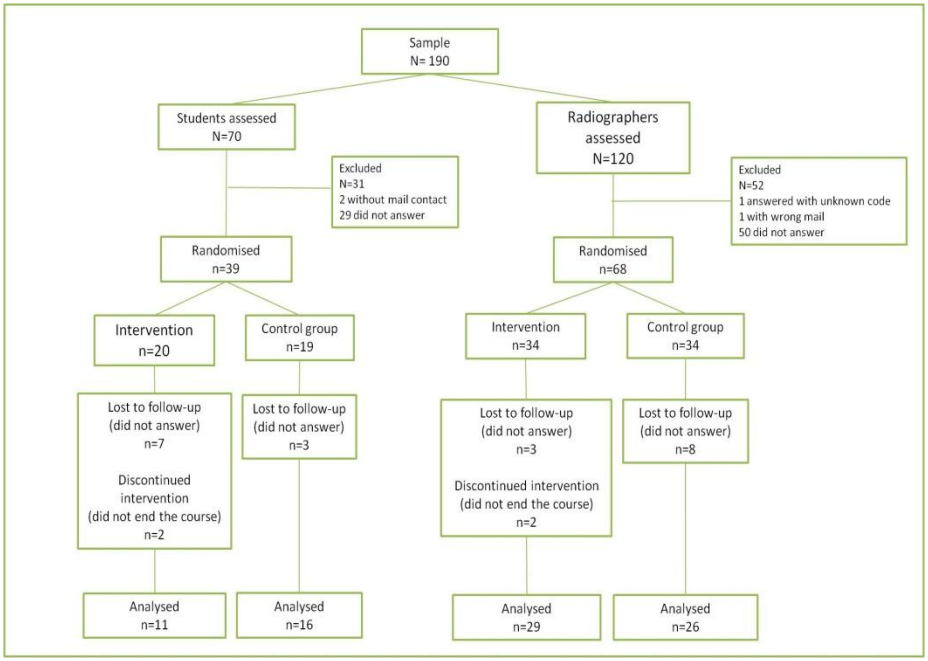

Figure 7: Diagram showing the sample enrolled and respective dropouts.

In order to follow the intention-to-treat analysis, we asked the "lost to follow-up" and "discontinued intervention" individuals who were allocated to the intervention group to perform the post-test. As a result, there were two radiographers and two students identified as "lost to follow-up" and one radiographer and one student identified as "discontinued intervention" who answered to this test. In total, there were 46 individuals in the intervention group (14 students and 32 radiographers) and 42 in the control group (16 students and 26 radiographers) to analyse the "evolution" variable.

5.1 Sample description

Considering demographic variables, globally within 107 individuals 39 (36%) are students and 68 (64%) are radiographers, of whom 85 (79%) are female and the remaining 22(21%) individuals are male; regarding radiographers, in the control group there are more seven male individuals than in the intervention group (p=0.041).

The median age for students is 21 years old (21; 22), and 33 years old (28; 40) for radiographers. Overall, 11 (10%) are 3rd year students, 28 (28%) are 4th year students, 1 (1%) is identical due to professional experience, 8 (8%) have bachelor degree, 54 (51%) are graduated and 5 (5%) have master's degree.

In the radiographers group, the median years of professional experience is 12 (5; 17); 21 (31%) individuals do not perform mammography, 36 (53%) perform less than 30 per week, 4 (6%) perform between 30 and 40 per week and 7 (10%) perform more than 40 per week.

Regarding the percentage of correct answers, in the pre-test there was a failure rate of 14% (n=15). We observed that 51% (n=55) of the results were between 50-75% and 35% (n=37) had better results than 75%. In the post-test, the failure rate was of 7% (n=6), 31% (n=27) of the results were between 50-75% and 62% (n=55) had better results than 75%.

Concerning the query of radiographers need for continuing education, during their professional life, all radiographers answered positively; beyond 48 (71%) individuals showed to be receptive to eLearning programmes in any topic of professional interest (19 (28%) answered "maybe" and 1 (2%) answered "don't know").

The description of the sample dully stratified and divided into groups is presented in Table 7.

5.2 Efficacy

As mentioned above, the efficacy was assessed according to the intention-to-treat analysis. However, to better expose the results, we also considered the per-protocol analysis, thus allocating the individuals that in the invention group did not end or did not perform the course in the control group.

5.2.1 Intention-to-treat analysis

Regarding pre-test, both intervention and control groups have similar results (intervention: Md=63%; control: Md=63%; p=0.159). Also students and radiographers responded equally (students: Md=63; radiographers: Md=63; p=0.626).

In respect to the post-test, the individuals from the intervention group answered differently when compared to the control group, obtaining better results (intervention: Md=88; control: Md=63; p<0.001). Among students and radiographers no differences have been recorded in the results (students: Md=75; radiographers: Md=75; p=0.261).

As shown in Figure 8, the participants had an overall positive evolution (μ=13, CI 95% [8, 18]), which is different in the two groups (intervention: μ=21, control: μ=4; p<0.001) and similar in the professional status categories (students: μ=11; radiographers: μ=14, p=0.601).

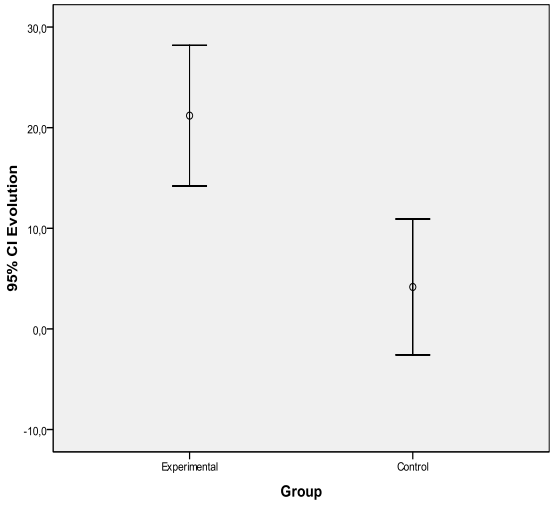

Figure 8: Error bar of the "evolution" variable stratified by intervention and control groups. Overall, the CI interval observed in the experimental group do not overlap the IC interval obtained in the control group (p<0.001).

Stratifying the results by "Professional Status" (Figure 9), the evolution of students within the intervention group despite of being positive is not statistically significant (intervention: μ=18, control: μ=5; p=0.098), while in the radiographers the evolution is more significant (intervention: μ=23, control: μ=4; p=0.004). Among students and radiographers there is no differences in

the evolution both in the intervention group (students: μ=18; radiographers: μ=23; p=0.531) and in the control group (students: μ=5; radiographers: μ=4 p=0.905).

Table 7: Sample's description and comparison between groups. Acronyms and symbols: S – Students; R – Radiographers; G – Global; I – Intervention group; C – Control group; CI – Confidence Interval; P_{25} – Percentile 25; P_{75} – Percentile 75; ; ‡ Chi-Square test; †: Fisher's exact test; Δ - Mann Whitney's test; * - T test Student.

	Intervention			Control			Global			I vs C (*p* value)			S vs R (*p* value)		
	S (n=20)	**R (n=34)**	**G (n=54)**	**S (n=19)**	**R (n=34)**	**G (n=53)**	**S (n=39)**	**R (n=68)**	**G (n=107)**	**S (n=39)**	**R (n=68)**	**G (n=107)**	**I (n=54)**	**C (n=53)**	**G (n=107)**
Age, median	21	31	27	21	37 (29;40)	29	21	33	28	0.390Δ	0.06Δ	0.124Δ	<0.001Δ	<0.001Δ	<0.001Δ
(P_{25}; P_{75})	(21;22)	(27;38)	(21;3)	(21;22)		(22;40)	(21;22)	(28;40)	(22;38)						
Professional Status, n(%)												0.898‡			0.898‡
Student			20 (37)			19 (36)			39 (36)						
Technologist			34 (63)			34 (64)			68 (64)						
Sex, n(%)										0.235†	0.041‡	0.015‡	1.000†	0.646†	0.613†
Male	2 (10)	4 (12)	6 (11)	5 (26)	11 (32)	16 (30)	7 (18)	15 (22)	22 (21)						
Female	18 (90)	30 (88)	48 (89)	14 (74)	23 (68)	37 (70)	32 (82)	53 (78)	85 (79)						
Academic qualifications, n(%)										0.333‡					
3rd year	7 (35)		7 (13)	4 (21)		4 (8)	11 (28)		11 (10)						
4th year	13 (65)		13 (24)	15 (79)		15 (28)	28 (72)	1 (2)	28 (26)						
Equivalent		3 (9)	0		1 (3)	1(2)		8 (12)	1 (1)						
Bachelor		28 (82)	3 (6)		5 (15)	5 (9)		54 (79)	8 (8)						
Graduation		3 (9)	28 (52)		26 (77)	26 (49)		5 (7)	54 (51)						
Master			3 (6)		2 (6)	2 (4)			5 (5)						
Years of profession, median		8			15			12			0.091Δ				
(P_{25}; P_{75})		(4;17)			(7;17)			(5;17)							
Routine Mammography, n(%)											1.000†				
0		12 (35)			9 (17)			21 (31)							
<30 per week		16 (47)			20 (59)			36 (53)							
30-40 per week		3 (9)			1 (3)			4 (6)							
>40 per week		3 (9)			4 (12)			7 (10)							
Pre-test, median	63	63	63	63	63	63	63	63	63	0.106Δ	0.509Δ	0.159Δ	0.544Δ	0.766Δ	0.626Δ
(P_{25}; P_{75})	(63;75)	(50;75)	(50;75)	(50;63)	(50;75)	(50;75)	(50;75)	(50;75)	(50;75)						
	n= 14	**n= 32**	**n= 46**	**n= 16**	**n= 26**	**n= 42**	**n= 30**	**n= 58**	**n=88**	**n=30**	**n=58**	**n=88**	**n=46**	**n=42**	**n=88**
Post-test, median	88	88	88	63	63	63	75	75	75	0.003Δ	<0.001Δ	<0.001Δ	0.596Δ	0.696Δ	0.261Δ
(P_{25}; P_{75})	(72;100)	(88;100)	(75;100)	(50;75)	(59;75)	(50;75)	(63;88)	(63;88)	(63;88)						
Evolution, mean	18	23	21	5	4	4	11	14	13	0.098*	0.004*	<0.001*	0.531*	0.905*	0.601*
(CI)	(5;30)	(14;32)	(14;28)	(-6;15)	(-5;13)	(-3;11)	(3;19)	(8;21)	(8;18)						

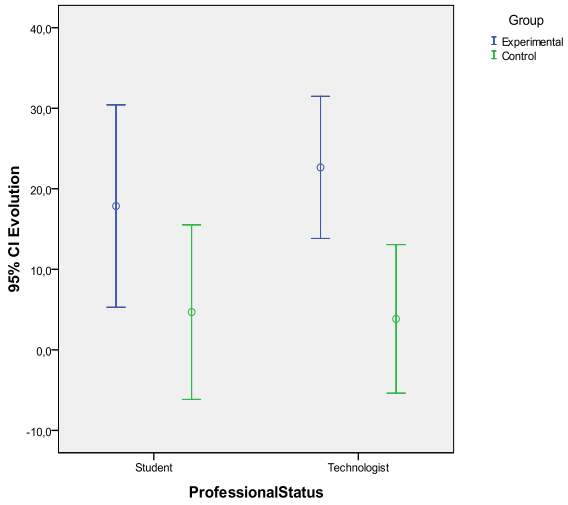

Figure 9: Error bar of the "evolution" variable, stratified by "professional status" (students and radiographers). In the students group, there is an overlapping of the CI between the respective experimental and control group (intervention: [5;30], control [-6;15]; p=0.098). On the ohter hand, regarding radiographers the CI do not override (intervention: [14;32]; control [-5;13]; p=0.004).

5.2.2 Per-protocol analysis

In this type of analysis those who were considered "lost to follow up" (n=10) and "discontinued intervention" (n=4) in the intervention group were allocated in the control group. As a result, the overall evolution is positively different in the two groups (intervention: μ=26, control: μ=2; p<0.001).

Unlike the intention-to-treat analysis, significant differences in students can be observed in the analysis protocol (intervention: μ=25, control: μ=3, p=0.004) beyond a remaining positive evolution among the radiographers (intervention: μ=27, control: μ=2, p<0.001). The confidence intervals can be seen in Figure 10.

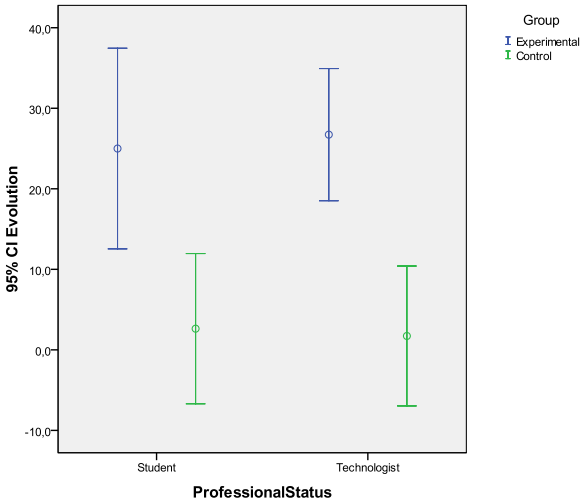

Figure 10: Error bar of the "evolution" variable stratified by "professional status" (students and radiographers) in the per-protocol analysis. The CI observed between the experimental and control group in students do not overlap (intervention: [13;37]; control [-7;12]; p=0.004), in the same way as radiographers (intervention: [19;35]; control [-7;10]; p<0.001).

5.2.3 Query regarding specificity

The query regarding the definition of specificity comprised the following structure:

"The Mammography is considered the best screening exam for breast cancer, because it has a high specificity, which means:

1. It is a painless and harmless exam to the women;
2. It has a good ability to detect cases without malignancy;
3. It has a good ability to detect a malignant lesion;
4. Allows better distinction of lesions in young women."

The answer which was considered correct was b). Overall, the failure rate associated to this query was 94% (n=100) in the pre-test and 55% (n=48) in the pos-test, reflecting an improvement of 41% (p<0.001).

In the pre-test, 89 (83%) individuals selected the option c), concerning the definition of sensitivity, and in the post-test there were 43 (40%) (intervention: pre-test - 42 (78%) and post-test - 12 (22%); p<0.001; control: pretest – 48 (89%) and post-test - 31 (59%); p=0.125).

The students presented a failure rate of 95% (n=37) in the pre-test and 43% (n=13) in the post test, thus reflecting an overall improvement of 43%. The respective intervention group had a failure rate of 90% (n=18) in the pre-test and 36% (n=5) in the post-test, thus reflecting an improvement of 64%. Regarding the control group, the rate failure represented 100% (n=19) in pre - test and 75% (n=12) in post-test, with an improvement of 25% (intervention vs control: p=0.030).

The radiographers presented a failure rate of 93% (n=63) in the pre-test and 53% (n=31) in the post-test, presenting an overall improvement of 40%. In the intervention group, there was a 91% (n=31) in pre-test and 25% (n=8) in the post-test, thus reflecting an improvement of 66%, and in the control group the failure rate was 94% (n=32) in the pre-test and 69% (n=18) in the post-test, thus demonstrating an improvement of 7%. (intervention vs control: p<0.001).

Regarding the difference of improvement between the two professional categories, were not found significant values.

5.3 Effectiveness and satisfaction

The majority of participants (81%) in the intervention group agreed to take the course (13 students and 31 radiographers) and four (9%) did not attend the full course, being considered "discontinued intervention" (two (10%) students and two (6%) radiographers).

Every participant that concluded the eLearning course answered the satisfaction questionnaire (n=40). The answers can be observed in Table 8.

Considering global measures (Q25 and Q26), 85% are satisfied with the eLearning system and 88% consider that the system is successful (between six and seven-point; students vs. radiographers: p=0.660).

Concerning content (Q1-Q4), 38 (95%) learners think that the system provides useful, up-to-date and sufficient content. Regarding interface (Q5-Q15), almost all the participants consider the system user-friendly, easy to use and to understand.

Table 8: Satisfaction questionnaire results. The results are exposed in a seven-point Likert-scale.

	1	2	3	4	5	6	7	Median (P_{25}; P_{75})
Q1. The eLearning system provides content that exactly fits your needs.				1 (3)	11 (28)	17 (43)	11 (28)	6 (5; 7)
Q2. The eLearning system provides useful content.					2 (5)	18 (45)	20 (50)	7 (6; 7)
Q3. The eLearning system provides sufficient content.			1 (3)	4 (10)	11 (28)	14 (35)	10 (25)	6 (5; 7)
Q4. The eLearning system provides up-to-date content.				1 (3)	3 (8)	17 (43)	19 (48)	6 (6; 7)
Q5. The eLearning system is easy to use.					3 (8)		37 (93)	7 (7; 7)
Q6. The eLearning system makes it easy for you to find the content you need.					5 (13)	10 (25)	25 (63)	7 (6; 7)
Q7. The content provided by the e-learning system is easy to understand.					1 (3)	11 (28)	28 (70)	7 (6; 7)
Q8. The eLearning system is user-friendly.						6 (15)	34 (85)	7 (7; 7)
Q9. The operation of the e-learning system is stable.					2 (5)	12 (30)	26 (65)	7 (6; 7)
Q10. The eLearning system responds to your requests fast enough.		1 (3)	1 (3)		7 (18)	8 (20)	23 (58)	7 (6; 7)
Q11. The eLearning system makes it easy for you to evaluate your learning performance.			1 (3)		5 (13)	19 (48)	15 (38)	6 (6; 7)
Q12. The testing methods provided by the e-learning system are easy to understand.			1 (3)	2 (5)	1 (3)	12 (30)	24 (60)	7 (6; 7)
Q13. The testing methods provided by the e-learning system are fair.		1 (3)	1 (3)	2 (5)	8 (20)	16 (40)	12 (30)	6 (6; 7)
Q14. The eLearning system provides secure testing environments.			1 (3)	2 (5)	9 (23)	15 (38)	13 (33)	6 (5; 7)
Q15. The eLearning system provides testing results promptly.					2 (5)	3 (8)	35 (88)	7 (7; 7)
Q16. The eLearning system enables you to control your learning progress.		1 (3)			8 (20)	10 (25)	21 (53)	7 (6; 7)
Q17. The eLearning system enables you to learn the content you need.				2 (5)	3 (8)	24 (60)	11 (28)	6 (6; 7)
Q18. The eLearning system enables you to choose what you want to learn.			1 (3)	3 (8)	7 (18)	16 (40)	13 (33)	6 (5; 7)
Q19. The eLearning system records your learning progress and performance.				2 (5)	6 (15)	17 (53)	15 (38)	6 (6; 7)
Q20. The eLearning system provides the personalised learning support.		2 (5)	2 (5)	5 (13)	8 (20)	13 (33)	10 (25)	6 (5; 7)
Q21. The eLearning system makes it easy for you to discuss questions with your teachers.	2 (5)	3 (8)	4 (10)	9 (23)	10 (25)	6 (15)	6 (15)	5 (4; 6)
Q22. The eLearning system makes it easy for you to discuss questions with other students.	3 (8)	3 (8)	6 (15)	10 (25)	8 (20)	5 (13)	5 (13)	4 (4; 7)
Q23. The eLearning system makes it easy for you to share what you learn with the learning community.	2 (5)	1 (3)	1 (3)	12 (30)	10 (25)	7 (18)	7 (18)	5 (4; 6)
Q24. The eLearning system makes it easy for you to access the shared content from the learning community.	2 (5)	1 (3)	3 (8)	8 (20)	11 (28)	8 (20)	7 (18)	5 (4; 6)
Q25. As a whole, you are satisfied with the eLearning system.					6 (15)	22 (55)	12 (30)	6 (6; 7)
Q26. As a whole, the eLearning system is successful.				1 (3)	4 (10)	22 (55)	13 (33)	6 (6; 7)

Regarding personalisation (Q16-120), 28 (70%) participants are satisfied with the control the learning progress, activating the content that the learner needs and choosing what the learner wants to learn. Also it records the learning progress and performance. However, 12 (30%) learners disagree about the personalised learning support. "Learning community" (Q21-Q24) was the category which learners showed less satisfaction; 27 (68%) learners agree that the eLearning system is not structured to facilitate knowledge sharing and contents discussion by elearners with their teachers and colleagues.

Of the 40 elearners, 4 (10%) had previous eLearning experience, and 2 (5%) performed it in the health area. However, the overall satisfaction did not differ between these participants and those who had no previous experience of eLearning (Q25: p=0.191; Q26: p=0.144). For all other questions only one difference was found in Q11, concerning the evaluation of the learning process (p=0.027).

6. Discussion

According to the literature review aforementioned in Chapter 2, the evaluation of eLearning systems has proved to be important for teaching and learning quality assurance purpose in these systems, thereby promoting eLearning at the expense of traditional method. Increasingly, the continuing education is valued within the professional scope and it is a fact that eLearning is increasingly sought and used, even in current days due to the budgetary constraints and economic crisis we are facing.

In the various studies reported in literature, the evaluation of these systems is based mainly on its efficacy and user satisfaction, filling the requirements for the assessment of levels I and II of the Kirkpatrick's platform. In this project, the same approach was performed through a randomized controlled trial. There are some RCTs, but as aforementioned more studies are needed. Concerning the senology area, only a few eLearning courses can be found (one Brazilian and the others in English) but the respective evaluation methods and validation were not encountered in literature. For this reason, a comparative analysis between the results of the eLearning courses and our work cannot be carried out.

Through the analysis of the results attainted and in respect to the description of the sample we noticed that there are no statistically significant differences between control and intervention groups, which highlight the effect of randomisation. Regarding students and radiographers, besides age and academic qualifications, we did not find significant differences, which lead us to conclude that it was not necessary to stratify the sample. After studying the association between variables it was verified that there was no significant relationship between them.

Applying the "intention-to-treat" analysis overall it was observed an improvement of 21 percentual points (pp) due to the course performance. The evolution in students was not statistically different between the control and the intervention groups. Although the effect was not clear in students (intervention:

18pp *vs* control: 5pp; p=0.098), we found differences in post-test results between intervention and control (88% *vs* 63%; p=0.003) whereas such difference was absent in pre-test (63% *vs* 63%; p=0.106). This result could be explained by the fact that not all students that performed the pre-test did the post-test, being seven students in the intervention and three in the control group considered "lost to follow-up". In addition, probably some students can achieve more knowledge by self-learning or that there was interest from students in the control group in learning more after performing the pre-test.

Regarding the radiographers, those who were allocated to the intervention group have acquired better results at the post-test (23pp *vs* 4 pp), which can be explained by the positive evolution observed after the course performance. This reveals the importance of continuing education throughout their working lives.

The per-protocol analysis enhances the influence of the course, exposing a notorious effect on the students' group. Considering that the real course effect is probably in between the two statistical analysis, we can conclude that this RCT showed that the course is efficacious, since it brought improvement of knowledge to those who attended part of the intervention group.

Considering that the correct definitions of sensitivity and specificity are an important factor for a correct diagnosis of breast cancer and given that the radiographer participates in this process, it is essential to be aware about these definitions, as well as awareness of their role. Through this study we observed that a large number of students and radiographers failed in the definition of these terms. In this thesis the definitions were stated in accordance with the literature review in line with to Kavanagh *et al.* (2000) and FMUP (2004) in which the authors consider that mammography have a high sensitivity and specificity. However, recent studies have demonstrated that the specificity is lower in denser breasts (Ravert & Huffaker, 2010).

Beyond the fact that the course is efficacious, this RCT also demonstrated to be effective. In fact, only a minor percentage of the participants did not complete the course and those who concluded it revealed to be very satisfied with the eLearning system, across the satisfaction questionnaire. Concerning this topic, the success of the course has been shown mainly at the "interface" and "content" topics with a high degree of satisfaction, rather than in the topic of "learning community" which has a low degree of satisfaction. The construction design of the course consisted of an asynchronous eLearning system, simple and user friendly, not taking into consideration a teacher-student and student-student interaction; hence we can consider the low level of satisfaction in this segment as an expected result.

During this work we have encountered some situations that may be considered as limitations or biases to obtain the described results. In fact, if the time was not a constraint we could have extended the sample, and even designed a more complete course, thus possibly obtaining more significant results. In addition, user satisfaction questionnaires for the eLearning systems shown a lack of validation concerning the Portuguese language, however due to deadlines and timescales this procedure was not performed. Nevertheless, it should be noted that it was not possible to find in the literature any satisfaction questionnaire for eLearning systems in Portuguese, which suggests that a validation of the questionnaire used in this work can be taken as future work, taking advantage of the translation already carried out by a language skilled professional.

Another restraint is related with the manner how the study design was performed resulting in a time consuming process; due to the required accuracy not only in the selection and randomisation of the sample but also by the need of rigorous monitorisation. Furthermore we faced the risk of individuals resorting to external sources in order to provide correct answers to the tests, even if the authenticity was requested. This situation creates a slight bias which is difficult to control considering the study design. Following the study design, the randomisation was performed after completing the pre-test, i.e., only those who attended the pre-test were randomly allocated to intervention and control groups; though it can be considered as a positive fact because the same willingness of participants entering the study was clearly demonstrated, regardless of the group where they were allocated.

7. Conclusion

Breast cancer has become a serious public health problem relying on trusted diagnostic methods as the mammography, which is considered the best imaging technique for the screening of this disease. The radiographer has a key role in the screening and diagnosis of the disease, and participates in the process of reducing the mortality rate of breast cancer.

Despite some limitations, we consider that very satisfactory results were obtained, even overcoming expectations. Globally, this study underlines the importance of the radiographer as the first health care professional which interacts with the woman during the breast cancer screening process. In this context, the knowledge of senology concepts is an essential strength to the health professional, highly considered in some countries (such as in England, Denmark, Australia and USA). Unlike these countries, the breast cancer screening in Portugal is not organised by the government but by a private institution; this can be one of the reasons why there are no existing specific training programmes, and the role of the radiographer is not as differentiated and valued as in the previously mentioned countries. Another factor that may contribute to this situation in Portugal is the absence of a radiographers association, existing only private associations, such as trade unions, not directly related to radiographers.

7.1 Main findings

As the main finding we consider the improvement of knowledge on senology that the eLearning course provided to radiographers.

Overall, from this study it can be concluded that the course is efficacious, especially for radiographers, which highlights the need for continuing education, foreseeing also eLearning as an increasingly viable alternative to the traditional method.

This RCT also allowed to prove that the course is effective, since only 9% (4/44) of the learners dropped out during its performance. Moreover, the course showed to have a great level of satisfaction for both radiographers and students, mainly at the level of interface and contents topics.

Also, the high rate of participation in the study based in the sample assessed is an important aspect (57% of radiographers and 56% of students), which reflects the great interest shown by these professionals to participate in scientific research, thereby promoting their professional category. We consider that the motivation of these professionals and students to increase their skills and knowledge was remarkable. They took advantage of learning opportunities, namely this area of knowledge, which dignifies the radiographers' role as health care professionals committed to respond to the constant challenges that the profession provides them.

7.2 Main recommendations

We believe that this study highlights the importance of eLearning as a training platform increasingly sought and used, mainly due to budget constraints associated with the current economic context. ELearning should be the next trend for continuing education, and directors should invest in it thus improving the skills of their professionals and consequently enhancing healthcare services provided.

Regarding the future work, the ultimate goal may be to proceed to an overall improvement of the course, which could be, for example, the development of a practical training component, transforming the eLearning system from a web-based learning into a blended learning, consequently adding more credibility and effectiveness. Moreover, the accreditation of the course would be a crucial step for the certification of its quality. To cover the international market, the translation of the course into the English language could also be an achievable goal.

In addition, it would be interesting to realize a nationwide study in the same way that this project was developed.

In a more challenging long-term perspective, and even taking into account the development effort that this would imply, it could be interesting to explore the evaluation of the course towards levels 3 and 4 of the Kirkpatrick's platform, through the measurement of worksite implementation and the impact of organisation, and also studying the efficiency and costs aspects.

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Appendix

Appendix I: final pre and post-tests

Questionário

Este questionário está inserido num estudo para dissertação final de Mestrado em Informática Médica.

Realço que o objetivo do questionário não é avaliá-lo pessoalmente, pelo que agradeço a máxima sinceridade nas suas respostas, pedindo que não recorra a qualquer tipo de fontes externas.

Informo ainda que as respostas são direccionadas automaticamente para uma base de dados, sendo a mesma confidencial.

Desde já, obrigada pela sua disponibilidade.
* Required

Código para validação: *
Por favor coloque o código que lhe foi fornecido via mail, é FUNDAMENTAL. Caso contrário, não será possível a inclusão do questionário no estudo.

1. Qual a principal função das cristas de Duret? *

- a) Impedir a ptose mamária excessiva
- b) Unir os ligamentos de Cooper
- c) Produção de sebo
- d) Produção de leite

2. Que estrutura se evidencia mais na incidência médio oblíqua e que na incidência crâneo-caudal pode ser visualizada na parte posterior em cerca de ¼ das pacientes? *

- a) Músculo pequeno peitoral
- b) Músculo grande peitoral
- c) Espaço retromamário
- d) Prolongamento axilar

3. A mamografia é considerado o melhor exame de rastreio do cancro da mama, pois apresenta uma alta especificidade, ou seja: *

- a) Trata-se de um exame indolor e inócuo para a mulher
- b) Tem uma boa capacidade para detetar casos isentos de malignidade
- c) Tem uma boa capacidade para detetar uma lesão maligna
- d) Permite diferenciar melhor lesões em mulheres jovens

4. Qual é o achado mamográfico mais comum? *

- a) Calcificações
- b) Nódulos
- c) Distorção arquitetural
- d) Densidade assimétrica

5. Qual a principal indicação para a realização de uma galactografia? *

- a) Escorrência mamilar serosa unicanicular
- b) Escorrência mamilar hemática unicanicular
- c) Escorrência mamilar serosa pluricanicular
- d) Escorrência mamilar hemática pluricanicular

6. Qual é a definição de ginecomastia? *

- a) Aumento do volume da glândula mamária no homem
- b) Cancro da mama masculino
- c) Dor na mama masculina
- d) Diminuição do volume da glândula mamária no homem

7. Atualmente, a dose glandular média numa mamografia: *

- a) É cerca de 1 a 2 mGy por incidência
- b) É cerca de 0,3mGy por incidência
- c) É cerca de 10mGy por exame
- d) É cerca de 12 a 14mGy por exame

8. Numa paciente impossibilitada de efetuar ortostatismo e acamada, a mamografia consiste: *

- a) Apenas nas incidências craneo-caudal
- b) Nas incidências standard de rotina
- c) Apenas nas incidências oblíquas médio-laterais
- d) Apenas nas incidências perfil estrito

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Questionário

Este questionário está inserido num estudo para dissertação final de Mestrado em Informática Médica.

Realço que o objetivo do questionário não é avaliá-lo pessoalmente, pelo que agradeço a máxima sinceridade nas suas respostas, pedindo que não recorra a qualquer tipo de fontes externas.

Informo ainda que as respostas são direccionadas automaticamente para uma base de dados, sendo a mesma confidencial.

Desde já, obrigada pela sua disponibilidade.
* Required

Código para validação: *
Por favor coloque o código que lhe foi fornecido via mail, é FUNDAMENTAL. Caso contrário, não será possível a inclusão do questionário no estudo.

1. Qual é o sinónimo de amastia? *

- a) Ausência de mama
- b) Gigantomastia
- c) Escorrência mamilar
- d) Dor na mama

2. Durante a realização da mamografia, aquando da compressão, a paciente apresenta uma escorrência de cor esverdeada. Este sinal: *

- a) Trata-se de um sinal de malignidade
- b) Não se trata de um sinal de malignidade
- c) Apresenta indicação para fazer uma ressonância magnética
- d) Apresenta indicação para fazer uma biopsia

3. A mamografia é considerado o melhor exame de rastreio do cancro da mama, pois apresenta uma alta especificidade, ou seja: *

- a) Trata-se de um exame indolor e inócuo para a mulher
- b) Tem uma boa capacidade para detectar casos isentos de malignidade
- c) Tem uma boa capacidade para detetar uma lesão maligna
- d) Permite diferenciar melhor lesões em mulheres jovens

4. Qual o exame mais apropriado para avaliar uma ruptura de uma prótese mamária? *

- a) Mamografia
- b) Ecografia
- c) Tomografia Emitida por Positrões
- d) Ressonância Magnética

5. Qual a patologia mamária benigna mais comum? *

- a) Fibroadenoma
- b) Cicatriz radial
- c) Hamartoma
- d) Papiloma

6. Das opções a seguir indicadas, qual representa o cancro na sua forma mais precoce? *

- a) Carcinoma ductal invasor
- b) Tumor filoide
- c) Carcinoma ductal in situ
- d) Doença de Paget

7. Que factor determina a quilovoltagem adequada numa mamografia? *

- a) O material do ânodo da ampola
- b) A espessura da mama no final da compressão
- c) A filtragem da ampola
- d) O posicionamento

8. Qual a finalidade da incidência túnel? *

- a) Cobrir os quadrantes internos
- b) Cobrir os quadrantes externos
- c) Cobrir os quadrantes superiores
- d) Cobrir os quadrantes inferiores

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Appendix II: original satisfaction questionnaire

Measurement of electronic learner satisfaction

Q1. The e-learning system provides content that exactly fits your needs.
Q2. The e-learning system provides useful content.
Q3. The e-learning system provides sufficient content.
Q4. The e-learning system provides up-to-date content.
Q5. The e-learning system is easy to use.
Q6. The e-learning system makes it easy for you to find the content you need.
Q7. The content provided by the e-learning system is easy to understand.
Q8. The e-learning system is user-friendly.
Q9. The operation of the e-learning system is stable.
Q10. The e-learning system responds to your requests fast enough.
Q11. The e-learning system makes it easy for you to evaluate your learning performance.
Q12. The testing methods provided by the e-learning system are easy to understand.
Q13. The testing methods provided by the e-learning system are fair.
Q14. The e-learning system provides secure testing environments.
Q15. The e-learning system provides testing results promptly.
Q16. The e-learning system enables you to control your learning progress.
Q17. The e-learning system enables you to learn the content you need.
Q18. The e-learning system enables you to choose what you want to learn.
Q19. The e-learning system records your learning progress and performance.
Q20. The e-learning system provides the personalized learning support.
Q21. The e-learning system makes it easy for you to discuss questions with your teachers.
Q22. The e-learning system makes it easy for you to discuss questions with other students.
Q23. The e-learning system makes it easy for you to share what you learn with the learning community.
Q24. The e-learning system makes it easy for you to access the shared content from the learning community.
Q25. As a whole, you are satisfied with the e-learning system.
Q26. As a whole, the e-learning system is successful.

Appendix III: translated satisfaction questionnaire

Avaliação da satisfação do estudante e-learning

Q1. O sistema de e-learning fornece conteúdos que se adequam exatamente às suas necessidades.
Q2. O sistema de e-learning fornece conteúdos úteis.
Q3. O sistema de e-learning fornece conteúdos suficientes.
Q4. O sistema de e-learning fornece conteúdos atualizados.
Q5. O sistema de e-learning é fácil de utilizar.
Q6. O sistema de e-learning permite que aceda facilmente aos conteúdos de que necessita.
Q7. Os conteúdos fornecidos pelo sistema de e-learning são de fácil compreensão.
Q8. O sistema de e-learning é de fácil utilização.
Q9. O sistema de e-learning apresenta um funcionamento estável.
Q10. O sistema de e-learning responde com rapidez suficiente aos seus pedidos.
Q11. O sistema de e-learning facilita a avaliação do seu desempenho na aprendizagem.
Q12. Os métodos de teste fornecidos pelo sistema de e-learning são de fácil compreensão.
Q13. Os métodos de teste fornecidos pelo sistema de e-learning são justos.
Q14. O sistema de e-learning proporciona um ambiente de teste seguro.
Q15. O sistema de e-learning disponibiliza os resultados dos testes rapidamente.
Q16. O sistema de e-learning permite-lhe controlar o seu processo de aprendizagem.
Q17. O sistema de e-learning permite-lhe aprender os conteúdos de que necessita.
Q18. O sistema de e-learning permite-lhe selecionar o que pretende aprender.
Q19. O sistema de e-learning grava o seu progresso e desempenho na aprendizagem.
Q20. O sistema de e-learning fornece um apoio à aprendizagem personalizado.
Q21. O sistema de e-learning permite-lhe esclarecer dúvidas com os seus professores facilmente.
Q22. O sistema de e-learning permite-lhe esclarecer dúvidas com outros alunos facilmente.

Q23. O sistema de e-learning facilita a partilha dos conhecimentos adquiridos com a comunidade de estudantes.
Q24. O sistema de e-learning permite-lhe aceder facilmente aos conteúdos partilhados da comunidade de estudantes.
Q25. No geral, está satisfeito com o sistema de e-learning.
Q26. No geral, o sistema de e-learning é bem sucedido.