

## Characterization of breast imaging education and insights from students, radiographers and teaching staff about its strengths, difficulties and needs

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### ABSTRACT

**Introduction:** The study aimed to characterize breast imaging education and identify its strengths, difficulties and needs across five European countries according to student, radiographer and teaching staff perspectives.

**Methods:** An observation grid was used to collect data regarding breast imaging education and three questionnaires targeted to key-participants were developed/applied to collect data on strengths, difficulties and needs. Descriptive statistics and thematic analysis were performed according to the nature of the questions.

**Results:** Breast imaging curricula varied within and between countries. Response rate for questionnaires also varied (13–100%). More than one-third of the teaching staff (37.5%) was involved in breast research projects. This was identified as the main strength in breast imaging education followed by collaborations between hospitals and academia. Difficulties with their education program identified by the 97 students surveyed included teaching issues (45), breast positioning (18), variety of image evaluation strategies (10) and human interaction (6). The need to provide an explanation to the patient about the role of the student in the mammography setting, and performing exams and teaching at the same time (22.6%) was identified as difficult by radiographers. The need for education and training in communication, practice and technological developments was identified.

**Conclusions:** A bridge between academia and clinical practice is extremely important in order to overcome recognized gaps between theory and practice. The development of a European education program covering the needs identified by the participants could be a possible solution to improve knowledge and access, and also to harmonize education and training across Europe.

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### Introduction

Early detection of breast pathology increases the survival rate by facilitating a fast intervention in the course of the disease, improving the chances of a more effective treatment.<sup>1</sup> The use of medical

imaging, namely screening mammography, is the prime methodology to achieve an early diagnosis of breast cancer, alongside the technological improvements introduced in the past few years to improve sensitivity and specificity of the examination.<sup>1–3</sup> At the same time, efforts have been made worldwide to create patient-centred breast specialisation units, combining experts from all intervenient areas, for a more successful approach to deal with the disease.<sup>1</sup> In Europe, the European Society of Breast Cancer Specialists (EUSOMA) published<sup>4,5</sup> requirements that should be considered

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in setting up specialized breast units, where education and training for all parties involved in the process are highlighted, including radiographers. However, the radiography profession in individual European countries is based on different curricula and levels. Studies from the European Federation of Radiographer Societies (EFRS) and other European findings have emphasized the variability showing differences in the content, level of knowledge, practice and educational approaches.<sup>6–9</sup> Considering the different contexts, it is important to understand if EUSOMA requirements for breast imaging are being introduced into the curricula of radiography programs across Europe, and how the requirements are also being integrated into Continuous Professional Development (CPD) activities. It is relevant to verify if students and radiographers are exposed to the most updated knowledge and to all specialized areas available in breast imaging. This is to spot potential opportunities for optimization in work and training.<sup>6,10–16</sup> The purpose of this study was to characterise the current education situation regarding breast imaging. The main strengths, difficulties and needs in mammography education were explored across five European countries according to the perspectives of students, clinical radiographers involved in mammography internships and teaching staff.

## Methodology

To achieve the aims of this study, a mixed methodology was applied based on curricula analysis, using an observation grid, to compare the breast imaging/mammography courses,<sup>4</sup> and three dedicated questionnaires targeted to the three key-informant groups from five European countries involved with the EBreast Project,<sup>1,17,18</sup>:

1. Undergraduate students who had breast imaging/mammography education and training in their studies/curricula: second and third years in Finland, Estonia, Norway and Switzerland; third and fourth years in Portugal.
2. Radiographers of mammography departments who were clinical placement supervisors collaborating with the educational institutions providing medical imaging/radiography education.
3. Teaching staff involved in breast imaging/mammography education and training at educational institutions: Tartu Health Care College – Estonia; Metropolia University of Applied Sciences and Oulu University of Applied Sciences – Finland, Western Norway University of Applied Sciences – Norway; Lisbon School of Health Technology - Portugal; University of Applied Sciences and Arts Western Switzerland–Switzerland and Medi, Zentrum für Medizinische Bildung – Switzerland.

Depending on the nature of the information gathered, the questions were either open or closed-ended (Table 1). Using closed-ended questions, participants were asked their age, gender, country of residence, academic background and the duration of professional experience in mammography (Table 1). This information allowed the characterization of the respondent profile, and the grouping of answers by country facilitated the comparison. The questionnaires were designed to capture the common practice in education and training regarding breast imaging in general and mammography

specifically, including organizational matters and resources (Table 1). Both technological and organizational aspects were considered relevant due to their influence on the outcomes of the mammography process and examination, workload and workflow which can affect the time allocated to each exam and, consequently, the time spent by radiographers teaching mammography during clinical placements.<sup>19</sup> Other issues explored related to education and training in breast imaging, namely: difficulties in anticipating the challenges that can be faced during the educational process, needs for further education in building up better aligned courses/programs, and opportunities/strengths of breast imaging education to identify what was relevant and adequate. Open-ended questions were used to collect more detailed information and the answers were examined using thematic analysis.<sup>20</sup> These areas were partially explored in a previous study,<sup>16</sup> but to expand to a larger population, questionnaires were applied to collect more detailed information with a uniform approach.

Prior to distribution, the questionnaires were tested by key informant groups represented by three radiographers, three students and three radiography lecturers from all participating countries (Estonia, Finland, Norway, Portugal and Switzerland) to verify if the questions were relevant, the content was clear and if they were properly adapted to each group. The feedback was incorporated to improve the quality of the questionnaires, where appropriate. The questionnaire for radiographers was translated into the respective national languages of Finland, Portugal and Switzerland (French and German), using one-way translation followed by the verification of the language for clarity and content.

Statistical analysis of quantitative data from the closed-ended questions was performed using the software packages SPSS (version 21, IBM) and MS Excel (version 2010, Microsoft). Descriptive statistics were used due to the exploratory nature of this study.

The educational institutions obtained approval from their respective Executive Boards, thereby meeting the requirements for each institutional context. All participants involved in this study gave informed consent immediately after reading the cover letter on the first page of the questionnaire, informing them about the context and objectives of the study.

## Results

The results of this study are reported in two sections with one dedicated to the breast imaging curricula and the other to the questionnaires.

### Breast imaging curricula

Breast imaging education was covered in all medical imaging/radiography programs of the participant institutions (Table 2). In seven (out of ten) educational institutions, breast imaging content is spread over several units, while the remaining three institutions have a dedicated unit for the discipline. The number of contact and study hours ranged between 10 and 162 h, the topics covered and the clinical placement for breast imaging also varied (Table 2). All participant institutions covered anatomy, pathology, instrumentation, physics, quality assurance, quality control, mammographic technique, interventional procedures, magnetic resonance, ultrasound and tomosynthesis. In Finland, Estonia and Switzerland, their programs also covered patient care and safety, while in Portugal other topics were also included such as dosimetry, ergonomics, new developments, interprofessional approach and communication.

Clinical placement/practice for this area was mandatory in Estonia and Portugal, while in Finland it was mandatory or optional, depending on the institution. For the rest of participant countries (Norway, Switzerland), clinical placement was optional.

<sup>1</sup> The EBreast project is aimed at producing interprofessional mixed mode Open Access e-learning packages to increase the competences for early breast cancer detection and diagnostic procedures among health care professionals, students and teachers in the field, following the principles of interprofessional education. Considering the aims, this study was carried out to identify the areas that required more education and what are the current difficulties. The consortium includes Health Schools, Hospitals and a Radiation Protection entity from 5 European countries (Estonia, Finland, Norway, Portugal and Switzerland).

**Table 1**

The structure of questionnaires: dimensions, questions organized by dimensions, type of question (open/closed-ended) and target participants by questions/dimensions.

Dimensions	Questions	Type	Questionnaire targets
Participant profile	Gender (female/male)	Closed	Students
	Age (5 ranges)	Closed	Teaching staff
	Country of residence (5 countries)	Closed	Radiographers
	Academic background	Closed	
	Experience in radiology/mammography (years)	Open ended	Teaching staff Radiographers
Institution profile	Teaching/supervising experience (years)	Open ended	
	Type of institution (e.g. university, hospital)	Multiple choice	Teaching staff Radiographers
	Type of funding (e.g. private/public/shared)	Multiple choice	
Educational issues	Strongest points/Strengths	Open ended	Students
			Teaching staff
	Difficulties/Challenges	Open ended	Students
			Teaching staff
	Difficulties related to the clinical placement	Closed	Radiographers
	Reported needs of education and/or training	Closed	Students
		Open ended	Teaching staff
General	Research in mammography	Closed	Radiographers
	Areas of research	Open ended	Teaching staff
	Comments/Observations	Open ended	All

Material resources were not available for all educational institutions: four had mammography equipment installed, two had phantoms for positioning practice and three had phantoms for conducting quality control procedures.

### Questionnaires

A total of 254 questionnaires were completed by 97 students, 141 clinical radiographers and 16 teaching staff (Table 3).

### Characterization of students, radiographers and teaching staff

The overall majority of the students (79.4%, 77/97), radiographers (92.1%, 129/141) and teaching staff (87.5%, 14/16) were female. The majority of students (63%, 61/97) were in their third year of training on a radiography/medical imaging program, 17.5% (17/97) in their second year, 17.5% (17/97) in their fourth year and 2.1% (2/97) in postgraduate/Master's degree studies.

The participating teaching staff had at least a Master's degree (MSc) (37.5%, 6/16) and 25% (4/16) a Doctoral Degree (PhD), while more than two-thirds of radiographers working in clinical practice had a Bachelor degree (BSc) (71.4%, 101/141) but some also had post graduate studies and/or MSc (28.6%, 40/141).

The radiographers' average work experience in mammography was 12 years (ranging from 1 to 36) and the average supervision experience of students' clinical internship was 7 years (ranging from 1 to 29). The teachers' average experience in mammography education was 9 years (ranging from 1 to 20).

### Characteristics of healthcare institutions and educational institutions

Radiographers supervising students during their mammography internship were employed in healthcare institutions with different profiles (Table 4), mainly private. Teaching staff were mostly employed in public educational institutions (62.5%).

### Strengths of mammography education and training

The main strength highlighted by students from all participant countries was the theoretical content covered (Table 5). The practical training performed in the skills lab or during internship in a hospital or screening department was considered a very positive aspect of breast imaging education by students from Finland and Portugal. The students from Portugal and Switzerland also referred to clinical case analysis and image evaluation criteria as very important and well performed, they considered this as strong

preparation during their education. Estonian, Portuguese and Swiss students reported communication and interaction with the patient as a topic emphasised in theoretical studies as well as in practical modules. Norwegian students highlighted the workshops and lectures provided by hospital staff prior to clinical placements as strengths in their education. The radiographers gave them an insight into the real context, preparing them for what they can expect regarding mammography specifics and requirements.

Portuguese teaching staff highlighted as the strengths of mammography education the use of various teaching strategies, e.g. theoretical lectures combined with practical training in the skills lab, case studies and discussions in small groups. Additionally, the specific breast imaging unit available in the program allowed for the inclusion of all imaging modalities and techniques used to study the breast, the role of interventional procedures and exposure to other professionals working together on breast pathology diagnosis. Teaching staff in Norway and Finland reported on the introduction of quality assurance topics and the integration of theory and practice as strengths of mammography education. Research projects have been developed by 37.5% (6/16) of the teaching staff involved in mammography education and training, relating to breast imaging, compression optimization, implementation of quality control and evaluation of its impacts, and were considered by them as a strength.

### Difficulties in mammography education and training

Based on 97 (out of 110) student responses to the open-ended questions about difficulties in breast imaging education, five areas were identified: transition from theory into practice, lack of resources, time allocated, breast positioning and image assessment and interpretation (Table 6). The most common difficulties reported by students were related to issues such as insufficient contact hours, pedagogical approaches used, and teaching skills (45 responses), followed by breast positioning issues (18 responses). Image assessment (10 responses), lack of resources (4 responses) and human interaction (7 responses) were also identified as difficult aspects of learning and practice. Mammography education was considered too brief in Finland, Norway and Switzerland, involving only a few contact hours at school and the transition from theory into practice was referred to as challenging.

Regarding breast positioning, the Medio-lateral Oblique (MLO) technique was considered very demanding as was image quality assessment, especially when the PGMI (perfect, good, moderate, inadequate) scale is used to check positioning performance and

**Table 2**  
Summary of breast imaging curricula for the ten participating educational institutions.

	Estonia	Finland	Norway	Portugal	Switzerland
Radiography program duration/ECTS	3.5 years/210 ECTS	3.5 years/210 ECTS	3 years/180 ECTS	4 years/240 ECTS	3 years/180 ECTS
Units covering breast imaging education and training	Yes 3 ECTS (incl. lab 18 h)	Yes 4 to 6 ECTS (including labs) depending on educational institution	No Breast Imaging spread across several units	No/Yes Breast Imaging spread across several units OR Breast Imaging unit (4 ECTS) depending on the educational institution	No Content related to mammography in one unit, but, other breast imaging modalities, physics and radiation safety related to digital mammography and breast cancer treatment spread across different units
Hours	1 ECTS = 26 h of student work	1 ECTS = 27 h of student work	10 h (theoretical)	Between 20 and 108 h depending on the educational institution	22 h theoretical 6 h labs and case scenario analysis 1 h nuclear medicine
Topics covered	<ul style="list-style-type: none"> <li>- Anatomy</li> <li>- Pathology</li> <li>- Instrumentation</li> <li>- Physics</li> <li>- Patient care, incl. patient preparation and evaluation of image quality</li> <li>- Breast screening</li> <li>- Clinical mammography</li> <li>- Further examinations: MRI, US, nuclear medicine</li> <li>- QA/QC</li> <li>- Patient safety</li> <li>- Breast self -examination</li> </ul>	<ul style="list-style-type: none"> <li>- Anatomy</li> <li>-Pathology</li> <li>- Instrumentation</li> <li>- Physics</li> <li>- RIS</li> <li>- Patient care in breast imaging including evaluation of clinical image quality</li> <li>- Breast screening</li> <li>- Clinical mammography</li> <li>- Interventions in mammography</li> <li>- Further examination: MRI, DBT, CEDM, US</li> <li>- QA/QC</li> <li>- Patient safety in breast imaging</li> </ul>	<ul style="list-style-type: none"> <li>- Anatomy</li> <li>-Pathology</li> <li>- Instrumentation</li> <li>- Mammography</li> <li>- Intervention</li> <li>- DBT</li> </ul>	<ul style="list-style-type: none"> <li>- Anatomy</li> <li>- Pathology</li> <li>-Patient/radiographer communication</li> <li>- Instrumentation</li> <li>- Physics</li> <li>- Radiation Protection and Dosimetry</li> <li>- Mammography: diagnosis, screening, follow up, intervention</li> <li>- Further exams: MRI, DBT, CEDM, NM, US</li> <li>- Breast imaging developments (Breast CT, Breast Laser CT, thermography, PEM)</li> <li>- QA/QC</li> <li>- Interprofessional collaborations for diagnosis and treatment of breast pathologies</li> <li>- CAD system</li> <li>- Display systems</li> <li>- Post processing tools</li> <li>- Ergonomics</li> </ul>	<ul style="list-style-type: none"> <li>- Anatomy</li> <li>-Pathology</li> <li>- Physics</li> <li>- Instrumentation</li> <li>- Mammography including patient care, technical parameters, positioning QA/QC of clinical mammograms</li> <li>- Further exams: MRI, DBT, US, NM</li> <li>- Radiation Safety</li> <li>- Epidemiology and breast cancer screening programs in Switzerland</li> </ul>
Material resources	- Laboratory and Phantom available for positioning	- Laboratory available - Phantom for positioning not available	- Laboratory available, no mammography equipment available - Phantom for QC available	- Laboratory available - Phantom for positioning not available - Phantom for QC available	- Laboratory not available at school but in the university hospital - Phantom for QC and positioning available
Clinical practice	Obligatory 3 ECTS; additionally 3 ECTS in the final year if the students already know that they are going to work in mammography after graduation	In some institutions optional, in some obligatory about 80 h	120 h practical eligible	Minimum hours in clinical practice for breast imaging: 30 h	Clinical practice in mammography is optional 40 or 80 h depending the project of the student. Option rarely requested by students

Observations	Clinical practice includes diagnostic and screening mammography as well as assisting in biopsies	Variation in contents depending on educational institution Topics related to mammography have been divided into different study units: Physics, Radiation protection, Mammography and US examination	Clinical practice include diagnostic and screening mammography, intervention and breast MRI	Clinical practice include diagnostic and screening mammography, intervention and breast MRI	This information is valid for Western Switzerland
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**Notes** Total number of Medical Imaging programs available in this group of countries: 24; Number of educational institutions participating: 10.

CEDMI: Contrast Enhancement Digital Mammography; US: Ultrasound; MRI: Magnetic resonance Imaging; NMI: Nuclear Medicine; QA/QC: Quality Assurance, Quality Control; DBT: Digital Breast Tomosynthesis; CAD: Computer Aided Detection; CT: Computed Tomography; PEM: Positron Emission Mammography.

image quality. Identifying breast pathology in dense breasts was another area considered as challenging and difficult.

Portuguese, Swiss and Finnish students reported on the absence of skills labs and/or phantoms and its impact on practical training, primarily because it was not possible to acquire images. Communication with patients was noted as very difficult during hospital placements.

Radiographers when responding to the question: “*What are the difficulties and their frequency in mammography education in your daily practice?*” noted difficulties in explaining all of the content to students (31/141; 22%), supervising them (31/141; 22%) as well as performing clinical examinations and teaching at the same time (29/141; 20.5%) (Fig. 1). Management of the work list and the mammography room were considered very challenging in Portugal (75/141; 52.9%) and Switzerland (34/141; 24.1%). The need to provide an explanation to the patient about the role of students inside the mammography room was identified by radiographers as the most evident difficulty during internships in Portugal and by some radiographers in Switzerland.

Teaching staff reported insufficient breast position training in the skills lab due to the lack of relevant phantoms and/or reduced contact hours, an issue also reported by students. Even the training strategy for positioning and communication, with students playing the roles of radiographers and patients, was considered limited by the teaching staff. It was not possible to simulate the context of screening programs (anxiety, body habitus, life experience, image acquisition and analysis) as students are mostly younger and have less life experience compared to the breast cancer screening population. Another aspect pointed out by teaching staff in Finland was the number of contact hours, e.g. five 45-min lectures. They noted that the number of contact hours available for breast imaging was insufficient to cover all the topics and only a few students had an opportunity to practice their skills in clinical practice, making communication with patients to be not well developed.

#### Education and training needs

The majority of students [61% (59/97)] and radiographers [80% (112/141)], but mainly those from Switzerland and from Finland, reported the need to update their knowledge and skills in all areas of breast imaging (Figs. 2 and 3). Portuguese and Estonian students reported a lower need for further education and training in breast imaging.

Students indicated that they need more education and practical training, namely to improve positioning and compression skills, as well as training in communication relating to interaction with patients (Fig. 4).

The areas highlighted by radiographers are different from students and are more related to the new techniques associated with mammography, e.g. tomosynthesis and contrast-enhanced digital mammography [54.3% (61/141)]. The identification of breast pathology [35.7%], improvements on breast positioning [30% (34/141)], optimization of procedures [26.4% (30/141)], image quality analysis [27.1% (30/141)] and quality control practice [20% (22/141)] were also emphasised. Promotion of anatomy knowledge [17.9% (20/141)], communication with patients [16.4% (18/141)], post-processing tools handling [14.3% (16/141)] and communication with the mammography team [12.1% (14/141)] were other topics addressed concerning areas where knowledge and skills need to be developed.

#### Discussion

This study combined the perspectives of students, teaching staff and clinical radiographers to explore the breast imaging curricula

**Table 3**  
The number questionnaires sent by country, informant profile and response rate.

Country	Profiles	Number of questionnaires sent	Number of answers obtained	Response rate (%)	Observations
Estonia	Students	17	4	24	Questionnaires sent to 1 out of 1 Radiography Program (3.5 years' programme – EQF level 6) available.
	Radiographers	16	8	50	
	Teaching Staff	1	0	0	
Finland	Students	138	24	17	Questionnaires sent to 2 out of 6 Radiography Programs (3.5 years' programme – EQF level 6) available.
	Radiographers	81	38	47	
	Teaching Staff	2	2	100	
Norway	Students	120	11	9	Questionnaires sent to 2 out of 6 Radiography Programs (3 years' programme – EQF level 6) available.
	Radiographers	47	10	21	
	Teaching Staff	4	3	75	
Portugal	Students	88	38	43	Questionnaires sent to 3 out of 6 Medical Imaging and Radiotherapy Programs (4 years' program – EQF level 6) available.
	Radiographers	33	19	58	
	Teaching Staff	4	4	100	
Switzerland	Students	88	20	23	Questionnaires sent to 2 out of 5 Radiography Programs (3 years' program – EQF level 6) available.
	Radiographers	500 (estimated)	66	13	
	Teaching Staff	12	7	58	
Total	Students	451	97	22	Designation and length of Radiography/Medical Imaging programs vary between the countries.
	Radiographers	677	141	21	
	Teaching Staff	23	16	70	

**Table 4**  
Profiles of healthcare institutions involved in mammography education.

Type of institution	Number of institutions	Percentage (%)
Public	29	20.7
Private	35	25.0
Partnership public/private	10	7.1
General hospital	28	20.0
University hospital	18	12.9
Clinic	2	1.4
Breast screening centre	7	5.0
Breast cancer centre	11	7.9
Total	140	100.0

content, strengths, difficulties and needs for mammography education and training.

#### Breast imaging curricula

Comparing content requirements for radiographers' education from EUSOMA<sup>4</sup> to the content available in breast imaging curricula offered by the participant educational institutions, it was possible to verify they were not fully covered in the units allocated to this specialisation. Health management of cancer and treatment options, communication, promotion, breast cancer and family history are the contents missing in more than three curricula analysed.

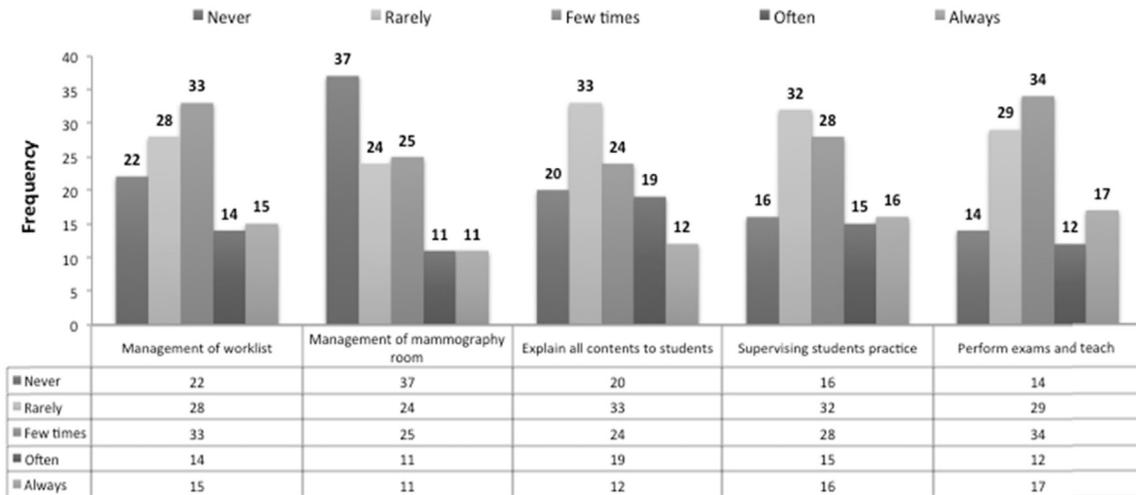
**Table 5**  
Strengths in mammography education and training identified by students.

Strengths in breast imaging/mammography education	Estonia	Finland	Norway	Portugal	Switzerland
Breast imaging/mammography - general theory	0	3	3	7	1
Anatomical theory	1	2	0	6	0
Pathology theory	1	0	0	4	0
Physics/technological/technique theory	1	2	0	7	2
Patient care, communication and empathy theory	1	1	0	8	1
Criteria for image quality assessment	0	5	1	3	0
Analysis of clinical case scenarios	0	0	0	6	7
Practical training	0	10	0	2	1
Peer tutoring/practical training	0	0	0	10	0
Practical training in hospital/collaboration with clinical Radiographers from hospital/screening programs	0	2	6	1	2
Critical thinking adapted to mammography/breast imaging	0	0	0	3	0
Having this topic in the program	0	2	0	0	0
Stimulation of self research	0	1	0	0	0
Answer not provided/None/Too soon to say	1	1	1	0	5

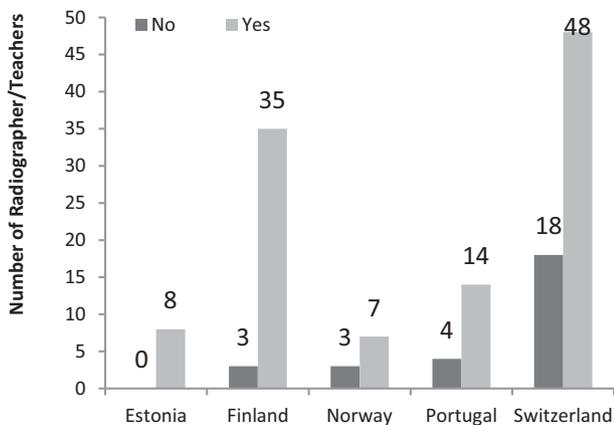
That could be due to the different structure of programs (radiography/medical imaging only) or due to the fact that in some of the participant institutions the subject is not compulsory. The requirements regarding practical content were included in breast imaging curricula for those institutions that had mandatory units and had equipment available (Estonia, Portugal). Institutions in Finland, Norway and Switzerland have partially included the requirements at BSc level when that unit was selected by students by using other facilities to overcome the absence of training materials (phantoms, mammography equipment). Estonia and Switzerland offer extra education and training for those students who elect to work in mammography adjusting the offerings to specific needs. These variations are expected since previous European studies<sup>9,21,22</sup> had already demonstrated the differences in medical imaging/radiography education across Europe. To some extent, the differences in mammography education can be justified by different requirements such as legislation, culture and resources available in each country. On the other hand, the perspectives students and radiographers have about mammography (repetitive nature, restriction to female staff only and high stress to get all imaging criteria correct) can lead to a lack of interest to specialize in this field, thereby affecting the availability of this area in medical imaging programs.<sup>15,16,23</sup> In the future, content that is not covered in basic breast imaging education could be developed as activities under the continuous professional development requirements, considering also the specific demands of job market.

**Table 6**  
Difficulties and/or areas for improvement in mammography education and training identified by students.

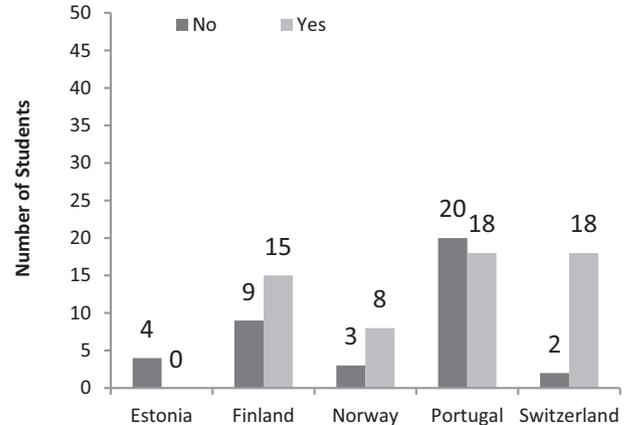
Difficulties related to breast imaging/mammography education	Estonia	Finland	Norway	Portugal	Switzerland
Transition of theory into practice	0	1	0	4	3
Theory and practice did not match well	0	3	0	0	0
Only theory no practice	0	0	2	0	0
Short allocation to other modalities (US, MRI, CEDM, DBT, intervention)	0	0	0	3	0
No material resources/lack of positioning phantoms	0	0	0	3	1
No practical training with phantoms at school before hospital	0	6	1	0	7
Few contact hours/Short time allocated to mammography education	0	4	4	0	2
Short time allocation to practice	0	0	0	4	0
Patient positioning (mainly MLO)	0	3	1	10	2
Male positioning	0	0	0	1	0
Perform and assess special views	1	0	0	0	0
Image quality assessment (PGMI) and pathology identification	2	0	0	5	3
Little/Few hours of practical training	0	7	0	0	0
No internship	0	1	3	0	0
Stressful to practice and interact with patients/communication	0	3	0	4	0
Lack of skills – teaching staff	0	1	0	0	0
Development of practical skills	0	0	0	2	0
Male students are not allowed at hospital	0	0	0	0	1
Answer not provided/None difficulty/Too soon to say	1	3	2	3	4



**Figure 1.** Answers frequency (never, rarely, few times, often or always) provided by radiographers to the question: “What are the difficulties and their frequency in mammography education in your daily practice?”



**Figure 2.** Number of radiographers/teaching staff referring needs of mammography education and training by country.



**Figure 3.** Number of students referring needs of mammography education and training by country.



**Figure 4.** Students' needs of mammography education and training presented by topic.

### Strengths of mammography education and training

The results also showed that the most evident strengths among the participant countries related to the preparation of theory and practice involving staff from the hospitals prior to clinical placements. According to student responses, this preparation, including discussion of clinical scenarios, enabled them to be more aware of challenges that they could face in the clinical workplace such as communication, patient positioning, and image quality assessment. The exposure to these experiences shared by clinical radiographers can help students understand the diversity of patient presentations, behaviours and expectations and it can encourage students to reflect upon the speciality of mammography practice. The use of multi-teaching/learning strategies may also help to overcome the discrepancies already observed between theory and clinical practice<sup>16</sup> making the transition between them easier. It may also motivate more students to pursue this specialism due to an increased exposure to clinical reality.<sup>23,24</sup>

The teaching staff identified involvement in research to improve mammography practice as a strength for mammography education. The research projects can promote multi professional teamwork, critical thinking and the acquisition of new knowledge that can be passed on to students and colleagues. Further, research builds up evidence to support practice and thereby helping to increase the quality of healthcare services.<sup>25–28</sup>

### Difficulties identified in mammography education and training

Even using mixed or blended teaching styles, students from all participant institutions still found difficulty in the transition from theory into practice due to the lack of labs and/or use of phantoms, and also because clinical reality is difficult to simulate. Patient profile (anxiety, fear of a breast cancer, type of breast, body habitus) is hard to mimic, making it challenging for students to communicate, position and anticipate actions as required in clinical practice. One of the approaches that can be used to solve the transition between theory and clinical practice, according to some studies,<sup>29–32</sup> is peer-to-peer support and peer-assessment. The students undertake training on peers in the labs by positioning each other and communicating to give feedback. These studies<sup>29–32</sup> have demonstrated the effectiveness of such approach in learning by increasing motivation. This approach can also facilitate the

verification of student performance by confirming its accordance to the outcomes of training and by providing suggestions for adjustment and improvement. Development of critical thinking and reflection skills (both important in medical imaging) can also be stimulated by this pedagogical strategy.<sup>31</sup> This type of practice seems to be only applied by two of the participant institutions, but the other institutions have implemented a simulation-based approach using phantoms. Simulation-based training is a valid method also,<sup>33,34</sup> mainly in positioning the breast in a more realistic context, since it was considered very difficult to prepare students more effectively for the transition to the clinical setting. These simulations can provide an opportunity to build up confidence in students while learning in a safe environment.<sup>33,34</sup> The introduction of virtual simulation can be another option to use in this discipline. This strategy has already been studied<sup>35</sup> in plain radiography, showing a valuable role for the development of technical and cognitive skills but seems that it is not yet available in breast imaging. As these examinations involve exposure to ionizing radiation, it is not possible to produce images and immediately observe the impact of the technique selected and positioning. These circumstances limit the student's ability to identify the skills they need to improve, to recognise the mistakes that can occur and identify strategies to use to correct them. Virtual simulation can produce images using a specific software which allows the student to develop knowledge in a safe environment, also making it possible to assess the image quality and thereby improving their skills.<sup>35</sup>

According to the radiographers' perspective, performing exams and teaching students at the same time can be demanding and difficult. This finding can be explained by the limited experience in mammography education of some participant radiographers (<2 years) and also their high workload. The workload in private healthcare institutions and in screening departments is generally higher compared to other diagnostic healthcare institutions.<sup>2,19,36</sup> The need to explain different topics of the specialisation in a combined approach is also demanding, mainly due to the technological changes/developments observed in the last few years. Some studies<sup>37–39</sup> showed that daily activities in medical imaging departments are not fully planned, making the learning place a complex environment due to the variation of clinical circumstances of each patient, and also due to low collaboration from clinical staff.<sup>37</sup>

## Education and training needs

Communication with patients, new technologies and techniques (e.g. tomosynthesis and contrast-enhanced mammography), positioning, image interpretation and post processing tools were the main topics presented as requiring further education and training. Identifying those topics was not surprise considering the difficulties presented by participants and with the introduction of new technologies and techniques in clinical practice demanding changes in exposure parameters, positioning, image quality analysis, processing and workflow.<sup>2,19</sup>

The main limitation of this study was the relatively small number of European Educational Institutions participating in the study and also the small number of participating students from Finland and Norway (response rate <20%). For this reason, the generalizability of the study is limited. The differences in education and mammography practice were difficult to address when constructing the questionnaires. The authors tried to reduce these gaps by testing the tool using different profiles (students, radiographers and teaching staff) and including suggestions provided by the members from all participating countries in the EBreast project. Consequently, further research is suggested to include the maximum number of countries and realities across Europe to identify the educational strategies that suits the majority of European clinical contexts. The radiographer' questionnaire was translated into the respective national languages, but not back and forth which may have caused some bias.

## Conclusions

Apart from the differences on the length, content and resources available for breast imaging units in the participant educational institutions, the difficulties identified in education and training were similar. Those difficulties were mainly related to the student's transition from theory to practice within the limited time allocated for mammography education in medical imaging programs. Breast positioning without skill labs/phantoms at schools and communication with real patients in the clinical context were identified as issues. Combining the efforts of academia and clinical contexts seems to be a suitable strategy in overcoming the limitations of mammography education. Research can also promote teamwork, knowledge and critical thinking, allowing improvements in all areas and ensuring practice is evidence-based. Further studies should include more countries and realities making it easier to identify what is working, what needs to change and, no less important, the real impact on mobility of students and professionals across countries. The harmonization of education in European countries is under the spot light, and is a challenge due to the different structures of medical imaging programs, clinical practice and job demands.

## Conflict of interest statement

None.

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