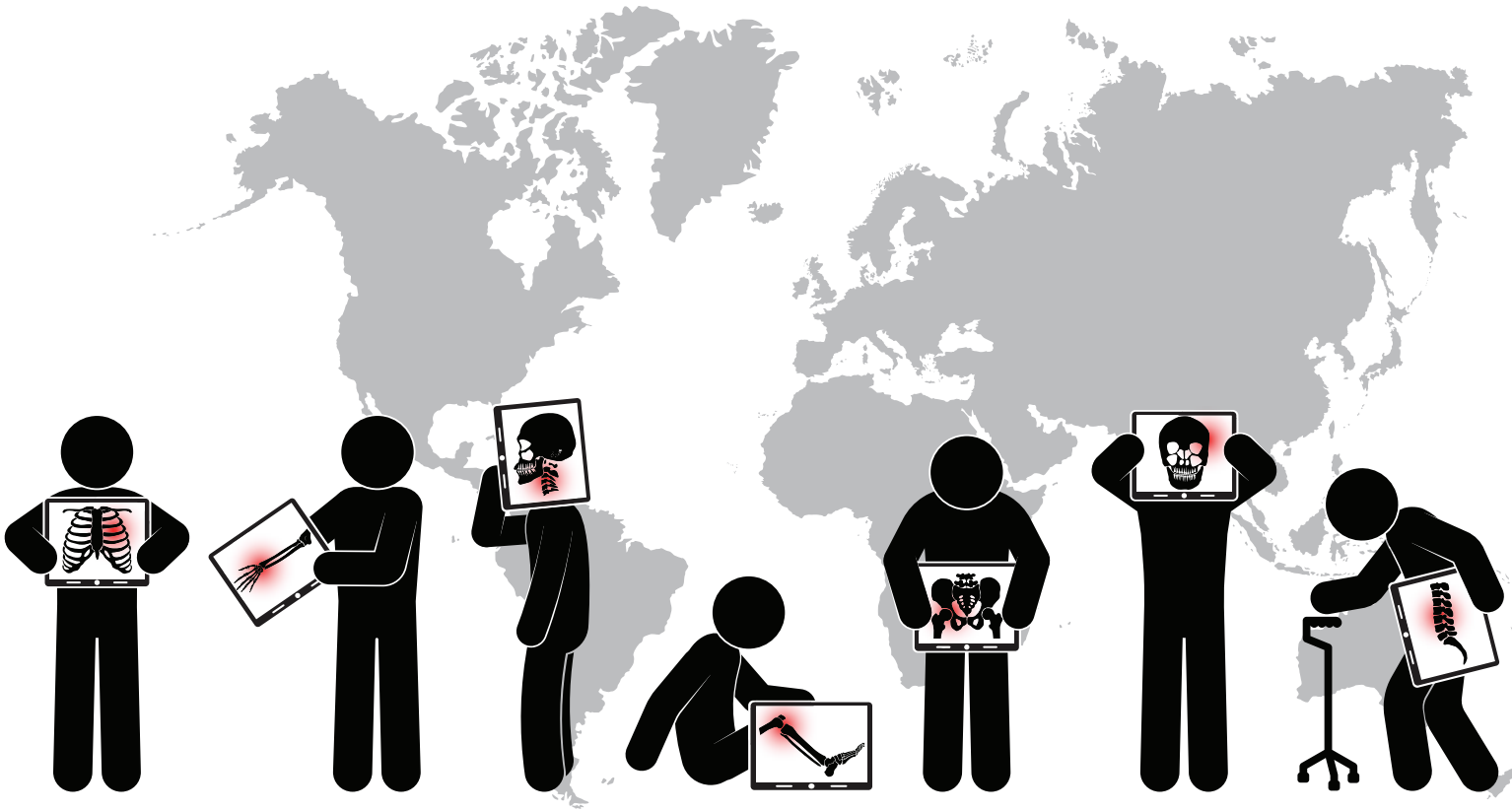

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Does Training Have An Impact on Radiography Students' Approach to Chest X-Ray Image Quality Assessment?

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Abstract

Introduction: Radiography is evolving, and education must evolve with it. Radiography training mainly consists of theory-centred classes and clinical practice; however, this varies from country to country. Image quality assessment is a critical part of radiography. This study examines how aspects of training influence student radiographers' decision making.

Aim: To investigate whether training (academic study, clinical experience and country of education) received by undergraduate radiography students in four European countries influences their assessment of image acceptability/quality.

Materials and Methods: 23 radiography students from four European countries completed the task of accepting or rejecting 30 chest radiographs on the basis of image quality. Each participant gave reasons for any rejections. The total time taken, reject rate and reasons for rejection were compared between students in earlier/later stages of their degrees, those with more/less clinical experience, and those from different countries.

Results: Clinical experience, academic experience or country of education did not influence time taken by participants to view images. Participants with more clinical experience rejected more images than those with less. Clinical experience and country of education also influenced reasons for image rejection; participants with more clinical experience rejected significantly more images for absence of a lead marker, while Irish and Norwegian students rejected more images based on exposure than Swiss students.

Conclusion: Clinical experience had an influence on student radiographers' assessment of chest x-ray image quality in terms of both rejection rates and reasons for rejecting images. Country of education also influenced reasons for rejection.

Introduction

Radiography education programmes are constantly changing and evolving across the world in academic and clinical content. Radiography education consists of theory-centred classes in universities and clinical practice in hospitals (1). It is anticipated that the differences in education between countries is likely influenced by different roles of the radiographer in different cultures and healthcare settings (2). In Europe, most of the universities have the freedom to frame their curricula, which leads to variation between and within countries (3). Harmonisation of radiography education has been suggested by England et al. (4) and is promoted by the European Federation of Radiographer Societies (5), with the goal of producing radiography graduates educated to a more similar standard. This would also allow greater mobility of radiographers between European

countries (3). For example, students participating in this study from the institution in the Netherlands do not undertake any clinical practice until the third year; until then, students are taught mainly in skills labs and 3D simulations. Norwegian students begin clinical practice from year one. Switzerland has a small portion of its clinical practice concentrated on projection radiography, but Irish students are exposed to clinical practice from early in the first year, focusing on projection radiography.

High rates of image rejection have implications for 'management, training, education, as well as for quality' (6), and previous authors have highlighted the need to understand the "inter-subjectivity of radiographers' perception of, and attitude towards, both clinical and technical image quality criteria" (7). Therefore understanding how different training methods impact radiographer behaviour may inform recommendations for radiography education.

This study aimed to investigate whether the experience received in clinical practice and radiography education in four European countries (Ireland, Netherlands, Norway and Switzerland) influences how radiographers assess images for quality and the differences between them. Radiography training is very broad but for the purposes of this study we have chosen to investigate the influence of 1) percentage of degree completed 2) the amount of time spent in a clinical setting 3) the country of education on the time taken to assess image quality, rejection rates, and reasons chosen for image rejection.

Materials and Methods

In this study, radiography students were asked to accept or reject chest radiographs on the basis of image quality.

Ethics

The study was reviewed by the UCD Institutional Research Ethics Committee and granted exemption from full ethical review (Ethics reference number: UREC-SM-2018-26). Prior to beginning the study, written informed consent was obtained from each participant, after a description of the experiment. Participants were informed that the results of the study will remain anonymous. The images used were completely anonymised and used with permission from clinical sites from which they were sourced.

Pilot Study

A pilot study was conducted to identify potential issues with the research method and to modify it accordingly (8). A pilot study was performed with two participants from non-European countries. The data collection from the pilot study was analysed and the method was altered (adjusting the criteria used to

categorise reasons for rejection and the provision of a more informative instruction leaflet).

Images

A total of 28 anterior-posterior (AP) and postero-anterior (PA) chest x-ray images were selected from a collection of chest images from a previous study with permission from the clinical sites where they were generated. Two of the images were replicated within the test set to determine participant response consistency. The images were not selected on the basis of normality / pathology and represented a range of technical qualities. Each chest radiograph was converted from Digital Imaging Communication in Medicine (DICOM) to lossless Joint Photographic Experts Group (JPEG) file format.

Equipment and Environment

The images were displayed at 1920 x 1080 resolution on a 23" Thin-Film Transistor (TFT) Liquid Crystal Display (LCD) monitor. Environmental lighting conditions were representative of radiographers' / bedside clinical conditions at 378.85 lux and were consistent throughout the study (9).

Participants' eye movements were recorded using a Tobii TX300 eye tracker (Bildal, Sweden); however, the results of this eye tracking are not presented in this paper and may be used in a further study. Calibration was performed for all participants prior to viewing images. The eye tracking did not require any immobilisation and should not impact participants viewing behaviour.

Participants

Radiography students from four different European third-level educational institutions were invited to participate in this study. Each participant had completed at least one year of a diagnostic radiography degree and was attending the 2018 OPTIMAX Research Summer School. Basic demographic data collected included: country of education, course duration, most recent year of study completed and number of weeks spent in radiographic clinical practice to date. Table 1 demonstrates participant demographics according to country of education, course duration, mean level of study and mean number of weeks spent in clinical practice. The participants were grouped in two further categories for analysis for the effects of academic and clinical experience (Table 2).

Task

Participants were informed of the total number of images in the study and that there was no right or wrong answer. Participants assessed a total 28 of chest x-ray images and accepted or rejected them on the basis of image quality. When the participant had made a decision on each image, he/she pressed the spacebar to advance to a multiple choice

Country	Number of Participants	Total Course Duration (years)	Median Years of Study Completed	Mean Weeks of Clinical Experience
Ireland	7	4	2(1-2)	10.0
Netherlands	5	4	2(1-2)	0.0
Norway	5	3	2(1-2)	16.8
Switzerland	6	3	2(2)	8.0

Table 1: Participant demographics. Range is shown in parentheses where applicable.

Grouped by clinical experience		Number of participants
Group 1	≤ 10 weeks spent in a clinical setting	14
Group 2	> 10 weeks spent in a clinical setting	9
Grouped by academic experience		
Group A	< 50% of degree completed	13
Group B	> 50% of degree completed	10

Table 2: Participant groups used to test for the effects of clinical and academic experience

questionnaire allowing him/her to record their decision to accept or reject the image. Participants could not go back in the image viewing task. There was no time limit placed on the image viewing session. Figure 1 shows an example of how the images and questions were presented.

The total time taken to complete the image viewing task was measured using Tobii Studio Software (Bildal, Sweden), which indicated the initial time the participant started the task and their time of completion.

After the participant finished the image viewing session, they were brought into another room by a researcher. Here they were presented with each of the images they had chosen to reject as a reminder, and they were asked why they had rejected the image. Participants' responses were categorised in groups based on image quality criteria (Table 3) listed in the European Guidelines (10). No medical justification for the images was provided other than they were chest x-ray images that they should be evaluated for general radiographic image quality.

Data Analysis

The quantitative data was recorded into an Excel spreadsheet and imported to the IBM SPSS 24 program for analysis.

All hypotheses were tested using non-parametric tests because the data did not have normal distribution. The Mann-Whitney U test was used for comparisons of two groups and the Kruskal Wallis test were performed to test for differences between countries of education, with post-hoc testing completed using Mann-Whitney U tests. The level of significance was set at $p \leq 0.05$.

Results

Intra-observer variability

The decisions made by participants on the repeated images were compared and 22 out of 23 participants gave the same response for both repeated images, indicating good consistency.

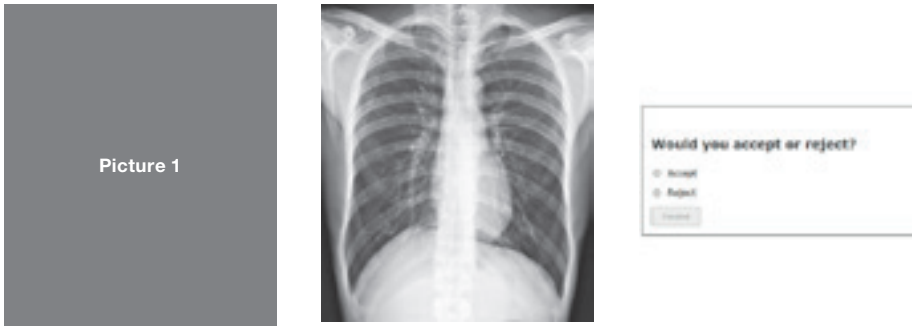

Figure 1 Presentation of the task

Image quality criteria	Example of reasons for rejection in this criterion
Exposure	Overexposure/underexposure
Positioning	Rotation, tilt
Structures included	Anatomy cut-off
Patient motion	Blurring
Inspiration/expiration	Number of ribs visible
Centring	Direction of central ray
Lead markers	Absent/incorrect
Artefacts	Detector/ preventable/foreign object
Others	

Table 3: Criteria under which participants' reasons for rejection were categorised

Total time

The mean time (s) spend on the task was increased in group 2 (more clinical experience) as compared to group 1 (less clinical experience). However, the Mann-Whitney U test showed that the increase from 398 s to 506 s was not statistically significant. The test was also applied to groups A (less academic experience) and B (more academic experience) and showed no statistically significant difference between the two groups (Table 4). The Kruskal-Wallis test has shown that there is no statistical significant difference between the four European countries (Table 4).

Rejection rates

Students with more clinical experience (Group 2) had a statistically significantly higher rejection rate (50.2%) than those with less clinical exposure (Group 1) (36.2%). Students with more academic experience (Group B) had a similar rejection rate (42.14%) than those with less experience (Group A) (42.58%). Irish students had the highest rate of image rejection while Dutch students had the lowest.

Clinical experience					
	Group 1 <10 weeks	Group 2 >10 weeks			*p-value*
Mean time (s)	474.00	435.78			*0.88*
Rejection rate (%)	36.22	50.20			*0.03**
Academic experience					
	Group A <50%	Group B >50%			*p-value*
Mean time (s)	398.40	505.69			*0.12*
Rejection rate (%)	42.58	42.14			*0.88*
Country of education					
	Ire	Neth	Nor	Swi	*p-value*
Mean time (s)	491.00	519.40	420.20	403.83	*0.54*
Rejection rate (%)	51.53	31.43	47.14	36.90	*0.11*

Table 4: Results for total mean time(s), rejection rates (%) and p value for the clinical experience, academic experience and countries of education.

*statistically significant difference; p≤0.05

Reasons	Country				
	Ireland	Netherland	Norway	Switzerland	*p-value*
Exposure	16.67%	3.17%	10.68%	0.00%	*0.02**
Collimation	18.33%	28.57%	23.30%	13.92%	*0.52*
Positioning	22.78%	14.29%	11.65%	15.19%	*0.07*
Centering	3.33%	6.35%	1.94%	6.33%	*0.72*
Lead markers	1.67%	0.00%	9.71%	0.00%	*0.06*
All structures included	7.22%	15.87%	15.53%	16.46%	*0.71*
Patient's motion	3.89%	1.59%	0.97%	1.27%	*0.08*
Inspiration/expiration	10.00%	1.59%	7.77%	10.13%	*0.34*
Artefacts	14.44%	23.81%	16.50%	34.18%	*0.68*
Others	1.67%	4.76%	1.94%	2.53%	*0.88*

Table 5: Participant results from reasons for rejection divided by country of education

*statistically significant difference; p≤0.05

Reasons for rejection	Results and static significance					
	Clinical experience			Academic experience		
	Group 1 <10 wks	Group 2 >10wks	*P-value*	Group A <50%	Group B >50%	*p-value*
Exposure	6.28%	9.82%	*.096*	13.23%	5.95%	*0.26*
Collimation	19.37%	21.88%	*.369*	21.40%	18.45%	*0.12*
Positioning	17.80%	17.86%	*.141*	21.01%	11.90%	*0.19*
Centering	4.71%	3.57%	*1.00*	3.89%	4.17%	*0.74*
Lead markers	0.00%	5.36%	*.028*	1.17%	5.36%	*0.52*
All structures included	14.14%	11.16%	*.305*	8.95%	17.26%	*0.26*
Patient's motion	2.09%	2.68%	*.403*	3.50%	0.60%	*0.07*
Inspiration/expiration	5.76%	10.71%	*.083*	7.39%	9.52%	*0.93*
Artefacts	27.23%	14.73%	*.026*	17.12%	24.40%	*0.52*
Others	2.62%	2.23%	*.516*	2.33%	2.38%	*0.69*

Table 6: Results from reasons for rejection based on clinical experience and academic experience

Reasons for rejection

Reasons for rejection were compared between students training in different countries. No significant differences were found except for “exposure”, where students trained in Ireland and Norway both rejected more images than students trained in Switzerland.

A statistically significant difference in ‘lead markers’ being cited as a reason for rejecting images also existed between students with less (Group 1) and more (Group 2) clinical experience. Finally, there is no statistically significant difference for reasons for rejection between students with less (Group A) and more (Group B) academic experience. Full analysis of reasons for rejection may be found in Tables 5 and 6.

Discussion

The aim of this study was to investigate if clinical experience, academic study and country of education influenced student radiographers’ decision making when accepting or rejecting images on the basis of image quality.

The results of this study could help to inform standardisation of education of radiography students across the Europe. Indeed, the comparison in X-ray image quality assessment pointed out some differences between categories of clinical experience, academic experience and counties of education. Those differences could help the European universities to improve education and move towards standardization. Also, education standardisation could reduce time of adaptation in new employment, generating less stress and greater productivity. In addition, more uniform European curricula could increase labour demand and labour supply through countries.

Total time

None of clinical experience, education experience or country of education had a statistically significant influence on the total time taken to view all the images. This lack of difference in time taken could possibly be associated with participants having a similar viewing pattern, but further research would be necessary to confirm this assumption. Further research could also perhaps evaluate the scrutiny time per image to investigate whether images accepted or rejected for certain criteria require more time.

One study has shown that radiologists and experienced radiographers had a relatively shorter scrutiny time compared to students when searching for pathology (11). Contrary to the above findings, the current study has found that students with more clinical experience took on average over 100 seconds longer than those with less experience. Although this was not statistically significant, it may be due to a small sample size reducing the statistical power of the study.

Rejection rate

The results showed that participants with more clinical experience participants had statistically significantly higher rejection rates than those with less clinical experience. This could be explained by differences in perceptions of image quality. According to Mount, more radiologists accept poor (43%) and unacceptable (73%) images compared to radiographers (13%), and this could lead to unnecessary repeats (12). Furthermore, this study found that radiologists and radiographers use conflicting evaluation criteria, in which the radiologists focus on the diagnostic value of the images whereas radiographers consider closely the technical factors of the images. Therefore, the current study might indicate that the more clinically experienced radiography students were behaving in a way more similar to graduate radiographers, who appear to be very critical of image quality. The implications of excessively high reject rates may translate to higher patient dose, higher number of repeats, less waiting times, departmental costs and lower patient satisfaction (12).

Reasons for rejection

The participants with more clinical experience rejected significantly more images than those with less clinical experience because of the absence of lead markers on some of the chest radiographs. This could be related to those with less clinical experience either a) not noticing the lack of a marker, b) not believing lead markers are necessary or c) being more prepared to use only digital markers. For instance, a Maltese study revealed that most radiographers preferred to apply digital markers post-exposure because it was quicker than using pre-exposure lead markers (13). While different sites may have different protocols, and images may not require repeating solely on the basis of absent lead markers, the different approach taken by more clinically experienced students was interesting. Lead marker placement is important and should be done before taking an x-ray image especially in cases of possible anatomical situs invertus (reversal of major organs from their original position), and the European Society of Radiology has established a fundamental protocol of placing a lead marker before taking an x-ray of the patient (14). Therefore, theoretical teaching should emphasise the importance of lead maker placement before taking the x-ray image(s) so that students are aware of the importance of markers before starting clinical placement.

There was a significant difference in reasons for rejection between countries in terms of exposure. The difference was particularly noted between Ireland and Switzerland, and between Norway and Switzerland. This could be related to the differences in theoretical teaching or perhaps cultural differences, although further research is needed to

confirm this. Notwithstanding that previous studies have highlighted factors such as exposure, patient positioning, patient motion, artefacts and processing errors as the main cause of rejection—to some degree, exposure and processing errors continue to affect departmental performance regardless of recent digital advancements (12). Another study has shown that Belgian radiographers were more critical of image quality than Irish radiographers (15), and it is possible that those findings are similar to those of the current study, which may show that cultural or teaching differences according to countries or individual institutions influence rejection criteria.

Limitations of the study

The study had a limited sample size with only volunteer participants from the OPTIMAX program readily available to participate. Therefore, differences may relate to institutions rather than to countries as only single institutions from each country were represented. Also, it is possible that the effects of country and clinical experience may be linked in this study as some groups had very different mean clinical exposure (for instance, none of the Dutch students had yet undertaken clinical placement as their practical education in the earlier part of their qualification is lab based). Further analysis and study may help to differentiate between these factors

Conclusion

Students' exposure to clinical placement influenced student radiographers' assessment of chest x-ray image quality both in terms of time taken, rejection rate and rejection based on absence of a lead marker. Cultural or educational differences between countries / institutions also appears to influence rejection based on exposure. Even with a small sample size, this study indicates that clinical experience has an influence on the way student radiographers accept or reject chest images. It appears that percentage of degree completed did not have any influence.

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