

# DEVELOPING TRAINING AND ASSESSMENT OF RADIATION SAFETY REGULATIONS

**B. VAN DER MERWE<sup>1</sup>, S.B. KRUGER<sup>2</sup> & M.M. NEL<sup>2</sup>**  
CENTRAL UNIVERSITY OF TECHNOLOGY, FREE STATE<sup>1</sup>  
UNIVERSITY OF THE FREE STATE<sup>2</sup>

## Abstract

The absence of standardised training and assessment for radiation safety requirements at tertiary training institutions offering the radiography qualification in South-Africa, necessitated investigation. The methods included a literature review to contextualise and develop the outcomes for the training and assessment; a Delphi survey to establish a set of criteria suitable for a basic or advanced component of the training and assessment; and a questionnaire for radiography students to determine the knowledge of the radiation worker before and after training. The findings of this study can be a guide in the process to determine content and assessment criteria for other learning areas.

**Keywords:** radiation worker; standardised training; assessment

## 1. INTRODUCTION

Radiographers are occupationally exposed to ionising radiation and therefore considered radiation workers. The Department of Health mandates the responsibilities of radiation workers and licence holders in guideline documents, with the purpose to ensure the safe use of X-ray equipment so that ionising radiation exposure of staff and patients is kept as low as reasonably achievable. First-year radiography students are placed in clinical practice within weeks of enrolment without proof of knowledge of radiation safety requirements. Third-year radiography students on the brink of graduation may apply to be licence holders of X-ray equipment. There is currently no standardised training and assessment in the requirements for radiation safety and quality control for radiation workers and medical X-ray equipment licence holders in the higher education environment.

The number of diagnostic and interventional medical procedures using ionising radiation is increasing and procedures resulting in higher patient and staff doses are being performed more frequently. The need for education and training of medical staff and other healthcare professionals in the principles of radiation protection, therefore, is currently even more convincing (ICRP, 2009).

Although radiography training embraces the principles of radiation safety and protection, non-compliance is often observed in clinical practice. As the work-integrated-learning coordinator for the radiography programme at the Central

University of Technology (CUT), the researcher observed that student radiographers and qualified radiographers at eight different hospitals in city/province, do not adhere to the as-low-as-reasonably-achievable (ALARA) principle at all times (Van der Merwe, 2008). The entry level radiography student is placed in clinical practice during the first weeks of training and should be educated regarding the safety requirements before occupationally exposed to radiation. Furthermore, the ignorance of even senior radiography students with regard to radiation safety requirements was a cause of concern.

Radiography students may apply to own X-ray equipment upon graduation. Education of the requirements for owners of equipment should thus form part of the preparation of the graduate. It has to be kept in mind that the quality control requirements for owners of medical X-ray equipment were only published by the Department of Health in 2008. Even though curricula at the different tertiary institutions offering radiography training include academic exposure to the aspects pertaining to the regulations, the authentic interpretation of the qualification exit-level outcomes of every tertiary institution in South Africa may result in differences in subject content and assessment. Moreover, the Central University of Technology (CUT) was one of the first training institutions to implement the four-year qualification in Radiography in 2014. The improvement of the curriculum provided opportunity for action research in order to develop and implement training and assessment of the radiation safety requirements and guidelines of the Department of Health.

### **1.1 Issuing of dosimeters to students**

The responsibilities of license holders of medical X-ray equipment are listed in the Code of Practice for users of this type of instruments (DRC, 2011). Apart from equipment requirements, the licence holder and responsible person must ensure that persons occupationally exposed to ionising radiation (radiation workers) are identified and issued with personal radiation monitoring devices (PRMDs). Diagnostic radiographers employed in the X-ray department, radiography students in training, as well as other healthcare workers occupationally exposed to radiation, are regarded as radiation workers (RSA, 1973a). The code further mandates that every radiation worker receives education regarding the risks and safety rules of ionising radiation; that protective clothing, devices and equipment are provided and properly used; radiation safety rules are communicated to and followed by all personnel; operational procedures are established and maintained to ensure that the radiation exposure to workers, patients and public is kept as low as reasonably achievable without compromising the diagnostic efficiency of the result; and workers are educated in the hazards and risks of ionising radiation. (DRC, 2011)

The training institution places radiography students in clinical practice for workplace learning (WPL) as radiation workers. Either the hospital where the

student is placed or the training institution is accountable for the monitoring of radiation workers and to issue the workers with PRMDs. The PRMDs are commonly referred to as dosimeters, and can be ordered from the Radiation Protection Service (RPS) of the South African Bureau of Standards (SABS).

For this reason radiography training institutions have different policies regarding the training and issuing of dosimeters to first-year radiography students. As a rule the department in which the student is placed for clinical practice is responsible to register the radiation worker and to order dosimeters. The status quo at one training institution may be that the clinical department issues the dosimeters, while radiation safety lectures and assessment on radiation protection are incorporated in due time. The Central University of Technology (CUT) where the researcher is currently a lecturer, indicates to practices that students are prepared to be issued the dosimeters after an hour contact session with a physicist, complimented by a 20 question test for which the student must obtain a minimum mark of 80%. Another clinical placement issues the dosimeters within the first week of clinical practice only to lecture the academic aspects of dosimeters and radiation risks over the course of a year (Hudson, 2012 – electronic correspondence; Kekana – electronic correspondence, 2012). These practices lead to an undesired situation where the training institution places the radiation safety responsibility of the radiation worker solely on the hospital or practice (Van Dyk, 2012 – electronic correspondence) where the first-year student is placed.

The only requirement by the Directorate Radiation Control (DRC) before registration as a radiation worker and therefore issuing the dosimeter, is that a new radiation worker must undergo a medical examination to determine fitness for work (DRC, 2011). This implies that a licence holder may order dosimeters without submitting proof of education of radiation workers regarding ionising radiation safety. The concern is that the responsibility of the training institution is not signified, which may be one of the reasons for the oblivion observed in clinical practice in terms of the application of certain radiation safety principles.

## **1.2 Regulations for radiation safety for diagnostic radiation workers**

The Department of Health in South Africa applies the international standards for radiation safety as requirements and guidelines through the DRC. The DRC issues a licence if the product and usage comply with the legislative and international requirements for safety and performance (RSA, 1973b). The two documents that are effective when a licence is issued are:

- Code of practice for users of medical X-ray equipment (DRC, 2011); and
- Requirements for licence holders with respect to quality control tests for diagnostic X-ray imaging systems (DRC, 2012).

It is important that radiation workers are aware of the legislation and regulations underpinning the use of X-ray equipment. The radiation worker must hence be aware that the documents exist and consequently be educated in the regulations before application of the regulations can even be expected. Radiation safety training and assessment were for this reason contextualised from the perspective of legislation and regulations published in documents from the Department of Health. This study aimed to ensure that students are trained and show evidence of being knowledgeable of the regulations by means of assessment. This could be the first step to address the observed ignorance towards consistent implementation of the regulations in practice by equipping the student with knowledge. The learning activities could have the potential to empower a new generation of students to improve good practice, to ascertain that radiation exposure of radiation workers and patients is ALARA.

### **1.3 Is the radiation safety training need only relevant for South Africa?**

Knowledge and education have a direct effect on the implementation of protection measures (Mojiri & Moghimbeigi, 2011) and require meticulous focus. Radiographers in South Africa attend continuous professional development (CPD) events that may reinforce the tertiary exposure to radiation protection principles. The concern, however, is that radiographers are often deficient in the application of fundamental principles. A study in Sweden recently reiterated the importance of ensuring professional standards by means of continuous education and assessment of radiographers' clinical competencies (Andersson, Jacobsson & Brostrom, 2012). In radiography, the current situation regarding the training of radiation safety can be improved by providing proof that basic knowledge regarding the existing guidelines is mastered and implemented.

The International Commission of Radiological Protection (ICRP) acknowledges the importance of education and training in reducing patient doses while maintaining image quality (Vano, 2010). Training must be considered at different levels – not only for entry-level users, but also for retraining and certification. Vano (2010) discusses the European perspective within the framework of the Directive on Medical Exposures, which assures that the member states of the European Union shall establish curricula to certify competence in radiation protection. This urgent trend to accredit radiation protection curricula confirms the relevance of the training course developed during this study in the South African context.

## **2. EXPLORING A SOLUTION TO THE PROBLEM**

The purpose to develop standardised training and assessment for diagnostic radiography to address radiation safety was formulated by three objectives, namely:

- to determine appropriate outcomes for the radiation safety and quality control requirements training by using a Delphi questionnaire: basic for first-year radiography students (representing the entry-level radiation worker issued with a dosimeter) and advanced for third-year radiography students (representing the licence holder, responsible person and the qualified radiographer);
- to develop effective teaching and learning activities and assessment strategies for the radiography radiation safety and quality control requirements training to be presented at the Central University of Technology (CUT) based on the findings of the Delphi survey; and
- to assess with pre- and post-training questionnaires the entry-level participants' knowledge regarding radiation safety requirements for radiation workers, and for the advanced level, their knowledge regarding the quality control requirements.

The research aimed to improve the current process of radiation safety training of radiographers and was therefore considered action research (Denscombe, 2007). The findings generated from the Delphi survey were applied in designing the training course and compiling the questionnaires for the student survey. The processes of action and research were integrated because after the Delphi survey, the teaching activities and assessment were developed in alignment with the criteria accepted through the Delphi process (Denscombe, 2007).

Ethical approval for the research project was obtained from the Ethics Committee of the Faculty of Health Sciences at the University of the Free State (UFS). Approval to distribute the questionnaires to the student population and lecturers in the Faculty of Health and Environmental Sciences at the CUT was granted by the dean. The panellists involved in the Delphi survey and the students who completed the questionnaires gave consent to participate in the study.

### **3. METHODOLOGY**

#### **3.1 Data collection**

The data collection method entailed the Delphi process that was mainly quantitative in nature, with an invitation to panellists to add comments or suggestions. The qualitative findings were reported by incorporating the comments in the four rounds of the Delphi process. The outcome of the Delphi process established the content for the development of appropriate teaching and learning activities. The quantitative design was also followed to determine the extent of the students' knowledge before and after training. This was done by means of questionnaires – therefore, a pre-test/post-test design. The quantitatively designed questionnaires were accessible on the content management system (CMS) available at the CUT.

### 3.1.1 Contextualisation to determine the criteria of the outcomes

The DoH requirements for licence holders of medical X-ray equipment, contained in the Code of Practice and Quality Test documents (DRC, 2011; 2012), guided the criteria included in the Delphi questionnaire. The regulations in the documents were listed in the questionnaire as individual criteria statements under the following sections:

- General definitions and licencing conditions (n=84)
- Responsibilities of license holders/responsible person (n=18)
- Operators of equipment and radiation workers (n=38)
- Radiation protection of patients (n=81)
- Radiation protection for the radiation worker (n=77)
- Quality control tests for diagnostic medical systems (n=94)
- The training course (n=26)

The Delphi participants had to indicate whether the criteria statements were both relevant and suitable for the basic- or advance training.

### 3.1.2 Delphi process to determine the relevance of the criteria

The Delphi process was used to establish a set of criteria required for the design and development, and implementation of a training course on radiation safety for diagnostic radiography students. The Delphi process was regarded an appropriate method to determine the objectives for the training course. The participants were selected by the researcher based upon the value these individuals would add to the study (Denscombe, 2007). The process was completed after four rounds. The ten participants in the Delphi questionnaire were experts in the field of diagnostic imaging and included lecturers at higher education institutions involved in radiography training, medical physicists involved in quality tests in diagnostic departments, diagnostic radiography managers of X-ray departments and the Directorate Radiation Control (DRC).

### 3.1.3 Student questionnaires

The quantitatively designed student assessment was compiled with Respondus Version 4. The participants in the questionnaire survey included the diagnostic radiography students in the first and third year, enrolled at the CUT in 2014. Two student questionnaires were compiled; basic for the first-year radiography students (representing the other support staff, namely nursing staff) and advanced for third-year radiography students (representing the licence holder, responsible person, qualified radiographer). The criteria used in the Delphi questionnaires were aligned with the intended learning outcomes of the training material in like manner the formulation of 177 assessment items for the basic assessment and 194 items for the advanced assessment.

The assessments were delivered in the form of pre- and post-training student questionnaires. Various scaling methods were used in the questionnaires: for example, multiple choices, true and false, selection of two options and, for the advanced course, some open-ended questions. In compiling the questionnaires, the survey instruments of the International Society of Radiographers and Radiological Technologists (ISRRT) were used to benchmark the planned training and assessment (Phillips, 2013 online).

### 3.1.4 Compiling of teaching and learning activities

A student guide was compiled to include PowerPoint notes of 365 slides, various student activities (simulations and role plays) and the guideline documents so that the students could use it as a working/reference document. Learner activity is imperative to engage the students in order to promote deep learning. The researcher, with the assistance of the Instructional Designer at CUT, recorded a video of the theatre and of a mobile unit to indicate certain aspects to the students regarding radiation safety.

Other assessment instruments that were used during the presentation of the radiation safety training to the radiography students concerned, were portfolios and objective structured clinical examinations (OSCEs). The portfolio of evidence needs to be populated to complement the advanced student questionnaire assessment. The student must file proof of a record sheet of the Quality Control (QC) tests of the department to which the student has been allocated for clinical exposure. The aim of the portfolio was to grant the third-year student the opportunity and motivation to become familiar with the required QC tests. The final-year student is a potential licence holder of medical X-ray equipment and must be equipped with practical competencies to be informed about what the execution of the tests entails.

## 4 RESULTS

### 4.1 Delphi process

A response rate of 100% was obtained in all four rounds of the Delphi process. Consensus was pre-defined as 80% agreement among panellists on specific criteria. Consensus was reached on 309 of the 418 statements in the questionnaire, giving consensus of 74%. Among the 418 statements, consensus was reached on 13 selections for both basic and advanced training and assessment, 131 selections for basic training and assessment, and 137 selections for advanced training and assessment, with no exclusion of any statements from the training and assessment.

Stability may be declared when movement of opinion of the group as a whole has reached stability, which was reached on the remaining 26% of statements. The relatively high degree of consensus and stability, combined with no statements excluded from the training and assessment by a diverse group of

panellists, supports the appropriateness of the conclusions drawn from this data.

## 4.2 Student questionnaires

Comparison of the results of the pre- and post-test was explored by a statistical difference test. Tests of significance were used to determine whether the teaching and learning activities had influenced the knowledge of the students to meet the outcomes (Cottrell & McKenzie, 2011). The basic test consisted of 177 questions with a total number of 259.0 possible marks. The calculations were based on the 44 students that completed both tests for the basic questionnaire. The differences between the results of the pre-and post-test were calculated by the average score for all the graded attempts, the average completion time and discrimination of the questions. The maximum value for the pre-test was 164.33 compared to 227.22 for the post-test, showing an increase of 95.78. The standard deviation for the pre-test was 26.2 (variance 678.00) compared to 20.85 (variance 434.55) for the post-test. A 21.6% difference was calculated between the class average of the basic pre- and post-test questionnaires.

The advanced test consisted of 194 questions with a total number of 344 possible marks. The calculations were based on the 36 students that completed both tests for the advanced questionnaire. The minimum value for the pre-test was 115.67 and for the post-test 135.06. The maximum value was 216.78 for the pre-test and for the post-test 249.56. The median for the pre-test was 168.47 and for the post-test 194.58. The standard deviation for the pre-test was 20.94 (variance 438.59) and for the post-test 28.85 (variance 832.25). A difference of 7.5% was calculated between the class average of the advanced pre- and post-tests. Both tests proved significant differences after the training. The less significant difference of the advanced test can be ascribed to the pre-knowledge of the third-year students attained during the first and second years of study.

## 5. LIMITATIONS

The authors recognise the lack of enthusiasm of a minority of the third-year radiography students to prepare for the post-test. The fact that the student consent form indicated that the marks would not contribute to the official course mark, was identified as a contributing, but unavoidable factor. An assessment expert had not been involved in compiling the initial student questionnaires, which ensued in some assessment principles not being taken cognisance of. This oversight, however, was corrected in the subsequent questionnaires.

## 6. CONCLUSION

The research made a significant contribution to the preparation of the first-year radiography students with regard to radiation safety prior to placement in clinical practice. Previously, the only preparation they had received was a radiation safety talk scheduled for an hour, concluded with a twenty-mark test. The third-year students previously were not equipped with sufficient information and competence for the radiation safety aspects of his/her profession to take responsibility as a possible licence holder of X-ray equipment. The data acquired from the student questionnaires represent a significant improvement in the radiation safety knowledge of the students participating in the study. The training is further on par with international trends, because the QC testing has been implemented in South Africa only since 2008 (DRC 2012). Higher education institutes have an obligation to introduce the student radiographer to the requirements regarding QC tests. The content addresses the absence of formal standardised radiation safety training as a result of the recent requirement for QC tests. This study supports requirement documents by having determined the specific outcomes to satisfy the guidelines and developing a training course with aligned assessment.

The questions asked at the onset of the study were answered in the action research process. The safety requirements for radiography students and medical equipment licence holders were contextualised from the regulation documents. Experts in the field confirmed the outcomes for the training course for radiography students.

The outcome of the student questionnaires indicated that their knowledge regarding the hazards and risks of ionising radiation was improved. The effectiveness of the teaching and learning activities and assessment strategies that were implemented will be monitored as the degree is phased in over the years to come. The researcher is currently in the process to develop complementary learning material in electronic format to engage students. Standard setting in basic and advanced assessment of radiation safety, as well as simulations of the quality control tests require further research.

The improved training and assessment of the students will only be effective and maintained if complemented by a clinical environment where radiographers set an example of good practice. This study started the journey to improve the consistent application and implementation of safety regulations by preparing students but the work environment best practice needs improvement. The next phase of this action research will investigate continuous development of the radiographers in conjunction with the student activities in clinical practice. The modification of the current learning activities reiterated the significance of lecturers to reflect constantly on outcomes, assessment, and learning activities to promote deep learning.

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## Authors' contributions

B van der Merwe was responsible for the literature search, conceptualisation, design of the training and assessment and drafting of the manuscript. S Kruger, the study leader and M Nel as co-study leader, revised the manuscript critically. All three authors approved of the final version of the manuscript to be published. D Struwig, Medical Editor

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### **Electronic correspondence**

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