IAEA
International Atomic Energy Agency

A Handbook for the Education of Radiation Therapists (RTTs)

VIENNA, 2014

TRAINING COURSE SERIES 58

A HANDBOOK FOR THE EDUCATION OF RADIATION THERAPISTS (RTTs)

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INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2014

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A HANDBOOK FOR THE EDUCATION OF RADIATION THERAPISTS (RTTs)
IAEA, VIENNA, 2014
IAEA-TCS-58
ISSN 1018–5518

Printed by the IAEA in Austria
September 2014

FOREWORD

According to the International Agency for Research on Cancer (IARC) and the World Health Organization (WHO), the number of new cancer cases detected each year is expected to increase worldwide — and especially in low and middle income countries. More than half of all cancer patients will require radiotherapy as part of their disease management. Radiotherapy is a multidisciplinary field that uses complex technologies, including the use of radiation sources for the imaging and treatment of cancer patients. Radiotherapy facilities require specialized shielded rooms, careful planning and trained personnel not only to provide radiation protection but also to optimize workflow.

There is a significant gap in the number of national cancer control programmes, including radiotherapy services, available to cancer patients in low and middle income countries when compared with high income countries. To address this, the IAEA has produced general guidelines for planning national radiotherapy services and for establishing radiotherapy programmes, including clinical treatment, medical physics, radiation protection and safety aspects.

As populations age, the incidence of cancer and the number of patients requiring radiotherapy are expected to increase. To ensure optimum treatment for all patients, professionals in radiotherapy services require the appropriate education and training. In response to this, the IAEA has issued recommendations on the education of radiation oncologists, medical physicists, radiation biologists and radiation oncology nurses. The planned provision of a qualified workforce to meet this demand also requires an increase in the number of radiation therapy technologists (RTTs) who are competent to work in modern radiotherapy. This publication outlines recommendations on the professional education of RTTs and has been developed within the Training Course Series.

This publication is intended to provide a framework for the planning and implementation of education programmes for RTTs. It is aimed at professionals and administrators involved in the planning of education programmes in radiotherapy, medical technology schools and RTTs in general.

The IAEA is grateful to all the contributors who assisted in the drafting and review of this publication. The IAEA officer responsible for this publication was E. Rosenblatt of the Division of Human Health.

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1. INTRODUCTION

1.1. SETTING UP AN EDUCATION PROGRAMME FOR RADIATION THERAPISTS (RTTs)

1.1.1. Background

The need for accuracy in treatment preparation and delivery is a critical component of modern radiotherapy and requires knowledge and understanding of the basic sciences as well as the interaction between the technology used in radiotherapy and the site within the body that is irradiated. In an era of greater complexity of technology and techniques, the role of the radiation therapist (RTT) and his/her level of responsibility is continually evolving and expanding.

In many countries the profession of RTT is not officially recognized and there is no formal education programme or registration process in place. RTT education is frequently a very short component of a broader programme such as diagnostic imaging, nursing or a technical discipline. The academic content is limited and clinical training experience may be only a few weeks. The associated lack of recognition, status and a career structure in many countries has led to failure to recruit and retain staff with resulting RTT staff shortages in many departments. This staff shortage impacts directly on the ability to deliver optimum treatment and care. In developing countries there may be an additional difficulty due to active recruitment by countries with more attractive salary scales and career opportunities.

Given the complexity of modern radiotherapy, the recognition of the profession of RTT and development of dedicated education programmes specific to that profession must be addressed. Education programmes should provide the RTT with the scientific theoretical foundation of the profession and enable them, as practitioners, to be able to synthesize, evaluate and apply their knowledge in a clinical setting. On graduation, the RTT should have reached the level of competency to practice as an autonomous professional and effective member of the radiotherapy team.

In the publication IAEA TECDOC-1588: ‘Transition from 2-D Radiotherapy to 3-D Conformal and Intensity Modulated Radiotherapy’[1] the International Atomic Energy Agency (IAEA) has identified a series of steps in a typical 3-D conformal radiation therapy (CRT) process that RTTs are involved in either individually or as a member of the team. The steps include decisions on and the implementation of immobilization and positioning, image acquisition, structure segmentation following target delineation, verification of transferred treatment parameters, verification of patient position, beam placement and treatment delivery. These steps in the radiotherapy process were applied as the framework for this guideline for RTT education.

The shortage of well-trained radiation therapists (RTTs) limits the access to radiotherapy in many low and middle income countries. Another reason for the sub-optimal utilization of the existing facilities is the lack of a quality culture in many institutions. In this context, the establishment of training programmes is regarded as a high priority by the IAEA [2].

The aims of the recommended curriculum are to produce RTTs who are:

- Technically and clinically competent;
- Aware of radiation safety issues and the importance of quality assurance;
- Understand the theoretical basis for evidence based practice;
- Effective members of the multidisciplinary team;
- Prepared to participate in or initiate research into practice;
- Can work according to registration requirements on the respective continents.

All aspects of radiation therapy have been considered in the development of this curriculum together with the identification of the roles expected of an RTT-Educator in the development of a detailed syllabus.

1.1.2. Definition of a radiation therapist (RTT)

The RTT is a member of the multidisciplinary team comprised primarily of the clinician (radiation oncologist), medical physicist and RTT with the addition of oncology nurses and support staff as considered necessary in the local setting. They are the professionals with direct responsibility for the daily administration of radiotherapy to cancer patients. Depending on local policy this may include treatment preparation and planning, treatment delivery, clinical and psychosocial care of the patient on a daily basis during treatment and immediate post treatment review. However, the role of the RTT always encompasses the safe and accurate delivery of the prescribed radiation dose. As the professional in daily contact with the patient it also includes monitoring of side effects and appropriate referral. Furthermore the RTTs liaise with all the other associated professionals in ensuring that the needs of the patient are met.

1.1.3. Recognition of title and qualification

Within the multidisciplinary team, the professional responsible for the direct administration of the course of radiotherapy is the radiation therapist (RTT) also at times referred to as the radiation therapy technologist or therapy radiographer. Internationally many countries have adopted the title of ‘Radiation Therapist’ and following agreement by the working party drafting this publication; the IAEA and the authors recommend the use of this title (Radiation Therapist) and acronym (RTT) for this group of professionals. All recognized professions have an internationally accepted title that defines, within national limits, their role (see 1.1.15). Prior to the adoption of this title by the IAEA it had not been the case for the professionals directly involved in the delivery of radiation therapy to patients.

1.1.4. Education of the radiation therapist

When developing any education programme it is first necessary to complete a short survey of practice within the discipline, of existing programmes or courses and their content and the academic and clinical infrastructure already available. This information will assist in defining the needs and ensuring that planning of any new course or expansion of existing programmes is cost effective and efficient and avoids unnecessary duplication.

Programme planning should be outcome-based, meeting local and national manpower requirements, personal satisfaction and career potential for the graduate and supporting the development of the profession. In this, it requires input and collaboration from and with all interested groups.

Several approaches are possible depending on the level of resources, commitment and support available to the programme development group. A new programme may be a single discipline, i.e. radiotherapy specific and fulfilling the requirements of the radiotherapy workforce or may be part of a multidisciplinary approach, i.e. an additional component can be added to an existing course in a related discipline, or developed as an add-on or postgraduate course. Where a limited radiotherapy programme already exists a suitable expansion can be undertaken.

1.1.5. Education models

It has long been recognized that learning takes place at an increasing level of complexity from the simple recall of facts to the process of analysis and evaluation. This ascending order of complexity was first described by Benjamin Bloom, a US educationalist (1913–1999) [3], and is still the most widely used taxonomy or classification of the levels of thinking during the learning process. Bloom devised his taxonomy to classify forms and levels of learning in 1956. It was based on the premise that you cannot apply or evaluate something until you understand it and that learning at the higher level is dependent on having acquired the prerequisite knowledge and skills at lower levels (Fig. 1). In 2001 it was revised by Anderson and Krathwohl [4] to reflect more current approaches to teaching and learning (Fig. 1) but the basic premise remains the same. Bloom believed that teachers should design lessons and tasks to help learners meet the stated objectives, a belief that is still applicable and relevant today, but is now referred to more commonly in terms of aims and learning outcomes.

Bloom identified three domains of learning: cognitive, affective and psychomotor each with an ascending order of complexity. These domains and the level of complexity achievable are defined in each domain. According to Bloom the use of the correct verb is the key to the successful writing of learning outcomes.

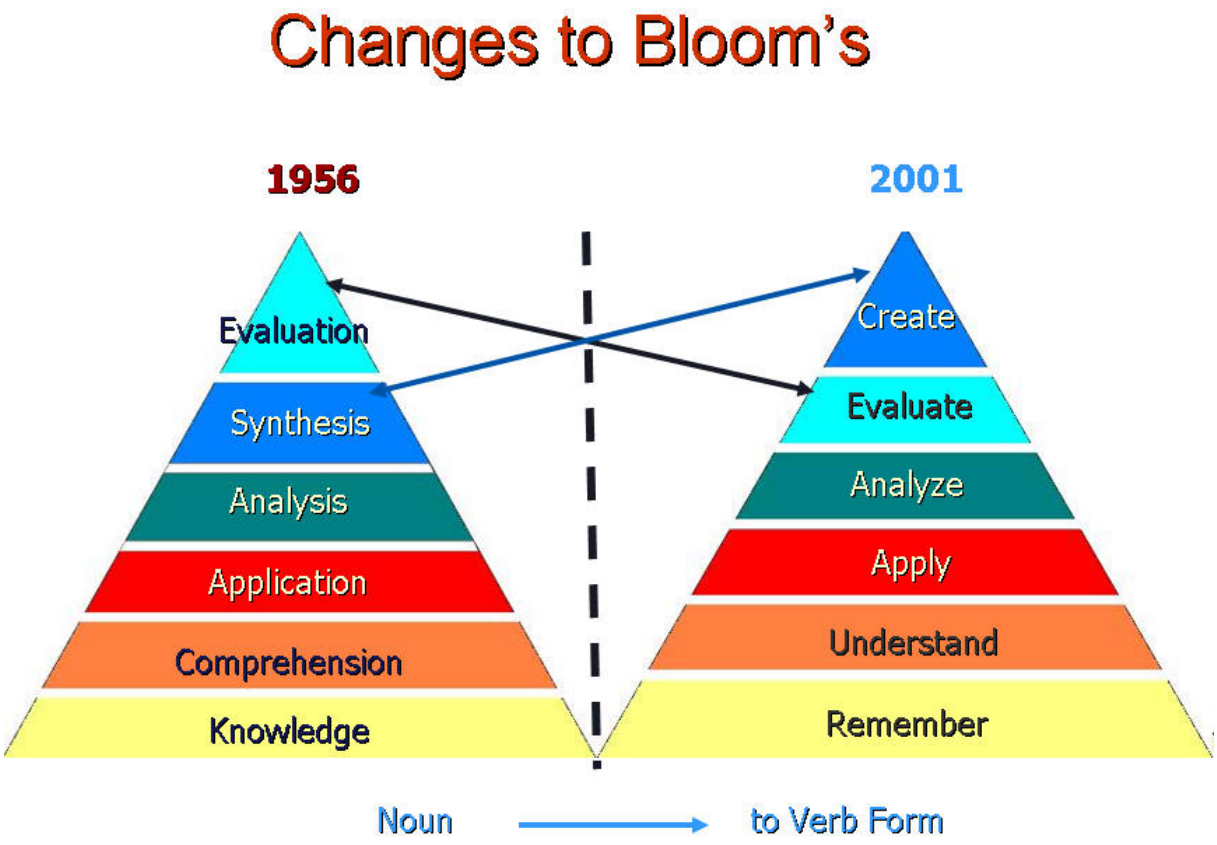

FIG.1. Shifting from learning expressed in noun format (Bloom's taxonomy) to leaning described by verbs (Anderson and Krathwohl) [from: Creative Collaborative Lifelong Learners].

One of the things that clearly differentiate the new model from the original is that it lays out components so they can be considered and used, in order for cognitive processes as related to chosen instructional tasks, to be easily documented and tracked. This feature has the potential to make teacher assessment, teacher self-assessment, and student assessment easier or clearer as usage patterns emerge.

- **Remembering** is retrieving information from long term memory;
- **Understanding** is constructing meaning from instructional messages including oral, written and graphic communication;
- **Applying** is carrying out a procedure in a given situation;
- **Analysing** is breaking the material into its constituent parts and determining how the parts relate to one another and to the overall structure or purpose;
- **Evaluating** is making judgements based on criteria and standards;
- **Creating** is putting elements together to form a coherent whole function: reorganising elements into new patterns of structure.

Based on Bloom's taxonomy, students should be able to display knowledge and comprehension of the basic science topics underpinning all aspects of radiotherapy preparation and delivery and patient support. In this taxonomy, 'knowledge' is defined as the ability to recall or remember facts, and 'comprehension' is the ability to understand and interpret learned information. Knowledge and understanding of the basic science subjects could be considered as the foundation on which the more specialized topics of radiotherapy practice are built.

1.1.6. Core competencies and scope of practice

There is a need within any curriculum to identify and define both the core competencies, that are course and profession specific, and the generic competencies that are essential workplace skills that cut across occupational and academic titles. Generic competencies are not generally taught in lessons as such but are fundamental to the philosophy of educational programmes and essential in professional courses. Mielke and Weber [5] identified seven generic competencies (core abilities): working productively, learning effectively, communicating clearly, working cooperatively, acting responsibly, valuing self positively and thinking critically and creatively. The generic competencies should be integral to both the academic and clinical programme. When designing the curriculum the core competencies can be described in terms of learning outcomes thus defining the appropriate content. They can be very effectively measured as a part of the clinical placement evaluation process.

When defining the content and level of an outcome based education programme it is important to first define the scope of practice of the graduate RTT. The level of responsibility that can be expected of a new graduate may be modified to meet the requirements of local practice and will determine the curriculum content and certification level.

One of the major changes is the shift from a focus based on theoretical knowledge and skills to competency based education and training. Optimal education/training requires that the student is able to integrate knowledge, skills and attitude in order to be able to perform a professional act adequately in a given situation. For the clinicians an example of these competencies are those described as the seven roles of a physician identified by the CanMEDS (Canadian Medical Education Directions for Specialists) system [6] originally developed by the Royal College of Physicians and Surgeons of Canada in order to ensure that postgraduate specialty training programmes are fully responsive to societal needs.

Based on the CanMEDS model competencies have been defined in Europe for the radiation oncologist, medical physicist and RTT and form the basis of their respective curricula [7, 8]. This change from theory and skills to knowledge, competence and attitude requires that education is broadened to include the defined competency areas with additional emphasis on training in a clinical environment, competency based supervision and assessment during training. Methods of assessment of learning outcomes within this new framework differ between professions but could include direct observations in practical situations, mini-evaluations (which is a 15 minute snapshot of professional/patient interaction and designed to assess the clinical skills, attitudes and behaviours of students), 360 degree assessments (a multi-rater written feedback from supervisors and other medical people about the trainee), delineation tools and tests and formal supervision during professional practice or clinical placement.

It is intended that the individual national societies and local departments of radiotherapy and oncology develop and use the teaching, assessment and evaluation methods that are most suitable for their local/national situation. This IAEA handbook outlines different useful

teaching, assessment and evaluation methods but it is up to the educational institution and/or the national society to suggest which methods should be used, how they should be used and when they should be implemented. This should be in accordance with the national guidelines established by the different bodies responsible for teaching programmes and for the certification.

The IAEA is committed to support Member States in the process of planning and implementing national education programmes for RTTs and has successfully accomplished this in a number of Member States.

Current technological developments in oncology require experts who are able to meet the associated growing challenges. This can be achieved by providing the knowledge skills and attitudes which underpin defined competencies in areas including communication, collaboration, social actions, organization and management. Knowledge and skills necessary for the application of certain techniques in specific fields of radiation therapy have been recognized and underlined as the major driving force for education and training in the past, which included implicitly the ability to carry out specific activities. Now a new explicit paradigm ‘competency’ expresses the knowledge, skills/competencies and attitude in a way that ensures professionals in current and future oncology related disciplines are educated appropriately in order to meet the growing demands of the more complex patient management approaches. This emerging comprehensive view of radiotherapy necessitated an update of knowledge and skills for the three professions and is clearly reflected in this curriculum. In addition the Division of Human Health of the IAEA identified the need to make explicit the requirement for professionalism and competency to meet the upcoming challenges resulting from the dynamic developments in the fields of radiation therapy patient care. For this reason the IAEA is including competency-based education as one of the components to define the content of the revised IAEA curriculum.

The transition to competency based education and training is facilitated by insight into the structure of the learning process (e.g. from ‘theory to practice’) which has a long history in the science of pedagogy, in the past more directed to learning processes in childhood and adolescence, but more increasingly transposed to adults (‘andragogy’). These analyses of major elements of learning (e.g. the internationally well recognized ‘Blooms taxonomy’) form the basis of the competency based approach presented here.

Following completion of an education programme at degree level, based on the recommendations in this guideline document, the RTT should be competent in the following eight areas:

- Understanding and interpreting the treatment prescription;
- Treatment preparation;
- Treatment delivery and patient management;
- Treatment verification;
- Information management;
- Professional responsibility;
- Radiation protection, health and safety;
- Ability to critically evaluate practice.

What follows is a detailed description of the learning outcomes, knowledge content and application/synthesis/assessment for each of these core competencies.

1.1.6.1. Understanding and interpreting the treatment prescription

The RTT needs to be able to understand and interpret the treatment prescription in order to accurately prepare and deliver a course of treatment to an individual patient. This requires knowledge of human anatomy, physiology, cancer as a disease, the technology used in radiotherapy and the interaction between them, knowledge of radiation physics, familiarity with radiotherapy doses and schedules and applied mathematics.

TABLE 1. CLINICAL COMPETENCE: UNDERSTANDING AND INTERPRETING THE TREATMENT PRESCRIPTION

Learning outcomes	**Knowledge/comprehension**	**Applications / synthesis / evaluation**
Able to interpret and evaluate a treatment prescription	Identify the area for treatment Quantify the practical problems associated with machine and accessory equipment limitations	Discuss the tumour stage in the context of treatment Create and evaluate treatment plans

TABLE 1. CLINICAL COMPETENCE: UNDERSTANDING AND INTERPRETING THE TREATMENT PRESCRIPTION (cont.)

Learning outcomes	**Knowledge/comprehension**	**Applications / synthesis / evaluation**
Able to check the prescription against local protocols	Describe the treatment protocols used routinely in the department Relate the dose prescribed to the protocol for that site Describe (or identify) the organs at risk and the dose values acceptable for these organs	Evaluate (with the radiation oncologist) departmental protocols with respect to evidence based practice
Able to assess if the treatment intent is curative or palliative	Define curative and palliative approaches	Apply the terms curative and palliative appropriately
Calculate the number of monitor units/exposure time for each treatment session to achieve the prescribed dose indicated by the physician	Define beam energy and the factors influencing it Define SSD/SAD Explain beam position, field parameters and beam orientation	Perform calculations Evaluate the effect of tumour depth, patient separation, size and shape of portals and use of beam-modifying and/or shaping devices in dose calculation
Alert the physician to any problems with the prescription	Describe how the treatment prescription will be applied in practice	Evaluate the prescription together with the plan and identify any areas of concern

1.1.6.2. Treatment preparation

The RTT is responsible for simulation, treatment mark-up and preparation of positioning, immobilization and shielding devices as required. As part of this role the RTT will take responsibility for evaluating the treatment intent and interpreting the information given with respect to the patient's disease and general condition to define the most appropriate position and effective immobilization method for set-up reproducibility. In addition all RTTs will be required to understand the treatment planning system however their role in treatment planning will vary according to the norms of the country and clinical department.

TABLE 2. CLINICAL COMPETENCE: TREATMENT PREPARATION

Learning outcomes	**Knowledge/comprehension**	**Applications / synthesis / evaluation**
Able to correctly position the patient	Define the common co-morbid conditions that patients may suffer from Be familiar with the techniques and equipment used Know the protocols used in the department	Evaluate the patient condition and the limitations that may result from any co-morbid conditions Analyze the information and integrate to define the optimal patient position
Able to prepare and / or produce and store immobilisation devices	Know the immobilization devices available Know how to use each device Recognize the associated health and safety issues	Construct the most appropriate device for the individual patient within the context of the protocol Apply the necessary precautions in production Implement correct QC, storage and handling procedures for immobilization devices
Able to prepare and / or produce shielding devices	Know the shielding devices/methods available Know how to use these devices Recognize the associated health and safety issues	Construct the most appropriate device for the individual patient within the context of the protocol Apply the necessary precautions in production Implement correct QC, storage and handling procedures for shielding devices

TABLE 2. CLINICAL COMPETENCE: TREATMENT PREPARATION (cont.)

Learning outcomes	**Knowledge/comprehension**	**Applications / synthesis / evaluation**
Able to conduct the simulation and mark-up procedure for all standard treatment techniques	Be familiar with the techniques and equipment used Know the protocols used in the department	Analyze the information to prepare the patient for treatment according to departmental protocols Operate the simulation equipment safely and accurately Implement correct QC, procedures for simulation equipment and mark-up procedures
Able to understand the place of treatment planning in the radiotherapy process and to operate the treatment planning system (TPS)	Be familiar with the TPS used Know the protocols used in the department	Prepare suitable plans/treatments for standard techniques Interpret and understand all planning techniques for the clinical site/s
Able to transfer all relevant information and complete accurate documentation	Recognize the importance of accurate transfer of information to allow for accurate treatment set-up according to the treatment plan and prescription Know what should be included Know to whom or where the documentation and information should be sent Be aware of the legal issues relating to documentation	Prepare the documentation Inform all the involved areas/personnel Ensure all legal requirements have been met

1.1.6.3. Treatment delivery and patient management

The RTT is responsible for the accurate delivery of the external beam radiotherapy treatment. This includes the actual treatment, accurate maintenance of all daily records, the updating of relevant information and careful monitoring on the patient status to detect any physical or psychological changes that require appropriate action.

The RTT must be able to understand the radiotherapy process and provide information to staff, patients and their families and members of the public as appropriate and be able to differentiate and fulfill the informational requirements of each group. As the main daily contact point for the patient on treatment, they must ensure that they inform the patient of the procedures at every stage and they must continuously monitor the physical and psychosocial status of the patient prior to any procedures taking place. The RTT also takes responsibility for patient care during brachytherapy procedures as appropriate to the department.

The RTT is responsible for maintaining the patient's daily record and updating any relevant information acquired during the course of treatment. They must make referrals to the relevant health professionals and ensure that all pertinent information is transferred accurately, concisely and in a timely manner.

TABLE 3. CLINICAL COMPETENCE: TREATMENT DELIVERY

Learning outcomes	**Knowledge/comprehension**	**Applications / synthesis / evaluation**
Able to carry out the daily organisation of the treatment unit	Recognise the importance of team interactions Explain the principles of effective communication Review the individual patient requirements	Participate in the organisation of the daily work schedule to maximise efficiency Inform the patient about the procedure
Able to accurately position and immobilise all patients	Discuss the importance of patient identification and how it should be carried out Be familiar with the treatment plans for all patients on the treatment unit Identify the co-morbidities that will impact on patient position Recognise the signs and symptoms associated with treatment in different sites	Interpret the treatment plan and prepare the equipment accordingly Identify the patient in accordance with recognised procedures and consistent with the department protocol Evaluate the patient's general condition prior to commencing positioning

TABLE 3. CLINICAL COMPETENCE: TREATMENT DELIVERY (cont.)

Learning outcomes	**Knowledge/comprehension**	**Applications / synthesis / evaluation**
Able to accurately and consistently set-up and treat the patient	Able to interpret the set-up information Discuss the importance of reproducible treatment delivery Discuss types of errors and how to avoid these Be familiar with the treatment plans and techniques for all patients on the treatment unit	Interpret the treatment plan and set-up the patient accordingly Work in a team to check set-up and treatment parameters and to avoid random errors Monitor the patient during each treatment
Able to prepare the patient for their first treatment	Be familiar with the treatment plan Identify preparatory procedures	Inform and educate the patient as to the treatment procedures Identify and explain the possible side effects to each patient Assess the physical and psychological status of the patient Check all preparatory procedures have been completed
Able to complete accurate treatment documentation	Recognise the importance of accurate documentation Know what should be included Be aware of the legal issues relating to treatment documentation	Complete the treatment documentation accurately Ensure all legal requirements have been met
Able to evaluate the patient performance status	Identify the systems used for evaluation of performance status	Assess the patient performance status in view of their diagnosis and co-morbidities according to institutional guidelines

TABLE 3. CLINICAL COMPETENCE: TREATMENT DELIVERY (cont.)

Learning outcomes	**Knowledge/comprehension**	**Applications / synthesis / evaluation**
Able to monitor, manage and record the patient's side effects throughout the course of treatment	Identify the side effects associated with the individual treatment Define the effects of concomitant treatment Be familiar with the follow up procedures List support groups that might benefit patients	Assess the daily physical and psychological status of the patient prior to treatment Advise the patient on management of side effects in accordance with departmental protocol Refer the patient as appropriate Record all side effects and any intervention recommended Advise patient on immediate post treatment care and inform of the follow up procedures
Able to advise patient on appropriate nutrition, sexual function, rest, skin care, nausea and other symptoms	Explain the impact of nutritional status on patient tolerance of treatment	Assess the patient's nutritional status
Able to support and care for the patient during a brachytherapy procedure	Be familiar with the treatment procedure Identify preparatory procedures Know what patient care is relevant for the procedure	Inform and educate the patient as to the treatment procedure Identify and explain the possible side effects to each patient Assess the physical and psychological status of the patient Check all preparatory procedures have been completed

1.1.6.4. Treatment verification

Verification of the daily set-up is a crucial component of treatment and the RTT must be competent to make decisions with respect to the accuracy of the treatment and to make adjustments within agreed protocols.

TABLE 4. CLINICAL COMPETENCE: TREATMENT VERIFICATION

Learning outcomes	**Knowledge/comprehension**	**Applications / synthesis / evaluation**
Able to carry out the necessary data transfer checks	Define and explain the data that must be transferred	Check and verify all treatment parameters Confirm approval and signatures
Able to position the patient for treatment	Explain the principles of positioning Define the parameters routinely used	Check all parameters are set correctly Check all immobilisation and beam modification devices are correct and correctly positioned Check reference or isocentre settings are correct
Able to acquire the initial verification images	Explain the different modalities/ methods used to generate verification images	Select the correct settings for imaging Acquire an appropriate image
Able to carry out treatment verification	Distinguish between systematic and random errors Define dosimetric and geometric errors	Compare and contrast bony anatomy and soft tissue matching Evaluate the images

TABLE 4. CLINICAL COMPETENCE: TREATMENT VERIFICATION (cont.)

Learning outcomes	**Knowledge/comprehension**	**Applications / synthesis / evaluation**
Able to carry out corrective actions	Recognise the critical structures on the verification images Identify the correct imaging protocol Explain the position verification protocols commonly used	Critically evaluate the verification images Make corrections in accordance with the protocol Record any corrections
Able to check the dose delivered	Identify the relationship between the prescribed dose, the entrance and exit dose and the dose level of critical organs to the monitor unit or timer setting	Carry out in vivo dosimetry Evaluate results and take corrective action as per protocol Report any inconsistency
Able to implement health and safety procedures	Explain the health and safety issues for patients and staff	Assess the safety features to ensure they are in place and adhered to

1.1.6.5. Information management

Large volumes of data are generated by all the professionals involved in treatment prescription, preparation, delivery and follow up. This information is important for the members of the multidisciplinary team and the patient. The RTT must understand how to interpret, apply and disseminate the appropriate information for each stage of the process to the relevant personnel. The RTT should assimilate the conceptual changes and technological developments in the global context of radiotherapy. He/she should exercise, in addition to technical activities relevant to the profession, the role of educator transmitting knowledge to new professionals, patients and families. He/she should conduct all professional activities with the highest scientific, ethical and moral standards.

TABLE 5. CLINICAL COMPETENCE: INFORMATION MANAGEMENT

Learning outcomes	**Knowledge/comprehension**	**Applications / synthesis / evaluation**
Able to interpret, apply and disseminate information as a member of the radiotherapy team	Define and explain the data that must be disseminated	Identify the appropriate personnel to whom specific information should be disseminated Communicate the correct, relevant and appropriate information
Transmit knowledge to new professionals, patients and families	Critique and summarise new information from reputable sources	Critically evaluate new information and distil it down to relevant components for the specific audience

1.1.6.6. Professional responsibility

As the RTT is the person who interacts with the patient on a daily basis, he/she must respect the dignity and privacy of the patient at all times. Inter and intra professional communication between all members of the multidisciplinary team is crucial to safe practice. As a member of the multidisciplinary team the RTT must ensure that relevant information is communicated in a timely fashion to the appropriate professionals. The public perception of the radiotherapy department can be directly influenced by the high visibility of the RTT who must be conscious of projecting a professional image at all times. This includes professional appearance and manner, self-awareness and competency limitations, a high standard of ethical and moral behaviour, reliability and responsibility, autonomy and respect for patients.

TABLE 6. CLINICAL COMPETENCE: PROFESSIONAL RESPONSIBLITY

Learning outcomes	**Knowledge/comprehension**	**Applications / synthesis / evaluation**
Able to demonstrate professional behaviour	Explain the legal and ethical guidelines related to the profession Be aware of your own competency levels Identify the elements that reflect professional appearance and manner	Practice in accordance with legislation regulations and ethical guidelines Promote collaborative practice

TABLE 6. CLINICAL COMPETENCE: PROFESSIONAL RESPONSIBILITY (cont.)

Learning outcomes	**Knowledge/comprehension**	**Applications / synthesis / evaluation**
Able to demonstrate a sensitive and caring attitude to patients	Explain the components of good communication Describe the main personality types Be aware of the patient' gender, age, cultural background, educational level and social situation	Self-awareness of their own personality traits Analyze how the differences in personality influence approach
Able to carry out best practice at all times	Be familiar with current literature and evidence based best practice	Critically evaluate and apply knowledge gained Apply problem solving techniques in the workplace
Able to participate in continuing professional development	Appreciate the importance of maintaining your knowledge and skills	Evaluate and justify your practice regularly

1.1.6.7. Radiation protection, health and safety

The RTT, in collaboration with and under the guidance of the radiation officer or medical physicist is responsible for the radiation protection and health and safety of staff, patients and the members of the general public during the time that they are present within their working area. This includes radiation protection for external beam radiotherapy and brachytherapy procedures as appropriate.

TABLE 7. CLINICAL COMPETENCE: RADIATION PROTECTION, HEALTH AND SAFETY

Learning outcomes	**Knowledge/comprehension**	**Applications / synthesis / evaluation**
Able to ensure radiation protection legislation is adhered to	Describe the radiation hazards and how they are managed Explain the legislation relating to radiation protection	Routinely inspect the area to ensure that radiation protection measures are in place and functional

TABLE 7. CLINICAL COMPETENCE: RADIATION PROTECTION, HEALTH AND SAFETY (cont.)

Learning outcomes	**Knowledge/comprehension**	**Applications / synthesis / evaluation**
Able to ensure that general health and safety procedures are adhered to	Identify the relevant legislation Describe the hazards that might be encountered and how they are managed	Routinely inspect the area to identify any health and safety hazards and to act and report where necessary
Able to carry out the daily/weekly Quality Control (QC) checks	Explain Quality Management System (QMS), Quality Assurance (QA) and Quality Control (QC)	Perform the daily/weekly/monthly QC procedures Analyze and record the results and report any deviations
Able to report incidents and near misses	Be familiar with the reporting system and reporting protocols	Report incidents and near misses according to the protocol of the department Examine any incidents or near incidents and how they can be prevented in the future

1.1.6.8. Ability to critically evaluate practice

The RTT must never allow his/her practice to become routine. He/she has a responsibility to constantly evaluate and improve practice.

TABLE 8. CLINICAL COMPETENCE: CRITICAL EVALUATION OF PRACTICE

Learning outcomes	**Knowledge/comprehension**	**Applications / synthesis / evaluation**
Able to review the literature	Define search terms for specific treatment sites	Identify the appropriate literature in the area of interest
Able to suggest implementation of research findings	Identify relevant sources of research	Evaluate research with respect to current departmental practice
Able to participate in local or international clinical trials	Define the areas within a clinical trial that are important for the RTT	Evaluate new clinical trials

TABLE 8. CLINICAL COMPETENCE: CRITICAL EVALUATION OF PRACTICE (cont.)

Learning outcomes	**Knowledge/comprehension**	**Applications / synthesis / evaluation**
Able to suggest topics for radiotherapy research	Identify literature to support research proposal	Review the literature in the area Formulate a research question
Able to initiate and carry out a research project	Define the necessary steps in preparing and carrying out research	Develop a research proposal/clinical trial submission

1.1.7. Entry requirements

The universal concept known as 'secondary school education' implies a level of achievement necessary for preparing the scholars to take their place in adult society. 'It is recommended, therefore, that the students entering the RTT programme should have completed the recognized secondary school studies which would provide the foundation for and prepare them for higher education studies [9]. The content of the RTT programme is such that a school leaving certificate including mathematics, life sciences and physical sciences is recommended.

1.1.8. Course duration

It is recommended that any programme developed from this curriculum should have a minimum of 2 years duration. Of this, one year should be devoted to clinical practice and this should be on a continuum of rotation from theory to practice over the programme. The emphasis in the first year should be on the academic content and establishing a strong scientific basis and in the latter year on the application of theory to clinical/reflective practice. Two years has been agreed as the minimum duration in order to ensure the acquisition of sufficient knowledge and understanding of the scientific basis underpinning the practice of radiation oncology and to acquire the adequate competencies necessary for the accurate preparation and delivery of radiation therapy. This includes the technical application and psychosocial care of the patients, with sufficient time to develop professional attitudes to practice. However a 3 year degree programmes is recommended to enable the development of the RTT as a key member of the multidisciplinary team and to allow for knowledge and competencies in advanced radiotherapy techniques and standard planning/dosimetry. Where appropriate a 4 year degree programme could be offered to enable the RTT to participate in advanced planning/dosimetry as well as comprehensive QA. A degree programme also enhances research skills and the development of a professional who can make a contribution to the advancement of radiation oncology in the country/region.

It is important to remember that an entry level professional education programme is not an end in itself. Developments in radiotherapy are on-going and a well-structured programme of postgraduate education is necessary to enhance clinical practice and widen professional knowledge for all RTTs. Continuing professional development or continuing medical education is compulsory in many countries and is seen as an integral part of being a professional. Experience gained in professional practice can provide part of this on-going

education provided such experience is recorded and supported by participation in academic courses [10].

1.1.9. Education level and certification

It is strongly recommended that the RTT programme is offered through a collaborative partnership of a Higher Education Institution (university or college) and one or more clinical sites. The level of certification will determine the content of the programme and the skills and competencies to be acquired by the graduate (Appendix I). The recommendation from the IAEA is that the qualification be offered by a Higher Education Institution.

Although there is wide variation in education programmes, RTT qualifications are already well established in many low, middle and high income countries. This document has been produced to aid RTTs to achieve degree level standard. In countries where degree level education is not immediately achievable the document can be used to guide and support the development of programmes at the diploma level in the interim. Where resources are very limited and staffing shortages impact on service delivery, education or training may take place within the clinical department with the student working under guidance of qualified staff. In these circumstances, the essential clinical competencies can be the focus of the initial education programme which can then be further developed as circumstances allow. This situation, however, is far from ideal and should only be used in resource constrained circumstances and for the shortest possible period.

It is important that qualifications gained by RTTs as part of a formal education programme be certified by a competent authority. This certification can be degree, diploma or other certificate but must be issued by a competent national authority confirming that an education programme is recognized and the student has successfully completed it.

It is desirable that any qualification is defined under an internationally recognized qualifications framework in force in the corresponding region such as Europe or countries such as Australia, New Zealand and South Africa, where an outcome-based approach has been increasingly adopted. Such frameworks are a useful mechanism for defining the level of learning achieved by the student. The aim of defining a qualification in this way is to provide international transparency, recognition leading to an equality of education and ease of mobility of personnel between countries. These frameworks or national mechanisms do not prescribe content but provide a context for the design of new qualifications consistent with the aims of this document. Furthermore a framework can act to bring about change and can be used to indicate where new programmes are required to meet societal needs including the introduction of new qualifications.

These qualification frameworks assist in the development of education programmes at several levels, facilitating institutions of education to prepare new programmes or extend existing programmes to meet workplace requirements and the professional and discipline needs for practice based on evidence. Qualifications can be described in terms of credits which directly reflect the required input of the students. In the Bologna framework system for instance [11], one academic year corresponds to 60 credits (European ECTs) or each credit corresponds to 25-30 hours of work by the student. In developing an education programme for RTTs the qualification framework of the region should be applied, if applicable.

1.1.10. Education environment

The importance of providing an adequate learning environment for the students cannot be overemphasized. Both the physical infrastructure and the teaching staff must be adequate. If they are not already in place, institutions should strive to attain the levels recommended below over a relatively short period of time. Even where resources are very low a designated room should be provided where student teaching and learning can take place.

1.1.11. Physical infrastructure

Teaching areas should facilitate different teaching methods. Where students share didactic lectures with other disciplines (e.g. diagnostic radiographers, nurses) large lecture theatres may be appropriate, but smaller teaching areas should also be provided for tutorial and problem/case-based learning approaches. In all venues where students are placed the health and safety standards must be adhered to.

Computers with internet access are essential for the teachers for maintaining current knowledge, updating information and communicating easily with colleagues. Wherever possible, students should also have access to computer facilities. This, of course, will depend on the resources available but where it is proposed to have e-learning or distance learning as an integral component of the programme the number of computers available for student use must reflect this. Where space permits a student common room should be available. Library access with a sufficient variety of relevant textbooks, reference books and current journals should be available for staff and students. The appropriate computerised databases should also be available. These facilities could be shared with other faculties in the university/hospital.

The IAEA has been providing educational materials on radiation medicine in general [12–18] and radiotherapy in particular to its Member States and can respond to appropriate requests through its Regular Programme and/or Technical Cooperation Programme.

1.1.12. Academic staff

Given the immense problems faced by many radiotherapy departments in low and middle income countries, there was agreement among members of the expert group that designating one person as the trainer would meet the short term requirements. However, there has been concern around the advisability of establishing a training programme dependent on a single person. Consideration should, therefore, be given to funding one trainer initially, followed as quickly as possible by a second person to ensure sustainability. The ratio of trainers to students should be no more than 10 students per trainer. To share the responsibility and decrease the single dependency situation there must be additional RTTs who are experienced in training and assessment on all of the available equipment.

1.1.13. Programme leader

For an RTT education programme, either stand-alone or as part of an existing programme in another discipline, a programme leader / coordinator must be appointed and this must be an experienced RTT. Depending on the structure of the educational institution the programme leader should have the appropriate level of authority and autonomy to make decisions that directly affect the day to day operations and development of the programme. He/she is responsible for the overall management of the programme and for ensuring that the criteria for the programme are implemented and outcomes achieved, national or professional

requirements are met and that there is on-going development. It is also important that a team is put in place to support the leader to develop the programme appropriately.

Where the education programme is university or higher education institution based the working group acknowledges that the first programme leader may not have the academic qualifications required within the system. It is, however, essential that interim exceptions to the rule are made initially to facilitate the integration of the profession within the university setting led by an appropriate experienced RTT. Provision should be made to enable this leader to acquire the qualifications over time.

The long term aim should be to recruit sufficient dedicated academic staff to meet national or institutional student/staff ratios as mandated. The IAEA focus on 'training the trainers' is crucial to the development of future education programmes and for maintaining an academic workforce. The dedicated staff should maintain their own knowledge of the advances in radiation oncology, as well as current thinking on education philosophy and developments. Invited lecturers could assist in the initial programmes where dedicated staff numbers are limited.

It is desirable that the academic staff actively participates in national and international professional organisations, maintain close contact with the clinical staff and maintain their own knowledge and expertise in a rapidly developing profession. The development of national and international networks can assist this.

1.1.14. Course accreditation

Within the university or higher education institution an on-going accreditation system is in place that is responsible for monitoring the standards of the programme. Where the course is developed outside of a university or higher education institution this will not necessarily exist and it is important to establish a structure (such as a programme board) who will oversee the quality of the programme on an on-going basis.

1.1.15. National recognition

The recommendation is that the programme leader or coordinator and his/her team identify the responsible national education and regulatory authorities. Recognition of qualifications and professions varies between countries. It is highly likely that the Ministries of Health and Education will also have some jurisdiction in relation to professional standards and recognition and these should also be consulted. In addition, there are international organisations that make recommendations relating to recognition which could impact on the development of the programme. These organisations include the International Labour Organisation (ILO) where the medical radiation therapist is listed under 'medical and pharmaceutical technicians' [19] and the World Health Organisation (WHO) [20].

The International Basic Safety Standards (BSS) report [21] makes recommendations on quality assurance and radiation protection for medical exposure. Regulatory requirements demand that the professionals are adequately certified:

"Requirement 35: Responsibilities of the regulatory body specific to medical exposure."

The regulatory body shall require that health professionals with responsibilities for medical exposure are specialized in the appropriate area and that they meet the requirements for education, training and competence in the relevant specialty.

The regulatory body shall ensure that the authorization for medical exposures to be performed at a particular medical radiation facility allows personnel (radiological medical practitioners, medical physicists, medical radiation technologists and any other health professional with specific duties in relation to the radiation protection of patients) to take on the responsibilities specified in these Standards only if they:

- are specialized in the appropriate area;
- meet the respective requirements for education training and competence in radiation protection, in accordance with paragraph 2.32;
- are named in a list maintained up to date by the registrant or licensee.

The leader / course coordinator should also confirm the legal status of the profession within their own country. This should include whether statutory (state) registration is in place or whether recognition is delegated to a professional body. It is also useful to identify what the situation is in other countries with respect to national or international recognition of professional education programmes.

Policies with respect to freedom of movement of personnel within a region or between countries can also be helpful in determining the level of the national education programme.

1.1.16. Professional representation for RTTs

A profession is strengthened by the support of a dedicated professional body (association or society). This body can take the initiative in negotiations at government level to support the educational development in radiation therapy. It is important to carefully consider the various options for professional representation to ensure that maximum benefit is gained.

As with education, the optimum situation is a professional body that represents RTTs specifically. However, in some instances this will not exist and the team should find out what the local situation is with respect to establishing professional bodies. For RTTs this may be as part of an existing professional body also representing diagnostic radiographers or other health professionals with whom education programmes are shared.

Collaboration with national societies representing radiation oncologists and medical physicists is often very beneficial for the RTTs. In addition international professional society membership should be promoted and linkages made wherever possible.

1.1.17. Ensuring that the specific needs of RTTs are met

It may be the case that the radiation therapy community within a country is not sufficiently large to support an independent professional body. Where a multidisciplinary professional body represents radiation therapy it is essential that the structure is redefined to ensure that the radiation therapy representation is appropriate and the specific needs of the RTTs are met.

Where the community is large enough then it is important to clarify the national regulations regarding the establishment of a new professional society.

1.1.18. Teaching, learning and assessment

Learning may be defined as changes in knowledge, understanding, skills and attitudes brought about by experience and reflection upon that experience. At the first level learning indicates an increase in the quantity of information that a student acquires and retains and the

acquisition of new facts or skills. At a higher level learning involves the processing of the information acquired to make sense of it, abstracting meaning and identifying ways in which it can be related to other situations. It thus becomes an active, interpretive process requiring higher level skills. This higher level of learning is necessary for RTTs because they will be working in a high technology, dynamic and interactive discipline.

As wide a range of learning experiences and assessment methods as is feasible should be used to facilitate the spectrum of student learning styles. Learning theory has led to a change in the methodology. Teachers are moving towards a more advisory role encouraging students to be more proactive in their learning and to seek knowledge for themselves. The goal posts have changed from teaching facts, to helping students learn how to find relevant information, how to assess it and how to organise disparate information into a cohesive whole.

Teaching is about motivating students to learn, and how to learn in a manner that is relevant, meaningful and memorable. It is important for teachers to remain abreast of developments within radiation therapy and cancer management and to be able to bridge the gap between theory and practice. Good teaching is about caring, nurturing and developing minds and talents. In radiotherapy it is particularly important that the clinical and academic components are integrated and reflective of each other.

It is a useful exercise to consider the teaching methods available and to list the strengths, weaknesses, limitations and level of preparation necessary for each, in order to evaluate the most appropriate and realistic method for the expected outcome. Compromises may be necessary depending on the available resources but the aim should be to move towards the optimum teaching method to achieve the desired outcome.

1.1.19. Teaching methods

It is important to engage with the students on courses and encourage them to actively participate in the learning process. It is important to ask questions and discuss topics raised even if not directly related to the lecture itself. When the facilitator is unsure of an answer, he/she should indicate to the students he/she will find out and ensure he/she will get back to them as quickly as possible. The faculty can also indicate where the student may find the information for themselves and ask them to look it up and feedback to the class in this way again generating more active participation.

Timing is essential when the lecture is the chosen teaching method. It is generally acknowledged that the attention span varies throughout the traditional lecture. Active breaks where a question is posed or teaching technique changes are useful tools to keep the students attention. The faculty should encourage students to collaborate as this enhances the learning experience for all. Faculty should remember that students also have a responsibility for their own learning.

A wide range of teaching methods are possible and the method should reflect the audience, aims and learning outcomes. In reality, resources frequently dictate the type of methods used and in this case the faculty must try to optimize the method as far as possible within these constraints.

Below are short outlines of some commonly used teaching methods that may be useful to consider. Further details on teaching methodology can be accessed on the internet sites given (see page 93).

1.1.20. Lectures

This is perhaps the most traditional teaching method and has many advantages as well as limitations. It is most suitable for large groups where what is required is the delivery of factual information. The greatest limitation is that the audience is often passive and communication is frequently one way. It is difficult in this context to gauge what students are learning outside of the examination process. Where possible the lecturer should give examples in practice of the topic he/she is teaching, break the lecture into discrete time blocks separated by a question, short discussion, worksheet to complete or some similar approach. This helps to maintain the concentration of the students. In structured courses it can be useful to have a guest lecturer who will give an overview of the topic or set the scene as it were and the lecturer can then develop the concepts in smaller learning units.

1.1.21. Laboratory based

With access to a computer laboratory it may possible to use interactive software for teaching a small group of students or for students to revise some aspects of the work covered on their own.

1.1.22. Clinical topics

Where the topic has a strong clinical element such as positioning and immobilisation several approaches can be used. It may be possible to obtain immobilisation accessory equipment that can be used for demonstration purposes. This may require some financial outlay. It may also be possible to use the clinic outside of regular treatment times to demonstrate accurate positioning procedures and equipment manipulation.

1.1.23. Tutorials

Tutorials are an excellent way of encouraging student participation. They may be stand alone or offered to support lectures. In these tutorials the student is usually given some preliminary work to do and the tutorial then becomes an active discussion rather than delivery of information. It is useful for clarification of problems or to stimulate students to take greater responsibility for their own learning. It is important to identify clearly the topic for discussion and to give references where material can be sourced.

1.1.24. Journal club

A journal club is similar to the tutorial but the students are given a selection of journal articles on a specific topic and asked to analyse them and provide feedback during the session. This helps students to read articles critically and to differentiate between the levels of quality of the research carried out. This can be very useful in providing students with the most current information on a topic.

1.1.25. Case studies

This method can be very useful in radiation therapy as it directly relates theory and practice. Real clinical issues can be raised and discussed and this helps the students to consider problems and ways in which they can be addressed. It allows individual experiences and situations to be considered and does not necessarily impose solutions that may not be applicable in every specific situation. This type of approach also encourages professionalism

identified by many as an end point in itself. It is dependent on good material selection and requires skill by the facilitator.

1.1.26. Problem based learning (PBL)

First developed in McMaster University, Canada [22] problem based learning (PBL) is a student-centred approach where a problem is set to a group of students who must divide the problem into separate components and then allocate tasks to individuals within the group. The group arranges meetings and feedback session where the information obtained is shared with the full group and discussed in the context of the problem. It is an excellent learning method but is resource intensive and often difficult to implement as a complete curriculum design where resources are limited. A modified scenario/problem based learning methodology can be implemented to achieve the advantages of PBL that; encourages active learning and enquiry on the part of the student, collaboration within the group and communication skills and that provides the student with lifelong skills in terms of addressing difficulties that subsequently arise in the clinical setting.

1.1.27. Simulations

Medical simulations, in general, aim to imitate real patients, anatomic regions, or clinical tasks, and/or to mirror the real life circumstances in which medical services are rendered.

Virtual reality (VR) simulations are even newer innovations in which a computer display simulates the physical world, and user interactions are with the computer within that simulated (virtual) world [23]. The learner is required to react to the simulation as he or she would under real-life circumstances; although it is understood that the fidelity of a simulation is never completely identical to the real world. Some reasons are obvious: engineering limitations, psychometric requirements, cost and time constraints. Nonetheless, technological advancement leading to higher fidelity and increasingly realistic simulations has been a significant contributor to the recent rise in the use of this technology throughout medical education.

Spanning the continuum of educational levels and bridging multiple health care professions, medical simulations are increasingly finding a place among our tools for teaching and assessment. Technological advances have created a diverse range of simulators that can facilitate learning and evaluation in numerous areas of medical education. Simulation technology holds great promise to improve RTT training and, thereby, to impact patient safety and health care outcomes in a positive and significant way.

Virtual reality tools for the training of RTTs can simulate a virtual environment of a radiotherapy treatment room including a life size linear accelerator which is virtually controlled by the trainee using a real control handset. In this way students can have unlimited practice without using valuable accelerator time and without risking harm to patients or equipment while enhancing the understanding of radiotherapy concepts and skills which are often difficult to teach in a classroom.

Simulation in medical education is here to stay and the field continues to grow [24]. There are advantages in terms of patient safety, reduction of errors and lower healthcare costs. There are some practical limitations to implementing simulation training programmes. These are faculty/academic staff time constraints, lack of educator training and cost of the equipment, since many of the technologies implemented for simulated teaching and learning are expensive. Simulations for the training of medical students and RTTs cannot completely

replace the direct contact and care of patients in the clinical environment. Rather it is seen as a preparatory phase for the real clinical work. Moreover, simulators do not replace good educators.

1.1.28. Assessment

Assessment is the process of documenting, usually in measurable terms, the extent to which the learning outcomes have been achieved and can cover knowledge, skills, attitudes and beliefs.

Assessment plays a very important part in the education process and often dictates what a student will learn. It determines both how and what we teach to a large extent. It should not simply be about the allocation of grades but should help to inform and support student progress and identify areas where additional input is required. Assessment should be seen as facilitating learning and should focus on what is learnt rather than what is taught consistent with the focus on learning outcomes.

Assessment should be transparent and assist rather than intimidate students. It is quite disappointing learning a large volume of information and not being able to apply it in the examination. In this context assessment should reflect the learning outcomes and measure to what extent they have been met which then is an evaluation of the effectiveness of the teaching process. It can be used by the faculty to measure how effective the linkages between the learning outcomes and the teaching methodology have been and indicate areas where further review is required.

Assessment can be classified in many different ways, some of the most usual are:

- Formative or summative;
- Objective or subjective;
- Formal or informal.

Summative assessment occurs at the end of a course or module and its purpose is generally to enable the awarding of a grade while *formative assessment* takes place throughout a course or project and is used to aid learning and give continuous feedback on performance to students. These two methods are routinely used in larger courses to complement one another.

Objective assessment in its simplest explanation is the use of a form of questioning where there is a single correct answer. This could perhaps be something like a multiple choice question (MCQ) or a mathematical calculation as in dose/fractionation calculations. *Subjective* on the other hand may have more than one correct answer or there may be more than one way of answering the question. Essays can be considered in this way and again an example would be the treatment of a tumour site where more than one option could be considered as correct.

Informal assessment doesn't usually require a written answer and can be very useful in guiding students during class or practical sessions. Informal assessment can include observation, peer and self-evaluation, discussion or checklists. *Formal* assessment, on the other hand, usually implies a written examination in some format and may be external.

Assessment is one of the most obvious ways to evaluate what the student has understood, whether they can apply the knowledge and/or carry out the particular practical skill or

whether they have developed the affective skills such as good communication. It is also a means of evaluation of the effectiveness of the programme as a whole and its individual components.

Assessment should be an integral component of course design and the amount and level of assessment should be consistent with the defined learning outcomes. It is about finding out what the student has achieved and giving it a value.

There needs to be assessment of student performance in relation to both the theoretical and clinical components of the course and these must be clearly stated [9].

A programme developed from this IAEA curriculum can employ a wide range of assessment tools which can be administered throughout the course as appropriate to the stage of education of the students. Methods of assessment will vary across the various countries or regions.

Assessment may be carried out by the teachers, clinical staff, peer group and the learners themselves. In addition to individual assignments, progressive assessment of knowledge, understanding and skills of the students should be made throughout the duration of the course. Evaluation is designed to monitor the progress of a course and, in particular, the degree to which the objectives it is intended to meet are being implemented.

Clearly identifiable objectives need to be set for evaluation during course planning. These may relate to the theoretical content of the course, the practical or clinical setting, the personnel and the available resources. All aspects of course design and planning may vary depending upon the environment in each country but each will need to be considered by the team developing the curriculum. The course planning team will be involved in monitoring the quality of the course and its outcome, and for making revisions as necessary.

1.1.29. Assessment methods

Assessment can and should take many forms thereby testing a wide range of knowledge, skills and attitudes consistent with the taxonomy defined by Bloom [11, 25, 26].

In all assessment that will be allocated a mark or grade, it must be made clear to the student as to how the marks are going to be allocated. This will also indicate to them the level of detail required on each aspect of the topic. A short overview of some of the more commonly used assessment methods is given below.

1.1.30. Traditional examination

Traditional examinations are usually at the end of a block of learning, either a module or end of a full academic year. This type of assessment is generally fair and consistent from the student perspective. The method ensures that what is returned is the student's own work. They do not, however, usually allow for feedback and learning as they take place at the end of a module/course/programme.

It is noted that some students are naturally better at sitting examinations, have greater ability to recall large numbers of facts, to set out answers clearly and even to write faster. The answers may however not always reflect either the level of understanding of the student or their ability to apply knowledge in a wider context.

Since it is quite challenging to write clear and unambiguous examination questions it is useful to write them with at least one other person and to ask somebody to read them to ensure clarity. The writer has to be very clear on what the focus of the question is and what exactly is being tested. It is useful for the examiner to answer the question personally and to use this as a guide to marking. However, the examiner must remember that there may be other points of view or approaches to answering the question and one should not penalize students who do not give back exactly what was drafted in the sample answer. This necessitates a high level of knowledge on the part of the examiner.

1.1.31. Open book examination

This is similar to the traditional examination but the student is able to take source or reference material into the examination room. This is a useful method when a lot of factual information, that does not necessarily have to be learnt and remembered by the student, is required in the answer. This method of assessment can also be used to assess how well students can use source or reference material and apply the information gained to a specific question or problem. This is a valuable skill for students to have in their future professional lives.

1.1.32. Types of questions used

1.1.32.1. Essay type questions

Long essay type questions are used where students are expected to apply principles or knowledge to a given situation. Students will usually be expected to give an opinion or to draw from other experiences they may have had. This type of question gives the student the opportunity for self-expression and to show wider reading or understanding and must be marked with this in mind. Long essay questions can disadvantage students whose vocabulary is limited or who have poor essay writing skills.

1.1.32.2. Short answer questions

Short answer questions are used to test a single more specific aspect of a topic. They are used to test a breadth of knowledge over a wider range of topics. The examiner may prepare an entire examination paper of short answer questions or may choose to include one or longer essay questions. What is important is that all the questions reflect the learning outcomes defined initially.

1.1.32.3. Multiple choice questions examinations (MCQS)

In this form of assessment students are asked a question or presented with a statement, the stem, and given a set of possible answers from which, in its simplest form they are required to select the correct answer. The correct answer is termed the key and the incorrect answers the distractors. Stems should be clear, the key should leave no area for doubt (it should be well referenced) and the distractors should be incorrect but not ridiculous. They should test the students' knowledge directly. MCQs can take a range of forms and can include diagrams, short scenarios or case studies. It is also possible to test depth of knowledge by developing a linking series of MCQs on a single topic. Well written MCQs can be a very effective method of assessment.

1.1.33. Portfolio

The portfolio is a compilation of a range of work built up over a period of time and has the advantage of showing evidence of the student's achievement over time. The portfolio can also be very useful for qualified students when they apply for positions or for continuous professional development (CPD) in the future. The biggest disadvantage is for the teacher as they are time consuming and difficult to mark. The portfolio is a good method for the assessment of clinical practice.

1.1.34. Reflective diaries

These allow the students to record their experiences and to reflect on what they have learnt from them. They help students to focus on what they have learnt and how they have integrated this content into their own thinking. They are used to record experience and to help understanding, to increase the ability to consider a problem or experience and reflect on how the student may address it. It is applicable in the clinical setting in encouraging practitioners to think about what they are doing, why they are doing it, and whether there is a way to do it better.

1.1.35. Oral examinations

These are usually used in conjunction with other assessment methods and give students an opportunity to clarify points that were unclear from their examination papers or to demonstrate a higher level of knowledge and understanding. They can also be used in place of a practical examination to test the application of knowledge to the clinical setting. This can be useful when resources are scarce and practical examinations cannot be arranged. It is advisable to have both academic and clinical examiners to assess how well the student is linking theory and practice.

1.1.36. Objective structured clinical examination (OSCE)

These are frequently used in the medical setting to test practical skills or affective skills such as communication [27]. They normally consist of several stations, where a station is a discrete section within a specially laid out room where a single topic is assessed. Students are expected to move through each of the stations and to answer the problem set within a defined time period usually 5-10 minutes. The stations may ask a dose calculation question or may set a case scenario and ask the student how they would deal with it. In more sophisticated systems actors may be used to present the student with a problem where their ability to communicate can be tested. OSCEs are very useful in testing a range of skills but can be

subjective if the assessment criteria are not specific, determined in advance and documented. Great care must be taken in both setting and marking the stations.

1.1.37. Presentations

These can be a very good method of assessment particularly for a short course. It allows for testing of the students' knowledge that was in place to allow for preparation of the presentation but in addition the level of depth and understanding that they have achieved can be assessed through questioning following the presentation. Students are also gaining a useful secondary skill that they can use later and they can be encouraged to prepare presentations for future study days, workshops, conferences and meetings. They learn the skills of communication, how to stand and project themselves and their voices to the audience to give the maximum benefit to their presentation.

1.1.38. Posters

Posters are similar to presentations in requiring students to summarize their learning or research findings in a concise way through identifying the most important aspects and exploring how to present them for best effect. This is also a very useful skill to give the students for their future professional life and it can encourage them to participate in activities where they may previously have not felt confident enough.

1.2. CLINICAL COMPONENT

The clinical department is a crucial component of the learning environment. In the clinical environment the students learn to put their knowledge into practice. It is important that conflict does not arise between educating students and providing clinical care to increasing number of patients, particularly in situations where resources are limited and the infrastructure often sub-optimal. The role of clinical staff in supporting the education and training of students is critical. Understanding, being friendly, showing interest and explanations by the clinical staff are particularly helpful. The on-going involvement of clinical staff is essential for an effective, high-quality programme and must be encouraged right from the beginning.

1.2.1. Clinical placement

Students should ideally be exposed to the widest possible clinical experience. This may not be possible where radiotherapy infrastructure is poor and necessitates clinical placement outside the locality or even the country. As a requirement, students must spend significant time on a megavoltage energy unit, a Cobalt-60 unit and preferably dual modality multi energy linear accelerators. Where possible the student should be placed where they can gain experience with a range of imaging facilities for verification and CT scanners/simulators for treatment planning purposes. It is also recommended that students have exposure to brachytherapy and other more complex teletherapy treatment units. The students should learn standard treatment planning in the education environment but where possible should also spend time in the clinical treatment planning facility. Students should also be placed in the support areas within the department and should attend QA, radiation safety and clinical meetings where these are in place.

Clinical placements should be structured to avoid overloading the clinical department. The number of placement areas should be carefully calculated and students timetabled for attendance to cause minimum disruption to the routine clinical care operations. Where

departments are working extended days or have a shift system, students could be accommodated outside of the 'normal' working day to keep numbers to an acceptable level and enhance the experience for both students and clinical staff.

1.2.2. Clinical educators

Ideally a member of the academic staff should be responsible for overseeing the clinical education programme. This should be done in collaboration with clinical RTTs who will take responsibility for the student's progress in the clinical setting.

The academic staff are responsible for setting the theoretical programme, but the clinical staff are more familiar with actual equipment and techniques and must take an active part in the clinical education. The aims and objectives of the clinical programme are to ensure that the student is competent to practice. Clinically active RTTs should therefore have an active role in the training programme. The expert group acknowledges the difficulties faced by clinical staff due to high patient numbers, low staff levels and lack of resources. Students must be clear as to their position within the clinical department. Motivation to encourage the involvement of clinical staff is a high priority and both the academic and clinical institutions should consider ways of acknowledging and rewarding their role. It is important that time and support are given to the clinical trainers, they are actively involved in designing the clinical education programme and they receive training in both clinical teaching and assessment.

1.2.3. Clinical assessment

Clinical assessment is an essential component of the clinical programme. It is the method by which the competence of the student in the practical setting is evaluated. In the absence of clinical tutors this can be carried out by trained clinical staff. To assist in the assessment process and to ensure standardization and fairness, the education institution, in conjunction with the clinical staff, should develop a set of assessment sheets reflecting the setting and expectations.

The clinical assessment forms should be designed to monitor the student's progress and to test increasing levels of knowledge, depth of understanding and application at each placement. Assessments should be both formative and summative and should include a statement of an observable performance by the student and an indication of the minimum acceptable performance standard. Assessment tests the quality and efficiency with which the student performs a specific task. The number of assessments completed will give an indication of student progress and development. Students should complete a series of assessments during their clinical programme. Examples of a series of professional and clinical assessment forms, together with an outline of how they can be used, are given in Appendix II.

It can also be useful for the students to complete case studies or treatment profiles covering a range of routine disease sites as this demonstrates the students' ability to integrate theoretical knowledge into the clinical setting. It is useful to link case studies/treatment profiles to the professional and clinical assessment as this shows how the students link knowledge, understanding, application and practical skills in a clinical environment.

Evaluation of the clinical placement by the student is also important and will allow the teaching staff to monitor the standard of clinical teaching. It also encourages the students to take more control of their own education experience and the opportunity to monitor their own progress and to give feedback to the clinical departments.

A final assessment of clinical competency and experience (based on the entire duration of the student placement) should be completed by the academic staff, based on the compilation of the student's clinical performance throughout the training programme. To achieve this, all assessment forms and feedback should be included and evaluated.

2. CURRICULUM

2.1.CURRICULUM: THEORETICAL

A curriculum is a broad term used in educational settings to describe the set of courses designed to enable a student to reach a certain level of competency or qualification. It can incorporate all activities, experiences and learning opportunities.

This curriculum for RTTs has been developed based on Bloom's Taxonomy [3] (Fig.1) to define the levels of learning appropriate to each area or outcome.

2.1.1. Academic component

The proportion of time allocated to each subject will depend on the overall duration of the programme and the final qualification awarded.

Courses can be designed to cover the basic sciences in the first year/s with subsequent building of the professional component in the later years or through the integration of science and professional subjects from the beginning. Course design will be influenced by practice in the individual education institutions.

2.1.2. Basic sciences

The basic sciences provide the knowledge base for the RTT and include the essential components that will facilitate higher level learning necessary for professional practice. A more in depth coverage of the spectrum of basic sciences will be required for a programme leading to a qualification.

2.1.2.1.Basic sciences

1. Biology;
2. Chemistry;
3. Biochemistry;
4. Introduction to physics and mathematics;
5. Anatomy;
6. Radiographic anatomy;
7. Physiology;
8. Psychology/Sociology;
9. Information technology;
10. Oncology science;
11. Radiobiology and molecular oncology;
12. Medical radiation physics.

2.1.3. Professional knowledge

Professional education includes professional knowledge that can be called discipline-specific content. This includes those components of the curriculum that meet the requirements of professional bodies or institutions.

2.1.3.1.Professional disciplines

13. Professionalism and ethics;
14. Patient care;
15. Patient positioning and immobilization;
16. Radiotherapy treatment planning;
17. Radiotherapy delivery;
18. Quality assurance, quality control and risk management;
19. Critical appraisal.

TABLE 2.1. DESCRIPTION OF THE OVERALL CONCEPT AND TOPICS TO BE TAUGHT

Topics	**Sub-topics**
1. Biology	
Understanding the structure and function of the normal and malignant cells underpins the student's understanding of the process of carcinogenesis and radiobiology. At a higher level greater detail on cellular organization, cancer biology and cell communication can be introduced and is supportive of higher level understanding of molecular oncology leading to an ability to understand treatment plans and dose distributions and at a higher level to allow for evaluation of research in the area.	
Introduction	
	Cell structure, cytoplasm
	Nucleus
	Cell division (mitosis and meiosis)
Cellular functions and energy pathways	
Glycolysis	
Biological membranes and cellular organization	
	Membrane permeability and transport
Chromosomes and gene regulation	
Cell communication	
	General principles of cell signaling
	Protein linked receptors
	Enzyme linked receptors
Introduction to cancer biology	Viruses, oncogenes, tumour suppressor genes Extracellular environments and cancer, hormones

2. Chemistry	
The chemistry topics will provide the students with an understanding of the interaction of cancer treatments with both malignant and normal tissue and in conjunction with the biology topics underpin the biochemistry component. At a higher level it will provide a background for understanding the pharmacology of commonly used chemotherapy and molecular targeting therapies and their interaction with radiotherapy.	
Definitions	
Basic concepts	
	Atom
	Element
	Compound
	Substance
	Molecules
	Ions and salts
	Acidity and basicity
	Equilibrium
	Energy
	Chemical laws

3. Biochemistry	
The biochemistry topics link the concepts of the biology and chemistry modules and aid in understanding their relationship. This knowledge underpins radiobiology and molecular oncology facilitating a greater understanding of tumour control and acute and late side effects following treatment and how they can be avoided or minimized. Biochemistry will be more appropriately included in a degree level programme.	
Amino acids and proteins	
Enzymes	
Carbohydrates	
Lipids	
Lipid metabolism: fatty acid oxidation	
Biological oxidation, respiratory chain	
Metabolism of nucleic acids	
Relationship to other ’molecular-scale’ biological sciences	

4. Introduction to physics and mathematics
Physics is a key component of all education programmes for RTTs and should comprise a

significant proportion of the overall syllabus. The physics modules will provide the scientific basis of dose calculation and treatment planning, the principles of the equipment used routinely in the administration of radiotherapy and an understanding of the basis of radiation protection and safe practice. Students should be able to draw, read, and report on graphs, charts and tables/ calculate ratios/ measure time, temperature, distance, make estimates and approximations and judge the reasonableness of the results and demonstrate an ability to evaluate and draw conclusions.	
Applied mathematics	
Systems of measurement	
Electricity	
Magnetism, electromagnetism	
Atomic and nuclear structure, radioactivity and magnetic resonance	
5. Anatomy	
Anatomy is a key component of all education programmes for RTTs and should have a strong focus on organ position, orientation and relationships. The topics provide the student with an understanding of the structure and relationships of the systems and organs of the body which is essential in patient positioning, treatment planning and accurate treatment delivery. The radiographic anatomy component will enable RTTs to evaluate images for treatment planning and verification.	
Introduction to macroscopic morphology	
Introduction to microscopic morphology	
Locomotor system	
Integumentary system	
Thoracic cavity and abdomino-pelvic cavity	
Cardiovascular system	
Immune system	
Respiratory system	
Digestive tract and associated organs	
Genito-urinary system	
Organs of the senses	
Endocrine system	
Overview of neuroanatomy	
Human embryo morphology	
6. Radiographic anatomy	
Emphasis on plain and cross-sectional radiographic anatomy	
Surface anatomy	

Plain film / conventional radiographs	
Mammography	
Computed Tomography (CT)	
Magnetic Resonance Imaging (MRI)	
Ultrasound	
Nuclear medicine	
Digitally Reconstructed Radiographs (DRR)	
Portal imaging	

7. Physiology

Physiology provides the students with knowledge of the function of systems and organs and their relationships and underpins the understanding of how cancer treatments can affect the function of normal tissue leading to late side effects. Physiology is important to all programmes with increased depth of content required where RTTs are being required to take a more active role in side effect recognition and management. This may be in departments where RTTs are increasingly taking some responsibility in this area or in resource constrained environments where nursing or medical staff are limited.

Cell physiology	
Electrophysiology	
Neurophysiology	
Endocrine	
Cardiovascular	
Lymphatic	
Immune	
Respiratory	
Digestive	
Urinary	
Reproductive	

8. Psychology and sociology

A diagnosis of cancer is considered as a major life event and affects patients and their families/carers in many different ways. It is important for RTTs to know the underlying psychology of health and illness and how these impact on the patient, family and carers. Communication is a key component of professional behaviour and the student must know how to communicate effectively. Psychology may studied be more in depth at degree level.

Sociology is important to all education programmes for RTTs. In order to appropriately help patients through their treatment, students need to have an appreciation of the sociological and cultural factors within their community.

Psychology	
Basic concepts within the field of psychology and their application to everyday human behaviour, thinking, and emotion.	
	Psychological issues before, during and after treatment
	Communication with the cancer patient
	Radiotherapy side effects
	Patient support or self-help group
	Lifestyle information
Sociology	
	Cultural / religious issues
	Gender
	Age related
	Family / careers
	Social relationships
Communication and support	
	Multidisciplinary team
	Inter- and intra-professional co-operation
	Patient and family
	Counselling skills
	Group facilitation
9. Information technology	
Modern radiotherapy is a high technology modality and computer awareness and skills are essential components of practice. Students should operate within the evidence based paradigm and be able to carry out effective internet searches to substantiate their knowledge, underpin research, evaluate information and advise patients.	
Basics of computer use	Computer literacy; Functional knowledge of word processing, how to use e-mail, spread sheet, databases, Internet, installing software, installing an operating system, navigating a computer's file system.
Computer networks	
Information security	
10. Oncology science	
This subject puts cancer, the treatment methods available and the patient pathway into context. It provides the student with an understanding of the other disciplines involved in the management of patients from diagnosis to follow up and how they interact with the	

radiotherapy department in the overall management of the cancer patient. This underpins how the information gained at the various stages can be used most effectively and appropriately. The topics related specifically to radiotherapy will enable students to analyze and evaluate treatment options and the associated side effects and how this information is used in defining the most appropriate treatment for each individual patient. It will provide students with knowledge of other therapies that patients may avail of and how quality of life issues can be addressed.	
Pathology	
Malignancies	
Carcinogenesis	
Co-morbidities	
Etiology and epidemiology	
Genetics	
Prevention	
Early detection	
Signs and symptoms	
Public awareness on early signs and symptoms	
High risk groups	
Screening programmes	Breast Colorectal Cervix Prostate Skin Oral cavity
Diagnosis of malignancy	
Clinical examination	
Biopsy	
Laboratory tests	
Imaging methods	
Staging and grading	
TNM staging system, other commonly used systems	
Treatment intent	
	Radical
	Adjuvant

	Palliative
Non-malignant diseases	
Primary management of malignancy	
Performance status	
Surgery	
	Principles of oncological surgery
	Indications
	Routine procedures
	Management of lymph nodes
	Prosthetic, reconstructive and cosmetic surgery
Chemotherapy	
	Principles of chemotherapy
	Indications and treatment intent
	Classification of cytotoxic agents
	Modes of administration
	Side effects and management
	Specific examples: – Head and Neck – Breast – Colorectal – Other relevant to context
Immunotherapy	
Hormonal therapy	
	Principles of hormonal therapy
	Classification of hormones
	Treatment intent
	Modes of administration
	Modes of action
	Side effects and their management
Radionuclide therapies	
Gene manipulation	
Complementary therapies	Objective evidence-based review of complementary therapies and their contribution to cancer and toxicity relief
Quality of life	

	Morbidity
	Cosmesis

11. Radiobiology and molecular oncology

In simplest terms, radiobiology is the study of the action of ionizing radiation on living structures and organisms. Radiobiology is the basic science behind radiotherapy and it can explain, and occasionally also predict responses of tumours and normal tissues to radiation.

Knowledge of the principles of radiobiology allows the RTT to comprehend the effects of different types of radiation, fractionation schemes, the use of radiosensitizers and other interactions he/she observes on a daily basis.

Cell kinetics	
Cell cycle control mechanisms	
Tumour biology	
Metastases	
The five ‘R’s of radiobiology	
Tissue structure and radiation effect	
The Linear Quadratic (LQ) model	
Tumour control probability (TCP), Normal Tissue Complications Probability (NTCP) models	
Acute and late side effects	
Sensitizers/protectors/side effect reduction	
Fractionation	
Treatment combinations	
Treatment scheduling	

12. Medical radiation physics

Medical physics is a branch of applied physics that uses physics principles, methods and techniques in practice and research for the prevention, diagnosis and treatment of human diseases with a specific goal of improving human health and well-being. Medical radiation physics concerns the use of ionizing radiation in medicine in general and in radiotherapy in particular. This topic also provides the student with knowledge of the more specialized equipment they may be expected to use at a later stage in their career or in a different clinical environment. Students will gain knowledge and understanding of the procedures and practices associated with external beam radiotherapy and brachytherapy.

Radioactivity and electromagnetic radiation	
Production of X rays	
Properties of X rays	
Generation of photon, electron and particle beams	

Interaction of ionizing radiation with matter	
Radiation Protection / Radiation Safety	
External beam radiotherapy (EBRT) (including beam generating mechanisms, beam characteristics, applied physics, design features e.g. MLC)	Superficial
	Orthovoltage
	Cobalt-60
	Linear accelerators
	Stereotactic radiotherapy
	Robotic radiotherapy
	Particle beam generators
	Helical tomotherapy
	Intra-operative radiotherapy
	Other as relevant e.g. proton therapy
Design and operation of imaging equipment for radiotherapy	Conventional simulator
	CT simulator
	CT
	MRI
	PET
	SPECT scanners
Accessory equipment	
Radiotherapy laboratory (mould room)	2D/3D computerized shielding
Brachytherapy	
	Design features
	Radiation sources
	Radiobiology
	Technique
	High dose-rate (HDR)
	Low dose-rate (LDR)
	Pulsed dose-rate (PDR)
	Applicators
	Planning and dosimetry
	Radiation protection in brachytherapy

	Shielding calculation
Radiation detection	
Radiation protection	General public, patients and staff

13. Professionalism and ethics

As a health-care professional the RTT is committed to the health and well-being of individuals and society through ethical practice, profession-led regulation and high personal standards of behaviour.

Elements include altruism, integrity and honesty, compassion and caring, morality and codes of behaviour, responsibility towards patients, colleagues and society, commitment to high quality practice, self-awareness, self-assessment and disclosure of errors or adverse events.

Health care structure	
Hospital / hospice / home care	
Structure and function of a radiotherapy department or unit	
Departmental management	
Evidence based practice	
Career development	
Professionalism / rights and obligations	
Role development	
Ethical and legal issues	
	Ethics
	Relevant laws
	Data protection
	Confidentiality
	Patient rights

14. Patient care

In this context, patient care refers to all non-radiotherapy related aspects of the work that the RTT does while interacting with patients. This ranges from communication to the identification and referral for radiation related toxicities to cardio-pulmonary resuscitation.

Communication (from Latin ‘communis’, meaning to share) is the activity of conveying information through the exchange of thoughts, messages, or information, as by speech, visuals, signals, writing, or behaviour. Communication skills are essential for the RTT; not only is he/she the first line of interaction between the patient and the health care team, but the nature of radiotherapy departments demands continuous and fluent interaction among the different professional groups.

First aid including Cardio-Pulmonary Resuscitation (CPR)	
Informed consent	
Patient management on treatment	
Radiotherapy side effects	
	Acute
	Late
	Monitoring side effects
	Management of side effects
Information and communication	
	Documentation of patient health and side-effects
	Infection control
Treatment of palliative patients	
	Pain
	Bleeding
	Dysphagia
	Metastatic disease
Second primary malignancies	
Local recurrence	
Metastatic disease	
Rehabilitation	
Quality of life (QoL)	

15. Patient positioning and immobilization

The RTT must be able to apply the principles of positioning to the preparation of the immobilization device. Consideration must be taken of the practical aspects of immobilization device preparation. Examples of commonly used immobilization devices are given below.

Positioning aids	
	Breast boards
	Lung boards
	Belly boards

	Head-and-neck fixation devices
	Vacuum packs
	Stereotactic systems
Internal organ motion control	
	Bite blocks
	Gating systems
	Active breathing control
	Diaphragm compression
	Prostate immobilization
	Tracking systems. Laser/ positioning systems
Marking systems	
Isocentre determination	
Reference points	
Treatment couch	
	Type
	Indexing
	Referencing
	Attachments
Image acquisition for planning (and/or verification)	
Modalities for image acquisition for planning	
Simulation	
Types:	
	Conventional Simulation
	CT Simulation
	Virtual Simulation
Image processing and archiving	
Treatment verification	
	kVCT, EPID and portal imaging
	Mega-voltage Computed Tomography (MVCT)
	Ultrasound
	Dose monitoring
	Dosimetry
	In vitro dosimetry

	In vivo dosimetry (TLD, Diodes)
Protocols	
	Imaging protocols: development and implementation
	Non-action levels (NAL)
	On-line/off-line corrections
	Matching/co-registration methodology
	QA of imaging modalities
	Geometric uncertainties
	Documentation
	Adaptive radiotherapy
	Information management

16. Radiotherapy treatment planning

Medical imaging (i.e. computed tomography, magnetic resonance imaging, positron emission tomography, and single photon emission tomography) are used to form a virtual patient for a computer-aided design procedure. Treatment simulations are used to plan the geometric and radiological aspects of therapy using radiation transport simulations and optimization. Three-dimensional plans are often assessed with the aid of dose-volume histograms, allowing the clinician to evaluate the uniformity of the dose to the diseased tissue (tumour) and sparing of healthy structures.

The RTT must understand and where appropriate be able to:

Do planning and dose calculation	
Calculate Percentage Depth Dose (PDD), Tissue Air Ratio (TAR), Tissue Maximum Ratio (TMR), Tissue Phantom Ratio (TPR)	
Factors that influence the dose distribution and MU/time calculation	
Prepare two-dimensional (2D) plans	
Prepare three-dimensional (3D) plans	
Beam shaping and modification	
Describe Treatment Planning System (TPS)-algorithms	
Define Hounsfield units and relative electron densities	
Do required calculations	
Interpret ICRU recommendations in ICRU Reports 50,62 and 83	
Apply dose volume constraints and methods to determine	

Understand Gross Tumour Volume (GTV), Clinical Target Volume (CTV), Internal Target Volume (ITV), Planning Target Volume (PTV), Organs at Risk (OAR) delineation	
Conduct image fusion	
Do bony matching	
Do soft tissue matching	
Apply deformation registration	
Conduct treatment plan analysis and evaluation	
Prepare documentation	
The RTT should understand the principles of:	
Four-dimensional (4D) planning	
Inverse planning for IMRT	
Treatment planning for other techniques, e.g. brachytherapy, stereotactic radiotherapy	

17. Radiotherapy delivery

Based on Bloom's taxonomy, students should be able to analyze, synthesize and evaluate the information acquired in the radiotherapy specific modules in radiotherapy preparation, delivery and patient support. From Bloom's taxonomy, 'analysis' is the ability to break down the information into its component parts and look for interrelationships and ideas, 'synthesis' is combining information from a range of settings or experiences and 'evaluation' is judging the value of the information and how it is best applied.

The clinical competencies are defined in paragraph 1.1.6. The range and depth of coverage will depend on the local resources and programme duration but at least mention should be made of equipment not readily available in the country.

Orthovoltage / superficial	
Supervoltage / Megavoltage	
	Clinical markup
	2D techniques
	Three-dimensional conformal radiation therapy (3D-CRT)
	Intensity Modulated Radiation Therapy (IMRT)
	Four-dimensional radiotherapy (4D-RT)
Brachytherapy	
Stereotactic radiotherapy	
	Stereotactic radiosurgery

	Stereotactic radiotherapy – Cranial – Extra cranial (Stereotactic body radiotherapy SBRT)
	Total Body Irradiation (TBI)
	Total Skin Electron Irradiation (TSEI)
	Radiation therapy with neutrons, protons, and heavy ions

18. Quality assurance, quality control (QA/QC) and risk management (RM)

Quality assurance (QA) refers to the systematic activities implemented in a quality system so that quality requirements for a product or service will be fulfilled. It is the systematic measurement, comparison with a standard, monitoring of processes and an associated feedback loop that confers error prevention and provides accuracy of treatment. This can be contrasted with quality control, which is focused on process outputs.

The process of radiotherapy is complex and involves understanding of the principles of medical physics, radiobiology, radiation safety, dosimetry, radiation treatment planning, simulation and interaction of radiation with other treatment modalities. Each step in the integrated process of RT needs quality control and quality assurance (QA) to prevent errors and to give high confidence that patients will receive the prescribed treatment correctly. Recent advances in RT, including intensity-modulated and image-guided RT, increase the demand on the need for a systematic radiotherapy quality assurance program that balances patient safety and quality with available resources

Risk management is the identification, assessment and prioritization of risks (defined in ISO3100 as the effect of uncertainty on objectives, whether positive or negative). This is followed by an appropriate and achievable level of resources, to minimize, monitor and manage the impact of unintended events and reduce the probability of such events occurring.

Equipment	
Procedures	
Protocols	
Audits	
Incident registration and reporting	
Health and safety	
Manual handling	
Occupational injury	
Fire	
Infection control	

Risk management	
	Health and safety
	Quality management
	Learning from incidents and near incidents
Feedback	
Action	
Responsibility levels	
Radiation protection	
Guidelines for tolerance values	
Quality Control of Cobalt-60 teletherapy units	
Quality Assurance of medical electron accelerators	
Quality Assurance of CT scanners and simulators	
Quality assurance of measurement equipment	
Quality control test frequency	
Documentation and records	

19. Critical appraisal

Critical appraisal is the use of explicit and transparent methods to assess the data in published research, applying the rules of evidence to factors such as internal validity, adherence to reporting standards, conclusions and generalizability. Critical appraisal methods form a central part of the systematic review process. They are used in evidence-based healthcare training to assist clinical decision-making, and are increasingly used in evidence-based social care and education provision.

Methodology of clinical research in radiation oncology	
Evidence search	
Statistical methods	
Critical appraisal of publications	

2.2.CURRICULUM: CLINICAL

Clinical placement is central to the development of professional skills, professional attitudes and clinical competence. The student will begin to understand how the knowledge and skills gained during the academic year/s apply to clinical practice and will be supported in this by working closely with the radiation therapists.

As part of placement the student is expected to familiarize him/herself with the hospital and the radiotherapy department in particular, the staff involved in the management of the patient, how the team interacts with each other, with the wider multidisciplinary team and with the patient.

Experienced clinical RTTs are expected to support the students in gaining understanding and in developing their technical and psychosocial skills. The clinical environment is essential in providing students with the practical learning experience underpinning their future practice. The student is expected to work the same hours as the clinical staff of the department and full attendance is compulsory unless otherwise notified.

2.2.1. Professional development

During clinical placement the student will develop as a health care professional and gain an understanding of:

- how the radiotherapy department relates to and interacts with the other departments in the clinical environment;
- the patient pathway and the personnel involved at each stage;
- the radiotherapy team and the wider multidisciplinary team;
- their role and the appropriate communication skills and professional attitude in the clinical setting.

The learning outcomes that are related directly to clinical placement and the application of the areas covered in the academic programme are that the student should:

- Demonstrate an understanding of a typical patient pathway;
- Demonstrate an understanding of basic psychology and sociology and how these apply to the cancer patient;
- Apply their knowledge of the areas in radiotherapy, to the treatment of the patient with a professional and caring attitude;
- Explain the need for accuracy in treatment of the cancer patient;
- Demonstrate a sensitive and caring attitude to patients and discuss the necessity for good communication skills;
- Demonstrate a professional attitude and ability to reflect on their role;
- Apply principles of moving and handling for all practical manoeuvres;
- Reflect on their experience and how it has influenced their thinking.

2.2.2. Clinical competence

Clinical placements provide the student with an opportunity to experience the clinical environment and apply theoretical learning to the workplace. Each clinical placement will build on the student's existing knowledge from previous placements and from the clinical skills tutorials and enhance clinical competence by reinforcing learning continuously.

Learning in the clinical environment should be appropriate to the level of the student and the theory that is being learnt. Each clinical assessment must align to the specific learning outcomes of the level that increase in complexity from standard radiotherapy techniques to more complex treatments.

Clinical placements allow the student to become familiar with:

(1) The purpose/function of the equipment with particular attention to the following:

- Features of a radiotherapy treatment room;
- Safety features including interlocks, cameras and intercom;
- Equipment:
  - major components of linear accelerator (and/or Cobalt-60);
  - radiation types and energies;
  - treatment techniques;
  - shielding;
  - treatment verification;
  - in vivo dosimetry;
  - field size;
  - distance;
  - wedges;
  - bolus.
- Accurate patient positioning;
- Accessory positioning and immobilisation aids including:
  - masks;
  - mouth bites;
  - breast board;
  - vacuum forming devices;
  - belly board;
  - foot-fix;
  - knee-fix;
  - lung board;
  - any other in use in the department.

(2) Patient care and management before, during and after treatment with particular attention to the following:

- Communication;

- First treatment information;
- Daily care during treatment;
- Recognition of new signs and symptoms;
- Recognition and care of side effects;
- Appropriate referral.

2.2.3. Learning outcomes specific to clinical placement

The learning outcomes must be relevant to the programme/qualification and to the level of the student. In all programmes there is a progressive development of the student from more general outcomes to highly specific outcomes for complex professional practice. The outcomes listed below are in order of application from level 1 to level 3 and while all must be achieved, there can be some flexibility in the presentation and assessment of these outcomes. The students in all programmes will also be required to critically evaluate their practice through the process of reflection which in turn will enable them to become critical thinkers and reflective practitioners. The aim of clinical placement at this level is to ensure that the students develop a range of clinical competencies appropriate to a newly qualified RTT.

The assessment forms (Appendix II) are examples of possible criteria for the assessment of the learning outcomes.

The learning outcomes are that the student will be able to:

- Understand the general work that is undertaken on the unit or in the area to which students are assigned;
- Describe the overall radiotherapy process;
- Understand the psychosocial issues associated with cancer treatment;
- Explain the technical aspects of the treatment unit;
- Identify and describe the purpose of the features of the treatment room;
- Identify and explain the use and purpose of the safety features;
- Describe the equipment used in routine radiotherapy;
- Identify and explain the use of the various positioning and immobilisation devices;
- Identify, position and immobilise the patient correctly;
- Work as a team member on the unit or in the area to which they are assigned;
- Understand the radiotherapy process;
- Apply knowledge of psychology and sociology to patient care and management;
- Interpret the treatment prescription;
- Understand standard treatment plans;
- Participate in the simulation procedures;
- Explain the available image verification methods commonly used;
- Define patient assessment criteria and appropriate referral.

Students on a 4-year degree programme will have additional clinical placements to enable them to participate in treatment planning/dosimetry for complex treatment techniques (e.g. 3-D conformal radiotherapy) and to acquire the skills necessary to adapt to future developments in the field of radiotherapy, incorporating best practice and evidence- based medicine. Students at this level will be required to integrate fully in all sections of the Radiotherapy Department. The students will also be required to critically evaluate their practice through the process of reflection which in turn will enable them to become critical thinkers and reflective practitioners.

The assessment forms (Appendix II) are examples of possible criteria for the assessment of the learning outcomes in level 4.

The learning outcomes for level 4 that are additional to the learning outcomes already listed are that the student will be able to:

- Participate fully in and demonstrate competence in all aspects of localisation, planning/dosimetry, verification, treatment set-up and delivery which enable them to integrate fully as a member of the Radiotherapy team;
- Demonstrate professional attitude appropriate to a newly qualified RTT in terms of effective communication with patients, relatives, staff and the wider multi-disciplinary team;
- Critically evaluate their practice through the process of reflection which they will demonstrate by discussion with clinical staff and document in reflective diaries and case studies as part of their clinical portfolio;
- Evaluate patient conditions and respond appropriately in terms of advice and support relating to the treatment process;
- Analyse treatment plans and techniques in relation to best practice and evidence based medicine.

2.2.4. Student feedback

It is important to allow the student to give feedback and comment on their experience of each clinical placement. This can be a separate form specifically for student feedback; a section added to the continuous formative clinical assessment form or can be part of the clinical assignment that is completed during clinical placement (Appendix III, Part 2 ‘The Reflective Report’).

APPENDIX I.
TABLE OF TOPICS TO BE COVERED ACCORDING TO THE LEVEL OF CERTIFICATION

SUBJECT	COURSE DURATION AND LEVEL OF CERTIFICATION			
	Level 1A	**Level 1B**	**Level 2**	**Levels 3 and 4**
	Centre- based training (Less than 1 year)	**Certificate** (1 year)	**Diploma** (2 years)	**Diploma / degree** (3–4 years)
	Lectures delivered on the clinical site/s	Lectures delivered in the educational setting with clinical attachments	Lectures delivered in an educational setting with clinical attachments	Lectures delivered in a university setting with clinical attachments

I.1. GENERAL SCIENCE				
Biology	Cell structure and function	Cell structure and function	Cell structure and function. Energy pathways	Full course
Chemistry	X	X	Atoms, elements, compounds, substances, molecules	Full course
Physics	Introductory mathematics Atomic structure X rays	Introductory mathematics Atomic structure X rays	Introductory mathematics Atomic structure Electricity, magnetism, electromagnetic induction, AC, electromagnetic radiation X rays	Full course
Biochemistry	X	X	X	Full course

Anatomy	Systems overview Basic radiographic anatomy – organ relationships	Systems overview Basic radiographic anatomy – organ relationships	Systems overview Radiographic anatomy – organ relationships	Full course
Physiology	How cancer treatment changes function	How cancer treatment changes function	Overview of major systems physiology	Full course
Psychology and sociology	Cultural issues Multidisciplinary team	Cultural issues Multidisciplinary team	Cultural issues Multidisciplinary team Communication with the cancer patient	Full course
Information technology	Basic computer use	Basic computer use	Computer use Computer networks	Full course
Oncological science	Carcinogenesis Staging and grading Treatment intent	Carcinogenesis Staging and grading Treatment intent	Carcinogenesis Staging and grading Treatment intent Methodologies used in cancer management	Full course
Radiation physics	Linear Accelerator Cobalt-60 unit	Linear Accelerator Cobalt-60 unit	External beam radiotherapy physics Brachytherapy	Full course

I.2. RADIOTHERAPY SPECIFIC				
Professionalism	Confidentiality Professional appearance Communication	Confidentiality Legal aspects Ethics Professional appearance Communication	Confidentiality Legal aspects Ethics Professional appearance Communication	Full course
Interpreting a treatment prescription	How to read a treatment sheet	How to read a treatment sheet	How to interpret a treatment prescription	Full course
Positioning and immobilization	All aspects	All aspects	All aspects	Full course
Image acquisition and simulation	Basic imaging procedures	Basic imaging procedures	Applied imaging procedures Simulation methods	Full course
Treatment planning	X	X	Standard treatment plan interpretation	Full course
On treatment verification	X	X	Principles of on treatment image verification	Full course
External beam treatment delivery	Methods of delivery	Methods of delivery	Methods of delivery Complex techniques	Full course
Radiation protection and health and safety	Principles of protection – patients and staff Limited QC	Principles of protection – patients and staff Limited QC	Principles of protection – patients and staff QA/QC	Full course

Patient care and support	Communication Applied nursing	Communication Applied nursing	Communication Applied nursing Patient assessment Appropriate referral	Full course
Information Management	Accurate documentation	Accurate documentation	Record and Verify systems	Full course
Brachytherapy	X	X	Patient care during Brachytherapy procedures Radiation Protection in brachytherapy	Full course
Research	X	X	X	3 year programme – research proposal 4 year programme – research project
Education	X	X	X	Full course

I.3. CLINICAL PRACTICE				
	Professional Assessment and Clinical Assessment 1 (see Appendix II)	Professional Assessment and Clinical Assessment 1 (see Appendix II)	Professional Assessment and Clinical Assessment 1 and 2 (see Appendix II)	Professional Assessment and Clinical Assessments 1, 2 and 3 (see Appendix II)
	Clinical Assignment 1 (see Appendix III)	Clinical Assignment 1 (See Appendix III)	Clinical Assignments 1 and 2 (See Appendix III)	Clinical Assignments 1, 2, 3 and 4 (See Appendix III)

APPENDIX II.
PROFESSIONAL AND CLINICAL ASSESSMENT FORMS

The attached assessment forms are examples of some forms that have been designed to assess student progress and achievement as applicable to the content and duration of the programme followed. The appropriate level of clinical assessment for each programme has been identified in the table of topics to be covered according to the level of certification (Appendix I). Please note that this is not a complete set of assessment forms and that adaptation will be necessary to prepare assessment forms for the specific programme in each education centre.

A professional assessment form and a clinical assessment form at the appropriate level must be completed for all clinical placements.

II.1. PROFESSIONAL ASSESSMENT (ALL YEARS)

The Professional Assessment form is applicable for all programmes irrespective of content or duration and is used to assess the students' professional attitude and behaviour and their ability to communicate with staff and patients. This assessment also includes the student's understanding of radiation protection, health and safety and local infection control guidelines. These are considered key competencies of all RTTs and are applicable to all education programmes.

II.2. CLINICAL ASSESSMENTS

II.2.1. Title page for all clinical assessments

This form is an example of a cover page and can be adapted for use with all clinical assessments.

II.2.2. Continuous formative clinical assessment

Qualified RTTs in the clinical placement sites are important for promoting and assessing the professional development of the student. Continuous formative assessment should be used to assess whether the student has met the learning outcomes with regard to being a professional and being an RTT and to provide feedback to the student for their professional development and in preparation for summative assessment. The focus of such continuous formative assessment is for the clinical mentor(s)/supervisor(s) to assess the student continuously throughout each clinical placement. It is also advisable for the radiotherapy team to identify a suitable patient towards the end of the placement and to assess the student positioning the patient.

II.2.3. Summative clinical assessment 1 (level 1)

Clinical Assessment at level 1 is applicable for all programmes. It is the first clinical assessment and is designed to ensure that the student gains familiarity with the radiotherapy process, the equipment used and the members of the multidisciplinary team. The student will learn the procedures involved in patient preparation and treatment and how to work as an effective member of the team. The aim of this clinical assessment is to ensure that all RTTs irrespective of the content and duration of their education programme are competent to participate in standard treatment setups and are familiar with the equipment and terminology used in daily practice.

II.2.4. Summative clinical assessment 2 (level 1and 2)

Clinical Assessment 2 builds on the knowledge and skills acquired by the students during their previous clinical placements. The aim is for the students to now begin to interpret a treatment prescription and associated plan, to participate in the treatment simulation procedures and to define the departmental criteria for patient assessment and appropriate referral. The example given is an assessment that can be used for all standard treatments in the clinical placement sites.

II.2.5. Summative clinical assessment 3 (level 3 and 4)

Clinical Assessment 3 builds on the knowledge and skills acquired by the students during their clinical placements. The aim is for the students to now begin to integrate best practice and evidence-based medicine into their own practice and to begin to critically evaluate their own practice. The students are now expected to integrate more fully into the treatment team, to evaluate the physical and psychosocial status of the patient, to give advice and to relate all findings correctly and appropriately to the RTT team. The students should participate fully in the treatment preparation (immobilization devices and other accessory equipment and planning/dosimetry) that is routinely used in the department and be able to carry out all aspects of the treatment procedure. The example given is an assessment that can be used for all treatment techniques in the clinical placement sites. The difference between level 3 and 4 would be that while the 3-year diploma/degree student would be able to plan standard treatments, interpret all plans and apply all techniques, the 4-year degree graduate would be able to plan more complex treatment techniques (e.g. 3-D conformal radiotherapy), engage in research and contribute to developing the radiation therapy service in the department and country.

TABLE II.1. ASSESSMENTS AND ASSIGNMENTS RELEVANT TO THE PROGRAMME LEVELS

Assessment and Assignment forms to be completed	**Level 1a Centre based training less than 1 year**	**Level 1b Certificate**	**Level 2 Diploma**	**Level 3 Degree (3 years duration)**	**Level 4 Degree (4 years duration)**
Professional assessment	X	X	X	X	X
Clinical assessment	1	1	1 and 2	1, 2 and 3	1, 2 and 3
Clinical assignment	1	1	1 and 2	1, 2 and 3	1, 2, 3 and 4

TABLE II.1.1. PROFESSIONAL ASSESSMENT (PROFESSIONALISM)

COMPETENCY					
	PASS AND LEVEL OF COMPETENCE				
	PASS	**EXCEEDS EXPECTATIONS**	**EXAMPLES**	**FAIL**	**REASON**
Professional appearance (Uniform, orderliness, tidiness)					
Attendance					
Punctuality					
Reliability (carrying out tasks as directed)					
Willingness to participate					
Assumes responsibility within appropriate limits					
Courtesy					

	PASS	EXCEEDS EXPECTATIONS	EXAMPLES	FAIL	REASON
Communication with patients. Engages the patient in general conversation Recognises his/her limitations in patient interaction					
Communication with staff Asks questions Transfers information accurately Functions effectively as member of multi-disciplinary team Engages with patients, staff, public in a professional manner					
Professional manner with the patient (As appropriate for the stage the student has reached in the education programme)					
Additional comments:					

TABLE II.1.2. PROFESSIONAL ASSESSMENT (HEALTH AND SAFETY)

RADIATION PROTECTION AND HEALTH AND SAFETY		
STUDENT IDENTIFIED AND DISCUSSED THE PURPOSE OF:	**PASS**	**FAIL**
Personnel radiation monitoring devices		
Radiation warning signs and warning lights		
Entrance system (e.g. maze, gate) and wall thickness		
Door interlocks		
Emergency buttons		
Last man out button		
Fire-fighting equipment		
Fire alarms and fire exits		
Emergency / crash trolley		
Oxygen and suction equipment		

STUDENT WAS AWARE OF LOCAL INFECTION CONTROL GUIDELINES:	**PASS**	**FAIL**
Identified the materials required		
Helped to prepare the room for an infectious patient or outlined the procedure		
Helped with cleaning procedures following treatment of an infectious patient or outlined the procedure		
Helped to correctly dispose of waste material or outlined the procedure		
Additional Comments:		

[1]

[1] Adapted from the clinical programme of the Discipline of Radiation Therapy, School of Medicine, Trinity College Dublin.

II.2.1. TITLE PAGE FOR ALL CLINICAL ASSESSMENTS

Name:

Unit/Section:

Department/Hospital:

Placement Dates:

Attendance record	Detail	Comment
Full attendance		
No. of days and dates absent		
Staff member notified and date of notification		

Signatures following discussion between student and clinical mentor/supervisor:

Student: _____

Clinical mentor/supervisor(s): _____

RTT Educator: _____

Date: _____

II.2.2. CLINICAL ASSESSMENT

Continuous formative clinical assessment

Please comment on the student's core and generic competencies considering the student's ability to:

- Identify the area being treated and discuss related theory;
- Accurately set-up the patient according to the prescription and plan;
- Practice professionally within the team;
- Appropriately communicate with and care for the patient.

Were the aims and objectives, outlined at the beginning of this placement, fulfilled?

Yes No Partially

Name:

Signature: _____ _____ _____

RTT Instructor Student Date

Please comment on the student's progress throughout their time on this clinical placement.

1. Overall for this placement, this student is:

Adequate:_____
Reason:
_____
_____
_____

Needs further practice:_____
Reason:

_____
_____
_____

2. Indicate what aspects are excellent, very good, good, satisfactory or poor. Provide reasons and recommend areas that the student can work on:

Poor:_____
Reason:

_____
_____
_____

Satisfactory:_____
Reason:

_____
_____
_____

Good: _____

Reason:
_____
_____
_____

Very good_____

Reason:
_____
_____
_____

Excellent_____
Reason:

_____
_____
_____

Name:

Signature: _____ _____ _____

Clinical Supervisor Student Date

TABLE II.2.3. CLINICAL ASSESSMENT 1: PATIENT SET-UP

The student	**Did not complete**	**Completed with significant assistance**	**Completed with minimal assistance**	**Completed with no assistance**	**Excellent (no assistance and used initiative at all times)**
Read set-up details and prepared the treatment room appropriately (following health and safety procedures)					
Call and identify patient correctly					
Check patient's condition (communicates well with the patient)					
Positioning and immobilization of the patient (communicates well with RT team)					
Confirm parameters					
Additional Comments:					

TABLE II.2.4. CLINICAL ASSESSMENT 2: PATIENT SET-UP

The student:	**Did not complete**	**Completed with significant assistance**	**Completed with minimal assistance**	**Completed with no assistance**	**Excellent (no assistance and used initiative at all times)**
Interpret the treatment prescription correctly and check with the treatment plan for a standard setup					
Read set-up details and prepare the treatment room appropriately (following health and safety procedures)					
Call and identify patient correctly					
Check patient's condition (communicates well with the patient)					
Positioning and immobilization of patient (communicates well with RT team)					
Explain the image verification methods commonly used					
Define patient assessment criteria and appropriate referral					
Confirm parameters					

Additional Comments:

[2]

[2] Based on the clinical programme of the Discipline of Radiation Therapy, School of Medicine, Trinity College Dublin.

II.2.5. CLINICAL ASSESSMENT 3 AND 4: PATIENT MANAGEMENT AND TREATMENT

Learning outcomes for this placement

Agreed by:

Student Signature:

RTT Educator Signature:

Date:

Interim Review and discussion (not applicable if short placement)

Comments:

RTT:

Student:

Signatures: _____ _____

Date: _____

TABLE II.2.5.1. CLINICAL ASSESSMENT OF PATIENT MANAGEMENT

Ability to assist patients in all aspects of patient care					
The student:	**Unable to meet outcome**	**Significant assistance required**	**Minimal assistance required**	**No assistance required**	**Excellent and used initiative at all times**
Knew the local practice of patient identification and showed their ability to do this, appropriately and consistently throughout placement					
Communicated effectively with patients and relatives as appropriate					
Communicated effectively with the other members of the RTT and multidisciplinary team					
Appropriately assisted and supported patients throughout the treatment preparation procedures					
Evaluated patients' physical signs and symptoms and was aware of possible psychosocial issues					
Understood the potential patient difficulties with respect to patient condition, contrast, catheters, ink tattoos etc. and responded appropriately					
Followed good hygiene practices and infection control policies					

Additional Comments:

General:

Areas for development:

TABLE II.2.5.2. CLINICAL ASSESSMENT OF TECHNICAL KNOWLEDGE AND ABILITY (POSITIONING AND IMMOBILIZATION)

Assessing all aspects of mould room procedures		**Level of assistance required**			
The student:	**Unable to meet outcome**	**Significant assistance required**	**Minimal assistance required**	**No assistance required**	**Excellent and used initiative at all times**
Could interpret mould room request form and prepare equipment accordingly					
Understood the principles of good patient positioning and immobilization and could position and manipulate patients appropriately					
Understood the differences between the immobilization devices used and selected the appropriate device for the patient					
Understood the principles of production of the immobilization devices and could participate in their production					
Displayed knowledge of the principles of use of mouthbites/tongue depressors and other accessories and could participate in their production					
Understood the principles of magnification and beam energy when producing customized shielding (e.g. lead electron cut-outs) and could participate in their production					
Could interpret the information available in order to produce an accurate contour and could participate in the process					

Understood the principles of bolus and build-up and applied this knowledge in the production of customized bolus and build-up e.g. wax.					
Understood the importance of daily quality assurance in the mould room and participated in these procedures					
Understood the importance of accurate and clear documentation to ensure reproducibility of position throughout treatment					
Additional Comments: General: Areas for development:					

TABLE II.2.5.3. CLINICAL ASSESSMENT OF TECHNICAL KNOWLEDGE AND ABILITY (IMAGE ACQUISITION)

Assessing all aspects of patient set up					
The student:	**Unable to meet outcome**	**Significant assistance required**	**Minimal assistance required**	**No assistance required**	**Excellent and used initiative at all times**
Communicated effectively and worked as a team member in positioning the patients and using the correct immobilization devices for the individual patient					
Moving and handling patients in an appropriate and safe manner					
Understood the principles of contrast in imaging and carried out safety procedures correctly					
Understood the functions of radio-opaque markers and fiducial markers in imaging and applied them correctly					
Displayed knowledge of the principles of the techniques used and the reasons for any changes made for individual patients and could participate in the selection of field parameters					
Performed the final checks and verbal confirmation of all parameters prior to commencing scan					
Accurately completed all steps at the console to the point of ‘scan start’					

Recognized the importance of good quality image production					
Understood the importance of accurate and clear documentation to ensure reproducibility of position throughout treatment					
Understood the importance of daily quality assurance and participated in these procedures					
Additional Comments: General: Areas for development:					

APPENDIX III.
CLINICAL ASSIGNMENTS

III.1. CLINICAL ASSIGNMENT 1

Clinical Assignment 1 has two components. The aim of the first component of this assignment is to evaluate the student's understanding of the pathway of two patients commonly encountered in a radiotherapy department. These case scenarios are examples and can be changed to reflect the patient population in a specific department. The scenarios can also be adapted to reflect the techniques and modalities of treatment that should be assessed (e.g. external beam radiotherapy, brachytherapy and other modalities such as surgery, chemotherapy and other as relevant).

The second component is designed to encourage the student to reflect on their experience of the radiotherapy department, the role of the various members of the radiotherapy team and how this experience will impact on their working practice.

III.2. CLINICAL ASSIGNMENT 2

Clinical Assignment 2 has two components. The aim of the first component of this assignment is to evaluate the student's knowledge and understanding of the management of a patient with a malignancy commonly treated in the radiotherapy department where they are on clinical placement.

The second component is to assess how much the students have understood of the interaction between the radiation therapist and the patient attending for the first visit.

III.3. CLINICAL ASSIGNMENT 3

This Assignment has five components and is designed to assess the depth of knowledge and understanding that the student has acquired in the academic and clinical setting and their ability to apply their theoretical knowledge to clinical practice.

III.4. CLINICAL ASSIGNMENT 4

This Assignment builds on clinical assignment 3 and aims to evaluate the student's ability to apply their knowledge and understanding to more complex cases and to evaluate the student's ability to make decisions.

III.1. CLINICAL ASSIGNMENT 1

Year 1 of all levels

Name:

Department/Hospital:

Unit:

Placement Dates:

Date submitted: _____

Part 1: The patient pathway

While the student is on placement, select two patients: e.g. a young woman with early breast cancer and an older gentleman with more advanced head and neck cancer. The student should read the patient notes carefully and use the information gained together with information from the academic modules to complete the assignment outlined below.

Note: These are examples and can be adjusted to suit the department

Case Scenario 1:

The patient with early breast cancer is a 42 year old married woman with three children who works full time. She has been referred for radiotherapy and chemotherapy following surgery.

Case Scenario 2:

The patient with head and neck cancer is a 70 year old male diagnosed with advanced oral cancer and he has been referred for radiotherapy. He has a history of smoking and alcohol abuse. He lives alone.

Assignment

Based on your understanding of the patient pathway, the departments and personnel involved at each stage, and the practical and psychosocial issues relevant to each patient:

- Briefly describe how each of the two patients will be managed and the role of the personnel involved at each stage of their care;
- Describe in detail the management of the patients in the radiotherapy department.

Word count: Approximately 2000 words per case scenario

Part 2: The reflective report

During the first clinical placements emphasis is placed on professional behaviour and how this impacts on teamwork and the patient experience.

The student should reflect back on their first placement and discuss:

- First impressions, taking into consideration how first impressions might affect a patient attending for their first radiotherapy appointment;
- How understanding of all aspects of professionalism has evolved giving examples of the impact of professionalism on teamwork and the patient experience;
- How the student's experience has influenced his/her attitude to clinical practice in radiation therapy.

III. 2. CLINICAL ASSIGNMENT 2

Year 2 of level 2 and above

This assignment is an example of what can be completed throughout the year covering all clinical placements. The student should be encouraged to select a variety of patients that are representative of those treated in the clinical site. Alternatively a list of required or recommended sites/pathologies can be provided.

Name:

Department

Unit:

Placement Dates:

Date submitted: _____

Part 1: Patient case study

While the student is on placement he/she is required to complete one patient case study on a patient being treated in one the sites most commonly encountered in the centre.

The student should select one patient he/she has been involved in treating.

The student should read the patient's clinical notes carefully and use the information contained within them as well as the information/knowledge gained in the academic programme to complete the case study.

The case study should include information on the following aspects of patient management/care:

- A profile of the patient selected including the student's reasons for selecting this patient.
- An overview of the history, investigations and other treatments received.
- A detailed description of the radiotherapy technique used.
- The acute and late side effects associated with treatment at this site and the advice given to the patient.

Word count: Approximately 3000 words

Part 2: Giving first visit information to patients

The students will be asked to outline the procedure they have observed when an RTT was giving first visit information to a patient. Include in the answer:

- The setting in which the information was given;
- Who was present;
- The information given to the patient;
- The opportunity for questions and feedback.

Word count: Approximately 500 words

III. 3. CLINICAL ASSIGNMENTS 3

Year 3 of level 3 and 4

This assignment is an example of what can be completed throughout the year covering all clinical placements. The student should be encouraged to select a variety of patients that are representative of those treated in the clinical site. Alternatively a list of required or recommended sites/pathologies can be provided.

Name:

Department/Hospital:

Unit:

Placement Dates:

Date submitted: _____

Part 1: Two patient case studies

While they are on placement, students are required to complete two patient case studies of patients they are involved in treating and that represent the sites most commonly encountered in the centre.

This assignment is an example of what can be completed throughout the year covering all clinical placements. The student should be encouraged to select a variety of patient diagnoses or alternatively a list of required sites/pathologies can be provided (e.g. breast, prostate, lung, oesophagus, thorax, and pelvis, dependent on which sites are covered in the academic programme)

The student should read the patient's clinical notes carefully and use the information contained within them as well as the information/knowledge gained in the academic programme to complete the case study.

Each case study must include information on the following aspects of patient management/care:

- A profile of the patient selected including the student's reasons for selecting this patient;
- An overview of the history, investigations and other treatments received;
- A detailed description of the radiotherapy technique used;
- The acute and late side effects associated with treatment at this site and the advice given to the patient.

Word count: Approximately 3000 words

Part 2: Treatment verification

For one of the patients the student has selected, describe in detail the verification method used. Discuss the choice of method and evaluate its appropriateness

Word count: Approximately 1000 words

Part 3: Giving first visit information to patients

Outline where you gave the first visit information to the patient. Include in your answer:

- The setting in which the information was given;
- Who was present?
- The information given to the patient;
- The opportunity for questions and feedback;
- Applied theory;
- Include your own reflections on the process in your answer.

Word count: No more than 500 words

Part 4: The reflective report

For each patient selected:

- Based on the diagnosis, detail the acute and late side effects that you would expect this patient might experience, giving reasons, and indicate how they can be minimized;
- Based on the acute and late side effects, you have identified evaluate the quality and level of information given to the patient prior to their first treatment;
- Describe your role as a member of the team and in the management of the patient.

Word count: No more than 1000 word

III.4. CLINICAL ASSIGNMENT 4

Year 4 of level 4

Name:

Department:

Unit:

Placement Dates:

Date submitted: _____

To be completed throughout the year covering all clinical placements

Part 1: Patient case studies

While the student is on placement he/she is required to complete five patient case studies on patients being treated for five different sites or techniques. At least 3 of the case studies should be for curative intent and at least 1 should be a palliative case study. The RTT Educator may require 1 of the 5 case studies to reflect more specialized techniques that are not carried out in the centre and is therefore more theoretical.

Instructions to the student:

Select patients you have treated in any of the following regions (adjust according to the centre and programme):

- Paediatric patient;
- TBI;
- Extremities (e.g. soft tissue sarcoma);
- 3D conformal radiotherapy;
- IMRT;
- Stereotactic radiotherapy;
- Brachytherapy.

Read the patient's clinical notes carefully and use the information contained within them to complete the case studies. Refer also to the information/knowledge you have gained through your academic programme and include these in your discussion.

Each case study must include information on the following aspects of patient management/care:

- A profile of the patient selected including your reasons for selecting this patient;
- An overview of the history, investigations and other treatments received;
- The treatment prescription and the rationale for its selection;
- A detailed description of the radiotherapy technique used;
- The acute and late side effects associated with treatment at this site and the advice given to the patient.

For the palliative case study provide this in addition to the above:

- A brief overview of the relevant prior treatments;
- The specific care and support required for this patient and their family;
- Your role in the management of this patient.

Word count: No more than 3000 words

Part 2: Decision making

Based on the students' experience in a range of clinical settings and involved in the treatment of a wide range of patients they should discuss the aspects that must be considered in the day-to-day decision making on a treatment unit to ensure that each patient receives optimal care. An example of one aspect to consider is the duration of treatment and the scheduling of the appointments. Students should base their answer on two patients they have treated.

Word count: No more than 1000 words

Part 3: The reflective report

For this assignment students are expected to review their previous reflective reports and describe how their attitudes and beliefs have changed over the four years and the factors that have most influenced or brought about these changes.

Word count: No more than 1000 words

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USEFUL WEBSITES

IAEA Human Health Campus - http://nucleus.iaea.org/HHW/Home/index.html

American Society of Radiologic Technologists - https://www.asrt.org/

American Society of Radiation Oncology (ASTRO) - http://www.astro.org/

European Society of Radiotherapy and Oncology (ESTRO) - http://www.estro.org/

American Brachytherapy Society (ABS) - http://www.americanbrachytherapy.org/

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ABBREVIATIONS

2-D	two-dimensional
3-D	three-dimensional
3-D CRT	three-dimensional conformal radiation therapy
4-D-RT	four-dimensional radiotherapy
ASTRO	American Society for Radiation Oncology
BSS	International Basic Safety Standards
CanMEDS	Canadian Medical Education Directives for Specialists
CPD	continued professional development
CPR	cardio-pulmonary resuscitation
CT	computer tomography
CTV	clinical target volume
DRR	digitally reconstructed radiograph
EBRT	external beam radiotherapy
EPID	electronic portal imaging device
ESTRO	European Society for Radiotherapy and Oncology
EU	European Union
GTV	gross tumour volume
HDR	high dose rate
HI	high income (countries)
IAEA TCS	IAEA Training Course Series
IAEA-TECDOC	IAEA Technical Document
ILO	International Labour Organisation
ICRU	International Commission on Radiation Units and Measurements
IMRT	intensity modulated radiation therapy

ISO	International Organization for Standardization
LDR	low dose rate
LQ	linear quadratic
MCQ	multiple choice questions
MLC	multi-leaf collimator
MRI	magnetic resonance imaging
MV	megavoltage
MVCT	megavoltage computed tomography
NAL	non-action levels
NTCP	normal tissue complication probability
OAR	organs at risk
QoL	quality of life
OS	overall survival
OSCE	objective structured clinical examination
PBL	problem based learning
PDD	percentage depth dose
PDR	pulsed dose-rate
PET	positron emission tomography
PTV	planning target volume
QA	quality assurance
QA/QC	quality assurance/quality control
QC	quality control
QMS	quality management system
RT	radiotherapy
RTT	radiation therapist
SAD	source-axis distance

SPECT	single-photon emission computerized tomography
SBRT	stereotactic body radiation therapy
SSD	source skin distance
TAR	tissue air ratio
TBI	total body irradiation
TC	technical cooperation programme (IAEA)
TCP	tumour control probability
TMR	tissue maximum ration
TPR	tissue phantom ratio
TPS	treatment planning system
TSEI	total skin electron irradiation
VR	virtual reality
WHO	World Health Organization

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