Teaching physics in the discipline of medical radiations in an Australian university

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Abstract. Medical radiations and imaging are highly technologically driven professions. Adequate knowledge in physics is the basic requirement for any medical radiation technologists working in medical radiation centres where ionizing radiations are used. The purpose of this paper is to discuss courses of physics we teach and the challenges we face in teaching physics to the undergraduate students in the discipline of medical radiations in our university. Although laws of physics are applied in the development and use of diagnostic and therapeutic medical equipment, the physics is not loved by the students as a subject as it should be. Several medical radiations physics courses are taught in undergraduate medical radiations program in our discipline including radiography, nuclear medicine, radiotherapy, CT, MRI, and Ultrasonography. In this paper teaching methods of medical radiation physics are discussed and students' approach to learn this subject are analysed. The teaching techniques and initiatives are discussed along with their success and failure.

1. Introduction

Application of physics to diagnostic and therapeutic medicine is continuously increasing. For last twenty years the combined results of physics research and computing technology are producing very powerful instruments and techniques for clinical uses [1, 2]. X-ray imaging has become fundamental diagnostic tool in healthcare. More than four billion medical images are being captured globally in each year for clinical purpose by using ionizing radiations [3]. There is an increasing demand for delivery of additional diagnostic and therapeutic services from medical radiations and imaging sectors worldwide as the population is growing. Application of Physics in cancer treatment is expanding by linking advanced and functional imaging and radiotherapy [4]. Expansion of physics themes in medicine has direct impact on education and training requirements to maintain the quality of the professionals. For high-quality healthcare a sustainable medical radiations and imaging technology workforce is important. Bachelor of Applied Science (BAppSc) in Medical Radiations program at the School of Health and Biomedical Sciences in RMIT University is directly contributing to the Australian medical radiations technology workforce. The graduates from this program become work-ready through proper education and training required for the profession. The aim of this paper is to give the reader an overview of the physics components taught in this program and discuss the challenges the physics teachers and the students face and how they are solved. Structure of the program, curriculum, student cohorts, physics courses, teaching and assessment process applied in this program are discussed in the following sections.

2. Medical Radiations program

Being a rapidly advancing healthcare discipline, Bachelor of Applied Science (Medical Radiations) (BAppSc MedRad) program involves the application of ionising and non-ionising radiation for the diagnostic and treatment of injury and disease. Based on the nature of clinical work and application of medical radiations, this program has three distinctive streams: Medical Imaging (MI), Radiation Therapy (RT), and Nuclear Medicine (NM). MI allows the students to specialise in medical imaging and become diagnostic radiographers. RT allows the students to specialise in radiation therapy and become radiation therapist. NM allows the students to specialise in nuclear medicine and become nuclear medicine technologists. Students are admitted into one of the three study streams. The current program duration is 3 years of full time studies in six semesters. This consists of lectures, tutorials, lab works and 22 weeks of clinical placement during their study. After successful completion of the degree students get professional registration from the Australian Health Practitioner Regulation Agency (AHPRA).

AHPRA is the Australian national organisation responsible for the implementation of the national registration and accreditation scheme across Australia. AHPRA works with Medical Radiation Practice Board (MRPB) along with another 14 National Health Practitioner Boards in implementing the registration and accreditation. BAppSc (MedRad) program is accredited by MRPB. To identify the knowledge, skills and professional attributes needed to safely practise diagnostic radiography, radiation therapy and nuclear medicine technology, MRPB has developed professional capabilities for medical radiation practice for the entry-level medical radiation practice professionals. BAppSc (MedRad) program structured according to AHPRA guidelines, so that all graduates from this program developed these professional capabilities. The professional capabilities for medical radiation practice are categorised into five domains: (1) professional and ethical conduct, (2) professional communication and collaboration, (3) evidence-based practice and professional learning, (4) radiation safety and risk management, and (5) practice in medical radiation science: diagnostic radiography, radiation therapy, and nuclear medicine [5].

3. Program structure

The education provider must demonstrate the medical radiation practice educational program's learning outcomes and assessment ensure each student meets the requirements for the professional capability domain. The curriculum for the medical radiation professionals have special goals. Relevant professional societies around the world develop the curriculum guidelines for different group of professionals based on the special needs and requirements [6-11]. Our curriculum is based on the APHRA guidelines to comply with the set professional capabilities.

There are few subjects common to all students irrespective of streams, viz, Medical Radiation Physics in 1st year, Research Methods, Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) in 3rd year. Human structure and Functions are also common to all students in the program.

The subjects taught in MI, RT and NM streams are given in tables 1 to 3. All subjects are delivered through a range of learning activities including lectures, problem-based tutorials, practical labs, online learning activities and self-directed studies. Students in all stream do real time clinical works from 1st year semester-2. In three-year program, the students are placed in different clinics for total 22 weeks: 2 weeks in 1st year sem-2, 5 weeks in 2nd year sem-1, 5 weeks in 2nd year sem-2, 5 weeks in 3rd year sem-1 and 5 weeks in 3rd year sem-2. In each semester there are total 12 weeks of teaching. Students get one-week mid-semester break and one-week end of semester break. Then the final exam period lasts for 3 weeks at the end of each semester.

Table 1: Subjects taught in Medical Imaging stream.

Year	Semester	Subjects			
1st	1	Introduction to Medical Radiations	Medical Radiations Technology 1	Human Structure and Function 1	University Elective
	2	Introduction to Medical Imaging	Research in Medical Radiations	Medical Radiations Technology 2	Human Structure and Function 2
2nd	1	Medical Imaging Method 1	Medical Imaging Practice 1	Medical Imaging Technology 1	Introduction to Pathology
	2	Medical Imaging Method 2	Medical Imaging Practice 2	Medical Imaging Technology 2	Imaging Anatomy and Pathology
3rd	1	Medical Imaging 3	Medical Imaging Technology 3	Computed Tomography	Sonography
	2	Medical Imaging 4	Med Rad Interdisciplinary Applications	Magnetic Resonance Imaging	Health Psychology

Table 2: Subjects taught in Radiation Therapy stream.

Year	Semester	Subjects			
1st	1	Introduction to Medical Radiations	Medical Radiations Technology 1	Human Structure and Function 1	University Elective
	2	Introduction to Radiation Therapy	Research in Medical Radiations	Medical Radiations Technology 2	Human Structure and Function 2
2nd	1	Radiation Therapy Method 1	Radiation Therapy Practice 1	Radiation Therapy Technology 1	Introduction to Pathology
	2	Radiation Therapy Method 2	Radiation Therapy Practice 2	Radiation Therapy Technology 2	Imaging Anatomy and Pathology
3rd	1	Radiation Therapy 3	Radiation Therapy Technology 3	Computed Tomography	Sonography
	2	Radiation Therapy 4	Med Rad Interdisciplinary Applications	Magnetic Resonance Imaging	Health Psychology

Table 3: Subjects taught in Nuclear Medicine stream.

Year	Semester	Subjects			
1st	1	Introduction to Medical Radiations	Medical Radiations Technology 1	Human Structure and Function 1	University Elective
	2	Introduction to Nuclear Medicine	Research in Medical Radiations	Medical Radiations Technology 2	Human Structure and Function 2
2nd	1	Nuclear Medicine Method 1	Nuclear Medicine Practice 1	Nuclear Medicine Technology 1	Introduction to Pathology
	2	Nuclear Medicine Method 2	Nuclear Medicine Practice 2	Nuclear Medicine Technology 2	Imaging Anatomy and Pathology
3rd	1	Nuclear Medicine 3	Nuclear Medicine Technology 3	Computed Tomography	Sonography
	2	Nuclear Medicine 4	Med Rad Interdisciplinary Applications	Magnetic Resonance Imaging	Health Psychology

4. Physics subjects taught in the program

Medical radiation practice requires good understanding of the laws of radiation physics and their applications and needs to demonstrate understanding of radiation safety and risk management. Professional capability domains 4 and 5 set by MRPB clearly state that medical radiation practitioners are responsible for the protection of patients, others and the environment from the harm of radiation. At the same time they must be able to apply principles of medical radiation physics and instrumentation [5]. Physics subjects are designed to fulfil these aims of building professional capabilities.

The list of physics subjects taught in this program are given in Table 4. There are 4 to 6 hours of lectures delivered per week, 1 to 2 hours of tutorials per week and 4 to 6 hours of practicals per semester for each physics subject. The assessment items include mid semester test, practical lab reports, written assignments, and final examination.

5. Students in the program

To get admitted into this program students must pass Victorian Certificate of Education (VCE) or Higher Secondary Certificate (HSC) or equivalent. They must have taken Mathematics and chemistry or biology subjects in their VCE equivalent studies. University admission into undergraduate program in Australia is mainly based on the Australian Tertiary Admission Rank (ATAR). ATAR is calculated based on the results of VCE or equivalent examination. ATAR is a number between 0.00 and 99.95 that indicates a student's position relative to all the students in their age group. It shows the student's achievement in relation to other students [12]. Admission into this BAppSc (MedRad) program is very competitive. The students admitted into the program are basically high achievers. The lowest ATAR in 2018 in the program was 96.4 for MI, 91.05 for RT, and 88.65 for NM stream. More female than male students are attracted to the program. In 2018, 68.22% female and 31.78% male students are enrolled into the program. This gender ratio has been similar for last ten years. This gender issue is an important factor in physics teaching which will be discussed in the next section.

Table 4: Physics subjects taught in the program.

Year/Sem	Stream	Physics Subject
1/1	MI, RT, NM	Medical Radiations Technology 1
1/2	MI, RT, NM	Medical Radiations Technology 2
2/1	MI	Medical Imaging Technology 1
2/1	RT	Radiation Therapy Technology 1
2/1	NM	Nuclear Medicine Technology 1
2/2	MI	Medical Imaging Technology 2
2/2	RT	Radiation Therapy Technology 2
2/2	NM	Nuclear Medicine Technology 2
3/1	MI	Medical Imaging Technology 3
3/1	RT	Radiation Therapy Technology 3
3/1	NM	Nuclear Medicine Technology 3
3/1	MI, RT, NM	Computed Tomography
3/2	MI, RT, NM	Magnetic Resonance Imaging

6. Challenges in physics teaching

Teaching physics in any discipline is very difficult. It has been established for a long time that physics is hard even for physicists [13]. Moreover, survey reports show that physics is too hard for women [14]. As 68% of the students in the program are female and they have a kind of belief that physics is too hard for them, it is difficult at the beginning to make them comfortable with the course contents. The course contents cannot be made easy by simply avoiding the complex topics. Many medical physics topics needed to be covered which are sometimes conceptually difficult for undergraduate students. University degrees such as BSc or MSc are required in Europe and many other countries around the globe to enter medical physics education [15].

Another kind of challenge is with the students who never did physics before. As physics is not pre-requisite for admission into the program, there are number of students in the class who did not take physics before. It is difficult to teach the concepts of modern physics without building the foundation of physics and at the same time to give the genuine flavour of the methodology and practice of science [16].

Students in this program know that they will be working in one of the radiography, nuclear medicine, or radiotherapy clinics after graduation. Some of them develop a particular attitude like the pre-medical students – "I just want to do radiography, or nuclear medicine, or radiotherapy. As the modern technology has taken care of all the necessary physics principles, why do I have to study detailed, analytic physics which seems to have to relevance to our future practice" [17].

7. A different approach

Physics in the medical radiations discipline is technology-oriented. Students need to be able to see the physical theories they learn are applied in the diagnostic and therapeutic procedures - radiologic imaging, CT, MRI, PET. For students to be competitive after graduation it is important for them to be able to do more than apply formula to a given problem. They will need to expect the unexpected and to anticipate solving unfamiliar problems. A non-traditional teaching approach provides students with a framework that assures both competence and confidence in their creative thinking, their scientific reasoning and their understanding of physical concepts.

A traditional physics class would commence with the teacher discussing a new theory, followed by an explanation of the theory and an example of its application. However coherent conceptual framework cannot be achieved by just following traditional physics instructions. “Students need to participate in the process of constructing qualitative models and applying models to predict and explain real-world phenomena. For most students, explanations by an instructor are inadequate. They need a different type of assistance to bring about a significant change in their thinking.” [18]

In the different approach when students come to class they know that they will not immediately be confronted with new or unfamiliar concepts. Instead students are engaged directly in developing the concept with the teacher, stepping through the reasoning process to provide direct experience with scientific enquiry. This approach is supported by Crouch et al [19] who observed that Learning in physics is enhanced by increasing student engagement; students who predict the demonstration outcome before seeing it, display significantly greater understanding. An example of this process is provided in Figure 1, applied to the steps involved in cancer diagnosis. To teach the concepts and properties of x-rays, real life examples are applied and progressing questions are made to guide the students toward the intended topic. Reflecting the ideas promoted by the University of Washington’s Physics Education Group [18], the developmental process that have been employed ensure that students develop their scientific reasoning and their functional understanding of physics.

Figure 1: Approach to start teaching a physics topic. Introducing to the physics of x-ray production are given here as an example.

8. Conclusion

It is evident that students in medical radiations program look at physics courses differently compared to the students in other physics programs. In medical radiations students are eager to see more direct applications of physics compared to the basic theory behind it. Some students believe that it is possible to be a good radiological technologist without having proper understanding of physics. Some students have a general repelling attitude toward learning physics in this discipline. But this attitude can be changed with the modification of traditional method of physics teaching by showing its application in the field of medicine. In the discipline of medical radiations physics teaching is more effective when the applications of the physical laws in the modern medical technology and equipment are shown first and then gradually develop students' understanding of the links of these application to the basic laws of physics.

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