MEDICAL PHYSICS EDUCATION IN MALAYSIA –WITH THE EXAMPLE OF THE MASTER OF MEDICAL PHYSICS PROGRAMME AT THE UNIVERSITY OF MALAYA

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Abstract— **This paper presents an overview of the education and training of the medical physics at the postgraduate level in Malaysia. The history of formation, the curriculum and the execution of the Master of Medical Physics programme at the University of Malaya were described in details. This programme was launched in 1997 to meet the critical need of medical physics expertise in the country. The programme was accredited by the Institute of Physics and Engineering in Medicine (IPEM), United Kingdom in 2002. This was the first instance where recognition was awarded outside the British Isles. In 2008, it was successful in securing a reaccreditation by the IPEM and subsequently an extension of the accreditation to August 2015. Over the last two decades, the programme has undergone various cycles of curriculum review and improvement. The programme has been leading in the post-graduate education of medical physicists by adapting to the rapid development in healthcare.**

Keywords— **Malaysia, medical physics, postgraduate education, professional training**

I. INTRODUCTION

Technological advances and developments in medicine, particularly in radiology, radiation oncology (radiotherapy) and nuclear medicine, have created a demand for qualified medical physicists to manage and monitor the medical usage of radiation in all its forms. Worldwide, numerous master level programmes were created to educate and train scientists in this growing field.

The medical physics education and training as Master of Science programme in Medical Physics in Southeast Asia started in Thailand (1972), followed by Philippines (1981), Malaysia (1994), and Indonesia (1998). Vietnam established M.Sc. in Bio-Medical Engineering in 2003. As of 2010, 13 universities in South-East Asia provide medical physics education and training at different levels.(1)

In Malaysia, currently, there are three universities that offer a total of 10 postgraduate level medical physics programmes: namely, University of Malaya (UM), University of Science Malaysia (USM) by coursework; and University of Technology MARA (UiTM) by research. Further details of these programmes are listed in section VII.

In 1998 the University of Malaya launched the Master of Medical Physics programme to meet this growing national need. Since then, over 80 students have graduated from this programme. This is a one year programme, carried out within two semesters (one calendar year). The medium of instruction and assessment is in English.

The programme is accredited by the Institute of Physics and Engineering in Medicine (IPEM), United Kingdom since 2002.(2) At present, the University of Malaya programme is the only one outside the British Isles (United Kingdom and Ireland) to receive such prestigious recognition.

This programme provides postgraduate training in the clinical applications of physics in medicine and biology, particularly with regard to ionizing radiation. The main areas of focus are the planning, quality control and safety considerations for medical imaging (general x-ray machines, computed tomography (CT) scanners, magnetic resonance imaging (MRI) scanners, ultrasound scanners, etc.), nuclear medicine imaging (gamma cameras, single photon emission computed tomography (SPECT) scanners, positron emission tomography (PET) scanners, etc.) and radiotherapy (linear accelerator, brachytherapy equipment, etc.)

This programme trains and equips students to take up professional positions in education, research and service orientated positions in hospitals, universities, government agencies, research laboratories, regulatory agencies, medical industries and nuclear technology industries.

II. ENTRY REQUIREMENT

Primary requirement: a Bachelor's degree with honours in a programme of study consisting of significant courses in physical sciences from recognized universities, or equivalent qualifications.

Secondary requirements: candidates with good computing knowledge (e.g. programming, image processing), or having previous research experience (including basic statistical analysis), or are familiar with basic medical concepts (e.g. anatomy, physiology) will be at an advantage.

International candidates are required to have at least IELTS Band 6 or TOEFL 550 if their first degree is from a university where English is not the medium of instruction; or pass an English proficiency test approved by the University.

III. CLINICAL POSTING

This programme, being administered under the Faculty of Medicine, University of Malaya, allows the students access and exposure to the clinical environment of the University of Malaya Medical Centre (UMMC). The objective of the clinical postings is to give an overview of the role of medical physicists in Radiology, Nuclear Medicine and Radiation Oncology (radiotherapy). The students are required to carry out clinical postings in Radiology, Nuclear Medicine and Radiation Oncology departments for the whole duration of the programme.

IV. FACULTY MEMBERS

Teaching faculties comprise of the academic members from the Department of Biomedical Imaging, Clinical Oncology Unit, Department of Physiology, the Medical Physics Unit of the University Malaya Medical Centre (UMMC), Faculty of Science, Ministry of Health, Malaysian Nuclear Agency, and Atomic Energy Licensing Board (AELB). Teaching collaboration was also established with other local universities such as National University of Malaysia (UKM).

We have had visiting lecturers and professors, namely Dr. Adrian Perry, Professor Tomas Kron, Mr. Chris Fox, and Professor Anatoly Rozenfeld.

We had embarked on tele-teaching for our students. Our online teaching faculty were Dr. Perry Sprawls and Dr. Milton Woo.(3)

A list of the external examiners:

Period	External examiner
1998 Nov-2000 May	Prof. Larry A. DeWerd, PhD
2000 Nov-2002 May	Prof. Gary D. Fullerton, PhD,
2002 Nov, 2003 Nov	Prof. William R. Hendee, PhD
2003 May	Dr. Timothy Van Doorn, PhD
2004	Dr. David J. Dowsett, PhD
2004 – 2006	Dr. Roger M. Harrison, PhD
2006 Nov - 2008 May	Dr. David Sutton, PhD
2008 Nov -2010 May	Prof. Alan C. Perkins, PhD
2010-2011	Dr. Roger M. Harrison, PhD
2011-2014	Prof. David Lurie, PhD
2014-2015	Prof. Peter Metcalfe, PhD

V. PROGRAMME STRUCTURE

The programme is offered in the form of coursework programme. Since the programme first started, it has undergone four cycles of curriculum reviews.

VI. CURRICULUM REVIEWS

The initial framework of the coursework programme is shown in Table 2. The programme started out as a coursework and dissertation programme. The structure of examination is shown in Table 3. There were three papers and a dissertation. The passing mark for each component is 50% of the aggregate marks. Candidates who have obtained ≥75% of the aggregate marks will be awarded a Pass with Distinction.

Table 2: Course structure (Coursework and dissertation), first presented in 1997.

Part I	Courses	Credit hour
	Anatomy and Physiology	2
	Biostatistics	1
	Computing and Medical Informatics	1
	Applied Radiation Physics and Dosimetry	1
	Radiobiology and Radiation Protection	2
	Non-ionizing Radiation in Medicine	1
Part II		
	Medical Imaging	2
	Radiotherapy Physics	2
	Nuclear Medicine	2
	Medical Physics Research Project	

Minimum period: 1 year
Maximum period: 5 years

Table 3: Examination format (1997 – 2005).

Part I	Component	Maximum marks
A. Written Papers		
Paper I		100
	Anatomy and Physiology Biostatistics Computing and Medical Informatics	
Paper II		100
	Applied Radiation Physics and Dosimetry Radiobiology and Radiation Protection Non-ionizing Radiation in Medicine	
B. Continuous Assessment		100
Total marks		**300**

Part II		
A. Written Paper		
Paper III		200
	Medical Imaging	
	Radiotherapy Physics	
	Nuclear Medicine	
	Medical Physics Research Project	
Continuous Assessment		100
B. Dissertation		
	Dissertation	300
	Viva Voce	100
Total marks		**700**

In the first curriculum review held in 2002, there were no changes in the course structure. The same structure was used for the Malaysian Department of Public Service accreditation.

In 2005, there was a major revamping of the course structure following the introduction of semester system (instead of the term system) in the University of Malaya. Together with this system, the cumulative grade points average (CGPA) system was also introduced. The credit hours were changed to credits (Table 4). The total duration of the study was still kept to two semesters (equivalent to 1 year).

Table 4: Course structure after the 2nd curriculum review(2005)

Semester I	**Courses**	**Credits**
	Anatomy and Physiology	4
	Biostatistics	3
	Computing and Medical Informatics	3
	Applied Radiation Physics and Dosimetry	3
	Radiobiology and Radiation Protection	3
	Non-ionizing Radiation in Medicine	3
Semester II		
	Medical Imaging and Nuclear Medicine	3
	Radiotherapy Physics	3
	Nuclear Medicine	3
	Medical Physics Research Project	12
	Total credits	**40**

Minimum terms: 2 semesters
Maximum terms: 8 semesters
Total credits : 40

Table 5: Course structureafter the 2010 curriculum review

Semester I	**Courses**	**Credits**
	Anatomy and Physiology	4
	Biostatistics	2
	Computing and Medical Informatics	4
	Applied Radiation Physics and Dosimetry	4
	Radiobiology and Radiation Protection	4
Semester II		
	Medical Imaging and Nuclear Medicine	5
	Radiotherapy Physics	5
	Medical Physics Research Project	12
	Total credits	**40**

Minimum terms: 2 semesters
Maximum terms: 8 semesters
Total credits : 40

In 2010, following the requirements by the Malaysian Quality Assurance (MQA), the programme underwent a 3rd cycle of curriculum review. During this review, the topics which were originally covered under non-ionizing radiation in medicine were merged into applied radiation physics and dosimetry (for the physics part) and radiobiology and radiation protection (for the radiobiological effects parts) courses. in the 2nd semester, the nuclear medicine topics were merged with the medical imaging topics (Table 5).

In June 2015, we have completed 4th cycle of curriculum review.

VII. OTHER PROGRAMMES

There are a total of 10 postgraduate level medical physics programmes offered by various universities in Malaysia (Table 6).

Table 6: Postgraduate level medical physics programmes available in Malaysia.

University	**Name of the programme**
University of Malaya (UM)	Master of Medical Physics by coursework
	M. Medical Science (Medical Physics) by research
	PhD – Doctor of Philosophy (Medical Physics) by research
University of Science Malaysia (USM)	M.Sc. - Master of Science (Medical Physics) by research
	M.Sc – Master of Science (Physics) in Medical Physics and Radiation Science by research
	Master of Science (Medical Physics) by coursework

	PhD – Doctor of Philosophy (Medical Physics) by research PhD – Doctor of Philosophy (Physics) in Medical Physics and Radiation Science by research
University of Technology MARA (UiTM)	Master of Science Specializing in Medical Physics by research PhD – Doctor of Philosophy Specializing in Medical Physics by research

Amongst these, the coursework programme offered by the University of Science Malaysia (USM) has a similar programme structure to the University of Malaya. They are the only other programme that provides the alternative coursework master programme for medical physics in Malaysia. Their programme structure is shown in Table 7.

Table 7: Course structure of the M. Sc. (Medical Physics) programme (as of 2015)

Semester I	**Courses**	**Credits**
Core	Human Anatomy and Physiology	4
	Radiation Physics	4
	Dosimetry and Radiation Protection	4
	Physics of Diagnostic Radiology	4
	Medical Physics Practical	4
Semester II		
Core	Nuclear Medicine and Radiotherapy Physics	4
	Medical Physics Practical II	4
Elective	Ultrasound and Magnetic Resonance Imaging	2
	Radiobiology and Radiation Chemistry	2
Compulsory	Research Project	8
	Total credits	**40**

VIII. IPEM ACCREDITATION

The University of Malaya, in her quest to achieve excellence and international benchmarking, applied to the Institute of Physics and Engineering (IPEM), U.K. for the accreditation of the Master of Medical Physics programme.

On September 30 and October 1, 2004 two IPEM assessors, namely Professor Tony Evans and Professor Alun Beddoe, visited the University to carry out the accreditation process. This included: inspection of examination questions, outline answers, answer scripts; interviewing of teaching staff, current and ex-students; inspection of training facilities, laboratories, libraries, etc.

At the end of the visit, the assessors were satisfied with the high standard of the programme and they conveyed to us that we were successful. However they raised a few concerns that we have to address within a set time-frame, the major of which is the shortage of experienced teaching staff especially in the area of radiation oncology. The others are minor but relate to the method of assessment i.e. the style of the questions set.

The official notification and details were sent to the University after the IPEM council meeting on November 11, 2004. The recognition was for a 5-year period (October 2002 – October 2007) during which time we must progress towards overcoming the shortcomings that they have listed by submitting an annual report.

This is the first instance where recognition was awarded outside the British Isles. IPEM accreditation is very difficult to achieve since not only must the MSc Medical Physics degree undergo independent scrutiny by the Council of the IPEM but the external examiners and students involved, must also show high academic achievement.

Implications for the University of Malaya include:

1. The Master of Medical Physics of the UM programme has been awarded an international recognition never previously given to any other university programmes outside the United Kingdom and Ireland.
2. However we need to recruit more senior staff at the level of professor and associate professor to support the programme.
3. We have enquired with numerous eminent international medical physicists if they would like to take up our offer of a senior post but thus far we have not been successful. We will continue trying.
4. The programme has been operating with no additional funding or staffing to the Department of Biomedical Imaging, the budget for the purchase of books and teaching tools, etc. all additional programmes are operating with existing staffing.

In 2008, the programme was successful in securing a second reaccreditation from IPEM. This accreditation extended the accreditation till 31 August 2012. Dr. DA Bradley and Dr. H Porter visited the university in September 2007 for the accreditation purpose. In 2013, this programme was granted an extension of the accreditation until August 2015.

Any course accredited by IPEM will be eligible for the IPEM Student Prize Award Scheme. The student will receive a prize certificate and a cheque for £250(4). Table 8 shows the list of IPEM award recipients from 2011 to 2014.

Table 8: Recipients of IPEM student prize awards

Year	Recipients
2011	GS Sim
2012	N Abdullah
2013	JS Yong
2014	YL Woon

IX. DEMOGRAPHICS AND STATISTICS

Since the starting of the Master of Medical Physics programme in 1997, 86 students had graduated from this programme (Figure 1). Amongst them, 52 were female and 34 were male. More than 89% of the students were from Malaysia. The programme has also garnered much response from the international community (Figure 2). The programme is also recognised by the IAEA as a training programme for medical physicists, particularly for the training and development of medical physicists in the developing countries such as Cambodia. For the past three years, the IAEA has sent two students, funded under the IAEA fellowship to this programme.

The programme is structured to be a one-year programme. Most students (84.9%) completed the course within the stipulated one year programme (Figure 3). 7.0% of the students completed the course within two years. 7.0% of the students dropped out of the programme due to various personal reasons.

The graduates from this programme have been highly appraised by the industry with the employment rate of more than 88% (Figure 4). Amongst those employed, it was not surprising that a vast majority of the graduates worked as physicists, particularly in radiotherapy (Figure 5 and Figure 6). A large number of the graduates have also went on to further study (PhD) and joined the academia (8.1%).

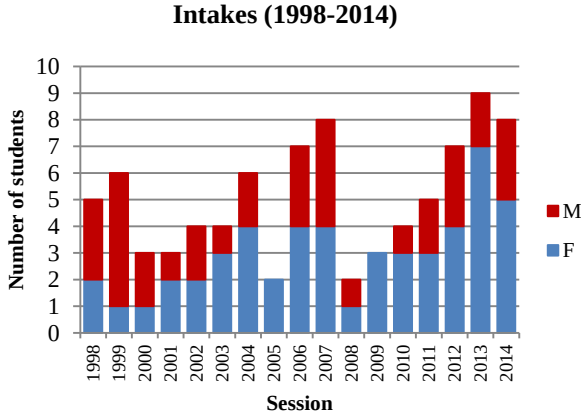

Figure 1: Number of student intakes from 1998 to 2014

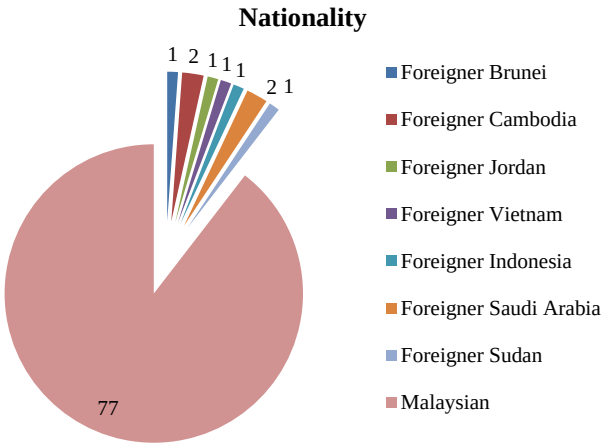

Figure 2: Nationality of the alumni

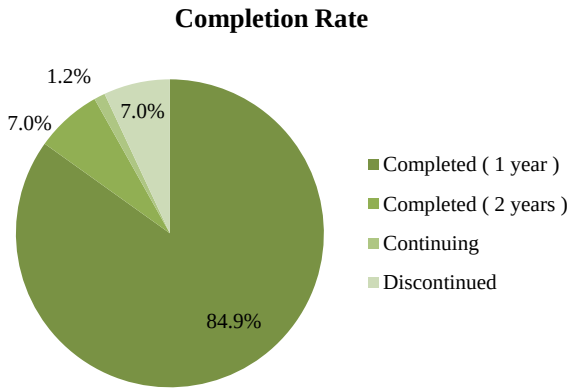

Figure 3: Completion rate of the alumni

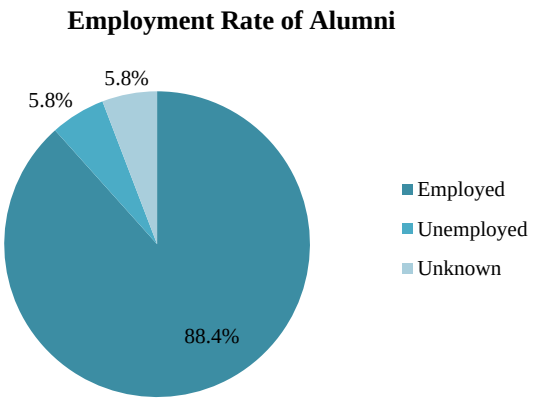

Figure 4: Employment rate of alumni

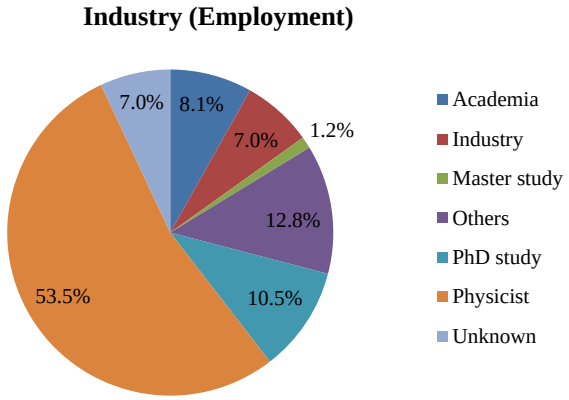

Figure 5: Distribution of alumni working in various sectors

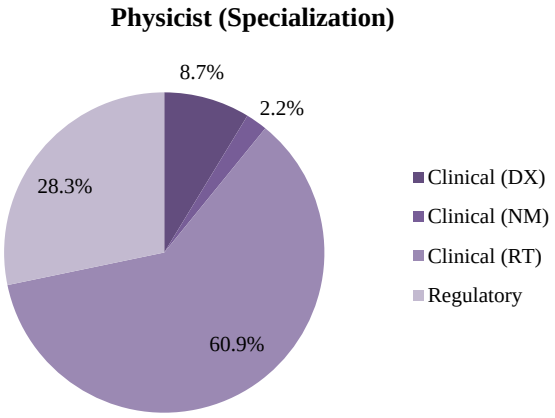

Figure 6: Clinical specialization distribution of alumni working as physicists.

X. STUDENT ACTIVITIES

The Master of Medical Physics programme of University of Malaya pride itself as a programme that aims to provide a holistic approach to the education of medical physics. The students were encouraged to participate in various activities, within and outside of the programme framework. These includes carrying out practicals (Figure 7) and research projects (Figure 8) at various departments. The students were encouraged to present their research projects by participating and presenting in various local, regional and international conferences (Figure 9). These exposures are important to develop various soft skills, training them to be all rounded individuals. In addition to attending conferences, the students, under the leadership of the medical physics professor and lecturers had participated in organising conferences (Figure 10).

In terms of teaching, we have engaged prominent researchers and medical physicists in complementary teaching, either via tele-teaching method (Figure 11) or by inviting them over to the university (Figure 12). The students were also kept updated with the trends and development of the field when the then IOMP president, Dr. KY Cheung visited our university in 14 May 2014 and gave a lecture on the "Global Development of Medical Physics – IOMP Perspective" (Figure 13).

At the International Congress of Medical Physics (ICMP) Brighton, 2013, Professor KH Ng, was recognized as one of the top 50 medical physicists in the world (Figure 14).

Figure 7: Practical session conducted in the radiotherapy department.

Figure 8: Students carrying out various research projects.

Figure 9: A strong presence of the Medical Physics team from the University of Malaya attending and presenting at the 13th AOCMP and 11th SEACOMP Congresses in Singapore (2013).

Figure 10: Student organizers for the EMF conference 2007 posing with some of the invited speakers.

Figure 11: Teleteaching session with Professor P Sprawls.

Figure 12: Students posing with Visiting Professor, Prof. Dr. Anatoly Rozenfeld after his lecture (2014).

Figure 13: The then IOMP president, Dr. KY Cheung visited our university and gave a lecture on the "Global Development of Medical Physics – IOMP Perspective".

Figure 14: Professor KH Ng recognized as one of the top 50 medical physicists in the world by the IOMP.

XI. CHRONOLOGY OF IMPORTANT MILESTONES

Table 9 shows the important milestones of the Master of Medical Physics programme, University of Malaya, Malaysia. Over a period of two decades, the programme has certainly come of age. From the humble beginning of one medical physics lecturer, with 5 students in 1997 to a full fledge team of medical physics academics (1 professor, 4 senior lecturers (with PhD qualifications), 2 lecturers (with master qualifications), and 1 trainee lecturer (on PhD study). The student intake has also increased to 16 in 2015.

Table 9: Important milestones of the Master of Medical Physics programme, University of Malaya, Malaysia.

Year	Milestones
1997	Set up of the Master of Medical Physics programme, University of Malaya
1998	1st intake of students (5 students)
2002	1st curriculum review
2004	Obtained IPEM accreditation (valid from 2002 – 2007)
2005	2nd curriculum review
2007	IPEM reaccreditation (valid from 2007 – Aug 2013)
2010	3rd curriculum review (MQF compliant)
2013	Extension of IPEM accreditation (valid from 2013 – Aug 2015)
2015	4th curriculum review

The Master of Medical Physics programme at the University of Malaya has largely maintained the same structure and content of the medical physics education since its inception in 1997.

However, the landscape of medical physics is experiencing drastic changes, with molecular revolution and with the advent of newer technologies such as nanotechnology, drug discovery, pre-clinical imaging, optical imaging and bioinformatics.(5)

The traditional distinction of the three major medical physics field (radiology, radiotherapy and nuclear medicine) is gradually blurring with knowledge and technology being more and more multi-disciplinary and cross-disciplinary in nature. Conventional method of training, confined within the traditional areas of medical physics may not be adequate in the near future. Perhaps, it is high time for medical physics education to embrace contemporary sciences e.g. molecular biology, systems biology, synthetic biology, nanotechnology, advanced materials, bioinformatics, spectroscopy, etc. Thinking beyond the narrow confines of our own discipline – e.g. chemistry, molecular biology and other subjects may become relevant depending on which area of innovation we decide to immerse ourselves in. Cross-fertilization between various disciplines often yields innovative ideas and techniques. (5)

With a positive outlook and the right approach, the next generation of medical physicists will remain relevant and could confidently look forward to making more significant contributions to achieve higher standards in healthcare.

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