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A summary account of the historical development and present state of the role of biomedical physics-engineering in the education of the healthcare professions

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1 Introduction

This paper presents a summary account of the historical development and present state of the role of biomedical physics-engineering (BMPE) in the education of the healthcare professions (HCP) as elicited from the English language literature. We first present a historical overview of the role of physicists and engineers in medicine as a backdrop to a better understanding of their role in the education of the HCP. This is followed by a review of the literature regarding the educator role itself. Included are relevant papers indexed principally in the three main healthcare related databases i.e., MEDLINE (search period: 1950 to present), CINAHL (Cumulative Index to Nursing & Allied Health Literature, 1982 to present) and EMBASE (Excerpta Medica, 1974 to present) and the educational database ERIC (1966 to present) with the words 'physics' or 'engineering' (and any relevant derivatives such as 'biophysics') in the title.

2 The role of BMPE in healthcare - a historical perspective

The importance of the contribution of BMPE to healthcare has a long history. Books with the titles 'Medizinische Physik' and 'Essentials of Medical Physics' were published in 1856 and 1891 respectively [1,2]. However, the influence of BMPE in medicine registered a quantum leap after the discovery of x-rays by Roentgen (1895) and radioactivity by Becquerel (1896). The first two x-ray laboratories were established in Berlin in 1896. The first chairperson of the first 'Roentgen society' was W. Wolf, a physicist. The first radiological society in England was set up in 1897 and the first president was S. Thomson, a physicist. The involvement in the first 10 years was mostly in radiodiagnosis, whilst that in radiotherapy started in 1910 [3]. From then onwards, the involvement of BMPE in medicine increased rapidly. The first comprehensive BMPE text was the 3-volume encyclopedia 'Medical Physics' (1944 -1960) which listed 23 domains of medicine requiring collaboration between BMPE and medical specialists [4]. Today BMPE plays an important part in most areas of healthcare.

3 BMPE curricula in courses of medicine

BMPE education for medical students has had a long and chequered history. The first documented contribution was that of J. K. Robertson, professor of physics teaching at Queen's University Faculty of Medicine in Canada in the years 1909 to 1951. Robertson started teaching medical students in 1909 at a time when the physics component in the medical curriculum was minimal. The number of lectures was two per week for a single

term and involved general non-applied physics with some laboratory work. Robertson considered this inadequate and instituted a course entitled 'X-Rays and the Physics of Electro-Therapeutics' as an option for final-year students. However this course was not a success. The reasons given by Robertson were two. First, he found that students who had learned their electricity and magnetism in the first year had forgotten everything by the final year. Secondly, final year students perceived that this final year course would be similar to the non-applied first year course and preferred to attend classes in areas directly relevant to their clinical practice. Robertson solved the problem by convincing the faculty to move this final year course to the second year of the programme. He then transformed the content of the latter into a combination of physics principles and clinical practical application in a single unit. Robertson stressed the applications of physics as opposed to limiting himself to non-applied theory. Robertson's second year course combining pure and clinically applied physics in one course "challenged the linear, rigidly structured medical curriculum of the day, with its strict separation of basic and applied science" [5]. However it seems that this initial brilliant flash of educational initiative was never followed up by the international physics community. In fact there is, a quasi-total absence of articles regarding the BMPE component in medical curricula. The few papers that do exist send ambiguous signals regarding the effectiveness of teaching. For example during a retrospective evaluation of the medical curriculum by final year students at the Hannover Medical School in 1996 students expressed the opinion that physics was the least relevant of all the subjects with a 'necessary subject rating' of only 18% compared with 48% for chemistry and 54% for biology [6]. At the moment there is a BMPE component in medical student curricula in practically all European countries (a notable exception being the UK) although the extent of involvement and content is highly variable [7,8]. An extensive programme of systematic curricular research is therefore required.

4 BMPE curricula in diagnostic radiography programmes

Physics has been included in the curriculum for diagnostic radiographers since the beginning of formal radiography education. In the UK a basic syllabus was developed in 1965 [9]. Most schools and organizations of Radiography have over time developed physics syllabi under such diverse names as 'radiation physics', ‘physical sciences’, 'radiation science', 'imaging equipment', 'imaging science and instrumentation', 'radiation protection', ‘imaging technology’ and others [10,11]. However as in the case of medicine research articles in BMPE for diagnostic radiography are practically non-existent and it was only recently that a comprehensive, research-based inventory of BMPE content for diagnostic radiography education has been published [12].

5 BMPE curricula in radiation therapist programmes

As in the case of diagnostic radiography, physics has been included in the curriculum for radiation therapy since the beginning of formal radiation therapy education, and even today, there is a strong BMPE component in most countries worldwide. In Europe, radiotherapy is an area in which physicists and other HCP have worked together in a concerted way and on a European scale to produce curricula in a systematic manner. An extensive curriculum development programme has been carried out as part of the project ESQUIRE (Education, Science and QUality Assurance for Radiotherapy) which is run

under the auspices of the European Society for Therapeutic Radiology and Oncology (ESTRO) and financed by the EC. An important outcome of the project included an endorsed guideline for European core curricula for radiation therapists [13]. The project led to a European core curriculum for radiation therapists which included a physics component [14]. A revised version has an improved physics component under the headings of 'physics' and 'equipment' [15]. A weakness of the curriculum is that it is not outcome competence based (as required by the Bologna process) but simply presents a list of syllabus topics. Further curriculum development research is therefore required in this area.

6 BMPE curricula in the postgraduate medical specializations of radiology and radiotherapy

Again physics has always been a component of the curriculum of these two postgraduate medical specializations albeit with mixed success [16-21]. In 1989, the Committee on Training of Radiologists of the American Association of Physicists in Medicine, published the results of a survey conducted among recently certified radiologists regarding their perception of radiological physics training [22]. The most relevant conclusions of the survey were the following:

a) 72% of the respondents had a negative opinion of physics as presented in their programs at the time, however, the same percentage continued to attend physics training even after graduating and *notwithstanding the fact that they were not obliged to do so for certification reasons*! This clearly indicated that "radiologists actually did consider physics to be a worthwhile endeavor".

b) The respondents however indicated that they would have liked to have "an emphasis on subjects that are directly relevant to everyday practice" as they felt that "although they acknowledged the need for an understanding of basic physics principles, they clearly perceived that theory had been overemphasized". The respondents wanted a greater emphasis on those topics relevant to the production of quality images and means of reducing radiation doses to patients.

The results of the survey triggered a discussion that has gone on unabated in some form or another ever since. It has been argued that it is indeed the superior knowledge that radiologists have of physics that gives them an edge over other clinicians who attempt to read medical images [23, 24]. In a point-counterpoint discussion it was argued that owing to pressure on radiologists' learning time only physics knowledge that is derived from the clinical practice should be taught. This has the advantage of demonstrating directly the relevance of physics knowledge. On the other hand it was argued that it is more important to use the time available to build firm broad conceptual foundations as past experience has often shown that physical concepts which may not be relevant at the time of learning could become highly relevant at a later date - such was the case for example of magnetic resonance imaging (MRI) which necessitated a basic knowledge of the concept of nuclear spin [25].

7 Conclusion: Current developments in BMPE education for the healthcare professions

Biomedical Physics at the Institute of Health Care, University of Malta is taking a leading role in researching and developing BMPE curricula for the HCP at the European level. Our research programme over the last four years has resulted in nine research papers [7, 12, 26-32] and several presentations at international meetings [33, 34]. Learning outcome competence inventories (in the format required by the Bologna process) for biomedical device physics education in Europe have already been published for diagnostic radiography, medicine and nursing [12, 27, 28]. These were developed following a survey of HCP curricula across Europe and an in-depth study of associated themes gleaned from the professional literature (e.g., role development of the various HCP). Inventories for other HCP are in the pipeline. The European Federation of Medical Physics (www.efomp.org) has invited the author of this article to set up a European Special Interest Group to work with other HCP groups to produce suitable curricula for them. The group should in the near future be producing its first articles for publication. *It is important to note that a similar group will be set up within GIREP during the 2008 conference in Nicosia. It is the opinion of the author of this article that the functions of the two groups should be complementary with the former focusing on curricular content whilst the latter on curricular delivery.*

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