An Initial Biomedical Physics Elements-of-Competence Inventory for First Cycle Nursing Educational Programmes in Europe

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Abstract

This paper presents an initial version of a biomedical physics elements-of-competence inventory for first cycle nursing educational programmes in Europe and describes the process used in its development. EU legislation and documentation, standards of proficiency promulgated by professional councils, educational benchmark statements published by higher education quality assurance agencies and articles in the healthcare, healthcare professional and higher education literature relevant to standards of nursing practice, role development and undergraduate nursing education were analyzed. The current outcome competence list for First Cycle nursing programmes developed by the nursing group working within the Tuning Educational Structures in Europe framework was examined. Nursing curricula across Europe were surveyed. Competences expected of a First Cycle nursing graduate that included major biomedical physics components were identified via document analysis. These competences were in turn broken down into specific elements-of-competence and those elements falling within the biomedical physics domain singled out. A structured elements-of-competence inventory was designed to serve as a practical curriculum development tool for biomedical physics educators servicing nursing programmes within Europe.

Introduction

The research reported in this paper forms part of an ongoing project the purpose of which is to put the role of the biomedical physics educator within Faculties of Health Science on a firm foundation. The results of the study have shown that a strategic mission for the role would be:

> "Biomedical physics educators will make a decisive contribution to quality healthcare professional education through the pursuit of practice-oriented curriculum research, development and delivery in the physics-engineering competences necessary for the scientific, effective, safe, ethical and efficient use of biomedical devices and the supervision of student research involving such devices. We will be guided in our efforts by our values of Excellence, Respect, Professionalism, Service, Teamwork and Lifelong Learning"

Biomedical devices are underpinned by physics principles. They are crucial to modern healthcare and the subject of several EU directives - hence offering an excellent opportunity for the physics educator to consolidate and develop his role. In this context 'effective' means ensuring that the medical device attains the intended healthcare purpose for which it is being utilized. 'Safe' refers to the avoidance of unnecessary risk to patients and the total elimination or reduction to acceptable levels of risks to users, colleagues and others from physical agents associated with medical devices. 'Physical agents' refers to ionizing radiation, mechanical, electrical, acoustic, ultrasonic, magnetic, electromagnetic, high temperature, optical, ultraviolet, infrared, and laser sources of possible risk. 'Efficient' refers to the extent that purpose is achieved at minimum device use time.

A generic curriculum development model which can be used to drive curriculum development for any healthcare profession was derived from the above mission statement. Aspects of the model have already been used for the construction of elements-of-competence inventories for

Diagnostic Radiography and Medicine (Caruana & Plasek, 2006, 2005). This paper applies the model for the development of a similar inventory for the nursing profession. Nursing is by far the largest of the healthcare professions yet it has been given the least attention by biomedical physics educators. Nursing is important as it has been the first regulated profession to be included in the Tuning Educational Structures in Europe framework.

Research Design

The research paradigm of this study was practitioner research, the research approach qualitative, and the philosophical perspective pragmatic. The conceptual framework guiding the study was competence-based curriculum development, the research technique document analysis. The Tuning document "Summary of Outcomes - Nursing" (Tuning Group for Nursing, 2005) which lists the competences expected of newly qualified nurses in Europe was scrutinized and the subset of nursing competences that included major biomedical device aspects singled out. Unfortunately, since the practice of nursing is very inhomogeneous across Europe the Tuning competences have been couched in broad terms and do not indicate specific devices. Therefore for further specification we surveyed EU legislation and documentation, national nursing standards of proficiency, educational benchmark statements from higher education quality assurance agencies and research articles relevant to standards of nursing practice, role development and undergraduate nursing education. We also examined European nursing undergraduate curricula. The competences were then carefully deconstructed into elements-of-competence and those elements falling within the biomedical physics learning domain inventorized.

Results

The analysis of the Nursing Tuning competences document indicated that the aim of physics teaching within nursing education would be to ensure that learners acquire the necessary physics elements-of-competence underpinning the following broad Nursing Competences all of which involve the use of medical devices:

1. Has relevant knowledge of the following and the ability to apply this knowledge to nursing practice, patient care and situations of uncertainty: Anatomy and Physiology, including basic knowledge of Histology and Medical Biology, Biophysics, Biochemistry and Radiology.

2. Able to appropriately use a range of nursing skills, medical devices, interventions/activities to provide optimum care.

3. Undertakes comprehensive and systematic assessments using the tools / frameworks appropriate to the patient / client taking into account relevant physical, social, cultural, psychological, spiritual and environmental factors.

4. Practices principles of health and safety, including moving and handling, infection control, essential first aid and emergency procedures.

5. Safely administers medicine and other therapies.

The absence of specific devices is highly evident. In fact, these vary by state, within large states and with time and have to be ascertained at the moment of curriculum delivery on a local basis. However, the documentation analysis indicates that at present the devices to be specifically included in undergraduate nursing are those used in vital signs assessment and delivery of medication (Boxer & Kluge, 2000). Vital signs assessment devices include thermometers (mercury, electronic, tympanic), blood pressure measurement devices (stethoscope, sphygmomanometer, electronic) and increasingly pulse oxymeters. Medication delivery devices include needles, syringes and needleless systems, piggyback, volume-control, and intra-venous infusion systems, and nebulizers (Pfeil, 2001). Learning about

medical imaging devices is also required. Although nurses are not authorized users of such devices, present nursing role developments (e.g., nurse practitioner role) indicate emergent learning needs in this area. Patient safety and occupational safety for all healthcare professionals are legal requirements which are still not being given due importance in nursing curricula (Ramsay et al., 2006; Wakefield et al., 2005). Learning regarding safety vis-à-vis *physical* agents should be included as it is required by several EU directives.

The suggested biomedical physics elements-of-competence inventory for nursing is shown in the Table. The inventory would guide educators in preparing students for use of the devices they would be meeting in their undergraduate practice and also lay the foundations for the learning of those devices they would need to use after their graduation. We intentionally avoided making the inventory too prescriptive; this prevents educator and student disempowerment with respect to content, allow for diversity, and permit the development of native solutions to local curricular targets. The suggested order of delivery might need to be modified to reflect local curricular structure.

Conclusion and implications

The deconstruction of broad professional competences into elements-of-competence and the construction of discipline-based inventories are essential in the systematic development of competence-based curricula. An important use of such inventories is that of a checklist to ensure that all essential disciplinary elements-of-competence embedded within broad professional competences are included in the curriculum and that all are eventually assessed. It has long been acknowledged that nurses' understanding of the physical science component of the knowledge underpinning nursing competences is inadequate (Wilkes & Batts, 1996). This paper is a first attempt to resolve this long-standing issue.

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An Inventory of Biomedical Physics Elements-of-Competence for Undergraduate Nursing in Europe
Define a medical device as described in the Medical Device Directives
Appreciate the range and importance of biomedical devices used in the clinical and research contexts.
Demonstrate awareness of the importance of a risk assessment (patient, occupational, public risk) with respect to physical agents before utilization of a device. Physical agents include ionizing radiation, mechanical, electrical, acoustic, ultrasonic, magnetic, electromagnetic, high temperatures, optical, ultraviolet, infrared, laser. EU medical device risk classes.
Explain the general structure of a biomedical instrument (including range of biomedical sensors, signal processing modules, output devices, basic *qualitative* frequency analysis, signal digitization, bit-depth). Utilize measurement concepts (e.g., accuracy, noise, uncertainty, precision, calibration) and data processing (use of formulas for uncertainty in the mean of a set of data, linear regression and correlation coefficients) in the collection and analysis of data from physiological and biomedical laboratory measurement devices. Explain ways of reducing risk when using such measurement devices.
Explain anatomical and physiological imaging devices in terms of measurement of the spatial distributions of physical and physiological properties of body tissues and their pictorial representation. Safety issues in biomedical imaging.
Understand the various forms of microscopy and the advantages and disadvantages of each.
Apply basic image processing (e.g., zooming, magnification, windowing, smoothing and sharpening filters) for increasing the diagnostic effectiveness of images.
Understand at a basic level the physical principles underpinning biomedical devices to be found in the following device groups: radiation based therapeutic devices, intensive and critical care devices, renal devices, surgical and pre-surgical (e.g., endoscopic) devices, prosthetic devices and biomaterials, assistive devices.
Understand the concepts of device performance indicator and device limitation and their relationship to clinical effectiveness and safety criteria.
Appreciate the importance of following user protocols to ensure performance indicators are not impacted negatively, to reduce effects of limitations of the device and to eliminate or reduce risk to all concerned.
Demonstrate awareness that a device needs to be quality controlled for ongoing effective and safe use. In particular, a device needs to be checked before use (daily QC), cared for during use and left in a condition for subsequent use by self or others.
Understand how to get maximum benefit from reading the user manual of a device.
Explain ethical issues in the use of devices (e.g., qualitative risk-benefit analysis, equitable use of resources, the importance of the economical use of devices, the obligation to optimize benefit and minimize risk).
Explain EU Directives regarding medical devices and patient and user safety.
Appreciate the variety and potential far-reaching effects on clinical medicine of emerging device technologies (e.g., telemetry, automation, robotics, point-of-care (POC) devices, micro and nano-devices, molecular imaging, virtual reality systems).
Apply the above competences to the effective, safe, ethical and efficient use of the specific biomedical devices used in their clinical practice (the specific devices varies by state, within large states and with time and has to be ascertained at the moment of curriculum delivery on a local basis).
Appreciate the need for patient radiation protection as required by the role of nurse prescriber.
Demonstrate a scientific attitude in the use of devices in biomedical research.

Note: Please address feedback regarding the above inventory to Carmel J. Caruana (carmel.j.caruana@um.edu.mt). Suggestions adopted will be acknowledged in future versions of the inventory.