Introducing Telemedicine and Telehealth in Undergraduate Medical Education

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Introducing Telemedicine and Telehealth in Undergraduate Medical Education

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***Abstract*— The introduction of telemedicine in medical curricula has mainly been facilitated over the last decade through either dedicated modules or through the inclusion of telemedicine aspects in Medical Informatics modules. This paper attempts to put across a taxonomy of telemedicine teaching approaches to be used by module designers in medical curricula. This is the first effort to classify the telemedicine contexts in the light of learning theories and given the availability of numerous teaching instruments available today.**

Keywords: Medical Education, Telemedicine, Taxonomy, Learning Theories

I. INTRODUCTION

Medical Informatics (MI) can best be described as an interdisciplinary theme since it draws from the fields of Medicine, Health Care, Information Systems and Computer Science (Information Technology in general). Teaching a course in MI is becoming an ever increasing challenge since you are always required to be on frontiers of these fast moving fields. The picture is not helped by the fact that since standard differences exist both within and across countries, it is not possible to refer to standard curricula, but rather follow generic recommendations that fit more suitably with the targeted learning outcomes, knowledge uptake and practical skill qualities that students should possess after their graduation.

Of course, basic Medical Education and Research lays the foundation for advancing and offering proper healthcare delivery. There is no doubt that deep knowledge of pure medical topics like for example anatomy is mandatory for successful MD practice e.g. surgery. Also, comprehensive knowledge of physiology is essential for grasping the principles of pathology, to avoid incorrect and inadequate practice of medicine. Similarly, medical informatics is not just a subject to be learnt and forgotten after the first graduation. In view of the fast changing world of medical/clinical practice, it is of utmost necessity for every medical student not only to become a good user but also an expert for advancing medical knowledge base through medical informatics.

In addition, health care practices continue to evolve with technological advances integrating computer applications and patient information management into telemedicine systems. To this end, telemedicine has become a core component of any Medical Informatics course with a pivot role in the envisaged course's learning outcomes.

Telemedicine covers a wide range of services and applications [1]. Since the first formal definition of telemedicine by Bird in 1971 [2], many researchers tried to define this term in order to clarify the boundaries of telemedicine and its use. There are now a number of terms in use, which cover all aspects of delivering medical care at a distance. Even though the core of these definitions is the same, telemedicine, and hence its definition, evolved dramatically as a result of the tremendous changes experience in the information and (tele)communication technologies (ICT). These changes were so significant that new terminologies like telehealth, e-health, and others were introduced, and explaining the difference between telemedicine and these new terms became important. Broadly speaking, telemedicine is that area where medical care is provided at a distance with the use of ICT; telemonitoring is a subset of that and relates to monitoring of people's vital signs e.g. at home [2]. Telehealth removes the focus on medical applications alone and, as suggested in [3], could include the wider issues of health promotion and illness prevention. Finally, telecare uses ICT to enable a greater independence for elderly or disabled people, helping them to avoid residential care and enjoy the social benefits of a hopefully improved life quality by remaining in their own homes. In this paper we have used the term telemedicine to indicate any interaction between a health/medical care service provider and its recipient, where the participants are not in the same location during contact.

As one understands, various definitions and numerous terminologies have been published, raising the need for a taxonomy that is detailed enough to define all the terms introduced [4]. Such a taxonomy, took into account relevant dimensions fitted together that help in categorising and comparing current/future telemedicine efforts, as well as, in planning several emerging telemedicine scenarios using new technologies.

Now, in order to discuss the introduction and best exploitation of telemedicine into undergraduate Medical curricula, one needs to consider it under the generally increased demands for accountability and transparency in

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the delivery of undergraduate medical education that developments in the National Health Systems/Services have created over the last decade or so [5]. As a result of this push for accountability, a new agenda for medical education now exists in the UK for example, with a readjustment from process to product [6]. It is argued [7] that medical educators must make their learning outcomes more explicit in order to deliver their learning programmes more effectively and, therefore, medical schools in the UK and the USA have engaged in this task as early as 1999 [8]. This means that pre-specified learning outcomes fuel the design of students' learning experiences and the effectiveness of educational experiences are determined by exploring the degree of match between the "product" of the learning experiences and the pre-determined outcomes. Grundy [9] argues that a fundamental issue in the product-orientated curriculum is control. Although the curriculum designer and the teacher may be the same person, in many cases they are not. In such cases, the curriculum designer controls the activities of the teacher and the teacher controls the learning environment of the student.

In the light of all the above, this paper attempts to put across a taxonomy of relevant items important for teaching telemedicine to undergraduate medical students. The taxonomy we propose here takes into account previous efforts of creating taxonomies for telemedicine efforts, taxonomies appearing in the field of education and learning theory, as well as, taxonomies for medical education, and merges them into a three level taxonomy, that may be used to effectively plan the best possible telemedicine teaching provision in medical curricula. To the best of our knowledge, such an effort has not been done before.

So this paper is structured as follows. In the next section, we describe the methodological building blocks of our approach. Sections III presents the three level taxonomy we are proposing, while the last section provides a discussion of the role it can play, in the light of regionally funded projects for collaboration in the application field of e-learning in medicine.

II. Relevant Methodological Background

A. Recommendations of IMIA

A few years ago, and three years after the first run of our course, the International Medical Informatics Association (IMIA) agreed on international recommendations in health/medical informatics education [10]. These were centred on the educational needs for healthcare professionals to acquire knowledge and skills in information processing and information and communication technologies, under a three-dimensional framework, namely, type of professionals in health care (physicians, nurses, etc.; dimension 1), type of specialisation in health/medical informatics (IT users, MI specialists; dimension 2), and stage of career progression (BSc, MSc, PhD; dimension 3). Of interest to the current piece of work are the learning outcomes defined in the above paper, in terms of knowledge and practical skills for healthcare professionals in their role as MI specialists and the associated recommendations for courses in MI as part of educational programs in medicine at the undergraduate level.

IMIA recommendations divide the learning outcomes into three levels of knowledge and practical skills, namely, introductory, intermediate and advanced. Furthermore, the knowledge and skill levels are classified into three domain areas of knowledge and skill. These domain areas are:

- Methodology and technology for the processing of data, information and knowledge in medicine and health-care.
- Medicine, health, and biosiences, health system organisation
- Informatics/computer science, mathematics, biometry.

Telemedicine, as a topic, forms part of mainly the first of the above domains in a module of MI in an undergraduate medical curriculum. However, the latter two domains also include elements of telemedicine examples. This is currently, taken into account as a 'norm of practice' in both the Aristotle University of Thessaloniki and the Democritus University of Thrace, Greece.

B. Taxonomies of Telemedicine

Previous attempts to classify telemedicine were motivated by (i) either the demand for evidence of its effectiveness [11], thereby focusing on strategies to evaluate the telemedicine applications and their effects on quality, accessibility or cost of healthcare; or (ii) the need to plan several emerging telemedicine scenarios using new technologies, thereby focusing on categorisations and comparisons of current/future telemedicine efforts from literature [4]. In the latter, the authors proposed five taxonomy dimensions as derived from their literature review and believed to be reflecting a combination of various classification schemes proposed in the early studies. Those five dimensions were related with the organisational aspects of Telemedicine, its delivery methods, and its associated medical/clinical concerns and encompassed factors such as Application Purpose, Application Area (Domain), Environmental Setting, Communication Infrastructure, and Delivery Options.

C. Education/Learning Theory Taxonomies

Bloom, an educational psychologist, developed a classification of levels of intellectual behaviour [12]. The classification featured the following levels of intellectual behaviour:

1. knowledge (the lowest level, pure recall of data),
2. comprehension (understand the meaning) ,
3. application (use a concept in a new situation),
4. analysis (identify components, see patterns),
5. synthesis (put parts together to form a new whole),
6. evaluation (the highest level, make judgments about

the value of ideas or materials)

Furthermore, there exist taxonomies of competencies. One such taxonomy was introduced by Benner [13] entailing degrees of competency such as Novice, Advanced Beginner, Competent, Proficient, and Expert. The degree of competency can be understood as the depth of expertise/understanding required in one field. For instance, no education is required to gain an understanding at Novice level, maximum education and experience is required to become an Expert.

The above two taxonomies have been taken into account by Hovenga [14] in the process of suggesting an Educational Framework for Health Informatics Professionals in order to provide national guidance on health informatics education. Fig. 1 illustrates how the above two taxonomies were combined in [14] to enable the application of the Health Informatics framework in Australia.

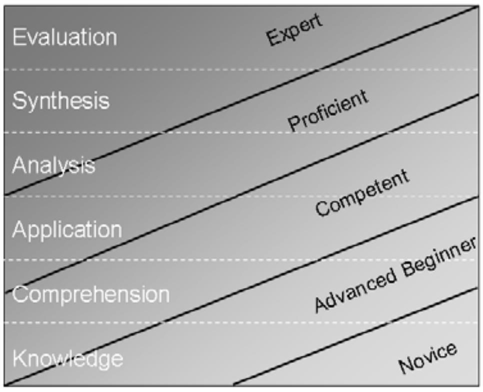

Fig. 1. The merging of Bloom's Taxonomy (white text and lines) on the left and Benner's degrees of competency (black font and lines) on the right as explained in the Australian Health Informatics framework (used in [14]).

However, if learners are seen as autonomous learners, actively constructing their own knowledge by engaging with it (either in the mode of meaningful reception learning or in the mode of discovery or, maybe, in guided discovery), then new knowledge is consciously related to relevant existing cognitive structure in a substantive and non-arbitrary way. In the constructivist's paradigm a number of conditions are to be satisfied and these conditions are centred on the material to be taught and the learner. According to Ausubel's theory of meaningful reception learning [15], there exist key elements in a constructivist's paradigm facilitating meaningful learning: Meaningful Learning, Potentially Meaningful, Existing cognitive structure, Progressive integration, Logically meaningful, Integrative reconciliation.

Last but not least, if one is interested in facilitating collaborative learning, using problem-based learning, there exist certain factors that have to be considered [16] [17]; these show which cognitive activities are taking place thereby facilitating learning, e.g. Conflict or disagreement, (Self-)explanation, Internalization, Appropriation, etc.

D. *Medical Education Taxonomies*

With the ever-expanding use of information technologies in medical education and medical education research, there are growing needs for robust and appropriate semantic and ontological systems to facilitate cataloguing, storage and retrieval activities. The METRO Project [18] was initiated three years ago in order to discuss controlled vocabularies, taxonomies and thesauri for medical education in the United Kingdom. The Best Evidence Medical Education Collaboration (BEME) was eager to develop a taxonomy for medical education, as it would be a great asset in the production of systematic reviews. METRO would be embedded throughout BEME's production of systematic reviews - from the formulation of research questions, to evidence retrieval, data abstraction, data synthesis, publication (including future BEME databases) and evaluation. The two areas of most immediate concern were data abstraction and evidence retrieval/searching [19].

Moreover, getting closer into the learning approach, Davis and Harden [20] issued a practical guide for health professions teachers providing a perspective of one of the most important educational developments in the past 30 years, that is, the Problem-based learning (PBL). They considered PBL as a teaching method, rather than used as the sole educational strategy, that can be included in the teacher' s tool-kit along with other teaching methods. In that work, key features of the PBL approach were identified organising the PBL teaching strategy ingredients in a list, that simulated, to our opinion, a PBL effort taxonomy.

In addition, Magzoub and Schmidt [21] proposed a classification of community-based education (CBE), by creating a taxonomy, based on the literature from reports of 31 active programs in various locations. The ultimate goal of creating that taxonomy was to contribute to the development of a theory of CBE and provide a more systematic way to study CBE, as well as, to demonstrate the various ways in which medical schools, their staffs, and their students can become involved with the communities served.

III. TELEMEDICINE TEACHING TAXONOMY

Our taxonomy is a three level, multidimensional structure built up from three different significances involved in telemedicine teaching. These are (i) the telemedicine effort contexts, (ii) the familiar learning/educational objects used, and (iii) the learning/educational approaches/strategies. Fig. 2 below illustrates the infrastructure of the taxonomy in the aforementioned three levels. So, the next few sections will describe in detail each of these three levels, and will explain their interaction.

A. *Level 1: Taxonomy of Telemedicine Contexts*

At this level, we start from the practice of medicine, which basically conforms into four basic areas as a whole [22], namely, diagnosis, consultation (communications), treatment, and education and training. These areas form a hypelevel of four generic contexts of telemedicine practice. They divide into mainly three dimensions, namely, the dimensions of organizations, delivery, and medical, as suggested in [4].

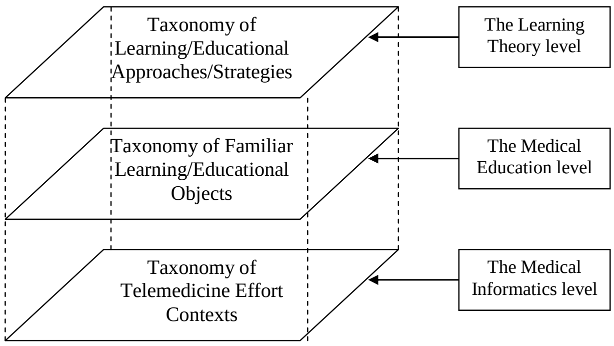

Fig. 2. The infrastructure levels of the Telemedicine Teaching Taxonomy.

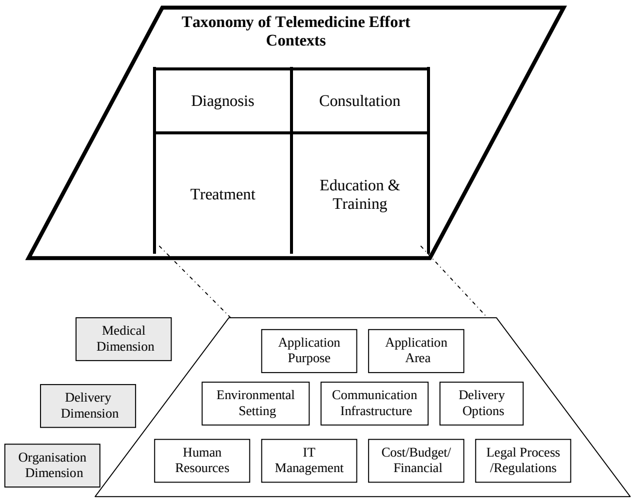

Fig. 3. Level 1: Telemedicine Effort Contexts Taxonomy.

Application Purpose refers to the purpose of communication and is categorized under two main groups: Clinical and Non-clinical. *Application Area* refers to the domains in the medical field. For instance [4] lists fields like Neurology, Home Care, Microbiology and Immunology, Cardiology, Ophthalmology, etc. *Environmental Setting* refers to the type of physical environment that the physician or the patient will be using during the telemedicine event, and can be dramatically different ranging from a patient at a primary care hospital to a mobile patient or a patient at home, or a health professional at a tertiary hospital to a professional being reached at home. *Communication Infrastructure* refers to the channels that are available for the transmission, emission, or reception of data or information in any format, based on various wired or wireless networks (e.g. radio waves, fiber optic lines etc). Finally, *Delivery Options* refers to the applications provided to conduct a telemedicine event by fully complying with the requirements generated based on the previous dimensions, as well as, the requirements posed by the health professionals and patients (e.g. synchronous, asynchronous, video, data etc). The additional group called *organizational dimension* consists of important aspects of any organization such as human resources and IT management (horizontally pervasive factors for any organization).

B. Level 2: Taxonomy of Familiar Learning Objects in Telemedicine Effort Contexts

To introduce first-year medical students to fundamental concepts in telemedicine and facilitate interpretation of the complex health care environment, a simple teaching approach consisting of active cases/problems/exercises plus group discussions, using familiar objects from everyday use, may be planned [23]. In the process of mentally reconstructing telemedicine issues through familiar objects, students are expected to learn the use of common telemedicine terms. Such objects may be:

1) *A rural MD in a remote Greek island and/or mountainous region needing guidance and assistance*
2) *an expert MD in a specialised tertiary hospital wishing to disseminate medical knowledge and clinical practice protocols at a distance*
3) *a Hospital manager wanting to expand/increase the efficiency/effectiveness of health care services provision*
4) *a Health Authority Manager attempting to homogenise the services in his/her supervision region*

Similarly to the notion followed in the first level of our taxonomy, we have mentally and formally split the familiar learning objects into four main categories as shown in Fig. 4. These are: (i) strategic level-oriented, containing objects referring to Health Authorities/Ministry cases like object number four above; (ii) Service-oriented objects that focus on service delivery (through both students and staff). The services may range from restricted curative services and second opinion protocols in primary care units to broader health community development services like health promotion (see for instance object number three in the list above; (iii) Research-oriented objects mainly involved in studying the problems of any health service level with an aim to reach an informed decision making, addressing, for instance, a health care delivery problem (see for instance object number two in the list above); and (iv) Training-oriented objects that focus on student or MD training in any Health service or community setting, be it a primary care unit, a defined community, or a hospital working environment (see object number one in the list above).

The innovative teaching approach proposed here, has already been pilot-tested at AUTH during the telemedicine sessions of the MI elective module. The students' understanding of these concepts was found to be good when evaluated at the pilot-run, by a simple (to start with) multiple-choice-questions test, suggesting that this is an effective method for introducing beginners to fundamentals of telemedicine, and integrating different aspects of it like the development of the regulatory framework (see for instance [24].

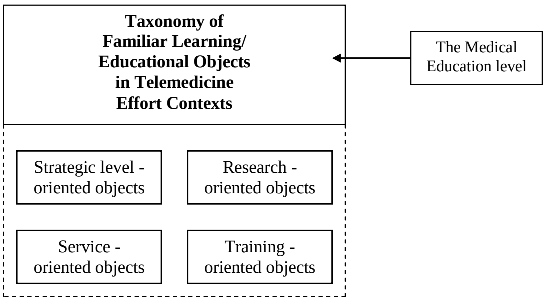

Fig. 4. Level 2: Taxonomy of Familiar Learning objects split into four general orientations, namely, strategic-level, service, research and training – oriented objects (see text).

C. *Level 3: Taxonomy of Learning/Educational Approaches/Strategies for teaching Familiar Learning Objects in Telemedicine Effort Contexts*

At this hyperlevel of the taxonomy, we have put the links to the teacher issues like the design of the module or module contents, and the associated concerns stemming from the various education/learning theory approaches. So, the level is conceptually divided into four (4) dimensions, and each of the latter is composed by a number of factors, similarly to the notion used in the previous levels, and more specifically in level 1. The aforementioned four dimensions are (i) curriculum control, (ii) aimed competence, (iii) delivery medium, and (iv) plurality/singularity. Fig. 5 illustrates the composition of this third hyperlevel of our taxonomy.

The *curriculum control dimension* is attempting to include in the module design the notion of alignment with Quality Assurance demands such as envisaging explicit learning outcomes as cited in the Quality Assurance Agency's Handbook for Academic Practice [25], which states that institutions are expected to set out the intended learning outcomes of their programmes. As also mentioned in the introduction of this paper, there exist generally two ways of achieving the expected learning outcomes: by following a *process-oriented* approach, or by setting up a *product-oriented* outcome assessment. In the first approach, one may employ traditional teaching methods, or Problem Based Methods, while in the latter, one should focus more on the notion of the student's practical experience and portfolio fulfillment.

The latter approach is designed with a series of special actions at AUTH. It is generally divided into practice in public health service points, and practice into private settings with a primary focus on health telematics enterprises rather than private clinical settings. Practical telemedicine experience of students in public settings is obtained through a recently funded project on primary health care, in which medical students are assigned to health care centres and rural offices, and are expected, within a two week period, to (a) fill up a report on telemedicine facilities available and local requirements to practice telemedicine and tele-health; (b) utilize micro-devices and submit vital signals of patients to a remote (University based) phone/voice operated contact centre; and (c) to simulate a telemedicine session of a second opinion protocol by starting a teleconference session over IP, having pre-filled a web based electronic patient record, elements of which are shared during the telemedicine session by a remote "team of experts". The *product* is the actual student's portfolio at the end of the practical experience period.

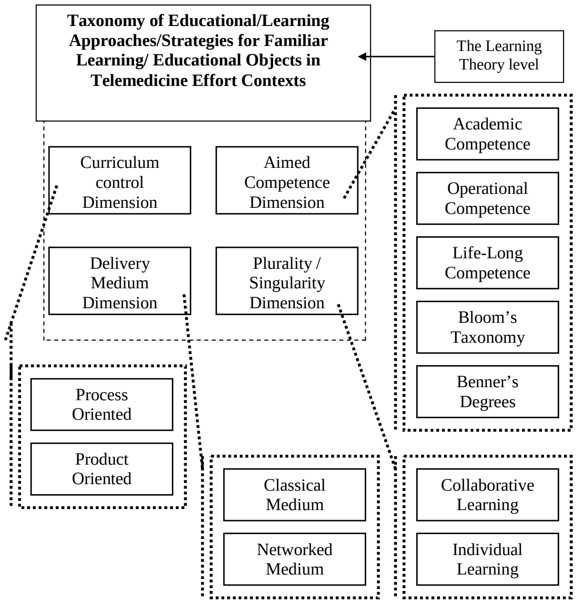

Fig. 5. Level 3: Taxonomy of Learning/Educational Approaches/Strategies; the level is sub-divided into four dimensions, namely, curriculum control, aimed competence, delivery medium, and plurality/singularity dimensions.

Practice into private settings is facilitated with the availability of projects like Mobinet [26]. In a similar way like in the case of public practice, students are expected to be involved through the Mobinet project, which is set for commercial launch in Greece, and its service commercial deployment is envisaged to contribute to the exploration of the dynamics of interactive monitoring. Within Mobinet, two different models for service provision have been designed, focusing either on the patient-end (patient-centric) or the healthcare professional-end [General Physician (GP) –centric]. In both cases, lightweight handy devices are used for the collection and wireless transmission of the vital signs to a web server. The aimed "student product" in the first case is linked with educating the patient on using the devices and completing the tele-monitoring procedure, while in the second case, it is linked with the student's involvement in running the web-based application that enables: graphical presentation of medical results, “Second Opinion” capability between physicians, encrypted web storage of patient medical files, paperless transactions, immediate access to patient medical data, bi-directional connectivity between physicians and patients and/or physicians and experts.

The *aimed competence dimension* is driven by the fact that many competency models that follow the concepts of either academic competence or operational competence, have lately been subject to criticism [27]. So, in accordance with what has been described in the student practice part above, there is a need for replacing criterion-referenced models in favour of a model that engages the higher order competence, performance and understanding which represent professional practice at its best. Finally, in assessment of the outcome, Bloom’s taxonomy and Benner’s degrees, as outlined in Fig. 1 are used in this dimension.

The *delivery medium dimension* is linked with the teachinng environment as such. In the *classical approach*, we have the amphitheatre, the labs, the library, etc, while in the *networked approach*, we have options like web based, multi-tier, virtual, client-server, intranet/extranet etc.

Finally, the *plurality/singularity dimension* sets the mode of work, by specifying either a *collaborative approach* (with elements like Conflict or disagreement, (Self-)explanation, Internalization, Appropriation, Shared cognitive load, Mutual regulation), or on *individual learning approach* (with elements like self-motivation, instruction, semi-instruction).

IV. CONCLUSIONS

The purpose of this work was to define a taxonomy for telemedicine teaching to medical students, by merging developments in medical informatics, medical education, and learning. The approach outlined and demonstrated how certain issues of concern may be utilized from different levels of context in order to facilitate the best learning outcomes/products. It is needless to explain that, interactions are allowed both vertically and horizontally in our taxonomy, constituting a grid of available options, tools and teaching instruments for the teacher, but also a plethora of learning elements for the student. In an e-learning approach, the taxonomy may be easily developed into an ontology, which is easily then modeled by UML classes by using certain tools (e.g. Protégé), which in turn could facilitate classes of learning approaches in an e-learning or web-collaboration environment. It remains to see, whether the actual, measurable effect of such an approach will have the envisaged outcome or not.

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