Distance-Learning Educational Material in the Biomedical Engineering Degree Program

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Abstract: - This paper presents the development of distance learning, and more specifically, self-learning educational material to benefit our Biomedical Engineering undergraduate program. In a pilot project we applied distance-learning concepts in developing educational material for Electrocardiography (ECG), one of the core subjects in our curriculum. We developed a text, which we submitted to a small-scale evaluation in order to identify and correct potential shortcomings. The initial results were encouraging and we intend to expand our activities to the creation of interactive multimedia and internet-based training material.

Key-Words: - Biomedical engineering, education, distance learning, electrocardiography

1 Introduction*

Although a number of definitions for distance learning (DL) have been proposed over the years, the majority seems to agree on the basic elements, which differentiate the method from conventional teaching and learning. Such elements include separation of the teacher from the learner in space and/or in time during at least a major part of each educational process, the use of special training material to unite teacher and learner and carry course content, the provision of two-way communication between them, and the control of learning by the student [1], [2].

Biomedical Engineering (BME) is undergoing a rapid evolution, characterized by the development of new and advanced equipment and techniques. To remain at pace with the dynamics of this field, the BME professional should be involved in continuing and lifelong learning activities [3]. Both abovementioned target groups, i.e. the BME student and the BME professional, are among the numerous cases of people whose educational needs can be assisted by the particular aspects of DL.

In the present work, the development of DL educational material for Electrocardiography (ECG) is described, as a pilot trial to gain experience in expanding the material to other subject matters of electrical biosignal recording devices.

2 Methodology

In the present study, we developed a self-learning educational text based on existing conventional material already used in the classroom. This seemed to be a logical approach, as opposed to creating something "from scratch" since it would be feasible to compare old and new material. The subject matter selected for this trial was electrocardiography (ECG), a basic element of our BME curriculum. The study material used to date was created by the ECG course instructor for a conventional classroom teacher-centered format, supported by student studying on own time.

The process of transforming the existing ECG study material to a version suitable for DL consisted of eight distinct steps. The main idea was to leave the text unaltered as far as its scientific content is concerned and to identify the particular aspects that

* Financial support for this paper was provided by the project "Upgrading of Undergraduate Curricula of Technological Educational Institution of Athens" (APPS program - T.E.I. of Athens), financed by the Greek Ministry of Education and the European Union.

needed modification in order to conform to DL material properties. A brief description of the procedure follows:

- **Reducing chapter size:** Smaller-sized, manageable chapters and subchapters contribute to the learning process by enabling the student to use study time more effectively.
- **Clearly stating learning objectives:** The student should be fully aware of what exactly is to be learned in each chapter.
- **Chapter introductions and summaries:** The introductory texts assist the student by presenting briefly the content that follows. Summaries provide easier revision and retention of important aspects of the material.
- **Redesigning the optical content:** Pictures, figures, diagrams, charts, etc. are very important aspects in any educational material as they augment understanding of the subject matter. In the DL context the student, who is engaged in a self-learning process, relies heavily on this.
- **Highlighting important information:** In the self-learning process, it is important for the student to understand which information or keywords are of particular importance and should be retained during study.
- **Increasing line spacing:** A particular aspect of any DL text must be its user-friendliness. Increased line spacing (i.e. fewer lines per page) makes reading easier, less tiring and more effective.
- **Study hints and parallel texts:** It is important that difficult points in the material are supplemented with examples and study hints to facilitate better comprehension. Furthermore, reference to parallel reading texts redirects the student to other learning sources that enhance understanding.
- **Self-assessment exercises:** Questions and exercises are accompanied by clearly defined answers and information why other answers or solutions are incorrect. Self-assessment questions and exercises must be closely linked to the learning objectives.

3 Results

3.1 "Before and after" comparison

By applying the steps described in the above methodology, the first draft of the DL text for the subject of ECG was produced. We compared it to the existing text with regard to specific criteria in order to obtain indications as to the changes made. This comparison is presented in Table 1. The most evident modifications are the increase in the pages from 35 to 133 (280%) and the word count from 10,794 to 19,126 (77.2%). This is obviously due to the line spacing adopted (from single to 1.5) and the rephrasing of the text in a friendlier language to enhance comprehension. It should be reminded that the actual content of the initial text was not increased in any way, only supplemented to adhere to the principles of DL study material.

The criterion of manageable sized chapters and subchapters was met by dividing the initial four chapters into a further eleven subchapters of relevant subject content with meaningful subchapter titles. The diagrams and pictures were increased from 33 in the initial text to 42 in the reformed DL material (27.3%). Five references to parallel texts were placed within the text and specific study advice is offered (study hints) in six particular parts of the text where the relevant content was considered difficult to comprehend. Highlighting of important information was applied and chapter and subchapter summaries were added throughout the text. Perhaps the most obvious modification was the addition of thirty-nine self-assessment questions and exercises along with model answers and explanations. Self-assessment was closely linked to the learning objectives stated in the beginning of each chapter and subchapter.

TABLE I
COMPARISON OF TEXT SPECIFICATIONS

Specifications	Before	After
Pages	35	133
Word count	10,794	19,126
Subchapters	None	11
Self-assessment exercises	None	39
Diagrams & pictures	33	42
Parallel texts	None	5
Study hints	None	6
Spacing	Single	1.5
Highlighting	No	Yes
Chapter summaries	None	Yes

3.2 Evaluating the material

A small-scale pilot-testing phase followed where the material was assessed by a small number (n=8) of its potential users, i.e. the students at our department and also by two experts in the field of open DL, with a background in medical physics and biomedical engineering. The purpose was to identify potential shortcomings, which would have to be corrected

before the material was actually used and assessed in the real learning environment. A 28-item questionnaire addressing specific categories of criteria pertinent to DL texts was developed for the evaluation process. The criteria assessed corresponded to the aspects of DL texts [2]. Each category of criteria were allocated weights and the total score (S) was transformed to a 0-100 scale.

The "evaluators" were provided with the distance-learning ECG text and asked to study it carefully before completing the questionnaire. Six of the eight students participating had already studied and passed the ECG course with the conventional text. The other two had not attended the course yet and were relatively unfamiliar with ECG (S=100,100). Encouragingly, the results show fairly high scores from both the DL experts (S=75,81) and the students (S=73,73,74,85,89,92,100,100). It should be noted that the two students who had not yet completed the ECG course and therefore had not been exposed to the previous text, were the ones who gave the 100 scores. Though this is a promising result, their inexperience both in ECG and even more so in the concept of DL yield the need for a careful interpretation of such results. Surprisingly, the other two groups, though distinctly different in knowledge and experience, provide very similar evaluations. The most noteworthy finding is the need to improve the self-assessment exercises and to provide more detailed answers. This was pointed out by all the evaluators.

4 DISCUSSION

Our aim was to exploit the potential of computer assisted instruction for teaching and creating a student-centered learning environment. It should be made clear that we don't suggest replacing well established teaching methods which have proven their effectiveness. Neither do we suggest that the traditional classroom and teacher should give their place to a "virtual" and highly technological teaching environment, just as distance education was not conceived for replacing traditional practice in education. On the other hand, certain evident and clearly demonstrated advantages of the methodology, should not be excluded from the learning process, but used complementarily in order to augment it.

The activities described in this paper are the first steps in reforming current methods and materials implemented at our department. These activities, together with a recent proposal for upgrading our curriculum based on current trends in higher education are foundations for modernizing undergraduate biomedical engineering education in Greece. Currently, we are involved in developing educational material for Electroencephalography (EEG) and Electromyography (EMG) based on the experience gained from the activities described in this paper. The main addition will be interactivity with multimedia-based material. It has been reported that the use of such material can supplement course and laboratory experience and free up classroom or laboratory time to be used for higher level activities such as synthesizing, analyzing, evaluating ideas, and discussing more difficult content that needs to be explained in detail by an instructor [4]. In addition, using interactive multimedia can be a versatile method of learning in that, if students wish to use the software program at home, commuting time may be lessened and time available for learning increased [5].

The present work is part of the project "Upgrading of Undergraduate Curricula of Technological Educational Institution of Athens" (APPS program - T.E.I. of Athens). The main goal of the project, as far as our Department is concerned, is the reforming and upgrading of existing laboratory subject matters, as well as the development of new teaching methods and materials. Within this context, we intend to exploit the results of this pilot test as far as the compatibility of DL and BME education is concerned.

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