Research Article

Insertion of medical biophysics in the integrated medical curriculum

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ABSTRACT

Background: Despite the definition of medical biophysics as interdisciplinary field, using the principles and laws of the physics sciences to describe and investigate biological processes for the purpose of medical application, the results and outcome of insertion of medical biophysics in the medical curriculum have no longer emerged and many medical schools restrict the medical biophysics to the preparatory phase or maximum in the basic years and omit it completely in clinical years. **Objective:** The objective of the study is to emerge our experience in the insertion of medical biophysics in the integrated medical curriculum in its two forms; horizontal and vertical and reveal its outcome in the student achievement in the whole curriculum. **Materials and Methods:** Following the Kern's six steps for curriculum development to plan and implement the medical biophysics in the medical curriculum. The questionnaire was applied to measure the degree of students satisfaction about all Kern' steps of the medical biophysics course. One-way ANOVA was used to estimate the degree of satisfaction about all Kern' steps. **Results:** Goals and objectives (step 3) revealed the followings: students showing strongly satisfied (86; 57.3%), satisfied (44; 29.3%), neutral (3; 2%) dissatisfied (11; 7.3%) and strongly dissatisfied (6; 4%) with significant *P* value obtained. For educational strategies (step 4): students showed strongly satisfied (55; 36.6%), satisfied (45; 30%), neutral (10; 6.6%), dissatisfied (23; 15.3%), and strongly dissatisfied (17; 11.3%). While the students satisfaction regarding the implementation step (step 5) revealed: strongly satisfied (65; 43.3%), satisfied (41; 27.3%), neutral (12; 8%), dissatisfied (22; 14.6%) and strongly dissatisfied (10; 6.6%). Regarding the students assessment step (step 6): strongly satisfied (25; 16.6%), satisfied (45; 30%), neutral (9; 6%), dissatisfied (32; 21.3%) and strongly dissatisfied (29; 19.3%). **Conclusion:** Medical biophysics is an interdisciplinary field and is considered a good example of integration at a high level. Hence, it must be heavily addressed in the medical curriculum to facilitate the understanding of major new approaches in the disease and cosmetic management that appeared in recent years and considered a new era in medicine.

KEY WORDS: Basic Science; Integration; Medical Biophysics; Medical Curriculum

INTRODUCTION

The curriculum of Al Baha School of Medicine (ABSM) adopted fully integration at all phases of the program. Shoemaker *et al.*[1] defined the integration as "education that is planned in such a way that it incises diagonally the subject-matter lines, carrying together diverse aspects of the curriculum into the consequential organization to spotlight on wide areas of study." Two types of integrations were represented in the ABSM curriculum horizontal and vertical forms. The horizontal integration brings the disciplines, subject, and topics, altogether as one unit.[2,3] Vertical integration brings basic and clinical sciences in all levels of curriculum and extends beyond into the postgraduate training and continuing with the professional development. This denotes that the learning of basic science is located in the context of clinical and professional practice and seems

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to be more significant and appropriate for the students.[4,5] As noted, the basic science is designated to be studied as integrated courses. Of these basic sciences is the medical biophysics which was defined as an interdisciplinary field, using the principles and laws of the physical sciences to describe and investigate biological processes for the purpose of the medical application.[6] This field involves collaboration between physics, biology, and the basic medical sciences, which is essential to learn about diseases and their processes, and how to effectively diagnose and treat them.[7]

Medical biophysics is seen as a discipline bridging physics, technology, and medicine. Hence, the selection of topics to be addressed for the medical curriculum is not quite easy and need to be studied well according to many factors as level and phase of the curriculum as well as the degree of difficulty.[8,9]

The aim of the study is to emerge our experience in the insertion of medical biophysics in the integrated medical curriculum in its two forms; horizontal and vertical and reveal its outcome in the student achievement in the whole curriculum.

MATERIALS AND METHODS

The first step in the designation of the course of medical biophysics within the integrated medical curriculum was done using a cross-sectional study through a well structured, valid, and reliable questionnaire to estimate the needs for the studying the medical biophysics within the core of integrated curriculum at the undergraduate level, also to explore which Harden' level of integration the medical biophysics can be addressed.[2]

The questionnaire was formulated by the medical education unit that follows the quality and development affairs of ABSM. The questionnaire was subjected to test for validity by insertion of a short cohort study on a small number of school staff with different disciplines. The analysis of this short cohort proved the reliability of the questionnaire. In addition, the results obtained ensured the needs of the school for the designation and implementation of medical biophysics in the two forms; horizontal and vertical. The horizontal form was in the form of the foundation of basic medical biophysics course within the integrated course named integrated natural science as a form of interdisciplinary integration and vertical form through the insertion of medical biophysics in some courses in all three phases of the curriculum which include the premed, basic, and clinical phases.

The second step was the foundation of the committee which was formulated by vice-deanship for quality and development affairs and documented from faculty deanship and the deanship of the institute, the committee consisted mainly of staff members of medical biophysics and radiology departments with few representatives from some basic and clinical sciences and representatives from administration of faculty to facilitate the logistic material needed for implementation of the module. The function of the committee was how to integrate the medical biophysics within the integrated curriculum. Following Kern' steps[10] (problem identification, general assessment need, formulation of goals/intended learning outcomes, teaching strategy, implementation, assessment, and evaluation), the committee studied the current situation for identification of the defect among medical students regarding the medical biophysics and emerge the importance of medical biophysics in the curriculum and to what extent the medical biophysics can serve in achieving the learning outcomes of all program. The upcoming step was to the assessment of the current needs and desired needs through the identification of the learning gap.

Several closed documented workshops were done for medical biophysics staff members to design the course, formulation of goals and objectives of the course objectives according to the SMART criteria (specific, measurable, applicable, reliable, and time-bound),[11] selection of the subject area with its appropriate the teaching strategy and tools to be matched with the students learning style[12,13] [Table 1] and identification of learning outcomes for the course [Table 2]. Furthermore, several meetings were done with whole committee members to stand on the final proposal to be embedded within the integrated medical curriculum.

The goal or objective is defined as an end toward which an effort is directed.[14] The goal is a broad educational objective or a directive. It communicates the overall purposes of the curriculum while the objective is a more specific educational directive that is usually stated behaviorally, i.e. it is measurable [Table 2].

Educational Strategies

Once the goals and objectives are determined, the next step is to develop educational strategies. It includes the designation of both content and method of delivery. The content is the specific material to be included in the curriculum while the methods are the ways in which content is presented. The content of the curriculum flows from its specific, measurable objectives [Table 1].

Implementation

This step encompasses the recognition of all resources needed including needs for personnel (faculty teaching staff members, and secretarial/administrative maintain) and facilities which include lab space and its equipment. Beside resources, the support is highly needed, which obtained either from internal or from an administrative authority (dean's office, hospital administration, department chair, program director, faculty, learners, other stakeholders for personnel, resources, political support or outside from government, professional societies,

Table 1: Distribution of the subjects related to medical biophysics in the integrated medical curriculum according to the phase and level

Topic	Module	Teaching method	Phase	Level
The universe as physics	Integrated natural science	Lecture	I	2
Physical quantities and measuring systems	Integrated natural science	Lecture	I	2
Energy, Work, and Power of human body	Integrated natural science	Lecture	I	2
Energy loss from the body	Integrated natural science	Lecture	I	2
Regulation of body temperatures	Integrated natural science	Tutorial	I	2
Donnan equilibrium and nernest equation	Integrated natural science	Lecture	I	2
Electricity within the body	Integrated natural science	Lecture and tutorial	I	2
Electrical signals recorded form the human body	Integrated natural science	Lecture and tutorial	I	2
Fluids	Integrated natural science	Lecture	I	2
Fluid dynamics	Integrated natural science	Lecture	I	2
Measurement of viscosity	Integrated natural science	Practical	I	2
Measurement of flow	Integrated natural science	Practical	I	2
Physics of blood circulation	Integrated natural science	Lecture and tutorial	I	2
Blood pressure measurement	Integrated natural science	Tutorial	I	2
Heat and temperature	Integrated natural science	Lecture	I	2
Thermodynamics of living systems	Integrated natural science	Lecture	I	2
Statics of human body	Integrated natural science	Lecture	I	2
Levers in the body	Integrated natural science	Lecture	I	2
Human arm Model as a third class lever	Integrated natural science	Practical	I	2
Sound and hearing	Integrated natural science	Lecture	I	2
Sound in medicine	Integrated natural science	Lecture and tutorial	I	2
Light	Integrated natural science	Lecture	I	2
Lenses and determination of the power of a glass lens	Integrated natural science	Practical	I	2
Physics of eye and vision	Integrated natural science	Lecture	I	2
Human eye model and image formation on the retina	Integrated natural science	Practical	I	2
Errors of refraction and their correction	Integrated natural science	Practical	I	2
Elastic properties of materials	Integrated natural science	Lecture	I	2
Hook's law	Integrated natural science	Practical	I	2
Biologically elastic materials	Integrated natural science	Lecture	I	2
Bones as elastic materials	Integrated natural science	Tutorial	I	
Radiation	Integrated natural science	Lecture	I	2
Radiation units	Integrated natural science	Lecture	I	2
Radiation in medicine	Integrated natural science	Lecture and tutorial	I	2
Nuclear medicine	Integrated natural science	Tutorial	I	2
X-ray production	Integrated natural science	Lecture	I	2
Interaction of X-ray with matter	Integrated natural science	Lecture	I	2
Making an x-ray image	Integrated natural science	Tutorial	I	2
Electron microscope and flow cytometry	Integrated natural science	Medical applications	I	2
Laser in medicine	Integrated natural science	Medical applications	I	2
Radiotherapy	Integrated natural science	Medical applications	I	2
Units, standards and measuring systems	Integrated natural science	Problem-based learning	I	2
Regulation of body temperature	Human body module	Seminar	II	3
Biomechanics	Human body module	Lecture	II	3
Physics of breathing	Respiratory module	Lecture and tutorial	II	4
Oxygen saturation and pule oximetry	Respiratory module	Lecture and practical	II	4
ECG biophysical aspects	Cardiovascular module	Lecture and tutorial	II	4

(Contd...)

Table 1: *(Continued)*

Topic	Module	Teaching method	Phase	Level
EEG biophysical aspects	Nervous system module	Lecture and tutorial	II	6
Physics of endoscopes	Gastroenterology and GIT module	Lecture and practical	III	7
Physics of Laser and light therapy	Dermatology and plastic surgery	Lecture and tutorial	III	9
Physics of hearing	ENT module	Tutorial	III	9
Defective vision and their correction	Ophthalmology module	Practical	III	9
Critical care equipment and monitors	Critical care module	Lecture and skill lab	III	11

ECG: Electrocardiogram, EEG: Electroencephalogram, GIT: Gastrointestinal tract

Table 2: Selection of some subject areas and its learning objectives in the medical biophysics curriculum in the current situation

Subject area	Learning objectives
Electron microscopes and flow cytometry	Illustrate the structure and operation of electron microscopes Types of electron microscope Describe the Image formation by electron beams Compare between light and electron microscopes Apply the medical uses of electron microscopes Illustarate the structure and operation of flow cytometery Explain the physical bases for flow cytometry List the medical uses of flow cytometry
Laser in medicine	Define the laser and its acronym Explain the laser tube and laser production Tabulate the different types of laser How to use the laser in medicine
Radiotherapy	Identify the principle of the radiotherapy List the indication for radiotherapy Discuss the types of radiotherapy used Formulate a radiotherapy treatment planning Be aware with side effects of radiotherapy

managed care, donors for funding, political support, curricular, or faculty development resource).

The last step is the student assessment and course evaluation (step 6): A cognitive assessment was done through a well-constructed written exam (quiz and final exam) which encompasses wide varieties of assessment tools. These questions were designed to measure all levels of depth of knowledge, and include multiple choices, extended matching, and a short essay. Psychomotor assessment has been done through a well-structured objective structured practical examination (OSPE), which contain a dynamic station to assess the professionalism besides the other station specified to assess the communication skills among the students. Examples of OSPE stations are represented in Table 3.

Course evaluation was to evaluate the course; the course evaluation was done using a Likert scale[15] to assess the degree of satisfaction among the students about the goals/objectives, educational strategies, and implementation phase. The questionnaire was mainly quantitative with a small area for qualitative evaluation in which the students can write comments and recommendations. The questionnaire was utilized by the 150 students representing the past 4-year-iterations [Table 4].

Kruskal–Wallis test was used to compare the degree of satisfaction for each question, in addition; one-way ANOVA and *post hoc* Tukey test were used to analyze the results of questionnaires in the present work, P value was considered significant at ≤ 0.05.

RESULTS

Problem Identification/General Needs Assessment (Step 1 and 2): The questionnaire applied for recognizing the needs and for course design among 64 staff members regarding the medical biophysics course revealed the following: staff showed strongly satisfaction was (41; 64%,), satisfied (12; 18.7%), neutral (2; 3.1%), dissatisfied (5;7.8%) and strongly dissatisfied (4; 6.2%) with significant P value obtained.

Regarding Need Assessment Step (Step 2)

Analysis of the gap between the current and desired needs revealed a shortage in some equipment and problems were resolved by listing these defects and well prepared by the faculty administration.

Regarding the Course Evaluation

the condensed course of medical biophysics was evaluated at the end of the course through a well-structured questionnaire, which revealed the followings.

Regarding Goals and Objectives

The 3-year-questionnaire applied to estimate the satisfaction of 150 students regarding goals and objectives (step 3) revealed the following: students showing strongly satisfaction (86; 57.3%), satisfied (44; 29.3%), neutral (3; 2%) dissatisfied (11; 7.3%) and strongly dissatisfied (6; 4%) with significant P value obtained($P = 0.003$). Examples of learning objectives are formulated in Table 2 [Table 4 and Figure 1].

For Educational Strategies (Step 4)

The results of the questionnaire applied to estimate the degree of satisfaction about the educational strategies revealed

satisfaction of the students as the followings: students showed strongly satisfied (55; 36.6%), satisfied (45; 30%), neutral (10; 6.6%), dissatisfied (23; 15.3%), and strongly dissatisfied (17; 11.3%). [Table 4 and Figure 1].

Regarding the Implementation Step (Step 5)

The students satisfactions about the mode of module implementation revealed the following: strongly satisfied (65; 43.3%), satisfied (41; 27.3%), neutral (12; 8%), dissatisfied (22; 14.6%) and strongly dissatisfied (10; 6.6%) [Table 4 and Figure 1].

Regarding the Students' Assessment Step (Step 6)

The students satisfactions about the mode of module implementation revealed the following:strongly satisfied (25; 16.6%), satisfied (45; 30%), neutral (9; 6%), dissatisfied (32; 21.3%) and strongly dissatisfied (29; 19.3%). [Table 4 and Figure 1]. A significant *P* value was obtained between all kern' steps with $P = 0.00001$.

Table 3: Examples for OSPE stations on medical biophysics in the integrated natural science course

Examples	OSPE station
Example 1	Using the given apparatus find the speed at which the given sphere fall in the given liquid. Calculate the viscosity of the given liquid. Name one of the forces affecting the sphere during fall?
Example 2	Using the given apparatus find the image distance (S\) corresponding to an object distance (S) of 17 cm. Using the thin lens equation determine the power of the given lens
Example 3	Using the given apparatus, find the elongation produced in the spring due to masses of 40 gm and 60 gm. Then calculate the spring constant
Example 4	Using the given human arm model find the biceps force (Fe) corresponding to masses of 10 gm and 20 g
Example 5	The straight line shown in your answer sheet represents the relation between mass and elongation obtained from an experiment to study the elasticity of a spring. Using this straight line find the spring constant. Using the given eye model show how the image is formed on the retina at two different object distances

OSPE: Objective structured practical examination

DISCUSSION

Despite the definition of medical biophysics as interdisciplinary field, using the principles and laws of the physics sciences to describe and investigate biological processes for the purpose of medical application, the results and outcome of insertion of medical biophysics in the medical curriculum have no longer emerged and many medical schools restrict the medical biophysics to the preparatory phase or maximum in the basic years and omit it completely in clinical years. However, in Al Baha faculty of medicine, the medical biophysics is strongly addressed especially in basic years with some dispersion of most subject areas along the courses of the clinical years as a part of the integration of basic sciences in clinical years. The mapping of the medical biophysics in the medical curriculum is matched with the experience of Vlk *et al.*[8] at the Department of Biophysics of the Faculty of Medicine, Masaryk University, and stated that teaching medical biophysics in different health-care faculties including medicine will lead to sharing common theoretical perceptiveness and terminology to function efficiently as a multidisciplinary health-care team in their upcoming careers. In addition, Vlk *et al.*[8] described and discussed the medical biophysics in both theoretical and practical curriculum for health-care students. The practical part comprises a basic set that is common to all health professions and which ensures a concrete foundation for all health-care students.

In the present study, we integrated the biophysics into biology, chemistry, and biology in one course termed integrated natural science, this coincides with the study of Woodin *et al.*[16] in which the physics and biology were integrated into more than one course for undergraduates with different levels, and many advantages have been revealed; of these, the courses

Table 4: Evaluation of the satisfactions among students regarding the condensed course of medical biophysics within the integrated natural science course mapped in Phase II

Kern' steps	Strongly satisfied	Satisfied	Neutral	Dissatisfied	Strongly dissatisfied	One-way ANOVA and *post hoc* Tukey test
Step 3: Goals and objectives	86; 57.3%	44; 29.3%	3; 2%	11; 7.3%	6; 4%	*P*=0.00001 Tukey's HSD (alpha=0.05): |Group 1-Group 2|=0.5824 (*P*=0.0004); |Group 1-Group 3|=0.3757 (*P*=0.05); |Group 1-Group 4|=0.7151 (*P*=0);
			Using Kruskal–Wallis test *P*=0.00001			
Step 4: Educational strategies	55; 36.6%	45; 30%	10; 6.6%	23; 15.3%	17; 11.3%	
			Using Kruskal–Wallis test *P*=0.00001			
Step 5: Implementation	65; 43.3%	41; 27.3%	12; 8%	22; 14.6%	10; 6.6%	
			Using Kruskal–Wallis test *P*=0.00001			
Student assessment	25; 16.6%	45; 30%	19; 12.6%	32; 21.3%	29; 19.3%	
			Using Kruskal–Wallis test *P*=0.00001			

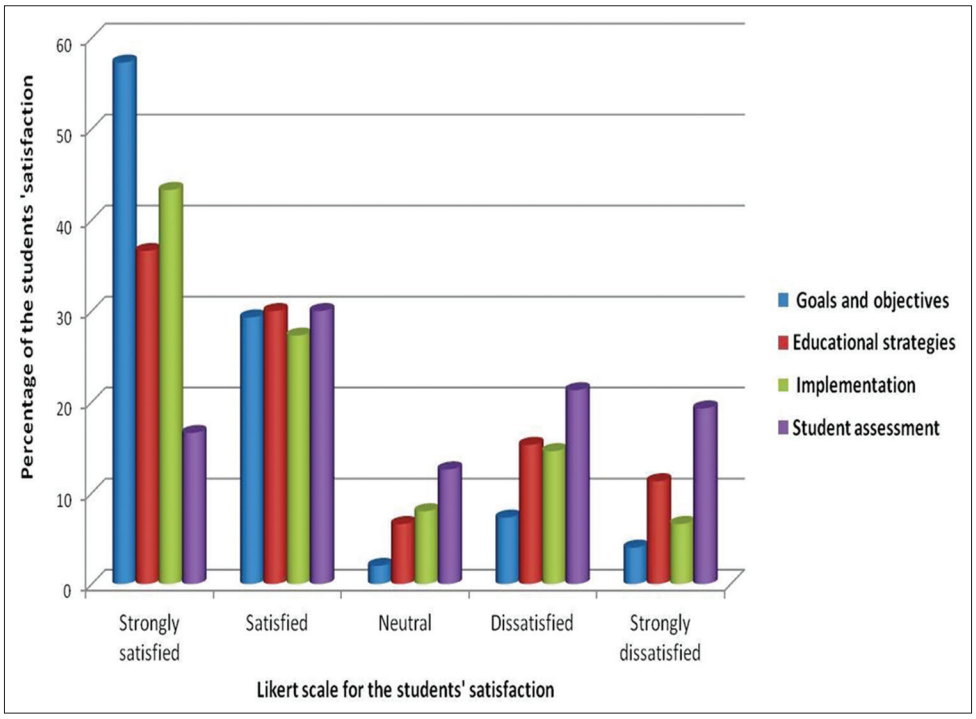

Figure 1: A graph showing the degree of students satisfaction about Likert' steps in medical biophysics course in the integrated medical curriculum

will be more applicable and integrated into more students, i.e. the students locate it more convincing to learn about physical principles by understanding definite biological natural phenomena, and faculty will be capable to benefit from findings by both disciplines regarding effective teaching procedures. Integration of physics with biology or as a part of the group of basic sciences as in current study will give rise to wide varieties of effective teaching approaches, and this will reflect positively on the comparison between these strategies and selection of the more effective one.[17-20] Finnerty *et al.*[21] stated that understanding of basic science content is crucial to clinical practice and that teaching should be talented across the whole experience undergraduate education and has to be integrated along clinical applications. In addition, learning the sciences, in general, plays an introductory role in the developing discipline and firmness in learners' skills, including critical evaluation, creativity, and reasonable problem-solving decision-making.

In the current work, the student's satisfaction about goals and objective of the medical biophysics was about to 86%, for teaching strategy, 81%; and for implementation of the course, 92%; and for the assessment of students, the assessment was 46%. These figures are matched with previous studies for the current situation.[22-25]

The dispersion of medical biophysics has a good impact on the understanding of many basic and clinical science.[16,20,26] The student achievement in radiology course was positively affected by studying the medical biophysics in the radiology course with a good understanding of the basic roles of computerized tomography, magnetic reasoning imaging, and ultrasound.[22-24] Furthermore, studying the medical biophysics has positive findings in the student assessment in dermatology, ophthalmology where laser and its medical applications were situated in these courses.[23]

CONCLUSION

Medical biophysics is an interdisciplinary field and is considered a good example of integration at a high level. Hence, it must be heavily addressed in the medical curriculum to facilitate the understanding of major new approaches in the disease and cosmetic management that appeared in recent years and considered a new era in medicine.

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