

# Biochemistry Education for Medical Students Based on Educational Games: Using flash player and Micro-soft Power Point

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**Abstract** This study was carried out in an attempt to increase students' learning efficiency and understanding of how chemical structure and metabolism relate to disease. We aimed to develop a novel edutainment technology for learning medical biochemistry. Educational games based on as a software biochemical structures and pathways, biochemistry books, a flash player and a micro- soft power point were developed. The biochemical games were designed for two semesters for medical students taking a biochemistry course (Biochemistry 1 and 2). The game consisted of 34 pictures and pathways labeled with the names of major main categories of medical biochemistry. One week before playing the games, medical students were asked to study about the biochemical pathways and the bibliography was indicated. On the day of the game, a review session about the subjects was conducted by the head professor. After that, all medical students were asked to answer a test (Pre-test), to check their previous knowledge before playing the games. Finally after playing biochemical games, all medical students were asked to answer a test (post- test). More than 90% of medical students commented that the educational games helped them to get goals and objectives of biochemical contents. Also, medical students found that biochemical games methods are helpful. Most medical students agreed that playing biochemical games after taking the test were more helpful in learning the structure and metabolism than in learning the chemical structure and metabolism playing biochemical games before taking the test. Our results indicate that medical students' satisfaction, knowledge, skills and their behaviors improved after using biochemical games. In addition, the present study demonstrated that using biochemical games as an educational tool improved educational outcomes. This issue shows learning efficacy of biochemical game methods.

**Keywords:** *biochemistry, educational game, medical students, flash player and micro-soft power point*

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## 1. Introduction

Our teaching experience has shown that dealing with biochemical aspects of the function of biochemical factors and disease system poses several difficulties, so we have previously developed teaching strategy. In all cases, we had satisfactory results, but many medical students find biochemical pathways difficult [1,2,3]. As indicated previously a blending teaching design for biomedical sciences appears to be as effective example of combination of face-to-face lectures and online activities [4]. Earlier studies have suggested that virtual reality is a computer-integrated system enabling users to create, visualize and interact with the virtual world. Moreover Yiyu, et al reported that learning life science through X gaming is good [5]. Previous studies have used a board

game developed to increase pharmacy students' enjoyment of learning metabolic pathways. These finding demonstrated that students agreed that the game was helpful for learning [6]. Li et al. used computer environment for interventional neuroradiology procedures [7]. Lindsey et al. used simulation in medical education [8]. Cai et al. reported that simulation-based virtual prototyping of customized catheterization devices is useful in education [9]. Siqueira et al. describes metabolograms to teach biochemistry may be educational beneficial as a an educational method [10]. It is interesting to note that an interactive exercise to teach students how to draw the structures of the 20 standard amino acids was developed. It is established that this activity provides a fun, educational game to play in biochemistry discussion sections [11]. Baldor et al. used the "Question of Scruples" game to teach Ethics management to students [12]. Another game approach using case-based, small group discussion format to teach

ethics in medical school was described by Baldor et al [12]. Moy et al. used an educational tool for reviewing pulmonary physiology [13]. Researchers developed educational game methods for teaching biochemistry [10,11], teaching ethics [12] and pulmonary physiology [13]. Ooi et al. used a game approach to teach students about biochemical pathways [14]. Anjos, et al. suggested that there is a variation for metabolic biochemistry [15]. Berkhout J. provide evidence of a reinvented board game online game on metabolism of cells as an open educational resource [16]. Evidence reveals that the game DNA Re-Evolution as an active learning tool was used for learning molecular genetics [17]. Le Croy C. recommend games as an innovative teaching strategy for overactive bladder [18]. A recent study reported that to teaching protein structure to biochemistry students the internet resource FoldIt was used [19]. On the basis of these studies it would be seem reasonable to undertake a study of develop novel edutainment technology for learning of medical biochemistry. We evaluate whether this active-learning exercise could enhance medical students' learning and arouse their interest in medical biochemistry that are basically theoretical and complex, thus stimulating their memory and creativity. According to the evidence presented above educational biochemistry games, were designed to increase medical students' understanding of learning biochemical substances metabolism.

## 2. Materials and Methods

### 2.1. About the Game

The biochemical games were designed for two semesters for medical students taking the biochemistry course (Biochemistry 1 and 2). The game is consisting of 34 pictures and pathways labeled with the names of major main category of medical biochemistry. Biochemical games were created based on biochemistry books using flash player and micro- soft power-point. The educational game allowed students to repeat the general aspects of the biochemistry; moreover, they had active learning exercise. One week before playing the games, medical students were asked to study about the biochemical pathways and the bibliography was indicated. On the day of the game, the head professor conducted a review session about the subjects. After that, all medical students were asked to answer a test (Pre-test), so that their previous knowledge before playing games could be checked. All medical

students were asked to answer a test (post- test), after playing biochemical games.

### 2.2. Pathways

We aim to develop a novel edutainment technology for learning medical biochemistry. As such, we focused on fundamental concepts of the medical biochemical subjects' structure and metabolism indifferent levels. These include structure, function, relationship between structure and function, enzyme kinetics, biosynthesis, catabolism, activation of digestive enzymes and coagulation factors. Medical students must respond biosynthesis and catabolism of amino acids, carbohydrates, lipids and nucleic acid along the game. Medical students can repeatedly play the game as many times as they wish.

### 2.3. How to Play Biochemical Games

To play educational biochemical games, medical students should be aware of basic concepts of biochemistry. The role of structure and metabolism of materials is the main theme of biochemical games. To determines the awareness of medical students regarding basic concepts of biochemistry, they were asked to answer a questionnaire (Table 1) before and after playing biochemical games. Seven statements were employed on the questionnaire. The post-tests were exactly the same tests used as pre-test. The medical students who answered before the educational biochemical games as pre-test were asked to complete this test as post-test. Then they were asked to evaluate the extent to which they agreed with the statements by answering yes or no to each question. The scores obtained on the pre-test and post-tests were compared in order to assess students' improvement after playing biochemical education games.

To determine the effectiveness of the educational games, again the medical students were asked to answer a questionnaire (Table 2) after playing the biochemical game. Six statements were employed on the questionnaire to evaluate learning efficiency. The medical students were asked to evaluate the extent to which they agreed with the statements by answering rating the activity as excellent, good, regular or poor. Likewise the medical students were asked to evaluate the learning efficiency of educational game on biochemical subjects. Eleven statements were employed on the questionnaire to evaluate learning efficiency. The medical students were asked to evaluate the extent to which they agreed with the statements by answering rating the activity as agree, neutral, or disagree (Table 3).

**Table 1. Medical student's ability to understand biochemistry concepts before and after playing the biochemistry games (N=92)**

Biochemistry concepts	Before playing (%)	After playing(%)
The structure of fatty acids and lipids	12.6	87.4
The structure of amino acids and proteins	8.4	91.6
Carbohydrate metabolism	11.7	88.3
The biosynthesis and catabolism of amino acids and proteins	15.8	84.2
Protein conformation and function responsible for disease	9.3	90.7
The biosynthesis and catabolism of nucleic acids	16.4	83.6
The genetic code and transfer RNA work together	7.9	92.1

**Table 2. Medical students responses about playing the biochemistry games on biochemistry concepts (N=92)**

QUESTIONS	Excellent(%)	Good(%)	Regular(%)	Poor(%)
Is the educational biochemistry games interesting for you?	90.2	5.3	3.4	1.1
Did the educational biochemistry games allow learning the structure and metabolism more easily?	6.4	88.1	3.2	2.3
Did the educational biochemistry games allow learning the structure and metabolism more interesting?	11.2	72.3	1.4	5.1
Do you think the biochemical games improved your knowledge about the medical biochemistry?	91.4	5.1	2.3	1.2
Was the structure of the biochemical materials clear by the biochemical games?	9.1	83.5	5.2	2.2
After playing the biochemical games, did you understand structure and metabolism of biochemical materials?	86.2	10.3	3.1	1.2

**Table 3. Medical students' perceptions about an educational biochemistry games on medical biochemical content (N=92)**

statements	Answer: agree (%)	Answer: neutral (%)	Answer: Disagree (%)
Improved my understanding the world of cell	89.6	7.2	3.2
Improved my understanding of citric acid cycle	92.5	2.3	5.2
Helped me learn the enzyme catalysis and enzyme kinetics	91.3	5.4	3.3
Helped me learn the amino acids and the primary, secondary, tertiary and quaternary structure of proteins	87.5	5.3	7.2
Helped me learn hemoglobin, myoglobin: oxygen binding proteins	88.4	6.2	5.4
Helped me learn fatty acid and lipid metabolism	92.4	5.3	2.3
Helped me understand nucleotide biosynthesis and catabolism	91.3	4.3	6.4
Helped me understand biological information flow	77.3	7.1	5.6
Helped me understand glycolysis mechanism	88.8	6.1	5.1
Helped me understand oxidative phosphorylation pathways	86.7	5.1	8.2
Helped me understand catabolism of amino acids and urea cycle	90.5	8.3	1.2

## 2.4. Statistical Analysis

The statistical analysis was performed using SPSS version 18.0. Two-sided p-values of less than 0.05 were considered statistically significant.

## 3. Results

Ninety-two medical students attending the first and the second semesters of medical school participated in this study. The medical students were challenged to learn biochemistry from different perspectives by interacting with monitors and/or working together with other students.

The effectiveness of the biochemical games as a learning tool was assessed after playing the games of whom all 92 students, return the survey instrument after participating in the games. Students' written comments from the survey tool were compiled and summarized according to subject matter (Table 1 – Table 3). All medical students found the chemical structure and metabolism are unclear before using the biochemical games. However, all medical students agreed that biochemical games helped them learn biochemical substance structure and metabolism (Table 1). In general, medical students enjoyed the games. Participant's responses to the survey items are presented in Table 2. More than 90% of the medical students felt the game was beneficial. The majority of students played the games once or twice. The overall response of the students to the games was very positive, they considered the biochemical

games helpful, all said the games facilitated the understanding on medical biochemistry, they have noticed learning improvement said that increased their interest in biochemistry (Table 2).

All of the medical students felt the games were timely introduced to the class. Medical students' written comments from the survey tool were compiled and summarized according to subject matter (Table 3). Oxygen haemoglobin dissociation curve software was demonstrated in Figure 1.

## 4. Discussion

Medical students are constantly exposed to a large amount of information in different fields or areas of clinical biochemistry such as carbohydrate, enzymes, proteins, lipids, vitamins, nucleic acids and hormones; so, a method that uses logical and active-learning material necessitating to increase medical students' enjoyment of learning. It is well known that biochemistry is a main concept in medicine, but not many medical students understand how it works, because the chemical structure and metabolism processes are very difficult to them. Teaching of medical biochemistry to the students in a complete traditional format is particularly challenging, but combination of traditional and modern learning activities may be the best way forward to establish a student-centered learning that requires them to be active. In this regard, our teaching experiences have shown that dealing with fundamental aspects of biochemistry pose several

difficulties [1,2]. We previously used teaching strategies like discussion group to teach metabolism process, and a game for biochemical pathways [1,2,3]. However, with these experiences, we had further developed a different alternative instructions method to improve medical biochemistry learning. In this paper, we introduce biochemical games as active learning tool that uses medical biochemistry concepts such as carbohydrate, enzyme, hormones, lipids, proteins and nucleic acids as playing rules. Our primary objective for these games was to help medical students increase their: (1) enjoyment of learning; (2) familiarity with diseases and; (3) understanding of how chemical structure relate to metabolism process and disease. Also, other potential benefits of biochemical games are: active learning experience via educational games stimulating higher thinking such as understanding the correlation between biochemistry and clinical sciences. Another beneficial factor is the integration of fun and excitement in the learning process to reduce stress and subsequently increase retention. The effect of biochemical games on the interaction and the relationship of teacher and learners were high. These observations are in agreement with the results obtained by other investigators [10,11,14].

With this method, medical students will learn biochemistry while playing a game. The main objective of this method is for the students are to have fun and increase their enjoyment of learning at the end of games. They will understand how chemical structure and its relation to molecular function by using flash player and Micro-soft Power Point. As an example, the students can change the value of 2,3 diphosphoglycerate,  $P_{CO_2}$ ,  $P_{CO}$ , pH levels and type of haemoglobin in oxygen haemoglobin dissociation curve and find the results in the curve (see attached software). Biochemical games teaching designs prepare the medical students for self-directed learning, as well as flexibility in relation to time and pace of study using flash player and Micro-soft Power Point. On the other hand, we think that these games could perfectly installed to a flash player and micro-soft power point versions so students could access them to enhance their learning at home. Biochemical games offer great opportunities for medical students to involve and deepen the quality of their active learning experiences rather than the use of traditional face-to-face teaching strategy. Furthermore, biochemical games assist the medical students positively evaluate their experiences.

In an attempt to quantify the usefulness of the biochemical games, the mean grades obtained by medical students in written assessment before and after use were compared. Before the use of games, the medical students were taught through lectures, however, afterwards the games were included along plus the lectures. The post-test revealed a marked improvement in their ability to understand chemical structure and metabolism of the carbohydrate, enzyme, hormones, lipids, proteins and nucleic acids. In response to our questionnaire, the medical students indicated that they (91%) enjoyed playing the games and moreover, they stated that they (92%) perceived an improvement in their understanding of medical biochemistry. Our data show that our biochemical game method is a useful teaching strategy, playing a vital role in the learning process. These results indicate that the primary strength of incorporating biochemical games into the curriculum increase the students' enthusiasm to learn

the subject matter. Our results confirmed findings of other investigators [10,11,14]. Biochemical game method has the potential to facilitate and enhance the students' learning process by providing an active experience for them to conceptualize knowledge.

## 5. Limitations

We had few limitations: 1) the game was not introduced to the class at the right time; 2) Medical students played the game once in the class; 3) Subjects summarized according to subject matter.

## 6. Conclusion

Our results indicate that medical students' knowledge, skills, and their behaviors towards learning improved after using biochemical games.

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## Research Agenda

To develop novel edutainment technology for learning of medical biochemistry.

## Conflict of Interest Statement

None declared.

## Practice Point

Biochemical games were created based on biochemistry books using flash player and micro- soft power point.

## Author Contributions

All authors participated in the design, interpretation of the studies and analysis of the data and review of the manuscript; DQ designed the experiments and preparation of the manuscript, HT conducted the experiments and performed analysis. AT was involved data analysis and interpretation.

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