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The effect of gaming approach on learning in basic microbiology education: A pilot study

Oyunlaştırmanın temel mikrobiyoloji eğitiminde öğrenmeye etkisi: Pilot çalışma

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ABSTRACT

Objectives: This study investigated the effect of using games instead of classroom-lectures on learning in a microbiology course and assessed the learning outcomes and the retention of knowledge, as well as analyzed students' perceptions of their learning.

Materials and Methods: The study was performed on 19 first year students of the Ankara University, Vocational School of Health, Division of Medical Laboratory Techniques. The students were randomly divided into two groups. The control group was given a lecture, and the study group was asked to construct either a gram-positive or a gram-negative bacterium by using stationary items and colored images of bacteria. Each group was evaluated by pre-, post- and retention-tests. The retention test was given two months later. Additionally, students filled a questionnaire. Kruskal Wallis H, Mann-Whitney U, and Wilcoxon Signed Ranks tests were used for statistical analyses.

Results: The groups did not differ in terms of the means of post-test, and retention test scores, although both groups' scores significantly improved after the lesson. When the questionnaires were compared, the study group gave significantly higher scores on topics about the effect of teaching method on learning and the learning process.

Conclusion: As the gaming approach was regarded as more motivating, positively reinforcing and dynamic, well-constructed educational games can be used in small groups to enrich microbiology education.

Keywords: Microbiology, Education, Game

ÖZET

Amaç: Bu çalışmanın amacı, temel mikrobiyoloji eğitiminde oyunlaştırma yönteminin öğrenme hedeflerine ulaşma ve öğrenmenin kalıcılığına etkisini araştırmak ve yöntemin öğrencilerin öğrenme algılarına etkilerini değerlendirmektir.

Gereç ve Yöntem: Araştırma, Ankara Üniversitesi, Sağlık Hizmetleri Meslek Yüksek Okulu, Tıbbi Laboratuvar Teknikleri Bölümü'nde eğitim gören 19 öğrenci üzerinde yapılmıştır. Öğrenciler rastgele olarak iki gruba ayrılmıştır. Kontrol grubuna sunum yapılmış, deney grubundan kendilerine verilen çeşitli kırtasiye malzemeleri ve renkli bakteri şablonlarını kullanarak gram pozitif veya gram negatif bir bakteri oluşturmaları istenmiştir. Gruplar ön-test, son-test ve kalıcılık testi ile değerlendirilmiş ve anket uygulanmıştır.Kalıcılık testi öğrencilere iki ay sonra uygulanmıştır. İstatistiksel analizde Kruskal Wallis H, Mann-Whitney U ve Wilcoxon Signed Ranks testleri kullanılmıştır.

Bulgular: Grupların ön-test, son-test ve kalıcılık testi skorları arasında fark olmamakla birlikte her iki grubun skorları ders sonrasında anlamlı olarak yükselmiştir. Anketler karşılaştırıldığında, kontrol grubunun eğitim yönteminin öğrenmeye ve öğrenme sürecine etkilerine dair maddelere daha yüksek notlar verdiği görülmüştür.

Sonuç: Oyunlaştırmanın daha motive edici, destekleyici ve dinamik bulunması nedeniyle, küçük gruplarda mikrobiyoloji eğitimini zenginleştirmek amacıyla iyi yapılandırılmış oyunlardan yararlanılabilir.

Anahtar Kelimeler: Mikrobiyoloji**,** Eğitim**,** Oyun

Introduction

Educational games are instructional tools which require the student to take part actively in a competitive environment in order to fulfill a specific aim under previously defined rules. In this process, the learners perform the activities demanded by the rules of the game, during which they evaluate the activities critically, and reaches conclusions [1-3]. Educational games can be classified in four categories: Simulations, Social and collaborative games

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(card games, team games, etc), Virtual games, and Alternative reality games. In social and collaborative games, the learner collaborates with other players in a social environment to win the game [1].

Adult learning differs from childhood learning on the basis of the importance of self-motivation and the need for self-directing the learning process. Adult learners prefer to participate actively in the learning and problem-solving processes. Educational games encourage critical thinking and participation, combine amusement and excitement, simulate real life situations and produce a dynamic learning environment. Because of these properties, games are an important instructional method in adult education [1-4].

Lectures are the most frequently used teaching method for transferring considerable amount of knowledge in a limited time. However, lectures have important limitations such as inability to encourage critical thinking and lack of active participation of learners [5].

This study investigated the effect of gaming approach in basic microbiology education of health professionals by means of 1) its ability to reach learning outcomes and persistence of learning and 2) its effect on students' perceptions of the learning environment and the learning process. A pilot study was performed on students of a health-care vocational school to compare the gaming approach with lectures in basic microbiology education and the results obtained from this study were examined in relation to data available in the literature.

Materials and Methods

The study was performed with first year students (n=19) of Ankara University Vocational School of Health, Division of Medical Laboratory Techniques (AUSH-MLT). AUSH-MLT is a two year higher education school involved in training medical laboratory technicians, with approximately 20 students in each year. A "Basic Microbiology" course is given to the first-year students during the 16 week autumn semester. The course includes two hours of lecture given weekly, and the achievements of students are evaluated by multiple-choice and open-ended questions. For the application of gaming approach, a two hour session, aimed at teaching the classification of bacteria with respect to cell wall differences and Gram staining was chosen. At the end of the course, the students were expected to understand the cell morphology of bacteria, to be able to classify the bacteria as gram-positive and gram-negative according to their cell-wall characteristics, and to associate the Gram staining procedure with cell wall properties.

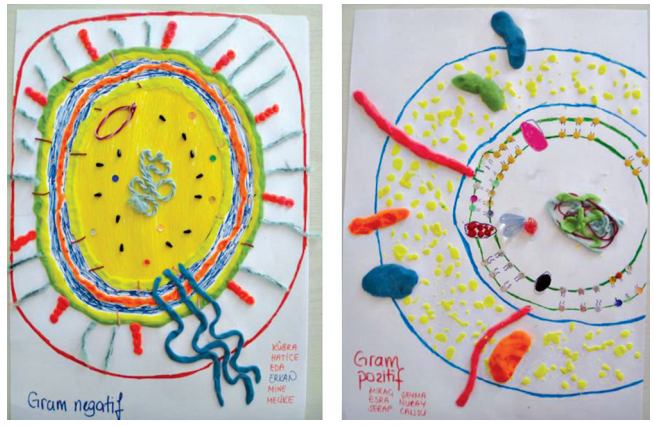

Figure 1. The materials prepared by the "gram negative bacteria" and "gram positive bacteria" study groups.

The 19 first-year students were randomly divided into two groups. The control group (n=7) was given a standard two-hour lecture. The study group (n=12) was equally divided into two groups, and after a five-minute description of the approach, each group was given colored images of bacterial cells with descriptions of the bacteria and they were then asked to construct either a gram-positive or a gram-negative bacterium by using different items such as colored cartoons, papers, plasticine, colored pens, beads, glue, scissors, etc. in 90 minutes. The study groups were asked to present and discuss their learning materials (Figure-1) with each-other for the last 30 minutes. The faculty member played a facilitatory role to support the learning process.

In order to investigate if the learning outcomes were achieved, both control and study groups were given a pre-, and post-test. The same test was given 2 months later in order to evaluate the retention of the knowledge. The test was made up of "fill in the blanks" questions. The first four questions were structured to assess the students' knowledge on general morphological properties of the cell and bacteria, and the fifth question tested their knowledge on the cell wall differences of gram-positive and gram-negative bacteria.

In order to evaluate the students' opinions on the efficiency of the teaching method, the learning process and their perceptions about the learning environment, a questionnaire was given to each group at the end of the lesson. The questionnaire consisted of 26 statements constructed as a Likert type five point scale.

The differences between the test and questionnaire scores of the control and study groups were investigated by using the Kruskal Wallis H, Mann-Whitney U, and

Wilcoxon Signed Ranks tests. p values of <0.05 were considered as statistically significant.

Results

Comparison of Lecture and Gaming Approach in Terms of Their Ability to Produce and Sustain the Learning Outcomes

The total test scores (TTSs) regarding the overall knowledge on cellular morphology and the fifth question's score (FQS) accessing the knowledge on the classification of bacteria according to their cell wall characteristics were evaluated separately. The pre-, post- and retention-test scores of the control and study groups and their comparison are given in Table I.

Pre-test TTSs were significantly lower in the control group than the study group (p=0.01), but no significant difference was observed between the groups for the means of the FQS. There was no statistically significant difference between the control and study groups' post-test and retention-test scores. Although not significant, the retention-test's FQS of the study group was higher than the control group (9.33 versus 6.29).

When the pre- and post-test scores were compared for the control and study groups, post-test TTSs and FQS were found to be significantly higher than pre-test scores in both groups (p<0.05). Both TTSs and FQS of the retention-tests of the control group were lower than the post-test scores. In the study group, the retention-test scores were slightly higher than the post-test scores, but the difference between the control and study groups' retention-test scores was not statistically significant.

Table I. Comparison of pre-, post-, and retention-test scores of control and study groups

	Mean TTS† (Maximum = 100)			Mean FQS‡ (Maximum = 20)		
	Control	**Study**	**p***	**Control**	**Study**	**p***
Pre-test	25.57±5.09	32.92 ± 5.96	**0.01**	0.86±0.90	0.83±1.403	0.57
Post-test	58.21±8.83	60.83± 9.03	0.47	8.57±6.08	9.25±2.59	0.57
p**	**0.018**	**0.002**		**0.046**	**0.002**	
Retention-test	53.29±16.87	62.33±14.75	0.20	6.29±4.15	9.33±4.52	0.09
p***	0.40	0.58		0.09	0.84	

† Total test score

‡ Fifth question score

*p value for the comparison of control and study groups

**p value for the comparison of pre-test and post-test scores in the same group

*** p value for the comparison of post-test and retention-test scores in the same group

Table II. Students' opinions about the effect of the teaching method on learning

Effect of Teaching Method on Learning	Mean score (Maximum 5)		p
	Control	**Study**	
1. An effective way of learning	3.86	4.83	**0.05**
2. It improves reasoning skills	3.57	4.92	**0.02**
3. It provides the application of knowledge	3.57	4.83	**0.04**
4. It expresses the need of learning	4.14	4.83	0.13
5. It improves problem-solving skills	3.00	4.17	0.75
6. I have gained new knowledge	4.71	4.91	0.48
7. I needed to have related preliminary knowledge	3.43	3.42	0.89
8. It eases to keep the knowledge in mind	3.43	4.67	0.13

Comparison of Lecture and Gaming Approach in Terms of Students' Perceptions and Opinions on the Learning Environment and Learning Process

The students' opinions about the effects of the teaching method was evaluated by eight statements (total 40 points). The highest mean score was for the "I have gained new knowledge" statement in the control group; and for the "I have gained new knowledge" and "it improves reasoning skills" statements in the study group. The lowest mean score was observed for the "it improves problem-solving skills" statement in the control group; and in the "I needed to have related preliminary knowledge" statement in the study group. When the study groups were compared with the control group, the study group scored higher in the statements regarding the gaming approach as "an effective way of learning (p=0.05)", "it improves reasoning skills (p=0.02), and "it provides the application of basic knowledge (p=0.04)" (Table II).

Students' opinions about the learning process were evaluated by eight statements (total 40 points). In the control group, the most frequent support was observed for the "the usage of time was appropriate" and "the process was well-organized" statements. For the study group, the highest mean scores were observed in the "the process was effectively directed" and "the lesson was supplied with suitable materials" statements. The lowest mean scores for the control group were observed in the "everybody was actively involved", and in the "the existence of preliminary knowledge was evaluated" statements. The students in the study group scored statistically significantly higher in the

Table III. Students' opinions about the learning process

Learning Process	Mean score (Maximum 5)		p
	Control	Study	
1. The purpose of the lesson was obvious	3.78	4.83	**0.02**
2. The lesson was well organized	3.86	4.83	0.41
3. The existence of preliminary knowledge was evaluated	3.46	4,.67	0.12
4. The usage of time was appropriate	3.86	4.83	0.13
5. The process was effectively directed	3.14	4.92	**0.00**
6. Everybody was actively involved	2.57	4.83	**0.00**
7. Participation in lecture/discussions was encouraged	3.43	4.75	0.08
8. The lesson was supplied with suitable materials	3.29	4.92	0.07

Table IV. Students' perceptions about the learning environment

Learning Environment	Mean scores (Maximum 5)		p
	Control	Study	
1. Meaningful	4.00	4.83	0.16
2. Entertaining	3.71	4.92	0.07
3. Stressed	1.57	1.83	0.55
4. Monotonous	1.57	1.32	0.12
5. Productive	3.71	4.83	0.16
6. Motivating	3.29	4.92	**0.01**
7. Tiresome	2.71	1.83	0.23
8. Positively reinforcing	3.71	4.83	**0.04**
9. Dynamic	3.14	4.92	**0.00**
10. Inessential	1.57	1.13	0.41

"the purpose of the lesson was obvious (p=0.02)", "the process was effectively directed (p=0.00)", and "everybody was actively involved (p=0.00)" statements (Table III).

The students were asked to qualify their learning environment by using 10 adjectives. When the perceptions of the control and study group students about the learning environment were evaluated, the highest mean score for the control group was for the "meaningful" definition, and the lowest mean scores was observed in the "stressed", "monotonous", and "usefulness" definitions. For the study group, the highest scores were obtained for the "entertaining", "motivating", and "dynamic" definitions, and the lowest scores were seen for the "usefulness" and "monotonous" definitions. The students in the study group found the process more "motivating (p=0.01)", "reinforcing (p=0.04)", and "dynamic (p=0.00)" when compared to the control group (Table IV).

Discussion

In this study, two teaching methods (a lecture and a gaming approach) were compared by means of their effect on gaining cognitive outcomes in a basic microbiology lesson aimed at teaching the cellular characteristics and classification of bacteria by cell wall morphology. The groups were compared by their pre-, post-, and retention-test scores, as well as their answers to a questionnaire. Although, the control and study groups were constructed randomly, the pre-test TTS of the study group was found to be significantly higher than that of the control group. However, the students' knowledge on the cell wall characteristics of the bacteria (the FQS) did not differ significantly between the groups. The preliminary knowledge of the students was based on previous courses taken during their high-school education. Although the post- and retention-test scores of the study group were higher than those of the control group, the difference between the groups was not statistically significant. In similar earlier studies evaluating the use of lectures and educational games in health-care education, conflicting results were obtained. In the studies of Bays and Herman [6], Jungman [7], and Hodges [8], no significant difference was found between the test scores of the lecture and gaming groups, as in our study. Investigators such as Cessario [9], Cowen and Tesh [10], Kelly [11], Patel [12], and Fritzche [13] found that the post-test scores of the gaming group were higher, while in the study of Montpas [5], the post-test score of the control group was found to be significantly higher. These differences observed in different studies can be attributed to the diversity of the games, the nature of the study groups, and the statistical methods used to evaluate the results.

The results of our study show that, both lecture and gaming approaches significantly improved the knowledge levels of students. O'Leary et al. [14] and Sealover and Handerson [15], also indicated that both approaches improve knowledge. In our country, the education system used in primary schools and high schools depends mostly on lectures, and thus our students are more accustomed to these. This may have contributed to the ability of our control students to improve their knowledge equally in the lecture section. On the other hand, as the students were more actively and dynamically involved in the learning process in the gaming approach, the study group also gained considerable knowledge during the lesson although the faculty member did not give a lecture to transfer knowledge.

When the retention of knowledge was evaluated, the level of knowledge retained was maintained in the study group, but there was a decrease in the control group. In the studies of Cessario [9] and Cowen and Tesh [10], the retention of knowledge was found to be higher in the educational game group when compared to lecture group wheras Bhoopathi et al. [16] could not find evidence that educational games improve knowledge in long term.

The students in the study group indicated that gaming was a more efficient way of learning; it improved reasoning skills, and gave a chance to use preliminary knowledge. They understood the purpose of the lesson better, participated in the lesson more actively, and the educational process was more efficiently directed for them. The learning environment was more motivating, reinforcing, and dynamic for them. Previous studies show that educational games including digital games are a more effective way of teaching; they improve the understanding of students, and they are more reinforcing and satisfactory [9, 17-19]. In a similar study using gaming approach to enhance students' interest and knowledge skills on antimicrobial mechanisms of action, more than 90% of the students found this approach interesting and an important way of improving learning skills (23).

The learning strategies of students differ from each other [20, 21]. The "innovative" teaching strategies such as gaming, respond to different learning styles (visual, auditory, or kinesthetic) of students and facilitates learning by making the learning process more exciting and entertaining [5]. Many studies have considered educational gaming as more entertaining and motivating for students [3, 5, 6, 11, 14, 22, 23]. The learning process involves not only the internalization of the knowledge, but also the emotional and social satisfaction of the learner. From this point of view, when the learning process becomes fun and elegant, the interaction between cognition and emotion grows stronger and the interest in gaining knowledge increases. In contrast, negative emotions (apathy, resistance to learning, becoming passive due to the high density of knowledge or to the traditional strategies), decreases the learning potential of students and block creativity. In the long term, it leads to the development of negative attitudes to learning and decreases the academic anticipations to the level of "passing the exam" only [24, 25].

When developing or deciding to use an educational game, its consistency with several outcomes must be taken into account [1]: its consistency with the context wanted to be given, the potential to teach learning outcomes, possible advantages (ability to elicit active learning experiences, to evoke high level thinking skills such as analysis, synthesis and evaluation, its capacity to diminish stress and anxiety by providing exciting and entertaining learning process, etc.), its cost, and the time and effort needed for its development or implementation. Gaming can be a good alternative for lessons which are harder to learn or for complicated contents. The most important advantages of games are their ability to decrease students' stress and anxiety, to improve the interaction of students, to increase excitement, entertainment, and motivation, and to develop a dynamic educational environment by decreasing monotony. Gaming also have some important disadvantages: Not all adults like games, and games may lead to stress and embarrassment in some individuals. Their cost is considerably higher, evaluation of individual performances may be harder, they may need a special preparation period, they can take longer to develop and perform, the management of the learning environment may become harder, and it becomes harder to use this approach in large groups [3, 5].

One important limitation of this study was the small group size of the study and control groups, and the shortage of time for the study. Although, using gaming approach in small study groups seems promising for active learning, it may be hard to apply it in larger groups and for many topics which must be covered in basic microbiology learning. As a result, when the facts are kept in minds that the students involved in the learning environments are adults in health-care education and that they differ in their learning strategies, well-structured and directed games can be used to enrich the basic microbiology education especially in small groups.

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