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Increased learning by using board game on muscular system physiology compared with guided study

Kelly Cristina Gavião Luchi, Lais Tono Cardozo, and Fernanda Klein Marcondes
Department of Physiological Sciences, Piracicaba Dental School, University of Campinas-UNICAMP, Piracicaba, São Paulo, Brazil

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Luchi KCG, Cardozo LT, Marcondes FK. Increased learning by using board game on muscular system physiology compared with guided study. Adv Physiol Educ 43: 149–154, 2019; doi:10.1152/advan.00165.2018.—The aim of this work is to describe the “Muscular System Game,” created to assist in the teaching-learning process concerning the physiology of the muscular system, and to evaluate its effect on the learning of university students. Participating in this study were first-year undergraduate students of the pharmacy course (game group, n = 21, 5 men and 16 women, age 23.57 ± 4.92 yr) and the nursing course (control group, n = 22, 2 men and 20 women, age 22.90 ± 4.93 yr), who had the same level of preparation. After theoretical classes concerning the physiology of the muscular system, all students were instructed to study the topic. In the next week, the students of the game group performed the activity with the board game, and the students of the control group undertook a guided study activity, which contained a list of exercises with the same questions used in the game, to be answered by groups. In the week following these activities, all of the students answered evaluation questions about the topic. The scores obtained for the two groups in the evaluation were compared using Student’s t-test for unpaired samples, considering a significance level of 0.05. The score obtained for the control group (5.78 ± 0.38) was significantly lower than the score for the game group (7.50 ± 0.47; P < 0.05). The results obtained indicating that the use of an educational board game about the physiology of muscle contraction resulted in significantly improved learning, compared with the use of guided study.

educational game; learning; physiology; teaching

INTRODUCTION

Studies worldwide have shown that, in health education courses, the use of active-learning methods, together with traditional classes, can enhance the teaching-learning process (20, 34, 48, 49), improving grades and the perceptions of the students, as well as reducing failure rates (10). Interest in effective active methods of teaching has increased, with events such as the ADInstruments Teaching Workshop, a satellite event of the International Union of Physiological Sciences (IUPS) Congress, which meets every 4 yr, attracting teachers, students, and researchers from around the world to discuss ways to improve the teaching-learning process applied to physiology (27, 30).

The human physiology discipline is considered difficult by many students from different courses in the area of health (32). According to the students, this difficulty is related to the need to memorize a large quantity of information, difficulty in understanding the relations between the morphology and function of organs and systems, and the perception of some topics as being too abstract (45). Knowledge of the physiology of the locomotor system is vitally important in order for undergraduate students of nursing and pharmacy courses to understand how endogenous substances and drugs act at neuromuscular junctions. Furthermore, it is crucial to understand the mechanisms of action of neuromuscular blockers used during surgery and in intensive care units (36), since these substances can cause death if used incorrectly (44a). Another example is botulinum toxin, which is used to reduce muscle spasticity (19) and in aesthetic treatments to reduce wrinkles (22), since the toxin can cause adverse effects such as muscle rigidity (42).

Given the difficulty involved in learning these vital contents, it is necessary to search for ways to provide an environment that motivates the student in the quest for knowledge, since intrinsic motivation is essential for the learning process, additional to the influence of external factors (47). Compared with traditional classes, active teaching methods can improve both learning (9, 24, 25) and the perception of students in relation to increased knowledge (28, 33), stimulating the development of autonomy and critical reasoning (11, 43). The combination of traditional classes and active teaching methods provides a way of improving the knowledge of students, as well as their attitudes toward learning (20).

Educational games, whether competitive or not (2), are strategies used to make the student more active and interested in the teaching-learning process (18). The use of an educational game creates a beneficial learning environment, requiring the interaction of the students in questions and answers that assist in retaining information and improving performance (1). In addition to the positive impacts on student learning, the use of educational games can increase involvement with activities related to the content of the course (41), as well as promote greater perception of improved learning by the students (9, 24, 28, 35, 40).

The aim of the present work is to describe the “Muscular System Game,” created to assist in the teaching-learning process concerning the physiology of the muscular system, and to evaluate its effect on the learning of health career academic students.
MATERIALS AND METHODS

Description of the educational game. The educational game about the muscular system consists of a design printed on an A3 sheet, showing a route consisting of colored sectors (Fig. 1), together with 6 colored pins, 1 die, and 50 colored cards with questions concerning the physiology of the muscular system, to be answered by the participants. The colors of the cards correspond to the colors of the sectors along the route of the game (blue, green, yellow, pink, and purple, as shown in Fig. 1).

Each colored card contains one question. Ten different questions are provided for each color, with the objective that all of the players can answer questions that have not yet been drawn by other participants. The questions are the multiple-choice type and involve filling in gaps.

The questions were elaborated using increasing levels of complexity (3). The first six sectors of the route on the board are blue, and the corresponding questions printed on the blue cards focus on the memorization of structures and the definition of concepts. The next six sectors are green, and the corresponding cards have questions that, in addition to knowledge, also require understanding of the content. Subsequently, questions associated with the yellow, pink, and purple sectors are related to the capacity to analyze information and apply the content studied in the solving of problem situations (Table 1). The intention of creating a game with questions of varying levels of complexity was to be able to evaluate memorization of basic concepts and the application of knowledge in situations related to future professional activities, as well as to encourage the development of communication and argumentation abilities, since the activity is performed in groups (17).

The game includes a feedback sheet providing the answers to all of the questions, which is given to one of the participants, as described below.

The strategy adopted is to use the educational game together with a theoretical class. The theoretical class, which is performed first, presents the content in a way that stimulates the interest of the students, demonstrating the use of the knowledge in the daily life of the practitioner. An example is the neuromuscular blockers that are frequently used in intensive care units and during surgery, where the aim of the class is to stimulate discussion about the risks and benefits of the use of these substances and the importance of understanding the associated mechanisms of action. Knowledge of physiology is an essential requirement for understanding the effects of different treatment procedures and medications. In addition to arousing interest by demonstrating the clinical application of knowledge, it is important to present the basic concepts of the muscular system, considering the distributions of cells and proteins in the different muscle tissues, together with their importance during muscle contraction. An introduction to the mechanism of muscle contraction should be provided, considering the arrival of the action potential and the subsequent movement and reorganization of proteins. After the theoretical class, the students are instructed to study the topic of the lesson at home, using a physiology textbook.

At the start of the next class, the teacher informs the students that an educational game activity will be performed and explains the rules of the game, as described below.

1. The students are divided into groups of between four and six participants. The students choose their own group members. In each group, one of the participants is appointed as the organizer of the game. First, the players select the colors of their pins and place the pins in the “start” position. The game organizer, who does not receive a pin, is provided with a sheet listing the questions and answers, to check whether the answers of the players are correct or incorrect. The organizer is also responsible for controlling the time taken to provide an answer.

2. Each group selects the player who will start the game, by rolling the die. The suggested method is that each player throws the die once, and the player with the highest number starts the game. The game then proceeds in a clockwise direction.

3. The player whose turn it is selects a blue card and reads the question aloud so that all members of the group can hear. After reading the question and the possible answers, the player has a maximum time of 2 min to indicate the correct answer out loud. The student organizing the game is responsible for controlling the time and checking the feedback sheet to see if the player has provided the correct answer.

4. The game organizer announces the correct answer after the response of each participant. The organizer is also responsible for ensuring that the time taken to provide an answer does not exceed 2 min, and that all the players follow the rules described above.

If the player gives the correct answer, the die is thrown, and the pin is moved forward, according to the number shown. In the next round, after the other team members have performed the same steps, the player chooses a card of the color of the sector in which the pin is positioned, and answers the question on this card.

In the case of an incorrect answer, the player is not allowed to throw the die and advance the pin, which remains in the same place until the next round. Hence, only the players who provide correct answers can throw the die and move the pins. In the absence of a correct answer, the player remains in the same sector. Only the members of the group will know that the student has made a mistake. The proposal is that the group work as a team, and members are not afraid or ashamed to make a mistake. The teacher seeks to show that students should learn together, respecting each other.

The questions were read aloud to the entire group, and, although only one student at a time answered the questions, the other students

![Muscle System Game](Image)

Fig. 1. Board of the muscular system game.
and 20 women, age 22.90

there is no difference between the pharmacy and nursing groups, since

groups for the study has not occurred, in the first year of graduation

23.57

all students. From the second year of graduation, the subjects become

4

Molecular and Cellular Sciences,

3

Environment and Microorganisms, 4 Culture, Society and Ethics, and high school was the same for

all students. From the second year of graduation, the subjects become

specific to each course. Therefore, in the first year of graduation they

had the same level of preparation.

After theoretical classes concerning the physiology of the muscular system, game and control groups were instructed to study the topic using the textbook provided (44), before participating in the different activities in the following week. The classes for the pharmacy and nursing courses occurred on different days and times, but included the same content.

In the week after the theoretical class, the students of the pharmacy undergraduate course performed the activity with the board game, as described above. The students of the control group undertook a guided study activity, employing the same questions used in the game (Table 2), but it was provided printed on a paper sheet, to be answered by groups of three participants. The group that solved the questions of the guided study received a similar level of feedback and interaction as the game group, because, during the guided study, the teacher walked around the class clarifying the students’ doubts and, at the end of the activity, the questions were discussed with the teacher.

In the week following the game and guided study activities, all of the students answered one exercise about the topic. The answers were not used for inclusion in the marks given to the students in the disciplines, since they were only intended for analysis and comparison of the effects of the educational game and the guided study, in terms of student learning. It was explained to the students that the purpose of these questions was to enable the teacher to identify any difficulties encountered by the students. After the evaluation, the students of the control group performed the activity with the educational game, whereas the game group undertook the guided study activity, to ensure the same treatment and the same learning opportunities for all of the students. The sequences of procedures are presented in Fig. 2.
To evaluate if there were differences in exercise scores between the groups after all activities were performed by both groups, the scores obtained in the academic exam of the subject Morphofunctional Sciences I were compared.

Analysis of the results. The scores obtained for the two groups in the evaluation were compared using Student’s t-test for unpaired samples, considering a significance level of 0.05.

RESULTS

The score obtained for the group that undertook the guided study was significantly lower than the score for the group that submitted to the educational game activity (5.78 ± 0.38 vs. 7.50 ± 0.47; \( P < 0.05 \)). There was no difference in the score obtained in the academic exam of the discipline Morphofunc- 

DISCUSSION

This work compared two teaching methods complementary to theoretical classes, with the results obtained indicating that the use of an educational board game about the physiology of muscle contraction resulted in significantly improved learning, compared with the use of a guided study. These results corroborated the findings of research undertaken in various countries and institutions, which also showed that the use of educational games could improve learning (4, 8, 9, 24). In a similar study, the effect of a detailed theoretical class concerning the cardiac cycle, with group discussion, was compared with the effect of a shorter theoretical class that did not present all of the content, associated with an educational game for teaching of the cardiac cycle. It was found that the group that performed the activity with the educational game showed increased learning, compared with the other group (9). Elsewhere, Ober (39) reported increased learning of undergraduate students of a veterinary course who performed an activity involving a game concerning the quality of radiographic images, compared with a group of students who did not undertake the game activity. In the present study, the number of questions answered by each player was not verified, but this activity did not influence the result, because all questions and answers were spoken aloud, so all players could reflect on all of the questions involved in the board game.

Similar results were also reported in research concerning advanced pharmacy practices, involving undergraduate pharmacy students. After identifying the two topics that were most challenging for these students, the authors created two educational card games, one concerning cardiology and another about infectious diseases, and the students performed activities with these educational games for at least 1 h, during three classes. Before and after application of the educational games, the students answered questions on these two topics, as well as on pharmaceutical practices (as a control). It was found that the students achieved higher scores in the evaluation when the content was delivered by means of card games, rather than by using theoretical classes and laboratory exercises (4). Three other studies using pre- and posttesting showed increases in learning with the use of educational games. One of these studies employed a divination board game on the topic of pulmonary physiology (8). A further two studies involved educational games concerning diabetes (16) and auscultatory measurement of arterial blood pressure (5).

Research studies of classroom teaching are complex, since it is extremely difficult, or even impossible, to isolate all of the variables and characteristics involved in the phenomena under investigation (31, 37). For many educational issues, this makes it necessary to use appropriate teaching methods that can improve learning.
it unfeasible to require evidence based on randomized data (38). Educational experiments performed under laboratory conditions would allow better control of the variables, making the results more robust and convincing, but it would be difficult to extend the conclusions of laboratory experiments to the classroom, precisely because the variables are not controlled in the classroom environment (31).

In the present study, the lack of equal sex ratio and the difference of courses between control and game groups illustrate some limitations of classroom research. The sex ratio varies among the different health careers, and it is a factor that could not be controlled by the researchers without some artificial way to exclude volunteers, to have an equal number of men and women in the both groups. If we did it, we will have another limitation related to the criteria that would be used for volunteers’ exclusion.

There was no significant difference in the score obtained in the academic exam of the discipline Morphofunctional Sciences I (pharmacy: $6.81 \pm 1.40$ vs. nursing $7.34 \pm 2.06; P > 0.05$). Since the experience was repeated with both groups, by the time the major exam was given, both control and treatment groups would have been exposed to the board game and the guided study activity. Therefore, if there was no difference in the academic exam score, it seems that the difference observed in the test score was related to the effect of the educational game, and not to some difference between the two groups.

Moreover, there is no difference between the pharmacy and nursing curricula in the first year. We believe that not having conducted a test to check the students’ level of knowledge before the activities was a limitation of this study. However, since high school was the same for all students and the subjects studied in the first year of graduation are the same, the students had the same level of knowledge. If not, it was expected that there would be significant differences in the exam scores.

In the present work, to evaluate the effects of the educational game and guided study on learning, the students were divided into groups according to the structure of the curriculum, the activities scheduled for the semester, and the time available in the weekly lessons timetable. Dividing the students of a class into two groups would require a longer classroom time, since the lecturer would need to repeat the activities so that both groups received the same experiences (9, 24). Another option for classroom studies is to evaluate the effect of the learning technique using pre- and posttesting (15), with the same students being evaluated before and after activities with educational games, which would facilitate inclusion of the tests during the period of the class (8, 12, 16).

Although the perceptions of the students were not evaluated in the present work, it was evident that, during the game, the students showed greater interest and enthusiasm for the topic, which created a more relaxed atmosphere. This is an important point, since the perceptions of students regarding the teaching environment directly influence learning, with positive perceptions leading to increased learning and academic success (23). Also, the collaboration among the students during the game encourages active engagement with the topic and enhances academic performance (14). A study of undergraduate students from different institutions and different courses, including the areas of medicine, biology, dentistry, pharmacy, and nursing, found a positive perception about the use of a cardiac cycle game to improve learning (28). Positive results concerning the perceptions of students toward the use of educational games were also found after the use of games on membrane and action potentials in dentistry (24), physiotherapy, and nursing courses (26); on respiratory physiology (35) and of blood groups (6) in medicine courses; on the fundamentals of nursing materials in a nursing course (7); and on international drug discovery in a pharmacy course (13).

It is important to highlight that, although the game used in the present work was developed for the topic of muscular system physiology, the strategy could be adapted for use with other topics. This would only require that the lecturer responsible for the discipline should elaborate questions relevant to the topic, increasing the difficulty of the questions according to progress through the sectors on the board. The game employed here has the advantage of not requiring the use of mobile devices or the internet; it employs inexpensive printed material that is highly durable (depending on the material used for printing) and can, therefore, be used in several different classes. It can be applied in any region of the world, independent of access to digital devices, and is lightweight and easy to transport.

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DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the authors.

AUTHOR CONTRIBUTIONS

K.C.G.L. performed experiments; K.C.G.L., L.T.C., and F.M. analyzed data; K.C.G.L., L.T.C., and F.M. interpreted results of experiments; K.C.G.L., L.T.C., and F.M. prepared figures; K.C.G.L., L.T.C., and F.M. drafted manuscript; K.C.G.L., L.T.C., and F.M. edited and revised manuscript; K.C.G.L., L.T.C., and F.M. approved final version of manuscript.

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