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Gamification: Intervention Experience to Improve Motivation and Performance in Anatomy

Gamificación: experiencia de intervención para mejorar la motivación y el rendimiento en anatomía

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Data availability
All relevant data is in the article. For futher information, contact the corresponding author.

Abstract

Introduction. The factors that best predict academic performance are motivation, learning strategies, and classroom climate. In this context, gamification has advantages for promoting these variables.

Objective. The objective of this research was to evaluate the effect of a gamified strategy on motivation and academic performance in the anatomy and physiology of systems course.

Method. The MSQL-SF questionnaire was administered to 81 nursing students to assess their perception regarding motivation and learning strategies. Motivation, in turn, considered the dimensions of task value and test anxiety. Learning strategies assessed metacognitive strategies, resource management, and intrinsic orientation. The effect of strategy on performance was analyzed using students' grades.

Results. The main results suggest that 70% of students feel anxious about evaluations, and 50% express difficulties in adapting a study schedule. Both findings are related to motivation. Regarding academic performance, there were no significant differences between the control and experimental groups.

Conclusion. The use of gamification in learning anatomy constitutes a supplement that has shown to have rapid adherence and affinity with health students in activities that are playful, entertaining, and based on collaborative learning. However, its evidence regarding performance is limited.

Keywords

Motivation; academic performance; anatomy; physiology; performance anxiety; gamification; learning; medical education.

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Gabriela Urrejola-Contreras: Conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, resources, supervision, validation, visualization, writing – original draft, writing – review & editing.
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Edgard Mesa Marciel: Conceptualization, data curation, formal analysis, resources, supervision, visualization, writing – original draft, writing – review & editing.

Resumen

Introducción. Los factores que mejor predicen el rendimiento académico son la motivación, las estrategias de aprendizaje y el ambiente en el aula. En este contexto, la gamificación cuenta con ventajas para promover estas variables.

Objetivo. Evaluar el efecto de una estrategia gamificada sobre la motivación y el rendimiento académico del curso de anatomía y fisiología de los sistemas.

Método. Se aplicó el cuestionario MSQL-SF a 81 estudiantes de enfermería, para valorar la percepción respecto de la motivación y las estrategias de aprendizaje. La motivación, a su vez, consideró las dimensiones consideración de la tarea y la ansiedad ante las evaluaciones. Las estrategias de aprendizaje valoraron las estrategias metacognitivas, la administración de recursos y la orientación intrínseca. El efecto de la estrategia en el rendimiento se analizó mediante las calificaciones de los estudiantes.

Resultados. Los resultados principales sugieren que el 70% de los estudiantes se muestran ansiosos ante una evaluación y el 50% manifiesta dificultades para adaptar un horario de estudio. Ambos hallazgos se relacionan con la motivación. En relación con el rendimiento académico, no hubo diferencias significativas entre los grupos control y experimental.

Conclusión. El recurso de la gamificación en el aprendizaje de la anatomía constituye un complemento que ha mostrado tener una rápida adherencia y afinidad con estudiantes de la salud, en actividades que resultan ser lúdicas, entretenidas y basadas en el aprendizaje colaborativo. Sin embargo, su evidencia respecto al rendimiento y la performance es limitada.

Palabras clave

Motivación; rendimiento académico; anatomía; fisiología; ansiedad por el desempeño; gamificación; aprendizaje; educación médica.

Introduction

In the pursuit of improving academic outcomes, new methodologies that promote students' extrinsic motivation and enhance their levels of attention have shown success in productivity and performance. Factors that best predict academic performance include motivation, learning strategies, and classroom climate [1]. It has been demonstrated that teaching resources that enhance motivation not only influence academic performance, but also play a significant role in activating learning, as students engage their learning strategies when motivated [2]. Thus, motivation may play a fundamental role between learning and academic performance [3].

Therefore, suggesting a class design based on a methodology that motivates students can improve the learning experience, yielding a positive effect on academic performance. Authors have revealed that participatory methodology significantly enhances student motivation and participation [4]. Moreover, student motivation has been positively associated with academic performance, as well as the roles of leadership and collaborative work among students [5,6].

In education, gamification is considered a strategy that improves motivation by incorporating game components into learning processes, termed "game-based learning" (GBL). This allows students to test their retention and knowledge through more dynamic, motivating, and challenging activities than those used in traditional education [7]. According to Brull et al. [8], GBL enables students to participate and create a learning community, enjoying the freedom to experiment and fail in a supportive environment. Thus, students have the opportunity to interact with different sensations that keep them motivated.

Evidence suggests that students engaged in gamified environments improve their learning, motivation, and commitment [9,10]. In the university context, various authors have found gamification to be an opportunity to enhance student motivation, group mechanics, attention, and meaningful learning [11,12].

Considering the context of education in morphological sciences in Chile, recent approaches to gamification in anatomy concluded that performance was significant in the experimental group (intervened with gamification). Results derived from student perception regarding the tool highlighted its recommendations for performance. The highest-rated components were challenges and tournaments, acting as active agents in promoting participation, leadership, and group collaboration to solve anatomy questions [13].

Accordingly, implementing a successful gamification strategy requires considering six elements [14,15]: firstly, clearly define the educational objectives to design gamification strategies coherently and effectively; secondly, delineate the behaviors to be enhanced in students, such as knowledge, attitudes, and skills; thirdly, identify the players and their traits to design activities relevant to their real interests; fourthly, establish activity cycles, defining the gamification system; fifthly, ensure fun, as it forms the foundation of any game, by describing the fun events included in the strategy [16]; lastly, consider resources, including tools for strategy development (measurement, tracking, indicators, etc.).

This work aims to evaluate the effect of gamification on motivation and academic performance in the subject of anatomy and physiology of human body systems in undergraduate students of the School of Health Sciences at the University of Viña del Mar, Chile.

Method

The study corresponds to a quantitative approach with an observational design of descriptive scope and cross-sectional temporal dimension and was conducted during the Structure and Function course, which covers the anatomy and physiology of systems for first-year students in health-related careers at Viña del Mar University, Chile. The sample consisted of 81 nursing students who were taking the course for the first time.

In the first stage, the intervention was designed using gamification strategy. Thematic units were selected, and challenges (games) were created to be implemented during practical sessions in the laboratory (see Figure 1). Six challenges were formulated, three of which focused on contents from the first thematic unit on the nervous system, while contents from the cardiorespiratory, digestive, and renal systems were not intervened. Subsequently, sessions were scheduled to incorporate these challenges or games into their strategies.

In the second stage, the gamification strategy was applied by introducing the challenges in the scheduled sessions. The dynamics were carried out in groups for 20 minutes of each class.

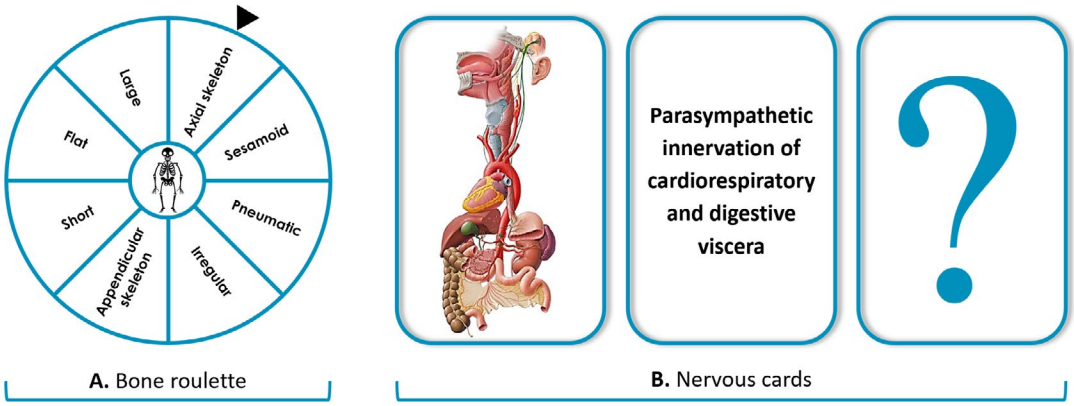

Figure 1. Examples of challenges/games used.

Note. ***1A. Bone roulette***. Each student throws the wheel and the student will mention an example according to the criteria requested by the wheel. ***1B. Nervous cards***. The student discovers, takes a card at random that contains an anatomical image of the nervous system and the student will indicate its function. In both examples, the game mechanics are in teams. If a student cannot answer, they will pass the question on to a teammate.

After completing the six sessions that included the challenges/games, students were administered the Motivational and Learning Strategies Questionnaire in its short version (MSQL SF), following the protocol of Masso et al. [17]. This instrument consists of 40 items that assess the perception of two major domains: motivation and learning strategies. Motivation is divided into two dimensions: task appraisal and anxiety about evaluations. On the other hand, learning strategies assess three dimensions: cognitive and metacognitive strategies, resource management, and intrinsic orientation. Students responded to the questionnaire using a Likert-type scale, assigning a score to each item according to their level of agreement (see Appendix).

To administer the MSLQ-SF instrument, two of the researchers, GU and EM (with training in science education), explained to the students what each item and question consisted of and provided examples of each to facilitate understanding. The students were informed that the questionnaire gathers information according to each individual's perception for each question. Each participant completed the questionnaire individually, and GU and EM were available in the classroom at all times to resolve any questions that arose. The interpretation was carried out by the same academics, considering that EM had prior experience in administering the instrument.

Each appraisal they had of each statement also presented a score, with possible response categories: very true (5), somewhat true (4, 3, 2 points), and not true (1 point) (see Figure 2).

Each unit was evaluated, and students' grades were recorded. A 60% requirement scale was considered. The grading scale used to evaluate performance ranged from 1 to 7, with a grade of ≥ 4.0 considered passing and <4.0 considered insufficient.

Subsequently, a descriptive analysis was conducted regarding the responses obtained from the MSQL-SF questionnaire, and performance was compared. For this analysis, Exam 5 corresponds to the grade derived from the thematic unit that used gamification (generalities of the nervous system), while Exam 6 corresponds to the grade of the thematic unit not intervened (cardiorespiratory, digestive, and renal). Additionally, performance was compared

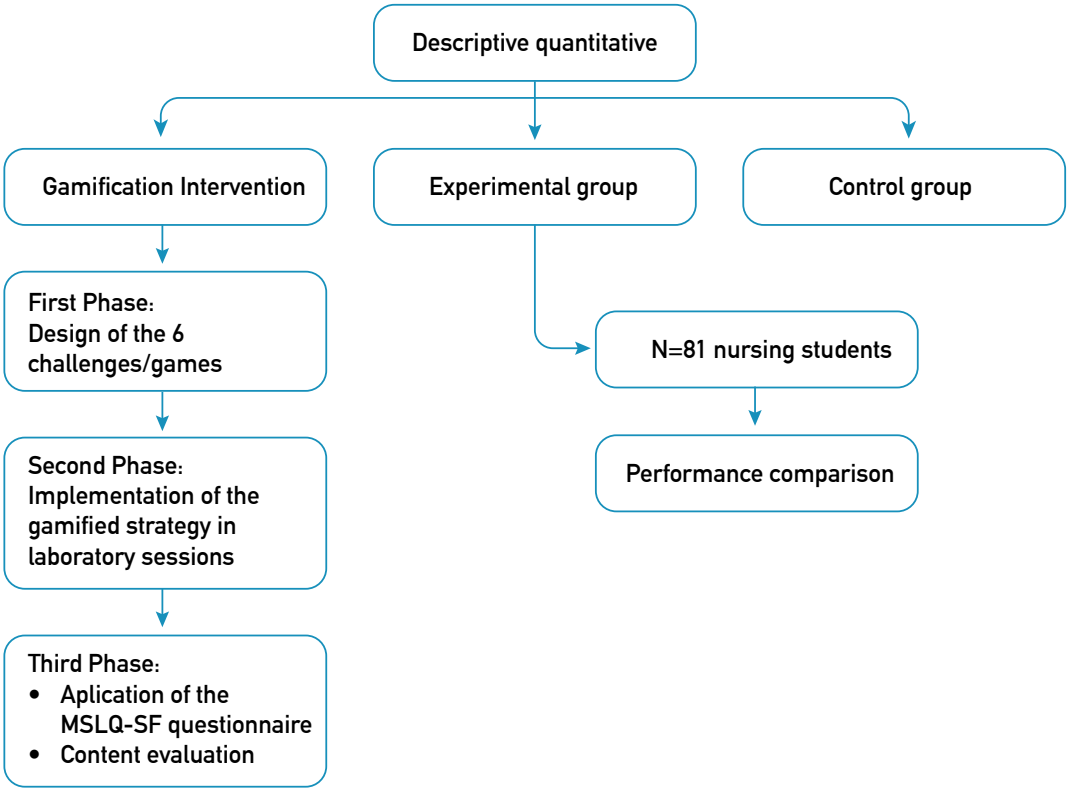

Figure 2. Methodological design of the study.

between the nursing course of 2024, which had the gamification tool implemented (considered as the experimental group), and the nursing course of 2022-2023, which did not have any interventions (considered as the control group I-II).

Ethical considerations

The work followed all institutional protocols and received approval from the ethics committee (CEC-UVM 12-24). Informed consent was obtained from the students, explaining the research methodology, their right to participate, withdraw voluntarily from the study, as well as the protection and confidentiality of data, which would only be used for research purposes by the principal author.

Results

The motivation item, regarding its dimension of anxiety about exams, showed that more than 70% of students assigned a score between 4 and 5 to their levels of anxiety when taking an assessment. When observing the second dimension of the motivation factor, task appraisal, it is possible to determine that at least 45% of students have difficulties managing the time and place of study for the subject (see Table 1).

A second factor analyzed in the MSLQ-SF instrument addressed learning strategies. When observing the results derived from the elaboration dimension, over 70% of students reported applying cognitive and metacognitive strategies to learn the subject. However, 57% of participants admitted to some extent giving up studying or only studying what was easier

Table 1. Percentages and mean for MSQL-SF Motivation Questionnaire.

Dimension. Test Anxiety	Average (SD)	Very true (5 points)	Somewhat true (4 points)	Somewhat true (3 points)	Somewhat true (2 points)	Not true at all (1 point)
In a quiz, I think my performance is poor compared to my peers	2,85 ± 1,49	17,7	21,5	16,5	16,5	27,8
Before an assessment, I think about the consequences of failing	4,09 ± 1,14	48,1	28,4	12,3	6,2	4,9
When I have an assessment, I feel uncomfortable and restless	4,04 ± 1,06	44,7	25,0	22,4	5,3	2,6
I feel my heart pounding rapidly when I take an assessment	4,01 ± 1,19	46,9	24,7	17,3	4,9	6,2
Dimension. Task Value Assessment						
I find it difficult to adapt to a study schedule	3,16 ± 1,34	15,9	31,7	23,2	11,0	18,3
When the content of the subject is difficult, I give up and only study the easiest parts	2,34 ± 1,42	10,1	15,2	16,5	16,5	43,0
I rarely find time to review my notes or readings before an assessment	3,15 ± 1,35	19,2	25,6	21,8	17,9	15,4

when the content appeared more complex. The organization dimension revealed that students positively related to strategies that allow them to manage resources for studying the content, such as summarizing, taking notes, and reviewing key concepts. Regarding critical thinking, an important finding is that 75% of surveyed students modify their study methods based on the teaching style of the instructor (see Table 2). Finally, in the metacognitive and behavioral self-regulation dimension, there was homogeneity among positive average scores for statements that inquire about going back through readings, solving application activities, and using learned material as a starting point for more complex inferences on the same topic.

For the intrinsic orientation goals dimension, about 70% of students strongly agreed or agreed with statements indicating interest in the subject and finding its content challenging and stimulating their curiosity. Regarding time and resource management and effort self-regulation, most students uniformly reported having a study environment conducive to concentration. Virtually all surveyed students considered the material provided useful for learning; however, the lowest score revealed that only 65% of participants try to review content they find boring or uninteresting.

Table 2. Percentages and mean for MSQL-SF Learning Strategies Questionnaire.

Dimension. Elaboration	Average (SD)	Very true (5 points)	Somewhat true (4 points)	Some-what true (3 points)	Somewhat true (2 points)	Not true at all (1 point)
I relate what I've learned in the subject's laboratory to what I already know	4,38 ± 0,84	54,9	32,9	8,5	2,4	1,2
I am generally interested in the contents of this subject	4,42 ± 0,73	38,0	53,2	6,3	2,5	0,0
Dimension. Organization						
When I study, I make summaries of main ideas, readings, and class concepts	4,31 ± 0,74	44,4	44,4	8,6	2,5	0,0
When studying for the subject, I review readings and class notes looking for main ideas	4,37 ± 0,69	51,9	39,5	7,4	1,2	0,0
When studying for the subject, I review my class notes and outline important concepts	4,35 ± 0,79	51,9	33,3	12,3	2,5	0,0
Dimension. Critical Thinking						
I try to change the way I study to meet the requirements of the subject and the teaching style of the professor	4,08 ± 1,07	44,3	31,6	15,2	5,1	3,8
Dimension. Metacognitive and Behavioral Self-Regulation						
When I study readings for this subject, I underline the material to help organize my thoughts	4,17 ± 1,09	51,9	25,9	14,8	2,5	4,9
I try to apply ideas from lecture classes to practical classes in the laboratory	4,49 ± 0,63	56,1	36,6	7,3	0,0	0,0
I use the course material as a starting point and try to develop my own ideas about it	4,16 ± 0,89	44,9	35,9	15,4	2,6	1,3
Dimension: Intrinsic Orientation Goals						
I prefer course material that stimulates my curiosity, even if it's difficult	4,30 ± 0,84	51,9	28,4	17,3	2,5	0,0
I am very interested in the area to which this subject belongs	4,51 ± 0,71	63,0	24,7	12,3	0,0	0,0
Dimension. Time and Resource Management						
I generally study in a place where I can concentrate	4,38 ± 0,82	55,0	30,0	13,8	0,0	1,3
I have a regular place to study	4,11 ± 1,14	51,3	22,5	17,5	3,8	5,0
Dimension. Effort Self-Regulation						
I think the course material is helpful for learning	4,60 ± 0,67	70,0	20,0	10,0	0,0	0,0

Note. Average score and assessment of the Learning Strategies aspect of the questionnaire. The mean score and standard deviation (SD) were considered for each item, as well as the percentage of students who rated each criterion as very true (5 points), somewhat true (between 2 and 3), and not true at all (1 point)

To determine the effect of the gamification strategy on academic performance, the average grades obtained were compared. Figure 3 shows that there were no significant differences between the average grades for Exam 5 (post-gamification) between the control and experimental groups (t-test, $p < 0.05$). Regarding the thematic unit that was not intervened, the average grade for Exam 6 (without gamification) in the experimental group was lower compared to the control group; however, this difference was not significant (t-test, $p < 0.05$).

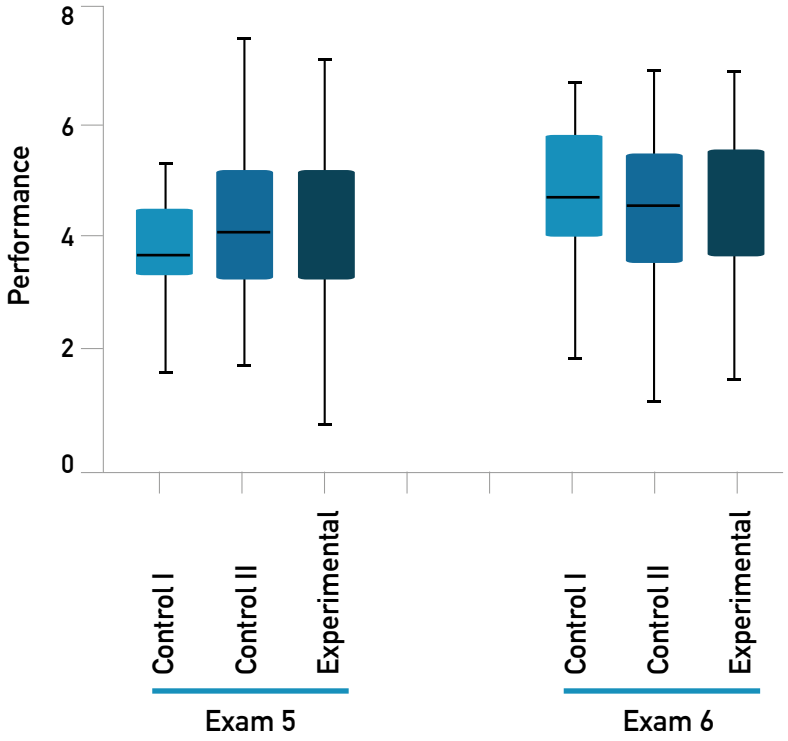

Figure 3. Effect of gamification on performance.

Note. Gamification had no effect on performance when applied to the contents of Exam 5 and Exam 6. The averages and standard deviations (SD) of academic performance were assessed for control groups I-II (nursing students without intervention during the years 2022 and 2023) and the experimental group (nursing students with intervention during the year 2024). The average academic performance scores obtained in exam 5 were (4.2 ± 1.3), (4.3 ± 1.19), (4.2 ± 1.2) for control groups I, II, and the experimental group, respectively. Regarding exam 6, the average academic performance scores were (4.6 ± 1.2), (4.5 ± 1.28), (4.4 ± 1.3) for control groups I, II, and the experimental group, respectively.

Discussion

The gamified strategy was well received by the students, who highlighted that its implementation allowed for increased engagement with activities incorporating game elements, making the approach to new content more entertaining for understanding anatomy and physiology of the human body systems, similar to what has been observed in other studies using this type of intervention. Another noteworthy point regarding learning strategies is that most students (approximately 80%) engage in activities focused on metacognitive

self-regulation and effort. Regarding the anxiety dimension, approximately 70% expressed feeling uncomfortable and restless with evaluations, as well as fearing failure. Additionally, half of the participating group reported difficulties in adapting a study schedule. No differences were found between the control and experimental groups in which the intervention was applied.

After analyzing the results of this study, a first point of debate relates to identifying conditions that promote motivation [18] and the relationship with the learning strategies employed by the students themselves [19].

It is useful to know that a significant group of students faces difficulties in adopting a study schedule and reviewing notes before an evaluation. Following this point, a relevant proportion of students also expressed anxiety about evaluations and thinking about the consequences of failing in this instance. Considering that both findings are related to motivation, an analysis point is to review the types of methodologies that improve students' adherence to scheduled activities, a criterion considered a predictor of academic success as demonstrated in other studies [20], in a subject that traditionally presents difficulties in student performance [21].

This search for new methodologies, accompanied by the digital literacy of teachers and students, has changed the ways of teaching and learning human anatomy [22]. An example of this has been gamification, a tool that combines strategies based on game mechanics, including playful activities that promote entertainment and student participation in their own learning process, which enhances metacognition [23].

In line with this, and also present in other works such as that of Perumal et al. [24], the statements were positive for items highlighting the concepts of fun, improving interest in learning, and being an interesting way to apply content in undergraduate anatomy study [25], bases that other authors have already incorporated as teaching tools in virtual environments and/or simulated games that are being exported to remote interaction platforms [26].

Another important point arises from the understanding that the majority of surveyed students declare trying to change their study methods to match the teaching styles of the instructor. However, traditionally, anatomy teaching has used resources based on rote memorization [27], which makes it difficult to transfer knowledge to practical and concrete examples. In this regard, and concerning the learning strategies evaluated with the MSLQ-SF questionnaire, a observed finding arises from the affirmative responses that virtually all students have regarding the activities they developed based on the "challenges/games" helped to reinforce the main ideas of each content and relate them to obtain a more complex understanding, similar to what was also observed in studies that implemented gamification in physiology courses [28].

From this point, it is possible to consider that gamification capitalizes on the inherent incentives in any gaming practice, improving the skills to interact, engage, and entertain even in learning tasks that are usually tedious for students [29].

In this regard, it is necessary to discuss the implications that combining different learning styles in the interaction of playful activities [30] with anatomy and physiology subjects may have on students, as well as its effects on performance, which literature has shown different experiences [31].

Indeed, while some experiences have revealed consistent improvements in grades or higher evaluation scores after implementing the gamified tool [32,33], the performance in this study did not experience an increase, which is consistent with other practices where an improve-

ment in student performance has not been evidenced [34-36]. Considering that performance did not experience a substantial improvement, it is possible to relate that the difficulty in finding and arranging study schedules leads to poor preparation before an evaluation, which could explain the high percentage of students with high anxiety, close to 70%, when facing evaluations [37].

A limitation of this research was comparing it with control groups from previous years that do not represent the same cohort, similar to the difficulties faced by other studies [38]. It is expected that future studies will provide results allowing the analysis of the heterogeneity of works that have tested the gamified methodology and can prove its effectiveness through results and statistical analysis [39], as well as incorporating instruments that assess the effect of the strategy/intervention carried out.

Conclusions

The strategy of implementing gamification in anatomy learning constitutes a complement that has shown to quickly adhere and resonate with health students, through activities that are playful, entertaining, based on teamwork, and collaborative learning. However, its evidence regarding performance and outcomes is limited.

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Appendix

Percentages and mean for MSQL-SF Learning Strategies Questionnaire.						
Dimension. Elaboration	Average (SD)	Very true (5 points)	Somewhat true (4 points)	Somewhat true (3 points)	Somewhat true (2 points)	Not true at all (1 point)
I relate what I've learned in the subject's laboratory to what I already know	4,38 ± 0,84	54,9	32,9	8,5	2,4	1,2
I am generally interested in the contents of this subject	4,42 ± 0,73	38,0	53,2	6,3	2,5	0,0
I try to relate my ideas to what I'm learning in this subject	4,31 ± 0,70	43,8	45,0	10,0	1,3	0,0
When the content of the subject is difficult, I give up and only study the easiest parts	2,33± 1,42	10,1	15,2	16,5	15,2	43,0
Dimension. Organization						
When I study, I make summaries of main ideas, readings, and class concepts	4,31 ± 0,74	44,4	44,4	8,6	2,5	0,0
When studying for the subject, I review readings and class notes looking for main ideas	4,37 ± 0,69	51,9	39,5	7,4	1,2	0,0
Before studying new content in the subject, I often review it to see how it's organized	3,63 ± 1,07	23,5	33,3	29,6	9,9	3,7
When studying for classes, I set goals to guide my activities in each study period	3,85 ± 1,04	31,7	36,6	18,3	12,2	1,2
I make good use of my study time for this subject	3,90 ± 0,95	29,5	39,7	23,1	6,4	1,3
If I take confusing notes in class, I make sure to organize them later	4,24 ± 0,95	51,3	29,5	16,7	0,0	2,6
When studying for the subject, I review my class notes and outline important concepts	4,35 ± 0,79	51,9	33,3	12,3	2,5	0,0
Dimension. Critical Thinking						
I try to change the way I study to meet the requirements of the subject and the teaching style of the professor	4,08 ± 1,07	44,3	31,6	15,2	5,1	3,8
When faced with a theory, interpretation, or conclusion, I determine its support in evidence	3,94 ± 0,86	29,5	38,5	28,2	3,8	0,0
I try to think through a topic and decide what I'm supposed to learn	4,09 ± 0,87	38,8	35,0	22,5	3,8	0,0

Dimension. Metacognitive and Behavioral Self-Regulation						
I continue weekly readings and assignments for the course	3,81 ± 1,13	35,0	27,5	25,0	8,8	3,8
When I study readings for this subject, I underline the material to help organize my thoughts	4,17 ± 1,09	51,9	25,9	14,8	2,5	4,9
I try to apply ideas from lecture classes to practical classes in the laboratory	4,49 ± 0,63	56,1	36,6	7,3	0,0	0,0
When confused about what I've read, I go back and try to resolve it	4,30 ± 0,77	47,5	36,3	15,0	1,3	0,0
Whenever I read or hear a statement or conclusion in this course, I think about possible alternatives	3,85 ± 1,02	33,8	31,3	26,3	6,3	2,5
I question myself to make sure I understood the content I've been studying in these classes	4,21 ± 0,81	41,5	41,5	13,4	3,7	0,0
I use the course material as a starting point and try to develop my own ideas about it	4,16 ± 0,89	44,9	35,9	15,4	2,6	1,3
Dimension: Intrinsic Orientation Goals						
I prefer course material that stimulates my curiosity, even if it's difficult	4,30 ± 0,84	51,9	28,4	17,3	2,5	0,0
When studying for this subject, I try to determine which concepts I don't understand well	4,20 ± 0,84	44,4	33,3	19,8	2,5	0,0
In a class I enjoy, I prefer course content that truly challenges me so I can learn new things	3,98 ± 0,92	35,4	30,5	31,7	1,2	1,2
I am very interested in the area to which this subject belongs	4,51 ± 0,71	63,0	24,7	12,3	0,0	0,0
Dimension. Time and Resource Management						
I generally study in a place where I can concentrate	4,38 ± 0,82	55,0	30,0	13,8	0,0	1,3
I have a regular place to study	4,11 ± 1,14	51,3	22,5	17,5	3,8	5,0
Dimension. Effort Self-Regulation						
I put academic effort even if I don't like what I'm doing	4,32 ± 0,70	45,7	40,7	13,6	0,0	0,0
I think the course material is helpful for learning	4,60 ± 0,67	70,0	20,0	10,0	0,0	0,0
The most satisfying thing in this subject is understanding the content as well as possible	4,59 ± 0,67	67,1	25,6	6,1	1,2	0,0

When the course materials are boring and uninteresting, I make an effort to finish them	3,84 ± 1,15	36,3	28,8	22,5	7,5	5,0
Understanding the content of this subject is very important to me	4,59 ± 0,67	67,9	24,7	6,2	1,2	0,0
If the course content is difficult to understand, I change the way I read it	4,28 ± 0,76	46,3	35,0	18,8	0,0	0,0

Note. Average score and assessment of the Learning Strategies aspect of the questionnaire. The mean score and standard deviation (SD) were considered for each item, as well as the percentage of students who rated each criterion as very true (5 points), somewhat true (between 2 and 3), and not true at all (1 point).