REVISTA CÁTEDRA

Estrategias lúdicas en el aprendizaje de la nomenclatura química inorgánica

Playful strategies in the learning of inorganic chemical nomenclature

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Resumen

La implementación de nuevas estrategias y metodologías dentro del proceso de enseñanza-aprendizaje en la educación universitaria surge de la necesidad de dar respuesta a las dificultades que se hallan avocados los estudiantes en su quehacer académico. En este contexto, en la Carrera de Pedagogía de las Ciencias Experimentales, Química y Biología de la Universidad Central del Ecuador, como unidad académica directamente relacionada en la formación de los nuevos docentes en el área de Química se planteó como objetivo evaluar la incidencia de las estrategias lúdicas en el aprendizaje de la nomenclatura inorgánica. Así, se desarrolló una investigación cuantitativa cuasi experimental aplicada a dos grupos de estudiantes de primer semestre, Grupo Control y Experimental al que se le aplicaron las estrategias lúdicas para el aprendizaje. Se abordaron tres ejes temáticos -Símbolos químicos y valencias; función óxidos: básicos, ácidos, neutros y compuestos y funciones hidróxidos, hidruros y ácidos hidrácidos- y para su valoración se aplicaron cinco evaluaciones, una diagnóstica, una al finalizar cada tema y una sumativa al finalizar la unidad. Para el análisis de resultados se trabajó con el 5% de error. Se aplicaron dos pruebas t de Student que determina la diferencia significativa entre las medias de dos grupos, y Kolmogorov-Smirnov, para distribución de la población, todo procesado con el paquete estadístico SPSS. Kolmogorov mostró que la distribución es normal y la prueba t, que existe diferencia significativa entre los grupos control y experimental en tanto que para las evaluaciones dos y tres, no evidenció diferencia significativa.

Palabras clave
Estrategias lúdicas, nomenclatura química inorgánica, enseñanza-aprendizaje, juego

Abstract
The implementation of new strategies and methodologies in the teaching-learning process in university education arises from the need to respond to the difficulties that students have in their academic work. In this context, in the Career of Pedagogy of Experimental Sciences, Chemistry and Biology of the Central University of Ecuador, in the area of Chemistry was set as an objective to assess the impact of playful strategies on learning inorganic nomenclature. Thus, a quasi-experimental quantitative research applied to two groups of first-semester students, Control and Experimental groups, was used. Three thematic axes were addressed - Chemical symbols and valences; oxides function: acids, neutrals and compounds and hydroxides, hydrides and acids- and five evaluations were applied for titration, one diagnostic, one at the end of each topic and one summative at the end of the unit. 5% of error was considered for the analysis of the results. Two Student t-tests were applied which determined the significant difference between the means of two groups, and Kolmogorov-Smirnov was employed for the population distribution, all processed with the SPSS statistical package. Kolmogorov showed that the distribution is normal, and the t-test indicated that there is significant difference between the control and experimental groups as for evaluations two and three, it did not show significant difference.

Keywords
Teaching, learning, play, nomenclature, chamical.

1. Introduction
The incorporation of playful activities in the educational field improves the teaching-learning process. In addition, it facilitates the understanding of complex themes. Inorganic chemical nomenclature is one of the content that creates more difficulty for students who start studying Chemistry, problem that persists at the level of higher education and that is observed in the Career of Pedagogy of experimental sciences of Chemistry and Biology of the Central University of Ecuador. This problem becomes more important as it is a career

related to teacher training. For this reason, the objective of this study was to evaluate the impact of playful strategies on the teaching-learning process of inorganic nomenclature.

In the face of the negative attitude that students adopt when developing content related to inorganic chemical nomenclature, it is important to incorporate active methodological strategies that promote a change of attitude and allow to address the contents in a participatory way. Playful strategies are a viable alternative to motivate the study of inorganic functions.

Incorporating games into classroom activities provides significant benefits. The game in the teaching–learning process arouses interest. This is manifested by Chacón (2008), "playful activity is engaging and motivating, capturing students' attention to the subject or for any area that wants to be studied" (p. 33). The game makes the student interested in topics considered "difficult", becoming an interesting strategy for the hard science teacher. Another significant benefit of playful strategies is skill development. The ability to solve problems, creativity, decision making, assertive communication, among other cognitive skills are enhanced by the typical dynamics of the game. Another important aspect developed through the game is social skills. Playful strategies strengthen the cooperative work. According to Martinez et al. (2011), the synergy between playful activities and cooperative learning enables "the interaction between peers, the acceptance of norms and the discussion of ideas, the recognition of the successes of others and the understanding of mistakes" (p. 403). There is no doubt that the interaction generated through the game consolidates learning, improves self-esteem and promotes respect for others. Therefore, the benefits of playful strategies are significant, it is worth incorporating the teacher´s practice.

In this context, this article describes the main problems associated with learning inorganic chemical nomenclature, the benefits of using games into in the teaching-learning process, and studies related to playful activities in different levels of school training. The materials and methods used in the research are presented as well as the results set out in this article derive from the experience of incorporating playful strategies into the teaching-learning of inorganic chemical nomenclature in first semester students.

1.1 Difficulties in the learning process of inorganic chemical nomenclature

Learning goes beyond the mere retention of information, it implies that the individual is able to process it, locate it under a specific context and provide a practical sense to it; as stated by Rivera (2004), " the process by which the significant personal representations that have a sense of an object, situation, or representation of reality is known as learning" (p. 47). Therefore, learning comprises cognitive processes that allow the tangible to be linked to the intangible. However, this fact may be a challenge in learning chemistry. Nakamatsu (2012) mentions that "learning chemistry is further complicated, as it requires working at the macroscopic level (physical world) and at the sub-microscopic level (atoms and molecules), and using a system of symbolic representations (formulas, equations, etc.) and a new language" (p. 44). One of the conceptual contents of inorganic chemistry is the chemical nomenclature. The study of this topic has represented in some students some suspicion when developing it. According to some authors, among the reasons that studying chemical nomenclature raises doubts in its learning are: the conception of difficult understanding of the subject, the application of an inadequate teaching methodology and memorization as the basis of their learning.

With regard to the conception of inorganic chemical nomenclature as a subject of difficult understanding, in the study "ICT in the teaching of the Chemistry of the training cycle for the first, second and third semesters of the Pedagogy of Experimental Sciences, Chemistry and Biology..." Cedeño (2019), corroborated the complexity of the aforementioned topic. This research surveyed students of basic training levels on conceptual topics that represent more difficulty in their learning within the subjects of General Chemistry I, General Chemistry II and Inorganic Chemistry for the first, second and third semesters, respectively. Based on the results, the author notes that one of the most complex topic for students is inorganic chemical functions. This is noted by Cedeño (2019) "... there is greater difficulty in unit four of the subject of General Chemistry I, whose name is Chemical Links and Introduction to the Inorganic Chemistry Nomenclature..." (p. 86).

Of the topics addressed within the aforementioned unit (chemical links, generalities and inorganic chemical functions), both the generalities of the nomenclature and the main chemical functions represent greater difficulty in understanding it for 25% and 30% of the students. The percentages indicated, although they do not exceed 50% of students with a similar criterion, correspond to those of higher rank, since the units that are not related to chemical nomenclature do not exceed 10%. It is clear that the study of inorganic chemical functions represents a real challenge for a significant percentage of students when reviewing them.

The methodology of teaching chemical nomenclature is another aspect that can hinder the learning of the nomenclature. Teachers in this field are usually part of a spontaneous teacher model and professionals base their teaching methodology on traditional techniques. There is an unsuitable way to develop this topic by the initial teachers. Among the mistakes made according to Fernandez (2013) are:

> ... the number of different concepts taught simultaneously. The student is surrounded by a conjunction of all of them making him/her impossible to assimilate them", "The disciplinary profile is reinforced by the classification quest, which ends up introducing compounds such as metal hydrides, at equal deal with oxides or salts...
>
> The belief in the primary role of the periodic table in formulating is very common. It is true that, among other things, it can facilitate the retention of valences/nox and the assimilation of the types of compounds, according to the different groups, but at the cost of a deeper memoristic effort...
>
> As for the procedure used to formulate, the 'exchange' rules and 'divisibility' lead to inconsiderable inconveniences. As taught, they appear before the student as arithmetic rules that are applied mechanically, without showing their chemical foundation. (p. 684-685).

The teaching under the spontaneous model affects teachers in training, and it is a significant fact that they tend to keep their professional practice based on their academic experience. Hence, there is a tendency to replicate the methods, techniques and activities that their teachers used with them during their training process.

> The predominance of the traditional teaching model in the subject of Chemistry is translated into a learning based only on the reproduction of the contents taught by the teacher, favoring the student´s memorization, a situation that does not correspond to what was established by David Ausubel's Theory of Significant Learning proposed in 1963, who conceives the student as an active processor of information, because,

> he/she transforms and structures it, creating a significant, non-memoristic learning (p. 12).

In the case of teaching chemical nomenclature, the use of memorization as the main learning strategy is even more frequent. Students' mastery of conceptual content such as symbols, valences and chemical formulas is often an essential requirement. This teaching conception is limited, because while chemical symbols, valence numbers and other conceptual elements require a degree of memorization, this process must be accompanied mainly by the understanding of them and not of the simple repetition.

On the other hand, the use of inadequate bibliographic resources promotes the repetition of content. According to Níaz (2005):

> ... many authors try to present the tentative as definitive, without explaining how certain conclusions were reached under certain premises, interpretations and evidence. Thus, instead of convincing the student with arguments, the texts simply present them with the opinion of some scientific authority, to conclude: 'Everyone thinks this is the truth.' Faced with this disjunction, students have few alternatives and generally end up memorizing the content (p. 411).

While teaching resources play a significant role in the teaching-learning process, careful selection of them is necessary. Chemical nomenclature texts are useful tools for teaching as long as they do not merely present chemical formulas as a simple result of compound formation. It is necessary to use texts that contemplate the explanation of the compound formation as a result of the characteristics of the chemical elements as well as their behavior.

Under no conception should content be prioritized over the intellectual learning processes of students. Prioritizing concepts leads to making mistakes for chemistry teachers both in the execution of classroom activities and in the use of teaching resources. These errors, in turn, lead to the lowest level of learning such as memorization.

1.2 Benefit of the implementation of playful strategies in the teaching-learning process

Playing is an inherent activity to the human being, since from an early age the game is part of the physical, cognitive and emotional development of the individual; and in the early years of schooling, it is an essential part of academic activities. Hence, why not incorporate playful strategies in High School and higher education? Some of the benefits of playful strategies in the teaching-learning process applicable to different levels of training will be discussed below.

One of the most notorious and forceful benefits of incorporating the game into school activities is undoubtedly motivation. This is stated by Montero (2017), "playful methodology helps to learn a subject by encouraging the motivation to continue this educational process..." (p. 76). It is certainly imperative to arouse interest in themes that would otherwise be monotonous or boring if traditional methodologies are applied as a single resource. The game incorporated into the educational process can get the attention and can change the dynamics of the class by making it more active. The incorporation of other elements such as ICT can be an effective methodology for young students and adults.

Developing skills is another important benefit of incorporating playful activities into the teaching-learning process. There are so many skills developed through the game based on the area of development as depicted in Figure 1. Thus, in the physical-biological area the game allows body expression, enhances the speed of response to stimuli as well as refines manual abilities and coordination (Chacón, 2008). While it is true that the benefits of games in this area are outstanding in the first years of human life, in young people and adults it allows to maintain and even strengthen their physical development.

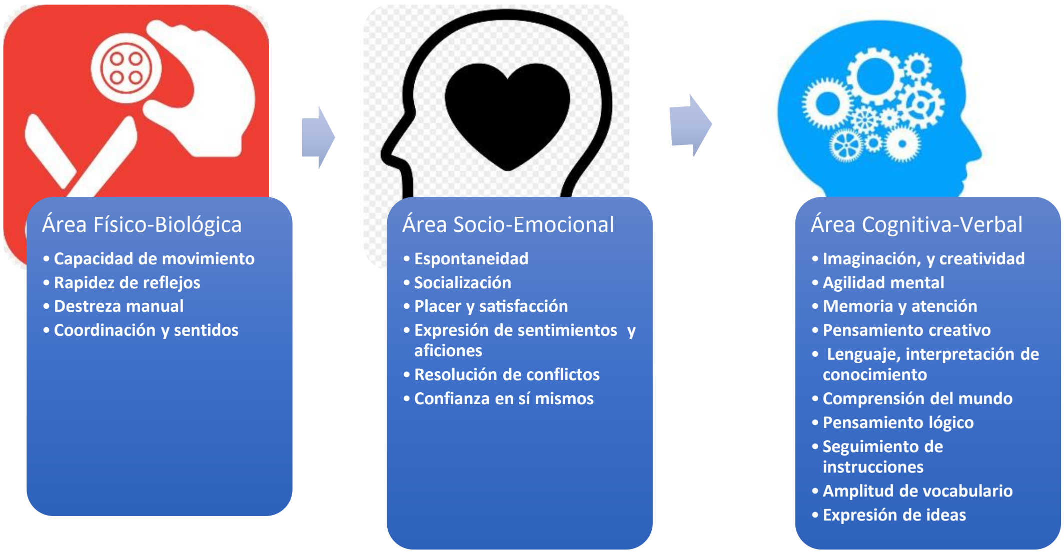

Figure 1. Benefits of playful strategies by areas in the human being. Source: (Chacón, 2008, p. 34)

Another important area in which the game contributes significantly is the socio-emotional area. The human being is by nature a social being, he/she needs positive interaction with other individuals. The game allows to improve the relationship between teachers and students and even strengthens self-confidence. This fact is relevant in shy students whose participation through a traditional methodology is limited or zero. This is manifested by the team “Elige Educar” (2014) "the most introverted students often feel threatened when they are required to participate by answering a question or solving an exercise in front of the rest of their peers, resulting in an emotional blockage and the consequent loss in their potential to learning..." (p.1). Playful strategies facilitate the integration of all students and therefore improve the social skills of introverted students, as the game improves assertive communication and raises their self-esteem.

Playful activities also allow to develop the cognitive-verbal area of individuals. The cognitive skills that stand out when employing playful strategies are imagination, creativity and logical thinking. The game represents a challenge that participants must overcome, for this they must overcome difficulties or problems in which mental agility is required, must know how to follow instructions, join ideas and express them with collaborative work. Oliva (2016) states that the game is more than a "simple entertaining and fun methodology, due to its integrative dynamics of knowledge; gamification becomes a training resource used to access the intellectual organization of the individual, thus determining cognitive functioning in certain mechanisms of how the student learns..." (p. 44). Therefore, playful strategies allow to enhance the cognitive skills of the student, facilitating a significant learning since, thanks to the dynamics of the game, the student focuses his/her attention on it, leaving aside the stress and monotony that would have a traditional class.

1.3 Related studies

In the teaching-learning process, playful strategies have been applied at different educational levels. In the literature can be observed works in Latin American countries such as Mexico, Cuba, Colombia and Argentina, where education has been strengthened with the implementation of recreational strategies in High School and higher education. These experiences demonstrate positive results without the student's age being limited. The works described below provide a more objective view of what is stated.

In 2014 in Guadalajara Jalisco, Mexico, the article Didactic Strategies in Teaching-Learning: Playful strategies in Learning the Organic Chemical Nomenclature in students of the Atonilco Regional High School was published, where the experience of the use of games as a strategy for the teaching-learning process is presented, with the topic Functional groups corresponding to Chemistry II of the General Baccalaureate for Skills. The authors say that it is very important to use game-based learning as a teaching-learning strategy, as it allows students to understand what they have learned (Zaragoza et al., 2016 p. 5).

During the years 2014-2014 in Cuba, the work didactic strategy based on playful activities for the learning of chemistry in High School was published, in which the authors show that didactic games were designed for the teaching of chemistry whose results in the experimental group showed higher score averages than those of the non-experimental course, and mentioned that there is acceptance of the games by the students and that playful work enables the development of cooperative work and the increase of the significant learning of students (Plutin-Pacheco and García-López, 2016, p. 623).

In 2018 in Bogota, Colombia, the study Inorganic Nomenclature: a playful proposal for the teaching of chemistry developed with tenth graders, was aimed at developing a playful tool in the tenth course of Elementary school in order to show the impact of the game on the learning process. It notes that, among other aspects, this strategy helps to achieve a better appropriation of traditional inorganic nomenclature and its relationship to the management of the chemical formula, it also affects the strengthening of teamwork and the establishment of a path between the construction and reconstruction of conceptual and methodological structures (García, 2018, p. 45).

In 2007 in Cundinamarca, Colombia was published a research entitled Communicative skills, teaching and learning of natural sciences: a playful approach, where the author determined that the game as a recreational exercise gives students the ability to develop communication skills and build knowledge. The author also mentioned that the game helps strengthen healthy academic competence and increases self-esteem under which students feel that they help effectively build true learning. On the other hand, it is mentioned that the playful strategy stimulates an adequate management of conceptual information and scientific language, elements that can be built, developed and expressed in a group context of continuous communication (Palacino, 2007, p. 295).

Similarly, in 1996 in Argentina, in the article How to promote the learning of inorganic chemical formulation with non-conventional strategies, the results of a study based on the adaptation of a game for learning chemistry are published. In this regard, the authors note that "non-conventional strategies, such as appropriately designed playful activities (games), constitute a valuable resource that can be leveraged as an alternative to get the student actively involved in the teaching-learning process " (p. 79). As a result of this study, it is disclosed that the use of the recreational activities allowed the study group to share interests, concerns, and responsibilities, favoring the assimilation of knowledge and its production (Pandiela, Nuñez, and Macías, 1996, p. 84).

2. Materials and methods

The research is quantitative and quasi-experimental. It was held in the Career of Pedagogy of Experimental Sciences, Chemistry and Biology of the Central University of Ecuador. The population consisted of first-semester students, corresponding to 35 students from the B-parallel (control group) and 43 students from the C-parallel (experimental group) to which playful strategies for nomenclature learning were applied. The following hypotheses were raised:

H_0: Playful strategies do not have a significant impact on academic performance related to inorganic chemical nomenclature.

H_1: Playful strategies have a significant impact on the academic performance related to inorganic chemical nomenclature.

The selection of the parallels was based on the similarity of conditions: evening study, teacher and number of students. The recreational activities were applied as strategies to reinforce the contents of unit IV corresponding to the bases of inorganic chemical nomenclature. The contents were developed in three stages:

- Chemical symbols and valences
- Function oxides; basic, acidic, neutral and compounds
- Hydroxides, hydrides and acids

At the conclusion of each stage, group games were applied on the basis of competence dynamics and using online questionnaires. 5 evaluations were carried out; the first corresponding to the pre-test (diagnostic test), three evaluations related to each of the stages and a final evaluation corresponding to the post test (unit test).

3. Results and discussion

Based on the results obtained with the application of the pre-test, parallel C was selected as an experimental group and the parallel C as the control group. Parallel B obtained a $\bar{x}$ of 8.70 and parallel C a $\bar{x}$ of 7.03. Having parallel C the lowest mean, it was intended to verify the impact of recreational strategies on the academic performance.

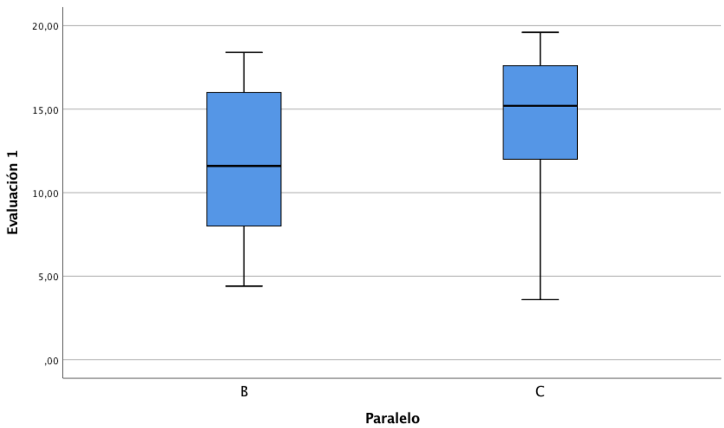

Figure 2. Box plot and whiskers with x = 12.09 parallel B, and x = 13.91 parallel C in the evaluation 1.

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Once the Kolmogorov-Smirnov normality test was applied, the t-test was performed for independent samples, matching variances were assumed for each of the three evaluations. The bilateral significance value for evaluation 1 is 0.037. Based on this value being less than 0.05, it is inferred that there is a significant difference between the scores obtained in evaluation 1 of the control and experimental groups, whose mean difference is shown in Figure 2, control group (11.79) and experimental group (14.20).

With respect to the statistical results of evaluations 2 and 3, the value of bilateral significance is 0.10 and 0.45, respectively. These values exceed 0.05, consequently it is deduced that there is no significant difference between the performance of the control and the experimental group. Although these differences are not statistically significant, the experimental group shows a better performance (See Figure 1). This diversity of the results is consistent with the academic performance variable, since it is multifactorial in nature as stated by Garbanzo (2007):

> Since the academic performance is multi-causal, it relates a huge explanatory capacity to the different factors and temporal spaces involved in the learning process. There are different aspects that are associated with the academic performance, including internal and external components to the individual, which can be social, cognitive, and emotional (p. 47).

The factors that may have affected academic performance related to the results of evaluations 2 and 3 are linked to the initial familiarization of the nomenclature standards, the persistence of prejudice over the degree of difficulty along with problems in the family and social environment that each student may face.

Evaluation	Control group $\bar{x}$	Experimental group $\bar{x}$
E. 1	11.79	14.20
E. 2	12.09	13.91
E. 3	13.28	14.04

Table 1. Means of the evaluation of the experimental and control groups

In order to verify whether playful activities contributed to improving the performance conditions of the experimental group, the correlational t-test was applied once normality was verified through the Kolmogorov-Smirnov test. The results can be observed in Table 2. The value of bilateral significance obtained was 0.00 and since this value is lower than 0.05 it is shown that there is a significant difference between the pre-test and the post-test, i.e., it has gone from a score of 7.03 in the initial test to a score of 14.51 in the final test. When comparing the calculated t values (2,704) with tabular t (-14,202) as shown in Figure 3, the calculated t-value falls outside the acceptance zone of the null hypothesis, therefore H_0 is rejected and H_1 is accepted, i.e., play strategies do affect significantly in the academic performance related to inorganic chemical nomenclature.

Test of paired samples									
		Paired differences							
					95% of confidence interval of the difference				
		Mean	Desv. Desviation	Desv. Average error	Inferior	Superior	t	gl	Sig. (bilateral)
Par 1	Diagnose evaluation - evaluation 4(Unit test)	-7.70615	3.38865	0.54262	-8.80463	-6.60768	-14.202	38	0,.000

Table 2. Test of paired sampled of parallel C

Note: A significance of 0.000 is observed, indicating a significant difference in the beginning of the course and its completion in terms of the parallel C.

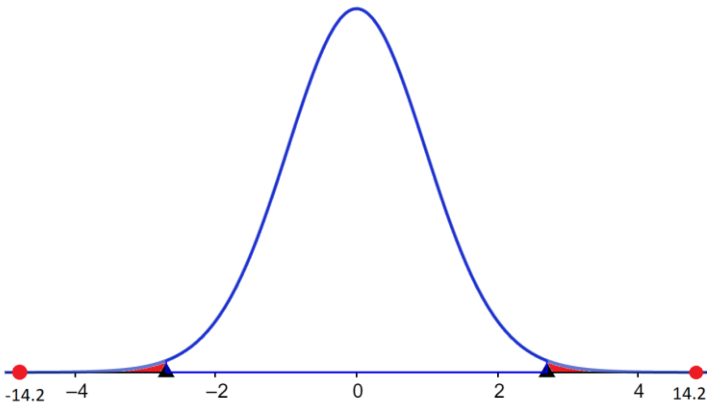

Figure 3. Hypothesis test

In order to verify whether playful activities contributed to improving the performance conditions of the experimental group, the correlational t-test was applied once normality was verified through the Kolmogorov-Smirnov test. The results of this can be observed in Table 2. The value of bilateral significance obtained was 0.00, and since this value is less than 0.05 it is shown that there is a significant difference between the pre-test and post-test, i.e., it has gone from a score of 7.03 in the initial test to a score of 14.51 in the final test. When comparing the calculated t values (2,704) with tabular t (-14,202) as shown in Figure 3, the calculated t-value is outside the acceptance zone of the null hypothesis, therefore H_0 is rejected and H_1 is accepted, i.e., playful strategies affect significantly the academic performance related to inorganic chemical nomenclature.

It is worth noting that applying the correlational t-test to the control group also shows improvement in the academic performance. This difference is not as marked as in the experimental group, as the control group increased by an average of 4.51 points while the experimental group increased by 7.48 points.

The result obtained between the pre-test and post-test of the experimental group is consistent with the results of similar studies that applied playful methodologies as well as Garza (2014), when implementing bingo as a methodological strategy, obtaining a value of bilateral significance lower than 0.05 (p = 0.001), and in the same way Da Silva et al. (2018), when applying the interactive game Say My Name reached a bilateral significance value lower than 0.05 (p = 0,0001). In both cases, a significant difference is demonstrated, i.e., the experimental group performed better than the control group.

It is important to note that in this research the experimental group started under conditions of lower performance (x = 7.03) compared to that of the control group (x = 8.70), and yet in the post test the experimental group exceeded the mean of the control group. This is consistent with Garza's experience (2014), demonstrating that playful strategies can improve the group performance even under adverse initial conditions.

In addition to the positive quantitative results, several aspects related to the attitude and behavior of students during the development of recreational activities should be mentioned. For example, a better willingness was observed during class, dynamism, companionship, joy, participation, which can be summed up in a motivational word. In the face of strategies other than those normally employed in inorganic chemical nomenclature classes, not only improved student performance was obtained, but a relaxation attitude was achieved, which is much more beneficial for learning than the fear that the students from previous semesters experienced while studying chemical nomenclature.

4. Conclusions

H_0 is rejected and H_1H1 is accepted, which expressed: The incorporation of playful strategies into the teaching-learning process of the chemical inorganic nomenclature allows to improve the academic performance. This is demonstrated by the results of evaluation 1 when applying the student t-test for independent groups as well as the results of the correlational t-test application. The difference between academic performance means in assessments 2 and 3 without being statistically significant denotes better performance in the experimental group.

This experience of the application of playful activities can be projected to other topics that also pose a challenge for students. Themes such as, periodic properties, electronic configuration and chemical quantities can be developed through playful strategies. The results obtained in this research could be improved with the incorporation of ICTs into playful strategies.

Playful teaching strategy is a positive experience even in adults as it generates a proactive environment, promotes creativity, teamwork and improves the willingness towards topics such as inorganic chemical nomenclature which is considered tedious. Therefore, this strategy should be incorporated into educational practice in higher education institutions as age is not a limit to developing learning processes through playful activities.

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