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INTERNATIONAL JOURNAL OF CURRENT RESEARCH

International Journal of Current Research
Vol. 12, Issue, 11, pp.14571-14581, November, 2020

DOI: https://doi.org/10.24941/ijcr.39914.11.2020

ISSN: 0975-833X

RESEARCH ARTICLE

DIDACTIC GAME AS A NLEARNING AID TOOL OF REDOX PROCESS IN THE LEVEL OF HIGHER MIDDLE EDUCATION

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ARTICLE INFO

Article History:
Received 10th August, 2020
Received in revised form
17th September, 2020
Accepted 30th October, 2020
Published online 30th November, 2020

Key Words:
TCG, Didactic Strategy, Oxidation Reduction, Chemistry Game.

ABSTRACT

Chemistry teaching learning is considered as difficult and boring. The definition of play, based on authors such as Freud, Piaget and Vigotsky, is presented as a stimulating, pleasant and voluntary activity that in the student facilitates his learning and encompasses the different facets of his physical, psychic, social and emotional development.. The recreational aspect is to attract attention, impress sometimes, and create the opportunity to make scientifically reflect. This type of teaching materials is especially effective in showing us properties or characteristics of matter that are difficult to visualize due to their nanoscopic nature and that their understanding requires the development of abstract thinking. The playful didactic materials are cheap, and their use is feasible within the teaching classroom. A playful-didactic material as an assistant to teach the topic of oxidation-reduction at High School is presented. The game was designed under the Trading Card Game mode in which 2 students face each other to oxidize the opponent's gearboxes with the help of the cards. The didactic sequence for teaching the topic redox reactions is shown which includes the didactic game, the analysis and the results obtained.

Citation: ***Omar Martínez D., Adolfo Eduardo Obaya V., Martha P. Hernández, B.Rubén Gerardo Ponce P., Carlos Montaño, O. et al.*** **2020.** "Didactic game as a nlearning aid tool of redox process in the level of higher middle education.", *International Journal of Current Research*, 12, (11), 14571-14581.

INTRODUCTION

The Game as a Didactic Tool. Some Psychological and Pedagogical Considerations of the Game: The game as an aspect of human social behavior or as a recreational activity has been widely addressed by great thinkers and educators over time. In the field of human development in stages such as childhood and adolescence, play is an activity that goes beyond recreation, but is an important part of the optimal development of the individual both mentally, physically, and socially. The game as support material in teaching must be taken into consideration main references in the fields of human and pedagogical development, so it is essential to address the ideas and impressions of authors such as Vigotsky, Piaget and Freud.

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From Jean Piaget's point of view (1951) the game plays a fundamental role in the cognitive development of the child. The game is the main means of early childhood learning. Children gradually develop concepts of causal relationships, learn to discriminate (premises), to establish judgments, to imagine, to analyze, to synthesize, among other mental processes, through play (Antunes et al, 2012)(Moustakas and Tsakiris, 2018). Piaget thought that the type of game we play is evolving and changing depending on the cognitive development of the person, in this way we play more complex games as we grow cognitively (Michael and Chen, 2006). As can be seen, Piaget considers the game to be an indispensable activity for the cognitive development of the child and the adolescent. Sigmund Freud (1938) relates the game to the need for the satisfaction of instinctive impulses of an erotic or aggressive nature, with the need for expression and communication of their vital experiences and the emotions that accompany these experiences. The game helps man free himself from his conflicts and resolve them through the fiction provided by this activity (Santiago and

Reyes, 2007). Therefore, the playful activities that the child performs serve him in a symbolic way (Hasim, N.A.B. et al, 2020).

Freud points out that the game has 3 peculiarities:

It is based on the principle of pleasure; b) transforms the passive into active, as a result the child gains the experience of mastery of his traumatic experiences; c) satisfies the compulsion to repetition by learning that is achieved with it and by the pleasure derived from repetition itself (Minerva, 2002). Freud sees the game as a form of expression with an included learning and, in a way, as an emotional relief activity necessary for the healthy emotional development of the child and the adolescent.

Lev Semenovich Vigotsky (1996) stresses that the fundamental thing in the game is the social nature of the roles represented by the child, so the game is a social activity, in which thanks to cooperation with other children, roles or roles that are complementary to their own are acquired. From a psych pedagogical perspective, Vigotsky states that the game serves to approach the study from a historical-cultural perspective, taking into account our environment and being able to create from it a theory that reflects our reality for your best understanding.

Johan Huizinga approached the game from a cultural point of view. Huizinga, in his *work Homo Ludens (1972*) describes the role of the game in the development of culture in different societies, tribes, ethnicities, etc., without involving the biological function that the game entails. In general, Huizinga proposes the game as the means which by each person can live with other individuals, and through this activity players are cultured giving rise to society (civilization). A lot of thinkers, psychologists, educators, philosophers, and scientists have studied the game from different points of view, given it their own definitions, therefore they have also postulated their own theories around this phenomenon (Russell, J., 1999).

Theories about the Game

Cognitive Restructuring Theory: Jean Piaget in 1951 started from the game being a form of assimilation. From childhood and through the stage of concrete operational thinking, the child uses the game to adapt the facts of reality to schemes he already has. In addition, Piaget sees the game as a phenomenon that decreases in importance as the child acquires the intellectual abilities that allow him to understand reality. (Meneses and Monge, 2001). Piaget relates the game directly to the genesis of intelligence. The game is regulated by "assimilation", that is through the game the child adapts reality and facts to his possibilities and schemes, the images, symbols, and actions that are familiar and familiar to him. In addition, Piaget proposes that the game evolves and changes throughout the development depending on the cognitive structure, the concrete way of thinking of each evolutionary stage. Detects 4 main categories of game, with its own characteristics and functions specific to each stage of development.

***Functional play*:** involves activities that include both the actions that the child performs on his own body and on objects, characterized by absence of symbolism. They are actions that lack internal rules and are carried out for the pleasure of action alone, without there being a different objective than that of the action itself. This type of games be executed by children between 0 and 2 years during the sensorimotor development stage. Examples of these games are when children move their arms and legs, take the objects they take to their mouths, crawl, etc. *Symbolic game*: in these games predominates discovery, and therefore imagination. The important thing in this type of game is not things or objects but rather what the child can do with them, so the toy in this type of game would become any object that the child can transform with his imagination. These games are developed by children in the preoperative stage of thinking between the age of 2 and 7. Example of these games is to play with a branch thinking it's a sword, when kids think a big box can be a house or when girls imagine that their dolls are their friends or daughters, etc.

***Building games*:** these are all activities that involve handling objects with the intention of creating something. These games are present in the preoperative stage between the 2 and 7 years, in the stage of concrete operations between the 7 and 11 years, and the stage of formal operations from the age of 11 of children and adolescents. Examples of such games is to build sandcastles, build "buildings" or things with building blocks, stack pots and pans to build a "musical battery", etc.
Rule game: these games are constituted, as the name implies, by a set of rules and rules that each participant must know, assume and respect if they want to perform the activity without so much interference or obstacles. Here, the child initiates predominantly social forms of play in which he shares the task with others. These games are presented during the stages of concrete operations between the age of 7 and 11 as simple and simple rule sets, and in the stage of formal operations in children and adolescents from the age of 11 as complex rule games. Examples of these games are board games, role-playing games, strategy games, football, or any game that acronyms rules and rules (Alshammari, 2020).

Traiding Card Game: In a relatively recent time, he began a new mode of playing cards outside the traditional rules of the card game, giving a total twist to the classic deck, adding a real or fictional theme, powers to the cards, even exclusive designs or illustrations of the game, introducing a complex game strategy, and awakening the taste for interaction and collecting through the cards. This new mode is called Interchangeable Card Game or TCG (Traiding Card Game) (Martínez-Díaz, 2008). Each TCG presents a different theme, rules and characters, so millions of possible combinations can be made with the cards in the deck belonging to each game; so each player creates a unique strategy, both on the cards in their deck and on their style of play.

The first TCG in history was *Magic:* *The Gathering.* This game was created Richard Garfield (1993). This board game-loving teacher had an idea to publish a game he called originally *Roborally.* In collaboration with *Wizards of the Coast,* Garfield designed a simple-to-produce card game, the prototype of which was called Mana *Clash.* The game was released as *Magic: The Gathering.* The game was so successful that it remains in force to this day, producing new "expansions" (set of cards with a specific theme, parallel to the game with a particular strategy) and performing local and global tournaments, either in person or online over the internet.

There are currently a lot of commercial TCG's, with a number large of children and young players around the world. The themes of TCGs are very varied: whether it is Japanese anime and manga, books, free themes, movies, video games, etc. The rules of the game are particular to each of the games and their cards have different design and development dynamics characteristics (Van Rooij, 2007).

Identifying the Problem: The oxido-reduction process have represented a learning challenge for higher middle school students due to the complexity of the concepts related to this topic, in addition to the difficulty in understanding the nanoscopic processes (Obaya et al, 2019) in the field when it suffers a redox reaction coupled with the lack of auxiliary teaching material in the teaching-learning process of this topic.

General Objective: Help students at the upper middle level improve their level of understanding of the concepts and respective characteristics of oxidation and reduction processes through a didactic game specially designed for this purpose.

Hypothesis: The inclusion of a didactic game in the teaching-learning process of the topic Redox Reactions at the level of Higher Middle Education will improve the acquisition of meaningful learnings by students, as well as facilitate the understanding of the concepts and nanoscopic processes related to this type of reaction.

Description of the Investigation: This research was developed with the aim of developing a teaching game that supports the teaching of concepts related to redox reactions, as well as improves the significant learning of them by students. The first stage of the research identified the problem, in this case, the difficulty of understanding redox reactions and the concepts related to them by students at the Higher Middle Education level. Once the problem was identified, it defined how to address the resolution of the problem through a didactic game that was attractive to students at the high school level and in turn facilitated the teaching process learning of the topic addressed in the problem. The corresponding didactic game and a didactic sequence were designed (Obaya and Ponce, 2007))(Salazar R.E., et al, 2019)(Jaramillo A., et al, 2019) to be able to apply the game in a chemistry class in a high school group (Annex A). The results were analyzed to determine the effectiveness of the teaching game in the teaching-learning process, as well as to improve the teaching sequence and the game through feedback obtained by the students. The research was conducted under the type of case study. Research design has a qualitative approach.

Experimental Design: The experimental part of the research was conducted under an evaluative experimentation scheme between a test group and a control group (Pérez-Rivero et al, 2109) (Morales et al, 2020). The groups were selected at random and have the following characteristics:

***Pilot group*:** consisting of 25 students, 11 men and 14 women, between 16 and 19 years. The group belongs to the chemical III subject of the Naucalpan College of Sciences and Humanities (CCH). The group was enrolled with the number 514, so the test group will identify with this number.

***Control group*:** Consisting of 26 students, 12 men and 14 women between the ages of 16 and 19. The group belongs to the chemical iii subject of the CCH Naucalpan campus. The group was enrolled with the number 518, so the control group will identify with this number.

Both groups are similar since they have the same number of students and the proportion of men and women, it is also worth mentioning that both groups were under the instruction of the same teacher in the subject Chemistry III. To test the effectiveness of the game was designed. each study group had a 2-hour session that aimed to teach the topic of redox reactions using a scenario as a learning basis for concepts related to oxide-reduction reactions with the same objectives and learnings, as well as the same information and development structure that consisted of an oral presentation accompanied by a computer presentation, subsequently a learning reinforcement activity was carried out, and the closure of the class. The difference is that the teaching sequence for group 514 contains a playful teaching activity for the inclusion of the game in the learning teaching process; instead, for group 518, didactic playful activity is replaced by theoretical exercises in which the concepts of redox reactions learned in the session are applied. To obtain results on student learning and differentiate between the two groups, a 5-item test was applied at the end of the teaching sequence. Additionally, Group 514 answered a sixth item to learn about the opinion of the students regarding the game for the evaluation that was applied (Annex B) Since the results are based on open question answers, the analysis of the data will be based on the qualitative evaluation of the answers obtained from the study groups.

RESULTS AND ANALYSIS OF RESULTS

The Didactic Game: Design, Components and Accessories: The main element of this research is the development of a didactic game that allows meaningful learning by students for the topic of rust-reduction reactions for high school. The TCG format was chosen for the development of the didactic game in question, as it is a popular game format in large groups of teenagers, allows interaction between the players involved in the game, requires the development of a game strategy with some intellectual complexity appropriate to the age of the students, besides that it does not have a default game scheme so it allows the adaptation of the game rules that the developer wants include and give you a specific approach. (Annex C) https://drive.google.com/file/d/1G7nxrcoYBK2LgSzma_u2oqt0TpkUEj1n/view?usp=sharing. Taking advantage of the flexibility that the TCG format offers with respect to the inclusion or design of specific rules, the didactic game of this research was regulated to be as similar as possible to a redox reaction but adapted from a macroscopic point of view, playful and with certain faculties that chemistry does not allow in real life

The didactic game is designed to be played between 2 people who face each other through a deck of cards. It is the graphical and direct representation of redox reactions in the game, in which oxidizing and reducing substances interact in a process or transformation.

- When a real-life redox reaction is carried out, an electron exchange is carried out between the oxidizer and the reducer (the substance that oxidizes loses electrons and the substance being reduced gains those electrons); In the same way in the game an exchange of "electrons" takes place in which, the player whose metals oxidize, loses their electrons and the other player wins them. The game's "electrons" are represented by chips or small objects and are an important part of the rules because, they allow you to win the game; however they also allow visual display of the exchange of electrons that occurs on a nanoscopic scale in a real redox reaction.

- The rules of the game specify that to carry out an oxidation-reduction must be respected the stoichiometry indicated in the number of electrons that allows to exchange each card, this so that students become familiar with the swing of reactions by the method of exchange of electrons, which is the most common for redox reactions.
- Metals can have two or more oxidation states in nature, which in the game are represented as well. On the other hand, to reach the maximum states of oxidation, you must first go through the intermediate oxidation states as happens in nature, this in order for students to become familiar with each of the oxidation states of the most common metals and also be able to better understand the series of changes in substances when they suffer redox reactions.
- In-game companion cards not only allow you to modify the circumstances within the game or gain advantages over the opponent throughout the game, they also seek to challenge the conceptions previously built by students about concepts related to redox reactions.
- The board was designed in such a way that it allows the development of the game and contains elements that students relate to their scientific work within their academic training.

Figure 1. The image shows the main components of the didactic card game that was developed. At the top is the board made up of 12 squares. At the bottom are examples of designed cards: green "Reductor" cards, violet "Alchemy" cards, orange "Oxidant" cards, and blue "Science" cards

The rules of the game propose context and parameters to similar those given in an oxidation-reduction reaction, but the physical elements that make up the game also play an important role within the purposes of this research.

- The letters "Oxidant"" and "Reducer"": these cards represent some chemical entities that could intervene in a real redox reaction. With these cards players carry out redox reactions in the game to try to win the game as the goal is to oxidize the opponent's reducers to their maximum oxidation state; however, the cards not only allow to win the game but students know the chemical species that are generated in a redox reaction, the number of electrons that can exchange those chemical species, as well as some characteristics that allow to know better the different characteristics of each substance.
- "Science" letters: These cards are inspired by laws, phenomena and scientific facts that surround us or are part of the student's scientific learning. With these cards, players can gain an advantage in the game but at the same time have the function of students knowing these phenomena, facts and scientific laws, their relationship with the everyday world and the scientific work.
- The letters "Alchemy": These cards are inspired by false beliefs that were held in ancient times about scientific facts and alternative conceptions that students still have today. These cards allow you to gain advantages within the game or try to decrease the effect of the opponent's cards; however, the purpose for which they were included in the game is to confront students with their own alternative conceptions, and that under the guidance of the teacher they can change them within a more appropriate scientific perception.
- The game board: it is designed in 12 squares that are divided into five main zones that allow the development of the game (Annex C) https://drive.google.com/file/d/1G7nxrcoYBK2LgSzma_u2oqt0TpkUEj1n/view?usp=sharing.
- Each zone has a name related to science, reactions redox and the role they play in the game. The "Warehouse" area of the board is the one that contains the cards of the deck that is used in the game; the "Labs" area allows you to play the cards necessary to be able to carry out the redox reactions necessary to win; the areas "Anode" and "Cathode" represent the electrodes of an electrochemical cell and are responsible for containing the electrons that we initially have and those that we gain by oxidizing the opponent's reducers respectively; the "Reactor" boxes contain the reducers in the different oxidation states, which will be shown according to the oxidations they suffer; Finally, the "Waste Container" box will be used to place cards that have already been used throughout the game.
- "Electrons": Objects are used within the game to represent the electrons that are exchanged when carrying out a redox reaction. There are no specific tokens to represent them, but any small object at hand can be used to physically represent them as tokens, coins, clips, paper balls, beans, etc. They are important within the game because they do not allow to win the game by winning the electrons of the opponent's "Ado"; but the real teaching importance is that students always take into account that a redox reaction involves an exchange of electrons and that they conceive them as particles present in the matter.

Together, the physical elements and conceptual elements of the game combine to achieve the goal of facilitating learning about redox reactions (Annex D) https:// drive.google.com/file/d/1G7nxrcoYBK2LgSzma_u2oqt0TpkUEj1n/view?usp=sharing

Results obtained in the Evaluation of the Application of the Game: The application of the game was carried out in a pilot group, to subsequently do a comparative analysis with a control group and in this way determine whether the game an effect had on the learning teaching process or not. For carrying out the comparative analysis between the two groups, the responses obtained by the students will be studied in the evaluations that were applied at the end of the respective teaching sequences. It should be mentioned that the analysis will be done for each group and specifying the results by sex (Annex B shows the applied evaluation).

Analysis of the Results obtained In the Evaluation of Groups 514 And 518: A comparison is presented between the two groups for each question, into order know the differences between the pilot group and the control group (Hernández et al, 2020).

Analysis of the Results of the First Item of The Evaluation: First, they do the analysis of their conceptions about the main terms of the topic, which are oxidation and reduction. About these.

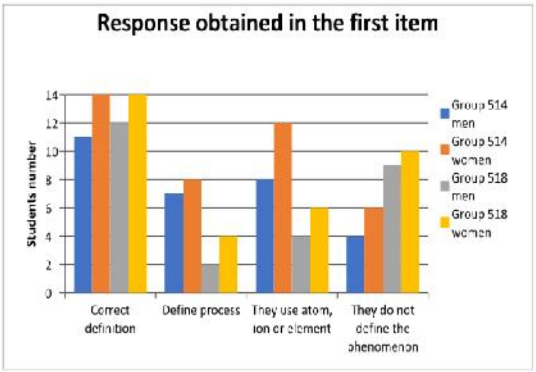

Figure 2

Figure 2: Bar chart representing the results of the first item in the evaluation. In this way you can easily observe the advantage of the students of group 514 over group 518, in the construction of theoretical concepts. As you can see, 100% of men and women in both groups conceive of oxidation as the loss or donation of electrons (in any case, we are talking about a decrease in the number of electrons), which is a correct conception; however, there is a difference in the concepts that students use to define oxidation in their own words. It should be clarified that although oxidation is not an isolated or independent process of reduction, in this case it is separated to know if students can recognize the difference between the two. First, attention is focused on the nature that students assign to the phenomenon they are defining. Figure 2 shows that 60% of the group in group 514 use the concept of "process" or "chemical change" to define oxidation, representing 63.63% of men and 57.14% of women. On the other hand, group 518 has lower figures than those presented by the pilot group, only 26.92% of the group define oxidation as a "process" or "chemical change", representing 36% of men and 28.57% of the women in the group. The figures indicate that the number of students who define oxidation more specifically in their nature of chemical change is practically doubled in the group that used the game compared to the group that did not use the game with a difference of 114.29%, this indicates that didactic play can help improve the cognitive construction of concepts related to redox reactions, as students who used the game built broader, complex, and more accurate definitions than students who did not use the game. On the other hand, the results show that 80% of the total group 514 used the words "atom", "ion" and/or "element" to indicate where the oxidation process takes place, representing 72.73% of men and 85.71% of women. By contrast, only 38.46% of group 518 specified that oxidation was carried out in "atoms", "ions" and/or "elements", representing only 33.33% of men and 42.86% of women. Again, there is a trend in which the number of students who specify and complement their response doubles if they use didactic play with a difference of 100%, compared to students who specify and complement their response but do not use didactic play; this confirms that didactic play allows students to improve the cognitive construction of their concepts. Finally, there is a 90% increase in the number of students in group 518 who do not define a nature for oxidation compared to those in group 514. In group 514, 40% of the group meet this condition, representing 36.36% of men and 42.86% of women in the group. In contrast to group 518, 73.07% of the group does not define oxidation in some general concept or category, representing 75% of men and 71.43% of women in the group.

Analysis of the Results of the Second Item of the Evaluation: A similar trend is obtained in the responses of the second reagent of the evaluation, which are presented in the following graph. Figure 3: Bar chart representing the results of the second item of the evaluation. In this way you can easily observe the advantage of the students of group 514 over group 518, in the construction of theoretical concepts. In the case of reduction, we observe a trend remarkably like that obtained in oxidation. 100% of students in groups 514 and 518 built a correct conception of reduction as the gain-acceptance of electrons; the difference lies, again, in the concepts on which they rely to complement their definition of reduction.

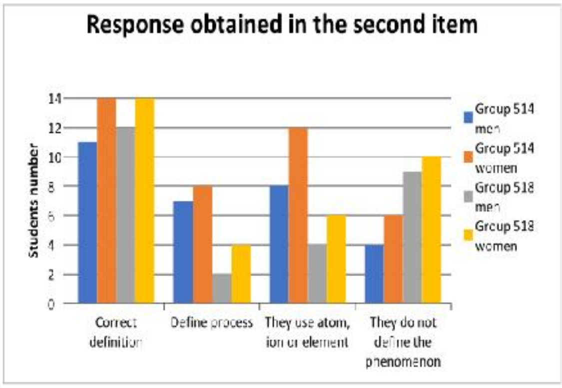

Figure 3.

Figure 3 shows the differences between the number of students who define reduction as a "process" or a "chemical change" and those who do not define a nature of the phenomenon. In group 514, 68% of the group's total defines the reduction as a "process" or "chemical change", which translates: 72.73% of men and 64.29% of the women in the group. By contrast, only 26.92% of the total group, i.e. 25% of men and 28.57% of women in group 518 define a nature of the phenomenon. This represents an increase of 142.86% favorable to group 514. Second, 76% of the total group 514 used the words "atom", "ion" and/or "element" to be more specific about where the reduction was carried out, which is equal to 72.73% of men and 78.57% of the women in the group. In the 518 group, smaller figures were obtained, with only 42.31% of the group's total meeting the condition under analysis, or 41.67% of men and 42.86% of women. As in the results of the previous reagent, there is a trend in which students who use the game are more specific in their conceptions than those who do not use the game, with a favorable difference of 72.72%. This again confirms that the game helps in the cognitive construction of more complex and specific concepts on the subject in question. Where a specific nature is not specified to the reduction process, there is a wide difference between the two groups. In group 514, 32% of the group meet this condition, representing 27.27% of men and 35.71% of women in the group. In group 518, 73.08% of the group meet this condition, representing 75% of men and 71.43% of women in the group. This represents a 137.5% increase in students in group 518 who meet this condition compared to students in group 514.

Analysis of the Results of the Third Item t of the Evaluation: By evaluating other aspects, the third reagent allows to know if students can recognize the main reagents of a redox reaction and relate them to their function within it. In this reagent we obtained that:

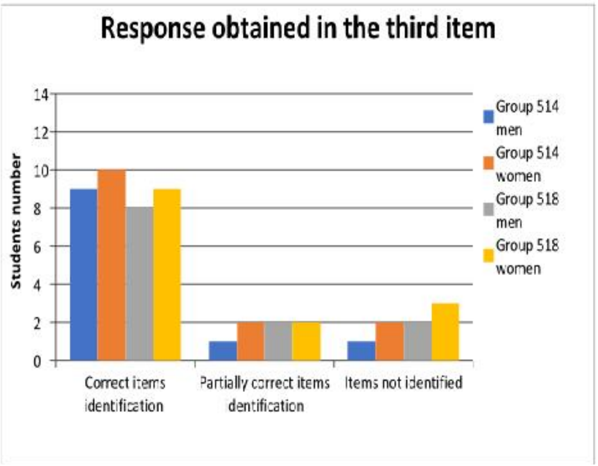

Figure 4.

Figure 4: Bar chart representing the results of the third item in the evaluation. In this way it can be observed that in the identification of the reagents participating in a redox reaction, the students of group 514 have a slight advantage over the students of group 518, however the difference is not significant between the two. In this case, as shown in Figure 4, there is no significant difference between the results of both groups. In group 514, 76% of the group managed to correctly respond to the reagent, represented by 81.82% of men and 71.43% of the women in the group; while in group 518, 65% of the group correctly answered this issue, represented by 66.67% of men and 64.29% of the women in the group. In this case, the difference between the two groups is only 11.76%. The same trend can be noticed in students who answered this reagent partially correctly since in group 514, 12% of the group responded in this way, representing 9.09% of men and 14.29% of women; by contrast, 15.38% of the 518 group met this condition, representing 16.67% of men and 14.27% of women. The difference between the two groups is only 33.33% where the increase occurs in group 518. Finally, students who were unable to meet what was required in this question are indicated in the following figures: by group 514, 12% of the group incorrectly responded to this reagent, representing 9.09% of men and 14.29% of women; in group 518, 19.23% of the group responded incorrectly, or 16.67% of men and 21.43% of women. The difference between the two groups is 66.66% where the increase is presented for group 518. The results show that, even though the students who used the didactic game performed better compared to their peers in the control group in identifying the reagents involved in redox reactions and their role in electronic exchange, it cannot be inferred that the game allows for better compression of redox reactions in this regard, since the difference between the two groups is minimal.

Analysis of the Results of the Fourth Item of the Evaluation: The fourth reagent of the evaluation is intended to know whether students can apply the concept of oxidation number with theoretical exercises of chemical equations representing redox reactions where they must assign oxidation numbers to each element involved in the reaction. The results obtained in the evaluation are shown in Figure 5.

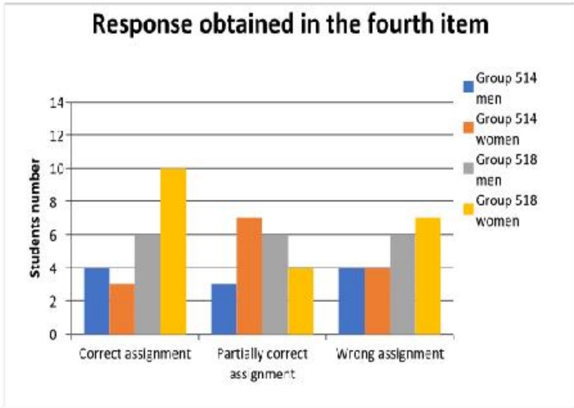

Figure 5.

Figure 5**:** Bar chart representing the results of the fourth item of the evaluation. In this way it can be observed that the students of group 514 have a lower performance compared to the students of group 518 in the assignment of oxidation numbers, which may be due to the absence of theoretical exercises in the didactic sequence of the pilot group. At this point the difference between the groups is significant and is more favorable to the control group. In group 514, only 28% of the group correctly answered the entire reagent, which is equal to 36.36% of men and 21.43% of women in the group; by contrast, 61.54% of the 518 group correctly responded to the entire reagent, or 50% of men and 71.43% of women. The difference between the two groups is 128.57% favorable to group 518. As for the students who obtained a partially correct response, there is a trend general of equality. In group 514, 40% of the group's total met this condition, representing 27.27% of the men and 50% of the women in the group. In group 518, 38.46% of the group's total responded partially correctly, representing 50% of the men and 28.57% of the women in the group. In this case, both groups obtained the same number of students who meet this condition. The trend observed in students who respond to this reagent incorrectly in its entirety or do not respond is significantly favorable to the control group. In group 514, 32% of the group's total meets this condition, representing 36.36% of men and 28.57% of women in the group. For his part, no student in group 518 fulfilled this condition. The difference in this case cannot be mathematically calculated by a percentage, however the evidence is clearly favorable to group 518. The

data shows that students in the control group have an advantage over students in the pilot group in assigning oxidation numbers. However, it should be mentioned that the students of the control group solved theoretical exercises on the assignment of oxidation numbers, while in the didactic sequence of the pilot group these theoretical exercises were omitted, which obviously represents a disadvantage for the pilot group. From this point of view, it is clear that it was a mistake to omit the theoretical exercises in the didactic sequence of the pilot group, since the didactic game alone does not allow meaningful learning of this concept, so a change in the proposed didactic sequence for the use of the game is suggested.

Analysis of the Results of the Fifth Item of the Evaluation: The fifth reagent of the evaluation is intended to apply together the concepts learned to solve the required exercise. The results obtained at this point, for both groups, are presented in Figure 6.

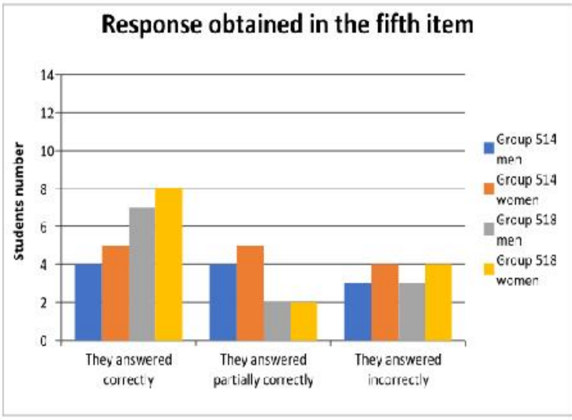

Figure 6.

Figure 6: Bar chart representing the results of the fifth item of the evaluation. This again shows a decrease in group 514 performance in contrast to group 518. The first point of analysis shows a favorable trend for the control group, as a greater number of students in group 518 correctly resolved the reagent in its entirety, compared to the students in group 514. In group 514, 36% of the group's total met this condition, representing 36.36% of men and 35.71% of women in the group. For their part, 57.69% of the total group 518 met this condition, i.e. 58.33% of men and 57.14% of women in the group. The difference between the two groups is 66.66% with an increase in group 518. The second point of analysis again shows a favorable trend towards group 518 compared to group 514. In group 514, 36% of the total group, i.e. 36.36% of men and 35.71% of the women in the group, responded partially correctly to this reagent. On the other hand, only 15.38% of the total group 518 responded partially correctly to this reagent, i.e. 16.67% of men and 14.29% of the women in the group. The difference between the two groups is 125% where the increase occurs in group 514.

The third point of analysis shows a trend of equality for both groups in the number of students who incorrectly answered the reagent. In group 514, 28% of the group's total, or 27.27% of men and 28.57% of the women in the group met this condition. Similarly, 26.92% of the total group 518 incorrectly responded to the reagent, i.e. 25% of the men and 28.57% of the women in the group. There is no difference between the groups at this point. A general favorable trend towards the control group is observed, however the difference is not as wide as that observed in the reactive room. Again, the disadvantage of the pilot group on the application of the concept of oxidation number in chemical equations becomes apparent, since the easiest way to identify the oxidizing agent and the reducing agent in a chemical equation is through the difference between the oxidation states of a chemical species in reagents and products. As in the previous reagent, a change in the content of the proposed didactic sequence is suggested in which theoretical exercises related to the assignment of oxidation numbers in chemical species are proposed.

Opinions and Suggestions Expressed by Group 514 Students Regarding the Game: The sixth reagent, included exclusively for the pilot group, is asked to express their opinion about the didactic game they tested to learn about their impression and the points that need to be improved in the playful experience. In this reagent, 4 men and 8 women expressed positive opinions towards the playful experience, in this regard students believe that the game is a fun experience and that it can help them learn better the topic of redox reactions, they also expressed that they felt relaxed and comfortable during the playful activity, as well as that it was an interesting activity to get out of the routine in the classroom. By contrast, 2 men and 2 women expressed negative opinions towards didactic play, they expressed that the game was too complicated, boring, some expressed that they felt confused during the activity or that they did not think it would help them better understand redox reactions. Finally, 5 men and 4 women gave answers expressing suggestions to improve the playful experience, some expressed that the activity lasted a short time and that it was necessary to extend the time, others expressed that the rules of the game were complicated and that they needed to be modified, others stated that the regulation was confusing and needed to be modified to make it easier to read and understand , and some expressed that playful activity needed to be repeated several times so that it could be understood and that it could meet its objective of assisting the learning of the subject.

Modifications to The Game Based on Students' Suggestions in The Sixth Reagent and The Results Obtained in The Evaluation: Considering the suggestions provided by the students of group 514 who tried the didactic game and the results obtained throughout the evaluation, the didactic game had some modifications:

- The graphical design of the regulation was modified to include images that would help students understand the rules of the game more easily and quickly.
- Some rules were changed to improve the dynamics of the game and thus easier the development of the game, so that the game can develop faster in case there is a restriction on the time of the activity.
- Reduced the amount of text contained on game cards, so that they contain only text related to their in-game utility, reducing confusion that extra text might cause.

- A change in the development of the proposed teaching sequence is suggested, as the time for the activity is short. It should be clarified that the teaching sequence used was designed in the manner indicated in Annex A due to restrictions on uptime that are allocated in teaching practice; however, it is suggested that playful activity be carried out in a consistent time of at least 30 minutes, and the game is always used later to the redox reactions class, as the teaching game is an auxiliary for learning.
- It is suggested that the game should always be applied later to the chair of the topic of redox reactions so that it fulfills its function as an auxiliary teaching material, even if the playful activity takes place in the same session in which you started the topic.
- It is suggested that theoretical class exercises continue to be applied on chemical equations involving redox reactions, as the results showed that the game is not able to replace the learning that theoretical exercises provide to the student.

Conclusion

A didactic game was designed, developed, and optimized to help improve the learning of upper middle-level students about oxide-reduction reactions. In addition, the game was tested within a didactic sequence applied to a pilot group of Chemistry III of the College of Sciences and Humanities to know the usefulness of the game within teaching practice through an evaluation. The data obtained from the evaluation were compared with results obtained in a control group with similar characteristics to the pilot group. Based on the objectives set out for the development of this work, the results obtained and the discussion of them are presented the corresponding conclusions.

- A didactic game was designed and developed as an assistant in the teaching-learning process of the topic of redox reactions. The created game has the Trading Card Game (TCG) format in which 2 students must face each other using game cards to beat their opponent. The game contains rules that suit you to try to make the game like a redox reaction, and in this way; it is a visual and practical helper.
- Playful activity was integrated into a didactic sequence designed and planned particularly to understand the concepts and phenomena that are part of redox reactions.
- The didactic game was applied in a pilot group of the subject of Chemistry III of the Naucalpan College of Sciences and Humanities through the corresponding teaching sequence. In addition, a didactic sequence was applied that did not incorporate the didactic game into a control group with similar characteristics to have a reference point and know the impact of the didactic game on the learning of the pilot group.
- An evaluation was subsequently applied in both groups to compare the results and know the effectiveness of the teaching game. The results indicated that:
- The pilot group's students had a better understanding of the theoretical concepts of redox reactions compared to students in the control group. Students in the control group build definitions that integrate a greater number of concepts and better specify the nature of changes in redox reactions, indicating that didactic play has a positive effect on cognitive concept building.
- Students in both groups obtained similar results in identifying reagents participating in a redox reaction and their role, indicating that the game does not have a significant impact on learning this aspect of oxide-reduction reactions.
- A utility of the game cannot be established with respect to oxidation numbers, because it cannot be accurately said whether the poor performance of the students in group 514 with respect to this concept is because of the game or by the omission of theoretical exercises in the didactic sequence. This indicates that the teaching game does not replace any activity within the teaching process, it is only an auxiliary. It also demonstrates that the theoretical exercises and examples prior to the application of the game are important in the teaching-learning process and to carry out the playful-didactic activity.
- The didactic game has a positive impact on learning about the recognition of the changes suffered by the reagents participating in a redox reaction, although it is not evident in the results of group 514 due to the deficiency presented in the allocation of oxidation states. It should be clarified that despite this deficiency, there is an increase in the number of students that can determine where the corresponding electron exchange takes place in the chemical equations proposed in the evaluation.
- The didactic game was optimized thanks to the feedback obtained in the evaluations, and the opinions and suggestions of the students who tested the game, with the aim that it is as effective as possible in the teaching practice in the real teaching classroom.
- The game partially fulfills its goal of improving the teaching-learning process for the subject that was designed, however it shows that teaching games are an attractive alternative to learning Higher Middle Level students.

REFERENCES

Piaget, J. 1951. *Play, dreams, and imitation in childhood*. New York: W.W. Norton &Company

Freud, S. 1938. Wit and its relation to the unconscious. In, *The basic writings of Sigmund Freud*. New York: Modern Library, 1938.

Antunes, M., Pacheco, M., Giovanela, M. 2012. Design and Implementation of an Educational Game for Teaching Chemistry in Higher Education. *Journal of Chemical Education*. 89, 517-521

Moustakas, L. and Tsakiris, I. 2018. Game as a learning tool in enviroment education. *International Journal of Innovation and Research in Educational Sciences*, 5, 6. 645-649.

Michael, D.R., and Chen, S. 2006. *Serious games: Games that educate, train, and inform*. Thomson course technology. 2006.

Santiago, A.; Reyes, L. 2007. *El juego como recurso didáctico de la capacitación*. Bachelor's thesis. UNAM, México.

Hasim, N.A.B., Karim, M.M.B.A., and Rahman, N.B.A. 2020. Aids in Physics: Design and development. *Momentum: Physics Education Journal*, 4 2. , 57-63

Minerva, C. 2002. *El juego como estrategia de aprendizaje en el aula*. Online document in PDF format extracted. Retrieved 31 July 2014 from:

http://www.saber.ula.ve/bitstream/123456789/17543/2/carmen_torres.pdf.

Vigotsky, L. 1996. *El desarrollo de los procesos psicológicos superiores*. Barcelona: Crítica

Huizinga, J. 1972. *Homo Ludens*. Alianza/Emecé. Madrid

Russell, J. 1999. Using games to teach chemistry-an annotated bibliography. *Journal of Chemical Education* 76, 4, 481-485

Meneses, M.; Monge, Ma. De los A. 2001. El juego en los niños: enfoque teórico. *Revista Educación*, 252. , 113-124

Alshammari, E. 2020. Implementing Educational Game in Pharmacy. *International Journal of Pharmaceutical Quality Assurance* 11 1. 148-153.

Martínez-Díaz, Y. 2008. *Propuesta gráfica aplicada en un Juego de Tarjetas Coleccionables Trading Card Game TCG. dirigida a niños para promover el gusto por el arte a través de las corrientes artísticas: El Renacimiento*. Bachelor's thesis. UNAM, México

Garfield, R. 1993. *Roborally*. In collaboration with *Wizards of the Coast Magic: The Gathering*

Van Rooij, R. 2007. *The 5/10 Method: A model for designing educational games*. Netherland: Utrecht University.

Obaya, A.V., Vargas-Rodríguez, Y.M., Giammatteo, L., Ruiz, C. 2019. The Role Of Educational Research In Teaching Chemistry. *International Journal of Development Research* Vol. 09, Issue, 01, pp.25253-25257

Obaya, A.V. and Ponce, R. 2007. La secuencia didáctica como herramienta del proceso enseñanza aprendizaje en el área de químico biológicas" *CONTACTOS. Revista de Educación en Ciencias Básicas e Ingeniería Universidad Autónoma Metropolitana-Iztapalapa*. 3ª. Época. No.63. 19-25

Salazar R.E., Obaya A., Giammatteo L., and Vargas-Rodríguez, Y,M.2019. Evaluating a didactic strategy to promote atomic models learning in High School students through Hake's method. *International Journal of Education and Research vol 7 No. 5 293-312*

Jaramillo A., Obaya A., Giammatteo L., and Vargas-Rodríguez Y., 2019. ADDIE, Instructional Design Based on Flipped Classroom for Teaching and Learning "From minerals to metals: Chemical Processes, usage and relevence" in a High School Chemistry course. *International Journal of Current Research vol 11 Issue 05 3993-3998.*

Perez-Rivero, M., Obaya, A.V., Giamatteo, L., Montaño-Osorio, C.,Vargas-Rodríguez, Y.M. Didactic Strategy for Learning and Teaching of Functional Groups in High School Chemistry. *Science Education International* 302. , 85-91

Morales, A., Obaya, A.V., Montaño, C., Vargas-Rodríguez, Y.M., 2020. Exploratory Assessment of Strategy for Learning Redox Reactions in High School. *Journal of International Education* Vol.8, No.1, 23-37

Hernández, B.P., Obaya, A. V., Montaño, O.C. Vargas-Rodríguez, Y.M. 2020. Didactic Strategy: Interactive Digital Board in Teaching Learning Heat Capacity for High School. *International Journal of Science and Research* Volume 9 Issue 10, 216-223.

Annex A. Structure of Didactic Sequence

<table>
<tr><td colspan="2">GROUP 514 DIDACTIC SEQUENCE
The sequence designed for study group 514 is presented, i.e. the experimental group in which the playful-didactic game designed in this research work was tested.
Subject: Redox reactions: basics</td><td>CLASS</td></tr>
<tr><td colspan="3">THEME OBJECTIVE: Introduce students to the topic of redox reactions.</td></tr>
<tr><td colspan="3">OBJECTIVE OF THE SUBTEMA:
Know and understand the concepts: oxidation, reduction, oxidizing agent, reducing agent, oxidation number.
Understand the processes represented in a chemical equation.
Correctly assign oxidation numbers.</td></tr>
<tr><td>LEARNINGS TO ACHIEVE:
-Explains that it is oxidation, reduction, oxidizing agent and reducing agent.
-Represents by means of equations the reduction reaction of a metal.
-Identifies a redox reaction by means of oxidation numbers.
-Balance equations to comply with the law of conservation of matter (Introduction to the subject for a later session).</td><td colspan="2">PREVIOUS KNOWLEDGE:
-Know and apply basic naming rules for inorganic compounds.
-Basic representation of chemical formulas of inorganic compounds.
-Know the particles that make up the atoms.
-Know the law of conservation of matter.</td></tr>
<tr><td colspan="3">A C T I V I TIES</td></tr>
</table>

	OPENING PHASE	

SOCIALIZATION OF OBJECTIVESTime: 5 min. / 5 min. Present the goals, learnings to be achieved and the agenda to students. Agenda: 1.- Evaluation and review of prior knowledge through open interrogation. 2.- Identify the topic of redox reactions through the study of obtaining lead from galena. 3.- Introduce students to the basics of redox reactions: oxidation, reduction, oxidizing agent and reducing agent. 4.- Teach and guide the student in the correct assignment of oxidation numbers. 5.- Couple activity: application of a didactic game to reinforce the concepts learned in class. 6.- Final individual activity: evaluation of acquired knowledge and teaching play. 7.- Impressions about the topic (doubts, observations, and ideas of students about redox reactions and didactic play).	*Technical:* *MATERIAL:* *Recommendations:*
1.- Evaluation of previous knowledge. Time: 5 min. / 5 min. ***Purpose of the*** activity: Evaluate and review the actual prior knowledge of the students to adapt the pedagogical intervention to the level of learning of the students; in addition to contextualizing them in the topic to be addressed in the class.	*TECHNICAL:* Oralpre guntas / brainstorming of students. *MATERIAL:* *RECOMMENDATIONS*:
2.- Identify the topic of redox reactions through the study of obtaining lead from galena. TIME 10 min. / 15 min. ***Purpose of the activity:*** Contextualize the student in the topic of redox reactions from the case of obtaining lead through the oxidation of galena (PbS) and the subsequent reduction of lead oxide (II) (PbO). This case will serve as a starting point for detonating students' questions about this process that will lead them to the topic of redox reactions.	*TECHNICAL:* Oral presentation *MATERIAL:* Computer (Power Point Presentation) / Blackboard *RECOMMENDATIONS:* Accompany the presentation with questions that trigger the reasoning, by the students, on the subject.

	DEVELOPMENT PHASE	

3.- Introduce students to the basics of redox reactions: oxidation, reduction, oxidizing agent and reducing agent. TIME 30 min. / 45 min. ***Purpose of the*** activity: Explain to students the chemical changes at the nanoscopic level that occur in redox reactions; also teach them to represent and interpret chemical equations.	*TECHNICAL:* Oral presentation *MATERIAL:* Computer (Power Point Presentation)/ Blackboard *RECOMMENDATIONS:* Accompany the presentation with analogies and symbolic representations.
4.- Teach and guide the student in the correct assignment of oxidation numbers. TIME 20 min. / 65 min. ***Purpose of activity:*** Learn how to assign oxidation numbers in each of the elements involved in a redox reaction with the help of the algebraic rules of the Kauffman method. This activity will be introductory for balancing equations by oxidation state method.	*TECHNICAL:* Oral Presentation / Paper Exercises *MATERIAL:* Paper / Pen / Board *RECOMMENDATIONS:* Practicing rules in exercises will help the student fulfill the stated purpose.
5.- Activity in pairs: Application of a didactic game to reinforce the concepts learned in class. TIME 35 min. / 100 min. ***Purpose of the*** activity: For students to reaffirm their learning through a card game specially designed for the topic of redox reactions	*TECHNICAL:* Playful-didactic activity. *MATERIAL:* Cards / board / clips. *RECOMMENDATIONS:* Continuous monitoring of the teacher towards students in the development of the activity.
CLOSING PHASE	
6.- Final individual activity: evaluation of acquired knowledge and teaching play. TIme 15 min. / 115 min. ***Purpose of the*** activity: The knowledge acquired by the student will be evaluated through an	*TECHNICAL:* Written questionnaire. *MATERIAL:* Paper / Pen.

open question questionnaire. In addition, the student will evaluate the didactic game implemented by the teacher to collect opinions that help improve the game.	*Recommendations:*
7.- Impressions about the topic (doubts, observations, and ideas of students about redox reactions). TIME 5 min. / 120 min. ***Purpose of the*** activity: Time for students to express doubts or questions that can be investigated for the extraclass activity.	*TECHNICAL:* Questions/ brainstorming. *MATERIAL:* *RECOMMENDATIONS:* That the teacher use the questions that the same students ask to develop their research capacity.

Annex B. Evaluation Instrument for Results

The evaluation activity consisted of 5 items of which 3 were open questions and 2 consisted of exercises to apply the concepts learned in the teaching sequence. The sixth item was only applied for group 514 and was a feedback activity for students to improve the game.

Evaluation activity: Redox reactions

Read the instructions carefully: Answer the following questions in print and readable. Before answering questions, write down your full name and age at the top right of the sheet. When you finish solving the questionnaire, give it to the teacher. If you require more space to answer any questions, use the back of the Lucky blade!

- What is oxidation?
- What is reduction?
- In a redox reaction What happens to the oxidizing agent and the reducing agent?

- Assign the corresponding oxidation numbers of each element in the following compounds or reactions.

$2Cu + 2HNO_3 \quad 2CuNO_3 + H_2$

$2Al_2O_3 \quad 2Al + 3O_2$

- Of the 2 reactions listed in point 4, indicate which elements are oxidizing and which are being reduced.
- Write down how you felt during the in-game activity that took place in the class, as well as give your opinion and suggestions that can lead to improved play.

Annex C. Regulations of The Didactic Game

https://drive.google.com/file/d/1N_Yjp7z_3sq5lHdM0ZZ129luJaqiRqP9/view?usp=sharing

Annex D. Game Board and Decks Created for The Didactic Game. Steel Deck

https://drive.google.com/file/d/1N_Yjp7z_3sq5lHdM0ZZ129luJaqiRqP9/view?usp=sharing

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