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# The use of the didactic game "Guess Which?" as an event conducive to revisiting the error and raising awareness of organic chemistry concepts

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## ABSTRACT

In the interest of stimulating alternatives that counteract a teaching reality that leads Brazilian students, especially from public schools, to a lack of knowledge, Teachers College-Columbia University, in partnership with the Lemann Foundation, invested in strengthening the performance of Brazilian researchers, launching the notice "Researching Teaching and Learning: An Equity Imperative for Teacher Education". Contemplated in this notice, the Center for Investigations, Development and Study of Games in Education (NIDEJE) proposed to investigate how situations of discursive interaction provided using didactic games can be a factor of change in a teaching scenario, in which doubts, and errors are disregarded as opportunities for (re)signifying understandings. For this, the didactic game "Guess Which?" was applied in a public high school in the Pernambuco countryside, the first application of the didactic game with the exclusive participation of students who had difficulties in the content of organic functions and the second application with groups composed with some students who had difficulties and others who had better academic performance in the chemistry subject. The externalization of students' thoughts in their planning, discussions, and reflections that occurred during the game were recorded and later analyzed through microgenetic analysis. In this way, we analyze the discursive interactions provided by the zones of imminent development (ZID) formed in the groups and the implication of the constitutions of the groups in the dynamics of this ZID and in the students' awareness of their mistakes being revisited. Finally, we observe that the didactic game can involve and motivate students to a collective action, which encourages them to make justified choices. Thus, they provide a favorable environment for reflections on the application of concepts and awareness not only about them, but also about their mistakes and difficulties, which helps them to overcome them. The quality of these reflections is favored by the ZID formed by students and professors by promoting the review of positions, justifications and resignifying concepts and procedures. We also emphasize that the role of the teacher as an interlocutor in the ZID grows in relevance when the constitution of groups is formed exclusively by students with more difficulty in the content.

**KEYWORDS**: Didactic game. Error. Awareness. ZID.

## INTRODUCTION

According to the Basic Education Assessment Department (DAEB), Brazil's results in the Programme for International Student Assessment (PISA) 2018 revealed that 55% of Brazilian students remain below the level considered to be basic in science, while less than 20% have surpassed this mark (BRASIL, 2019). The basic level refers to the students' ability to recognize the correct explanation for scientific phenomena, being able to use this knowledge to identify the validity of a conclusion referring to a simple problem, based on the provided data. This reality becomes serious, as it reveals that Brazil has had a situation of stagnation, since the last international assessments, without clear prospects for change. The report also reveals the strong impact caused by the socioeconomic status of students, especially in the results related to public schools in the northeast region and rural areas (OECD, 2019), which reflects the inequality of opportunities and perspectives historically constituted in Brazil, which it may be associated with the inflexibility of the teaching approach.

Seeking to encourage alternatives that counteract this reality and recognizing the importance of producing knowledge about didactics for the improvement of Brazilian education, College-Columbia University Teachers, in partnership with the Lemann Foundation, decided to invest in strengthening the performance of Brazilian researchers in this issue by launching the edict entitled “Researching Teaching and Learning: An Equity Imperative for Teacher Education”. The Center for Research, Development and Study of Games in Education (NIDEJE) was one of the eight groups covered in Brazil. In this research, the group seeks to investigate how discursive interaction situations provided by the use of educational games can be a factor in changing a teaching scenario, in which doubts and errors are disregarded as opportunities for (re)signifying understandings. Research demonstrates that social interactions can encourage students to think about their own understandings, cultivating a process by which they engage in learning and thinking about their mistakes. In this study, we consider that overcoming errors can occur through awareness (LEONTIEV, 1978, 2012) and therefore we sought to investigate: how do high school students learn concepts of organic function from the interaction with their own mistakes in the process of playing and in becoming aware of them? To answer this problem and returning to the theoretical framework adopted here, we take into account the Zone of Imminent Development (ZID) model, which will be discussed further ahead.

## THE HISTORICAL-CULTURAL PSYCHOLOGY AND ITS CONTRIBUTIONS IN THE EDUCATIONAL CONTEXT

The Historical-Cultural Psychology (HCP) is based on the works of Lev Semionovitch Vygotsky, and its fundamental principle is the understanding of human development based on historical-cultural issues. However, it also encompasses works by many other contemporary theorists and after Vygotsky, such as: Leontiev, Luria, Galperin, Elkonim, Davidov, among others (DUARTE, 2007). The HCP assumes the human psyche as the subjective image of the objective world and its development takes place through culture, through the objectifications and appropriations performed by individuals in socio-historical

conditions. This formed image may be closer or farther from reality, depending on the psychic instruments that individuals have.

To better understand these processes, two important concepts emerge in Vygotsky theory: Elementary Mental Functions (EMF) and Higher Mental Functions (HMF). These mental functions, elementary or higher, work in unity in order to make reality intelligible for human beings, thus forming images of that reality (MESSEDER NETO, 2016).

Both functions do not develop independently, but work together in the individual. According to Martins (2013), it is about recognizing that the substratum of all higher education is the lower one, which is denied and conserved in it, that is, transformed by the continuous confrontation between natural and cultural expressions.

Corroborating this idea, Messeder Neto (2016) points out that the entire learning process is culturally influenced by the context in which we live, however, for the development of the HMF it is necessary to expand this context by promoting the intentional appropriation of the human cultural legacy.

In order to understand the development of these processes and with the perspective that they are internalized in a sociocultural context through relationships, mediated by instruments and symbolic systems, of individuals with the other and with the world, Vygotsky attaches special importance to learning, considering it necessary in the development of human characteristics that are not innate, but historically formed. Thus, it can be said that learning is not, in itself, development, but a correct organization of the child's learning leads to mental development, activates a whole group of developmental processes, and this activation could not take place without learning (VYGOTSKY, 2009).

If learning precedes development, the school cannot be limited to what the child already knows how to do alone, it is necessary to develop what is potential in the child. It is necessary to focus on what is maturing and not on what is already mature (MESSEDER NETO; MORADILLO, 2017). For Vygotsky (2009), what is maturing in children is what they cannot do alone, but they can do in collaboration with an adult. And what children can do in collaboration with the more capable adult or peer corresponds to the Zone of Imminent Development (ZID). The term imminent, according to Prestes (2012), expresses the possibilities of development, as well as in its etymology, it refers to situations that may eventually happen, but may also not materialize if cultural factors and collaborations do not act on the individual.

The introspection process provided by the ZID causes a phenomenon called awareness, which is characterized as a metacognitive process, since when confronted in the interaction with peers, students think about their action. That is, the students internalize their actions on the object of study to the intellectual plan, relating it both to the experience itself and to the previously constituted understandings and contexts, thus providing a learning situation in which their own actions and interactions become the focus of the process.

## ACTIVITY, MOTIVATION AND CONSCIENCE

How the human being transforms objective reality into subjective meaning is discussed by Leontiev (1978) and it is called internalization. In other words, internalization consists of the passage of socially constituted external sensory practices and experiences into internal activity, in such a way that this process allows for a specific form of psychic reflection of reality, which is consciousness.

Consciousness, as in Leontiev's conception (1978), can be understood as the subjective product of the activity of human beings in interaction with other human being and with objects; in this sense, activity constitutes the substance of consciousness and is essential to study it.

> [...] it consists, therefore, in finding the structure of human activity engendered by concrete historical conditions, then, starting from this structure, to highlight the psychological particularities of the structure of the consciousness of the human being (LEONTIEV, 1978, p. 100).

In this sense, Perraudeau (2009) points out that accomplishing a task does not necessarily correspond to understanding the knowledge and/or actions involved. Comprehension requires lucidity, a domain not only of knowledge itself, but also of mental strategies to mobilize and articulate it in practice, and highlights that the verbalization of procedures enables students to reflect on cognition.

In order to understand the concept of consciousness, Leontiev claims that it is necessary to comprehend the concepts of activity, motive and motivation. From the perspective of Historical-Cultural Psychology, activity is a process that emerges in the human being-world mediation, aimed at satisfying a special, although not necessarily biological, need of human being (LEONTIEV, 1978, 2012).

Leontiev also emphasizes that reasons can be characterized as “just understandable reasons” and “really effective reasons”. The reason is said to be understandable when the individual understands the importance of performing the activity, but even so, this understanding is not enough for him/her to perform it. On the other hand, the really effective motive mobilizes the subject to carry out the activity.

In the same way that through teaching action it is possible to transform action into activity, it is also possible to revert the just understandable motivation into a really effective motivation.

The teacher's didactic actions should then be aimed at reverting actions into activities and promoting effective and really understandable reasons for learners (LEONTIEV, 2012), but for this, awareness of the actions, their context, their objective and their implications must be encouraged. Only in this way it will be possible to potentialize the engagement and self-regulation of the student's action of learning.

## THE GAME IN THE EDUCATION CONTEXT

For a long time, students were solely responsible for the failure and the difficulties in the learning process, as learning was related to the mere repetition of content. However, for some years now, this failure can also be associated with

the way in which the teacher plans activities and performs them with the students. (SOARES, 2013).

Burkley and Doyle (2014), in their article *Gamification and student motivation*, report how the gamification of learning is consistent with the engagement and motivation of students in the action of learning. In other words, by using game design elements in educational environments it is possible to favor a more active posture of the student, and thus expand the understanding of concepts and procedures, apart from providing situations of autonomy and collaborative constructions of meanings.

Kishimoto (2011), a Brazilian reference in the use of games in education, defends the action of playing at school, as he believes that in the game the student is free from judgments and pressures, characteristics that are rooted in summative or classifying evaluations. With this, in the game it is possible to emerge a climate of reflection, creativity and free expression, configuring a more potentiating environment for the students' protagonism in the learning process.

However, it is essential that researchers in the area pay attention to the need for further theoretical/epistemological deepening of such proposals and in the analysis of their potential contributions. Soares (2016) highlights, after systematized analysis of the chemistry didactic games produced in Brazil, the importance of seeking theoretical bases or discussions on the playful and educational functions in games. Besides to guiding them by a learning theory so that works are not restricted to “experience reports without adequate discussion” (SOARES, 2016, p. 12).

One of the great challenges in teaching and learning actions in the use of didactic games is the fact that it does not always guide the proposals and conduct of didactic activities in theoretical-methodological frameworks. Some theorists and educators, however, have brought important contributions to reflection in the light of learning theories in the orientation of didactic situations present in the experience of didactic games. One of these perspectives is the one that adopts the Historical Cultural Psychology (HCP) in its studies.

## POTENTIAL CONTRIBUTIONS OF THE DIDACTIC GAME FROM THE PERSPECTIVE OF HISTORICAL-CULTURAL PSYCHOLOGY (HCP)

The recreational activity, in its essence and especially how it is performed by human beings, has a social nature, because it emerges, it is transmitted and I is (re)experienced as part of a culture (HUIZINGA, 2014). In this way, in a Historical-Cultural Perspective, at the same time that it enables the socialization of actions, it provides the internalization of shared meanings, that is, a social construction of understandings.

The use of playful activities in chemistry classes should intentionally propose situations that favor learning, which means mediating the cultural elements that need to be assimilated by individuals. For Vygotsky (2009), the elements that need to be assimilated at school are the classical knowledge that are presented through scientific knowledge.



The playful, therefore, is a way of transmitting knowledge to the student, which internalizes the socially and the culturally constituted meanings (MESSEDER

NETO, 2016). It must be thought of in a systematized way, developing social and cultural aspects, helping the student in the appropriation of chemical knowledge.

It is noteworthy that the activities with games should not have the intention of making easy concepts and/or procedures that cannot be easy; because the learning process requires effort, dedication and these characteristics cannot be suppressed (MESSEDER NETO, 2016; ANJOS; GUIMARÃES, 2017).

In this way, it is understood that learning requires an effort that leads to reasoning, reflection, critical and creative thinking, and, consequently, to the construction of knowledge.

Thus, the game can enter the classroom as a psychological rescue for the students, so as not to abandon them to their fate. It needs to be inserted in classroom activities as a shortcut, so that the student, in a short space of time and with the help of the teacher, can rescue what was not developed previously and advance through the study to a more developed psychological level of thinking, enabling the understanding of scientific concepts. In this regard, Messeder Neto and Moradillo (2017) state that the game is a starting point and not an end. We should start with the game, but we should arrive to the main study activity.

Freitas (2019) also highlights the role of recursion in the teaching and learning process provided by the use of the didactic game, based on the HCP perspective. The author points out that the revisiting of challenges similar to those already experienced through the socialization of responses enables students to carry out an imitation process that, according to the HCP, is a fundamental step in the development of new learning.

In addition, the game at HCP acts in the child's zone of proximal development, boosting its development (VYGOTSKY, 2007). When playing, at any age, the individual mobilizes their HMF, being able to effectively contribute to attention (through concentration and focusing), voluntary memory through effort, imagination, abstraction through abstract thinking, discursive interaction between the pairs (players) and with the teacher. As well as working with feelings and emotions that aim to mobilize students to the activity and, mainly, to the appropriation and understanding of the concept/procedure/attitude that is being studied.

Thus, we emphasize that reflecting in the light of a theory of learning favors the perception that all events that have occurred and situations experienced by students have implications for the learning process. Among these, we highlight the action of making mistakes as part of the constitutive learning process. In this sense, in the next section, we will discuss overcoming errors as an important part of the action of learning and the game as a favorable environment for this revision of initial conceptions.

## ERROR, GAME AND LEARNING

In the educational field, the study of error can be approached from a multidisciplinary perspective, as there are studies on its nature, causes and reflections from various areas of experimental and scientific knowledge. In this context, the definition of the term "error", in itself, can take several meanings, depending on the conception that originates it.

According to Torre (2007), the error can assume different connotations and its effect can be referred to any of the four possible semantic perspectives: destructive, misleading, constructive, and creative. While the first two perspectives are related to the error as a result, the constructive and creative effect takes on a procedural aspect.

In the school context, the historically constructed perception, and still in effect, is related to the negative perspective, linked to a conception that is harmful to the student's self-esteem, destructive with regard to the procedural character of knowledge, classificatory and excluding in terms of social relations established in the school environment.

In this conception, not only the school content is understood, but the way in which it is presented as an absolute, unquestionable and correct truth in any context. Converging to this understanding requires considering wrong the entire set of thoughts, strategies or actions of the student that lead to any other response than the one presented as school content. Therefore, this negative reading of the error does not contribute to the student's improvement, which he or she would incur.

Based on this understanding, the error should not take on a negative character, which discourages students and makes learning difficult, but rather as a source of information relevant to the regulation of the teaching process and the self-regulation of the learning process. This indicates how students perceive and relate the questions they are asked to, how they organize their thoughts and how they mobilize and articulate the contents in the search for solutions.

For Torre (2007, p. 15), “creativity is not, of course, in error, but in people who are able to generate new ideas based on it.” Thus, it is important to emphasize that studying the error is not about making an apology for it, nor about transforming it into something essentially positive or negative, but about making use of the effect or imbalance, between what was expected and what was obtained, as a productive or progress instrument, reversing the result of the error into a process.

In this way, the error is not the result of the impossibility of learning, it is the expression of the knowledge that is being woven in the teaching and learning relationship, and it can indicate how much progress has been made in that understanding, what is already consolidated and what is being elaborated by the students, in addition to making explicit possible paths for new discoveries and for a further deepening of knowledge.

Another characteristic of errors in the classroom is their recurrence. Yerushalmi and Polinger (2006) report that students frequently tend to repeat the same mistakes made during assessment activities. This recurrence may be due to the fact that these errors are based on an alternative conception, and, therefore, endowed with its own and very resistant logic, although mistaken. Yerushalmi and Polinger (2006) suggest, then, a more active posture of the student in overcoming this difficulty, so that students can diagnose and reflect based on an argumentative process about their strategies and misunderstandings.

Considering the constructive perspective from the error, the use of educational games is promising, as it provides an environment free from pressure and, in this way, promotes an environment of freedom, stimulating interest, discovery and reflection. For Kishimoto (2011), playful behavior offers

opportunities to experiment with behaviors that, in normal situations, students would not dare to try, either for fear of error or fear of punishment. Furthermore, the playful environment favors the active participation of students, and their mistakes can show the teacher and themselves not only which concepts, procedures and strategies were not fully learned, but also how they were wrongly learned. In this way, knowing these errors can guide them about aspects of knowledge that are still to be understood or have their meanings better differentiated, promoting greater cognitive stability of this knowledge (CAVALCANTI, 2014).

While the students play, the problem situations are presented, allowing the players to agree on ideas and/or establish contradictions. In the last case, in an attempt to overcome them, it is probable that they (re)organize their conceptions and due to the problematization inherent in the discussion, it is possible to build new learning relationships in a collaborative environment.

When facing with the problematizations and challenges that are seen during the numerous rounds of games, it is necessary for students to reflect on their actions, whether right or wrong and create strategies that develop know-how from flexible and uncertain realities. This reflection, from the social and dialogic interactions present in the act of playing, provided by recursion, can favor the reformulation of students' strategies and the learning of conveyed knowledge. Furthermore, when the recursion process is potentiated, it makes the student able to work on revisiting their mistakes, seeking to understand them and consequently overcome them.

This interactive process of rebuilding understandings in order to overcome errors must be a socially constituted action. Whether mediated by classmates, the teacher, or even in the interaction with didactic objects that share the socially accumulated knowledge in a given culture, it is necessary to express and negotiate understandings to comprehend and overcome the error.

## METHODOLOGY

The research was carried out virtually, through the Google Meet platform, during Chemistry classes at the State Technical School Maria José Vasconcelos of the public high school system in the Pernambuco countryside. To this end, the application of the didactic game “Guess Which?” was carried out at two separate times. Each application involved 10 student volunteers, aged between 15 and 17, divided into two teams, which competed against each other. In the first application of the didactic game, we opted for the exclusive participation of students who had difficulties in the content of organic functions, with the selection of students being carried out by the professor of the discipline. For the second application, mixed groups were selected, with the teacher's help, made up of students who had difficulties and others who had better academic performance in the chemistry subject.

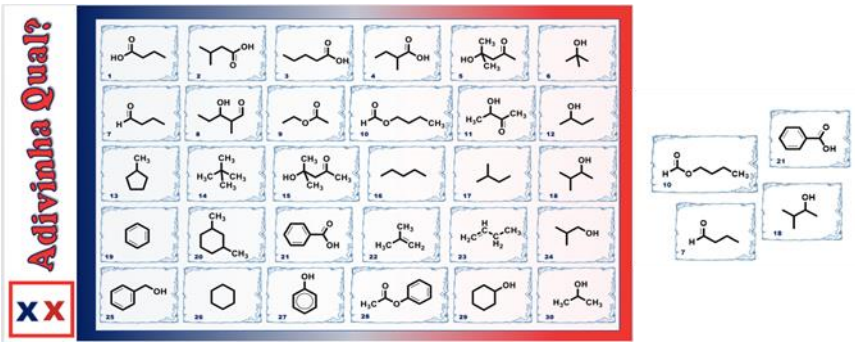
### Game Description: GUESS WHICH?

The game "Guess Which?" elaborated for the purposes of this research, it involves 2 teams of 3 to 4 players that must try to discover the structure drawn by the opposing team, asking, in turn, questions to another team about the structural

characteristics of the organic compound, to which the opposing team must respond reliably, only answering yes or no. Based on this information, the teams eliminate possibilities until only one structure remains, then arriving at the correct answer. The didactic game 'Guess Which?' presents a board with 30 structural formulas of different organic compounds, allowing the player to make an unequivocal differentiation based on criteria such as classification of carbon chains, presence of chiral carbons, among others. The structural formulas are numbered in order to favor the team's choice about which structures should be eliminated as a possibility based on the opposing team's answer. At this point, the teacher, the game's mediator, must eliminate only the structures indicated by the team. The team that first discovers the structural formula selected by the opposing team wins the game.

It is noteworthy that due to the lockdown and as a protection measure against COVID-19, classes in schools in Brazil, especially in the rural region of Pernambuco, in 2020 and 2021 started to be in remote format, using for this the virtual platform Google Meet, which led to the adaptation of the game to digital form. Using the Microsoft Office PowerPoint® program, a chart was created with the structures of organic compounds drawn in ChemDraw® and inserted as a figure on the digital board. To play, it is necessary to keep the screen off the presentation mode so that it is possible to move and paste images of an X (colored in blue and red to differentiate the teams) on the structures that were eliminated by each group. A card is sent through WhatsApp to a representative of the red and blue team, revealing the selected structure for each group, thus starting the game.

Figure 1 – Board and cards of the didactic game “Guess Which?”




Source: Authors (2021).

**Data collection instruments**

Data were collected through video recording using the resources of Google Meet's own virtual platform, that have been used by the school for classes in remote format. These data were stored in the digital cloud.

**Data collection procedures**

In order to capture the discursive interactions of students during the game, the groups were instructed to externalize, at all times, what they are planning, featuring the “Think Out Loud” method in which participants speak out loud any words that come to their minds while completing a task. The intervention was elaborated for the content of 'Organic Chemistry', specifically structures of organic compounds. After recording on video, the discursive interactions were transcribed for analysis.

### Analysis and Interpretation of Data

For data analysis, criteria established by the theories adopted were used, involving discourse analysis and microgenetic analysis in the appreciation of discursive interactions provided in the establishment of zones of imminent development (ZID) formed in the groups (and with the participation of the teacher as a mediator). And to analyze how the different constitution of the groups in the first and second application of the game can change the dynamics of this ZID and the awareness of students when revisiting their mistakes. The use of this method is justified, as variability in student understanding occurs on both the micro and macro timescales of development and reflects an important part of the development process. It is necessary a measure of comprehension that is sensitive enough to capture these fluctuations (BROCK; TABER, 2017).

## RESULTS AND DISCUSSION

In the applications of the game, the teacher/mediator sent through WhatsApp, the structures of the organic compounds selected for each group. Using digital data, it was decided that the red team would start the game by asking about the structure of the opposing team's compound.

The analysis of the results was based on the body of research constituted and expressed in the previous sections, which shows that, when students engage in didactic games, important elements such as social interactions mediated by language and other sign systems (VYGOTSKY, 2007,2009) they support each other, mediating learning (CARNEY, 2015; SOARES, 2013).

### First application of the game

The red team started by asking if the structure would be cyclic. However, the decision on this characteristic did not go through a broad group discussion. Since there was an immediate consent from the other components, there was no reflection process in terms of game tactics or seeking to understand the relevant contents. We note that the contribution made to the collective action in the game, the learning from the promotion of the zone of imminent development (ZID) does not emerge from the simple fact of performing a group activity, but rather from the resulting discursive interactions. We emphasize that the discursive interaction is not characterized by the turn-taking in speech of the students, but in the negotiation and review of their own thoughts and those of other teammates in the reflection on the positions (VYGOTSKY, 2009). In this sense, we realize that it was not possible to attribute this interaction, demanding a more incisive teaching action to instigate the discussion.

This action could be seen when the red team was asked to discuss out loud about which structures would be eliminated, based on the clue presented as an answer from the opposing team, which informed that the compound drawn for the blue team was not cyclic. In this way, they could begin to propose the possible structure of the opposing team's compound. The inquisitive actions of the teacher and the responses of the students are described in the excerpt of the speeches presented below:

*P: And then what structures should be eliminated.*
*A1: A16; A2: I think it's just this one; A2: Girls?*
*P: Any other structure that is not closed?*
*A3: I think so; A3: A 23 as well, I think.*
*P: Does everyone agree that there are only these to be eliminated?*
*P: Analyze how to recognize and then analyze the structures.*

At that moment, we noticed a certain difficulty for students to express their thoughts, when they limited themselves to informing the answer followed by the agreement of the other group members. As a way of minimizing this difficulty, the moderators (researchers and the class teacher) used pragmatic actions to encourage reflection and the positioning of the group members. Guiding, for example, with questions such as: *P: "Any other structure that is not closed? … Does everyone agree that there are only these to be eliminated?"* In this excerpt, we observe participation of the moderator not in giving answers, but in stimulating the revision of thoughts, a sharper look and interaction among students in order to provide them with conditions to collectively build an understanding that would not be possible without collaboration. These principles are in line with the Vygotskian perspective of the ZID (VYGOTSKY, 2009).

We noticed that students had no difficulty in expressing themselves about which chains were acyclic using different terminology "it is cyclic" or "it is closed" or "it is not acyclic" or "it is not open". What was observed was that the difficulty was not the concept, but how the knowledge of these concepts is materialized in actions in the form of choices and recognition of this characteristic in different structures.

This fact is in agreement with what Perraudeau (2009) points out when he emphasizes that the difficulty of students, sometimes, is not in the execution of the activity, especially when this refers to the reproduction of a term, but the understanding of this is expressed in actions such as recognizing, describing, mobilizing and articulating the concept. The author also points out that the reflection mediated by language is a path to the necessary meaning for the real understanding of this concept, which, we understand, involves the teacher's action in confronting the students' difficulties, as well as instigating them to articulate their understandings, doubts and questions.

We also found that the students' choice of what to ask was related to their own ability to recognize this characteristic in compounds, which makes the game's level of difficulty, in a way, self-regulating when it sends students the decision that elements of the structure will be evaluated, being impelled to look for other structural aspects, as a criterion for recognizing the structure. This care of starting from aspects that the student already has mastery and moving forward and discussing others in the course of the game enhances the participation of the student who feels more secure in expressing themselves.

This characteristic of the game's dynamics instigates students not only to choose, but also to develop strategies that must be expressed, defended and reflected upon in group. For this, the students mobilize and not only make decisions, but socialize that choice and their reasons for making it, which forces them to think about it and thus become aware of the mental process involved. At the same time being a group decision, the other components must accept or refute it, offering a counterpoint or alternative, being also invited to reflect on the colleague's idea, expressing their opinion and justification. According to Leontiev

(2012), this process favors a collective construction of understandings, in which the internalization of these meanings and awareness of the strategy is based on the choice and, therefore, on the knowledge mobilized for that decision. In this sense, it is noteworthy that the mere acceptance of the classmate's choice without opposing it, without questioning and without offering alternatives is harmful not only to those who accept it, but also to the classmate proponent of that choice who is not invited to review their own position.

In another moment, the blue team asks if the opposing team's compound is unsaturated. To this question, the students had difficulty in attributing meaning to the term. As shown in the excerpt below:

> *P: Did the other group ask if your structure is unsaturated?*
> *A1: Does it have double bonds?; A2: It has, hasn't it?; A1: That's right; (...)*
> *P: Are you sure?; P: Discuss in group*
> *A3: It has a double, right? Isn't it enough to have a double bond?; A2: It's not just that ( ), I don't think so;*
> *P: Does any double bonds characterize the instauration? See the definition*
> *A1: There must be the double bond in the structure; A3: That's right, having the chemical bond, must have;*
> *P: Compare the structures, where are the bonds in these compounds that you say you're sure of?*
> *A2: They need to be between carbons!; A1: that's right! Just between carbons to be unsaturated*

Initially they designated this characteristic to the simple fact that there was a double bond in its structure, which configures a conceptual error. Asked by one of the teachers about what would be an unsaturated chain, they stated the need for a double bond, and when asked by the other teacher if the double bond should be between any atoms, the students reminded that it should occur between carbon atoms. In this sense, the students interactively expressed their surprise and excitement when they realized how much difference this detail would make regarding the choice of structure, which characterizes awareness, when they modify their initial response, pointing out that their structure did not correspond to an unsaturated compound. The intervention of the moderators in this case took place because the answer regarding their own structure to the opposing team would refer to the reliability of the description of their own structure, which would harm the dynamics of the game. At that moment, the teacher's intervention consists of the action of an interlocutor, as a more capable component of the group, since he assumes the role of representative of an area of knowledge. This function reminds the teacher of his relevance in the ZID provided by the game, as he allows students to dialogue with their mistakes, their difficulties, but also with what they already knew, reaching stages of understanding that were only possible with their intervention. (VYGOSTSKY, 2009).

Questions such as, for example, if the chain would be heterogeneous were also made by the red team, requiring reflection on the definition that the heteroatom would need to be interspersed between two carbon atoms for the correct description of its own structure.

As the rounds passed, the students began to modify the strategy used, questioning the very definition of the characteristic before trying to recognize it in its structure, dialoguing with the action of choice with the very understanding of terminology. In this sense, we observed an alteration in the activity performed by the groups due to the internalization of a new strategy, collaboratively built in the

established dynamic between the teacher, moderators and students throughout the game, which leads to reflection on the meaning attributed to the characteristic before mobilizing it in the recognition of structures. We recall that Leontiev (1998, 2012) points to the transformation of the activity as an indication of awareness.

As the game progressed, more structures were eliminated, until the red group questioned whether the blue team's compound had ramifications in its chain. And from the negative answer, they mistakenly eliminated several structures among which was the one of the blue team's compound, leading them to the impossibility of finding the correct structure.

After completing the game application, the moderators explained that the student mistakenly attributed the characteristic of being branched to certain structures, being argued to the group as they understood it should be a branched chain. The group explained in terms of the indication of the main chain, exclusively based on a visual analysis, not referring to the recognition of tertiary or quaternary carbons in its structure. Although they knew how to recognize these carbons, such procedure had not been used in the recognition of the branched chains. By recognizing and remembering this broader definition and how it made a difference to a mere visual analysis of the compound, students again used verbal expressions of epiphany that suggest awareness and stated that they would never forget to use this definition.

This action corroborates the understanding pointed out by Messeder Neto and Moradillo (2017) when they stated that the game is the starting point and not the arrival point of an educational activity. In this sense, it is important for the teacher to reflect with students on the didactic situations experienced, on the learning, strategies, difficulties and errors, because by revisiting these experiences, the teacher enables students to become aware not only of what they have learned, but also of the entire construction process.

**Second application of the game**

In the second application of the game, the teams were made up of students who had an easier time with chemistry and others who had more difficulty. In this case, we verified a greater dialogic interaction in the groups in order to decide the best strategy, evaluating the characteristics of the remaining structures, as in recognizing the characteristics of the substances and the consequent choice of which structures should be eliminated based on the opposing team's responses.

The following excerpt shows the divergence of opinions and collective action in choosing the question that would eliminate more options:

> *A2: How about asking if the chain is closed?; A1: What do you guys think?; A3: How many would you eliminate?; A3: Wouldn't it be better to ask if it's open?; A2: And don't answering it doesn't matter?; A1: The problem is that the majority are mixed; A3: Do you want to ask if it's mixed?; A1: closed, it's not much, right; A4: and mixed too.*
> *P1: So? What to ask?*
> *A5: There are three unsaturated structures; A5: So, we would eliminate right away; A4: But there would still be many left; A1: It might be better to ask if there is carbonyl, because many of the compounds have it, so I would eliminate many of them; A2: Asking if there is carbonyl is a good thing; A3: Asking if it has carbonyl is better; A4: True.*

We observe that three different students raise different proposals regarding the question that would lead to a greater elimination of possible structures, which suggests a favorable environment for the participation and exposition of ideas. In this process, there is a divergence in the group, making not only the proposers, but the whole group think, analyze and recognize the structures that would fit that classification and how many would be eliminated. It is verified that the members of the groups do not simply accept or discard the ideas of their classmates, but they do consider them by analyzing the way to mention them at times. As, for example, when they discuss if they should ask whether the chain would be closed, open or mixed or when they assess how many structures would be eliminated and how many would remain from each proposal. This dialogic interaction allows each member of the group to evaluate beyond their own perspectives reaching a much broader understanding, and reflecting on their own ideas and those of classmates, which led them to elaborate justifications and oppositions to some of the proposals and thus reflect on the procedure for recognizing and classifying the compounds. In this sense, we can say that since the beginning, and with minimal teacher intervention, a ZID has been established in which understandings are re-signified from the discursive interaction among students (VYGOTSKY, 2009).

This reflective process, triggered by the necessary justification for positioning, promoted opportunities for reflection in the search for understanding of concepts, as portrayed in the excerpt highlighted below:

> *A3: Let's ask whether it is branched or not?; A1: Branching only takes place between carbon-carbon bonds, right?; A4: Branching is only when the bond is between carbons; A4: And many of the compounds have hydroxyl as a group outside the main chain; A3: If it's branched, we take a bunch; A2: Hmm true; A4: Because most are hydroxyl bonded and only contain carbon.*

These understandings often happened at different times in the game, that promoted the comings and goings in the review of these understandings, as occurred in the case of this same concept, this time in the evaluation of which of the structures to eliminate due to the fact that they are unsaturated:

> *A1: Eliminate compound 2; A1: Eliminate the 5; A4: Eliminate the 8; A1: Eliminate the 15*
> *A5: Eliminate the 1; A4: Not the Compound 1; A1: Not the 1*
> *P: Let's discuss why compound 1 should or should not be eliminated*
> *A4: Because the group outside the main chain is an oxygen; A1: To be considered a branch, it would need to be bonded to a carbon ( ) outside the chain*
> *P: Another way to be sure? What kind of carbon do we have in branched compounds?*
> *A2: Tertiary; A1: or quaternary; A5: Oh, I got it!*

Afterwards, the students are faced with the concept of branching, this time in cyclic compounds, a difficulty caused by the visual similarity between benzoic acid (compound 21) and phenyl ethanoate (compound 28), as shown in the following excerpt:

> *A1: Is compound 21 branched?; A4: Yes, it is; A2: Yes*
> *P: So, we eliminate structure 21? Go back to the definition and think about it.*
> *A4: There is a tertiary carbon; A1: Wait; A2: Jeez, (...), but what about the 28 then?; A4: How many others is carbon bonded to?; A1: In the case of compound 21 the carbon in the ring bonded to the carbonyl is bonded to 1, 2,*

> *3 carbons and in the 28 it is not bonded to any, because it is bonded to the oxygen that is in the middle of the chain.; A1: Got it; A5: Oh, I see; A2: That's right.*

This recursion made possible in the didactic game, in which the same procedure is used (in this case of recognition) in different circumstances, favors a much deeper reflection on the concept that underlies the procedure (ANJOS, GUIMARÃES, 2017), as well as awareness about the understanding of the concept, because this only emerges in the activity, that is, in a situation in which it is reflected on its use (LEONTIEV, 2012). However, the teaching action of instigating the revisiting of the concept as opposed to simply choosing is essential for students to make a reasoned decision.

Sometimes, the teacher's role must be to make students move forward, starting from what they already know and leading them to analyze what they do not know yet. In this way, urging them to signify the chemical language, inserting it in their vocabulary and helping them to express themselves adequately in their explanations. A situation like this occurred during the second application of the game in the context of the discussion of the recognition of which functions would be heterogeneous. The excerpt is described below:

> *A3: The organic compound 9, 10 and 28 are heterogeneous;*
> *P: Why this choice? Justify it to your peers;*
> *A3: I don't know, sir, I know how to do it but not how to explain it*
> *P: If you know how to do it then there is an explanation, shall we give it a try?*
> *A3: Heterogeneous is when there is "the thing" in the middle of the chain, they are 9, 10 and 28;*
> *P: What is this thing she pointed out?*
> *A1 and A4: It's the oxygen*
> *P: That thing is the chemical element Oxygen in the middle of the chain, as a heteroatom.*

The relationship between knowing how to do and knowing how to do based on understanding is directly related to awareness and real understanding of knowledge (PERRAUDEAU, 2009). Knowing how to describe a concept and not being able to apply it is as incomplete as merely performing an action without understanding it or knowing how to explain it properly. Unfortunately, teaching science content is often dissociated from reflection on concepts, which leads to a limited understanding of the concept and procedure and an appropriation of scientific terms loaded with little meaning. We also highlight the teacher's action mediating the assimilation of specific language by students, thus actively contributing to the ZID with their specialized knowledge.

## FINAL CONSIDERATIONS

We observed that the didactic game can involve and motivate students to take collective action, which encourages them to make choices that must be justified. Thus, they provide a favorable environment for reflections on the application of concepts and awareness not only about them, but also about their mistakes and difficulties, which helps them to overcome them.

We observed that the playful environment free of charge for results and with support regarding the review of errors by classmates and by the teacher favors the student participation. In this sense, we highlight the role of the zone of imminent

development (ZID) formed by the students and the teacher in promoting the review of positions, explaining justifications and thus reflections on concepts and procedures; it is up to the teacher as a mediator of the learning process, either to instigate discursive and dialogic interaction among students, or to act as an interlocutor, sharing knowledge with students that would allow them to advance in their understanding.

In this sense, we observe the contribution of the didactic game in both applications that differ in the composition of the teams, which would interfere in the zone of imminent development (ZID) and in the quality of the discursive interactions provided. However, what is observed is that while in the first application the interaction occurs with the actions of the teacher and moderators with the students, instigating them, making them reflect, in the second application of the game the interaction takes place among the students, diverging, negotiating and for that, also reflecting. As a result, the game dynamics in its second application becomes more fluid and this can reflect on the engagement, as it is more similar to an investigation situation in which students interact and collaborate to decide how to proceed, but even in the first application of the game the reflexive process takes place, but the moderators' actions must be taken into account for this to happen.

# USO DO JOGO DIDÁTICO “ADIVINHA QUAL?” COMO EVENTO PROPÍCIO À REVISITAÇÃO DO ERRO E DA TOMADA DE CONSCIÊNCIA DE CONCEITOS DE QUÍMICA ORGÂNICA

**RESUMO**

Buscando estimular alternativas que se contraponham a uma realidade de ensino que leva os estudantes brasileiros, sobretudo de escolas públicas, a um conhecimento deficitário a Teachers College-Columbia University em parceria com a Fundação Lemann investiu no fortalecimento da atuação de pesquisadores brasileiros lançando o edital “Researching Teaching and Learning: An Equity Imperative for Teacher Education”. Contemplado nesse edital, o Núcleo de Investigações, Desenvolvimento e Estudo de Jogos no Ensino (NIDEJE) se propôs a investigar como as situações de interação discursiva propiciadas pelo uso de jogos didáticos podem ser um fator de mudança de um cenário de ensino, em que dúvidas e erros são desconsiderados como oportunidades de (re)significação de entendimentos. Para tal foi aplicado o jogo didático “Adivinha Qual?”, em uma escola da rede pública de ensino médio do agreste pernambucano, sendo a primeira aplicação do jogo didático com a participação exclusiva de estudantes que apresentavam dificuldades no conteúdo de funções orgânicas e a segunda aplicação com grupos compostos com alguns estudantes que apresentavam dificuldades e outros que tinham um melhor rendimento escolar na disciplina de química. A externalização dos pensamentos dos alunos em seus planejamentos, discussões, e reflexões ocorridas no decorrer do jogo, foram registradas e posteriormente analisadas por meio da análise microgenética. Deste modo, analisamos as interações discursivas propiciadas a partir das zonas de desenvolvimento iminente (ZDI) constituída nos grupos e a implicação das constituições dos grupos na dinâmica dessa ZDI e na tomada de consciência dos alunos perante a revisitação de seus erros. Ao fim observamos que o jogo didático pode envolver e motivar os alunos a uma ação coletiva, que os instiga a realizar escolhas justificadas. Deste modo propiciam um ambiente favorável a reflexões sobre a aplicação de conceitos e a tomada de consciência não só sobre eles, mas também sobre seus erros e suas dificuldades, o que os auxilia a superá-las. A qualidade dessas reflexões é favorecida pela ZDI formada pelos alunos e professor ao promover a revisão de posicionamentos, justificativas e ressignificando conceitos e procedimentos. Destacamos ainda que o papel do professor como interlocutor na ZDI cresce em relevância quando a constituição dos grupos é formada exclusivamente por alunos com mais dificuldade no conteúdo.

**PALAVRAS-CHAVE:** Jogo didático. Erro. Tomada de Consciência. ZDI.

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