

Assessing the educational game “The Wall Chemistry Game” potential for kinetics chemistry teaching

ABSTRACT

The content of chemical kinetics is part of Diretrizes Curriculares Estaduais do Paraná, and is often considered abstract due to the absence of auxiliary didactic materials in the classrooms. One of the main problems with this content is the students' difficulty in understanding the factors that affect the rate of a reaction. To contribute to the solution of this problem, the purpose of this study is the construction and execution of “The Wall Chemistry Game”, an adaptation of the game “The Wall”. In light of this problem and thinking that learning cannot be monotonous, the adaptation of an entertainment model is presented, which consists of an interactive dynamic between four people and can provide a moment of socialization in the classroom to better understand the concepts about the chemical kinetics content. The work development took place in some courses in the Chemistry Degree at a Public University in the South of Brazil. The adaptation consists in the elaboration of materials similar to the television game, which is based on a small wall in which the players throw balls that determine the reward to be added or subtracted from the prize, according to the answer to the question. Questions about the factors that contribute to the speed of chemical transformations, namely: concentration, pressure, contact surface, temperature and catalysts, which were organized in twelve randomly selected cards. For some questions, the players had the chance to perform experiments, which provided a good comprehension about the established reaction. These experiments were inside a “secret box” next to the practical script. Thus, the investigative character in the manipulation of the necessary materials to perform the experiment and understand the concepts of a chemical transformation is emphasized. The didactic game was played by four people during a course of the public university, which made it possible to observe the importance of playful activities related to the chemistry learning process, as well as to evaluate the scope and the limitations of the game. The game also made it possible for players to point out potentialities regarding the interactivity of the product, in addition to a better understanding about the chemical kinetics concepts. In relation to the limitations, it is observed the high demand for time to play the game and also the reduced number of players per match, which is a problem when considering the public schools reality, which have many students in the classroom. It is also noticed that the game meet the current educational demand, in order to attract students through collective and active work so they can better understand some chemistry concepts.

KEYWORD: Playful activities. Chemical kinetics. The Wall. Educational games.

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INTRODUCTION

Chemistry is part of the Natural Sciences and its Technologies, according to the Base Nacional Comum Curricular (2018), being an essential course for the curricular completion of high school. Considering this, it is necessary to perform the scientific content in the best manner so that the student could achieve the expected learning.

The school subjects taught with monotonous ways and without the student interaction promote lack of interest and demotivation about the states of matter study and its transformations. According to Pozo and Crespo (2009), Chemistry, in a particular way, focuses at abstractions, which makes the learning process very difficult and, consequently, the student's interest in learning this science becomes very small. As a result, it is fundamental that the chemistry teachers develop didactic materials and playful activities for teaching the most varied chemical concepts which are abstracts, as well as diversify the teaching strategies (BRASIL, 2018).

The chemistry teaching is considered a challenge by many people (CATARINO *et al.*, 2018), however, there are several ways to make this process easier, such as through experimental practices, the use of technology, the construction of didactics materials and the exploration of playful activities like games, among others. A didactic material is a tool very often considered essential to explain certain contents (POZO; CRESPO, 2009), such as the Chemical Kinetics theme, which is considered a difficult content by many students.

Teaching tools widely used nowadays are the didactic games (SOARES, 2004), which allows great understanding in this cycle of human formation, seeing that, in addition to making the student interact with the material, in other words, interact with the chemical concepts, they also interact with classmates. In a recent study published by Rezende and Soares (2019), is emphasized the permanent idea that games stimulate learning.

Games, according to Zapateiro *et al.* (2017), can be a differentiating element in terms of learning construction, considering that, in addition to attracting the students' attention (CUNHA, 2012), it retrieves the proposed content in a less monotonous and facilitated way; which in Cunha's view can contribute to the construction of students' social and cultural identity, therefore, being important for school education, mainly "in the Chemistry teaching, the didactic games can and should be used as a didactic resource in concept learning" (CUNHA, 2012, p. 96).

In an attempt to attract the students' attention, the Chemistry teacher can use an adapted game, allowing the student to relate chemical concepts with television programs they watch. Flemming (2003), for exemple, teaches us that exists an certain creativity to elaborate adaptations or even create games to provide the construction of chemical acquirements, furthermore, the adptations are necessary depending on the game rules, class characteristics, quantity of students, available time, among others (FLEMMING *et al.*, 2003). There are many daily games that can be reformulated to be used in the classrooms, for exemple: "Show do Milhão" used by Martinez *et al.* (2008), "Passa ou Repassa" which is the base of the game developedment by Souza (2013), "The Wall" also used by Nascimento *et al.* (2018) and others.

The experimentation used to complement the practices with didactic games can improve the students' interest, expanding the possibilities of understanding the chemical concepts of the proposed activity. In summary, it is believed that with the playful games, the students can learn in a funny way and commit to their own learning process. Thus, through the didactic game "The Wall Chemistry Game", is proposed the introduction to a playful activity with the objective that the students can understand the chemical kinetics content through the game adaptation.

THE USE OF DIDACTIC GAMES IN THE CHEMICAL TEACHING PROCESS

The "game" definition is a complex mission (SOARES, 2004) considering that "the games have their specificities and their phenomena variety which finalizes the difficulty to define it" (SOARES, 2008, p. 2). The usual model is that people follow the proposed guidelines to advance the steps and win the game, which is played by a great number of people in their pleasure moments, as a way of fraternization between friends and entertainment, creating a playful character with these interactions (SOARES, 2004). Thereby, attach the games to the chemical teaching-learning process is meaningful, considering that are many scientific researches (ZANON; *et al.*, 2008; CUNHA, 2012; MATIAS; *et al.*, 2017) that discuss about the importance of this union and its use in the classroom.

The current scenario presents the students as part of the teaching-learning process, giving to the teacher the mission to attend this demand. So, the didactic game strategy (MELATTI, 2018) as a way to teach chemistry to the students can contribute to education. Batista *et al.* (2010, p. 1), for exemple, indicates the impact that the didactic games can cause to the chemistry learning:

[...] it is shown the importance of alternative methodologies, as playful games in the teaching-learning as a manner to energize classes, stimulate students' interest for chemistry classes, improving their understanding, as well as enriching the ways and methodologies to reach a concrete learning.

Felicio e Soares (2018), believe that a playful environment is more propitious for the students participate of the proposed theme and, consequently, seek to solve the problems of the playful activity. According to Ferreira (2012, p. 2): "a playful activity is any and all movement that aims to produce pleasure when in execution, that is, amuse the person that practices it. If there are rules, that playful activity can be considered a game".

In this context, it can be verified in the literature some didactic games used in the chemistry teaching. Ribas' dissertation (2018) presents a game' development named – 3D computational game in first person – to discourse physicochemical concepts from environmental issues, considering that the author concludes "the proposed game can provide to students an attractive and contextual learning" (RIBAS, 2018, p. 94). The article of Vicente e Comiotto (2016) exposes the proposed constructions of didactic materials and games like: Tabela Periódica Interativa, Química a Química and Super Trunfo da Química, the authors confirm "the games were developed, to achieve their playful and educational function, with the aim of stimulate the students' interest in the contents to be learned" (VICENTE; COMITTO, 2016, p. 456). Finally, Guimarães e Castro (2018) proposed a sea battle game to work the organization of the

periodic table and how the results identified that the games' activities can be a good didactic alternative, because it provides a not common interactive environment in chemistry classes. Based on the chemistry teaching literature, it is perceived that exists an emergency in the use of games in chemistry teaching.

In this context that the didactic game is presented as motivational to the learning of the chemistry (CUNHA, 2012), because, aligning the interest in the game, there are a learning environment more propitious and many times according to the context, in the means that the students can solve social problems from the scientific concepts studied in classroom.

With that in mind, the adaptation proposed to the game The Wall Chemistry Game contributed to the insertion of games in the chemistry learning. This activity allows experience playful activities in the abstract concepts learning, aiming the learning of factors that interfere directly on the reactions and chemical transformations. These activities can reduce the difficulty on learning the abstracts contents in chemistry area and stimulate the students' interest for the daily transformations.

THE WALL: AN ADAPTED PROPOSAL FOR TEACHING CHEMISTRY

Throughout the century XX started the initiatives that aim insert didactic adaptations related to games for teaching chemistry, wherein the use of that tools directly influences students' development of learned concepts, as emphasize Pereira (2016, p. 2):

The educational games present in the current context of contents and practical activities with educational purposes based at recreation and amusement, provide access to knowledge in a pleasure way. The learner motivation happens as a consequence of pedagogical approach, which facilitates the learning and also aids the construction of self-confidence and increase the motivation in the context of acquire knowledge.

The television format of The Wall consists in an international game show, in which a pair of people answers elaborated questions presented on a huge wall. The big challenge appears from the isolation of one of the participants, and the decision making regarding the bets to be made in view of the partner's ability to answer the questions correctly. The wall stipulates the cash reward through a system that redirect the balls positioned by the participant that is not in isolation, as well as, subtract the cash value if the answer is wrong.

According to Cunha (2012, p. 1), "the idea of teaching stimulated by students' interest became a challenge to teachers' capability", emphasizing the playful adaptations role for the chemistry teaching in the involvement of the students in the teaching-learning process. Therefore, it is emphasized that the selected game fulfills such need, which the players (students) must assume responsibilities before the strategies adopted by the partner. Regarding the development of the game, it is emphasized the use of investigative experiments to help solve the problems.

DEMONSTRATIVE INVESTIGATIVE EXPERIMENTATION IN THE CHEMISTRY CONCEPTS COMPREHENSION

Educational practices that use experimentation connected to chemistry teaching should be delimited according to expected objectives of teaching process. In which, it is emphasized, the investigative dynamic potentialities used together to the proposed game. The experimentation used in classrooms is responsible for provide stimuli and questions to the students being an efficient strategy on problematization and discussion of theory concepts (GUIMARÃES, 2009). The use of the strategy associated to the developed game assume the aspirations enhanced by Goi e Ellensohn (2017, p. 3) that “the proposal organization that works with alternative teaching methodologies, being them the experimentation and playful games can contribute to a better understanding about the scientific concepts”. In this study it is related the use of a playful activity united with an experimental practice.

The contribution of the cognitive aspects and stimuli directed to students are essential and according to Francisco Junior *et al.* (2008, p. 1), “as you plan experiments in which is possible narrow the link between motivation and learning, it is expected that the students’ involvement be more vivid and, thereby, results in conceptual terms evolution”.

The demonstrative investigative practices consist in an excellent opportunity for discussions about the concepts presented in the game’ questions, such that the importance of its utility also is shown on the premises of Oliveira e Soares (2010):

From simple situations, it is sought discuss previous concepts and cause questions about it, starting a discussion directed for a meaningful learning, this kind of activity allows to student make interactions that make it possible to find out the solutions for the problematic situation proposed by teacher, constructing their own school knowledge (OLIVEIRA; SOARES, 2010, p. 2).

In light of the importance of such strategy it is emphasized its utility as a resource during the playful activity development, in which the interpretation and the scientific reasoning are essential to understand the experiments on the resolution of the didactic game’ questions. It becomes evident the use of such resource through a rule elaborated on the adapted game, in which the participants could ask for help with an experimental practice for the question resolution, its executions required students to understand the chemical phenomena through materials for its elaboration.

METHODOLOGICAL PROCEDURES

Next, the construction and adaptation of the game for kinetic chemistry teaching is presented. This playful tool was developed and applied through two courses of teacher training during a Chemistry Degree Licenciante of a Federal University in the south of the country, all along first 2019 semester. The courses were fundamental for the pedagogical formation of the participant students due discussion and creation of games and playful tools directed to chemistry teaching, enriching methodologies and strategies hitherto little explored (FIALHO, 2008; SOARES, 2016; SOUZA *et al.*, 2018).

The games and playful activities course for teaching, a methodological discussion was realized on the importance of proposing fundamental moments to relate the chemistry contents to the educational needs of students. In which the playful activity is justified and discussed through its aims. Meanwhile, the course about instrumentation for chemistry teaching, discuss propositions that aim break traditional teaching still current in schools, being an excellent opportunity to know and discuss different methodologies possible to be used by the course students.

As a didactic intervention proposal of the games and playful activities course for the chemistry teaching, it was adapted the used tools of a television game show through low cost materials designated to the kinetic chemistry content, helping second high school grade students. The developed game, named “The Wall Chemistry Game”, required the construction of a small-scale wall with apin system responsible for deflecting the balls positioned by the players, in which they fall into channels at the bottom of the wall, revealing an amount of money to be credited or discounted from the pair² of players. For the confection of the wall were used materials like: a rectangular wooden box with front made of transparent glass, EVA plates, barbecue sticks, hot glue, adhesive tape, sulfite sheets and Foam Board plates (which consists of a thin sheet of Styrofoam coated with black cardboard). The ball deflection system was made through the barbecue sticks fixation on the Foam Board plate, as well used for the channel construction with the reward value written and glued on sulfite sheet as we can see in Figure 1. The balls used consisted of same sized baubles.

Figure 1 – Wall made and used in the game “The Wall Chemistry Game”



Source: The Authors (2019).

For the question cards confection, it was used cardboard, glue and materials graphically developed on a computer (adaptation of the game logo). In total, twelve questions about kinetic chemistry content were elaborated, together with an answer book directed to the game mediator identified in Figure 2. It is also emphasized that the time to answer the questions was determined to be about sixty seconds for player.

Figure 2 – Question cards and answers' guide



Source: The Authors (2019).

The entire layout of the game was organized and reproduced on a printed instructional material and distributed to players at the beginning of the game. The basic guideline are the division of two pair of people to face each other, positioned face to face and one of the players of each pair should be in a place where they cannot see the reward value revealed by the wall. One of the participants grab a question card and judge whether your playmate is able to answer it before reading the question out loud. Strategically, the player must stipulate how many balls to bet and the position in which to throw them, then the question is read out loud. In case that the companion of the player answer right the question, the indicated value by the wall is collected in cash (fake money note), and if the player answer wrong the question, the cash is transferred to the opposing pair of players. If a ball falls into a bonus gap, presented by a red X (Figure 1), the question must be answered normally, although the cash value will be credited or discounted of the opposing team. If there is any difficult with the question resolution, each team has two opportunities to ask for an experiment for helping them to understand the factors that induce the rate reactions, despite the fact that not all questions have this chance. The team wins the game with the highest accumulated financial profit over the rounds.

Experimentation was proposed as a helper feature for players on the questions' resolutions. In which was made an experimental guide with a material box that could be used to clarify some questions. The investigative character appears when the player's partner asks for help for the experimental box, which is produced without any explanation. Requiring interpretation and reasoning from the player who asked for help. We have as an example, the experiment regarding the contact surface factor, which influences directly on reactions' speed, where the script indicates the proper procedure from the use of the materials present in the box. The materials present in the experimental box were available: antacid tablets, glass, hot and cold water and spatulas, to deal with the persistence of doubts to answer the questions.

After the material elaboration for the game adaptation, it was used by students of a pedagogical training course from a Chemistry Degree Licenciade, with the participation of four people and developed in one hour. This application counted on the collaboration of the professor of the course, who gave us time to ascertain qualitatively the game applicability, as well as the viability of the developed materials.

The qualitative assessment counted on three people, who took turns helping to interpret the game rules, managing the financial resources given as a reward, carrying out the experiments and the photographic record to help in the results' analyses.

Another fundamental requirement made possible by the presence of three people dedicated to the application of the game was the time control that the players had to answer each question.

The qualitative research aimed identified how didactic games can contribute to chemistry teaching, thus, this qualitative survey followed Stake's precepts (p. 41, 2011):

Do not exist a single form of qualitative thinking, but an enormous form collection: it is interpretative, based on experiences, situational and humanistic. Each researcher will do that in a different way, but most of them will work a lot on the interpretation. They'll try to transform a history piece on experiences terms. They'll show the historic complexity and will treat the individuals as unique, even if similarly to others.

After the game application, it was essential a moment to discuss that aimed the survey of positive and negative points founded on the developed game, being an ideal time to identify the weaknesses of the material. We emphasize the contributions attributed by both courses, as the development of the game demanded a great demand of time given by some classes of the courses mentioned.

RESULTS AND DISCUSSION

It was evidenced that The Wall Chemistry Game can be used together with the kinetic chemistry content in high school (PARANÁ, 2008). It is highlighted the necessity of, at least, one class about the main concepts of kinetic chemistry in order to provide good results of the students in this didactic game. The observation is necessary because we applied this game in order to evaluate it together with colleagues in Chemistry degree. This application happened because of a request from the pedagogical training course teacher in which the game was made, even before we presented the work done for that teacher. The intention was that we could understand the potentialities and limitations of the didactic game, aiming to provide discussions with the class.

As was emphasized, we used this game only with chemistry Degree colleagues for evaluative purposes, so it is still necessary to use it with high school students. However, from the use of this game we can provide a prior assessment of this playful activity. In our judgment, The Wall Chemistry Game was well received by the undergraduate students, since they showed contentment and interest in the playful activity, mostly because of the way that the game was constructed and reproduced, on a smaller scale of the "wall of balls" (Figure 1).

We were able to notice some limitations of the game during the evaluation. In one of them, some of the elaborated questions were with very tiny graphics, what makes difficult the students' visualization, as presented by Figure 3, and we

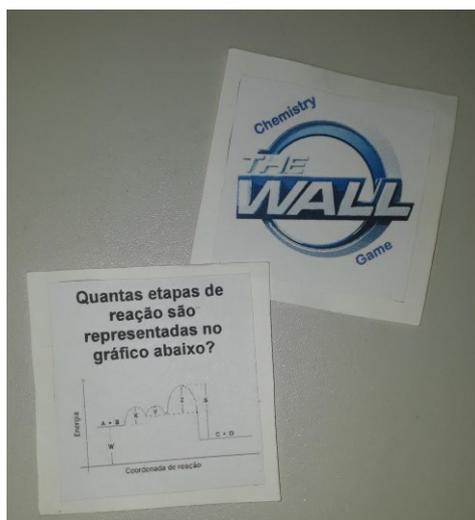
had not yet provide any of extra material (paper, pencil and rubber) so that the students could represent, for example, enthalpy, as shown in Figure 4.

Figure 3 – Game question card from the player’s perspective of “*The Wall Chemistry Game*”



Source: The Authors (2019).

Figure 4 – Game question card involving graph interpretation



Source: The Authors (2019).

These limitations are evident from the students’ speech and also because one of the class members needed a sheet and pencil to play the game. This factor makes us review the quality of the graphics resolution and the addition of sheets, pencils and other materials to the game box, so that players can represent the reactions and chemical transformations. Another limitation is related with the auxiliary experiments of the game box that was not united with the questions, so that the student get more agility to identify the relation between the question card and the auxiliary experiment available, in other words, the coding between the question and the experiment. Thereby, in addition to reviewing the questions, we will introduce question codes relating to the experiments to help the identification of the question on which there is the experiment to be carried out. In literature, difficulties and limitations are also presented, Ribas (2018), for example, “A deficiency was noticed in the scope of the contents of physical chemistry” (RIBAS, 2018, p. 93), thus, it is possible to observe the presence of

some obstacles on the didactic materials production, and these should be minimized, so that they not impede the didactic game proposal.

Regarding the possibility of evaluating students during their participation in the game (BATISTA; LORENZO; SANTOS, 2010; MATIAS; NASCIMENTOS; SALES, 2017), it is noticed that, by observing the application, there was a good evaluation of the players, since it was observed the effectiveness of collecting a sum of money during the game. This collect indicates that one of the game teams stood out in relation to the opposite team, because they answered right the questions proposed and also the expected bets when releasing the balls that entered the gaps expected, adding to this, two facts caused one of the pairs to raise a sum of money. Thus, in general lines, the effectiveness of this playful activity is shown, since after a period of approximately 50 minutes a pair of students had a higher amount (Figure 5) than the opposite pair of students, presenting a greater game strategy and knowledge of the potential of their peer response, as well as knowledge about kinetic chemistry.

Figure 5 – Amount of money collected by one of the pairs of “The Wall Chemistry Game”



Source: The Authors (2019).

We indicate that in a class with a significant number of students (GUIMARÃES; CASTRO, 2018), it is possible to foresee some difficulties with the applicability of the game, since the game rules establish only two pairs of players. This issue can be resolved by having more than one game available, in addition to the decentralization of the teacher and focus on the students (VICENTE; COMIOTTO, 2016) by naming the students themselves to continue the game.

The use of The Wall Chemistry Game for chemistry teaching adds to other recent discoveries in the literature, such as Vicente and Comiotto (2016), Ribas (2018) and Guimarães and Castro (2018); this presents us with the contemporaneity in the educational games' production, especially in Chemistry area, in which it is seen by some teachers and students as a limited science and possessing a technical rigor that does not allow these innovations. Games enable an environment of interaction between subjects, making the ludic environment more favorable (SOARES, 2004) to teach and learning, moving away from the conventional manner of teaching and contributing to different areas of teaching, above all, chemistry. This indicates that chemistry teaching can be motivated by the use of educational games, in particular, by the game The Wall Chemistry Game, that presented this playful environment during its application and thus

favored the teaching and learning of the factors that interfere the rate reactions, contributing to the kinetics chemistry teaching.

The game The Wall Chemistry Game attached with the investigative experimentation, during its application, proved that the visual and practical part of chemistry can conduce the students to the learning process, when they had to, in the game, carry out the experiments to assist the answers, thus relating the practical part of the theory, as explained by Guimarães (2009) who emphasized the importance of this union. So, the experiments were not present in the game just in order to “occupy space”, on the contrary, we planned this experimental part to contribute to the aspects surrounding the visualization of the part of the chemistry that is abstract (POZO; CRESPO, 2009).

In summary, we agree on the capacity of this game since the students appropriated the concepts of chemical kinetics through the game’s playful activity. The Wall Chemistry Game can break the absence of didactic materials for the physical-chemistry area, since we, undergraduate chemistry students, built this didactic material and were able to previously evaluate the potentials and limitations, being able to identify possible ways of solving emerging problems, as well as we’re minimally qualified to build this and other alternative teaching materials during our teaching practice.

We also emphasize that this evaluation phase of The Wall Chemistry Game was fundamental because it allowed us to evaluate and inquire the rules and purposes of the game. The proposals of colleagues from the undergraduate program were positive, as they provided improvements for the teaching material to achieve excellence when employed in high school.

CONCLUSION

This work aimed the construction and the execution of a game adaptation as a playful tool for teaching the factors that change the rate reactions, however, after the evaluation, it was observed that The Wall Chemistry Game provided amusement in addition to the learning, and the players were excited about the idea of winning. The players celebrated their victories many times, and it was possible to see that they were enjoying the playful activity.

In addition, it was analyzed through the answers to the questions that many of them acquired the knowledge minimally expected, although some questions were presented in a complex way, making it difficult to understand the content. There are brief and occasional adjustments to be made so the game can be better and it can be more easily achieved.

It is believed that through this kind of playful material, the teacher can enrich the chemistry classes and improving student learning, given the difficulty they have with this content and other chemical content. Thus, the playful material can also improve in professional training, presenting a great potential to instrumentalize not only the construction of a game, but also the ability to evaluate its potentialities and limitations.

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NOTES

1. More information about the game setup can be found on the website address: <https://gshow.globo.com/programas/caldeirao-do-huck/the-wall/>. Accessed: 26 Sep. 2019.
2. It is emphasized that the game requires two pairs of players in order to play it.

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