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Constructing a Periodic Table: A Proposed Practice Activity for High School Chemistry Classes

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Abstract

This experience report aimed to describe a playful classroom activity wherein high school students from a public school participated in the construction of a periodic table. This descriptive study applied a qualitative approach to a case study. To achieve this, a practical activity to construct a periodic table with accessible materials was proposed with the aim of promoting students' understanding of the periodic table and relating it to their daily lives. The methodology used enabled the students to review the chemical elements of the periodic table and their distribution and classification into different families, thus highlighting the interaction among the student group members. The activity's content contextualization provided a better understanding of the subject and made it more realistic. Thus, schools must consider the importance of playful activities in student development and propose learning situations that will enable teachers to diversify their teaching methods and make classes more dynamic and differentiated.

Keywords

Playful Activity, Active Methodology, Social Interaction

1. Introduction

The school, which offers intellectual and moral preparation to students, is a space of great social significance, and it is also a place for social interaction (Silva & Ferreira, 2014). Silva and Ferreira (2014) claimed that the function of the school included not only transmitting information but also preparing students to seek knowledge according to their needs and their individual and collective development. Furthermore, Klein and Pátaro (2008) agreed that schools, as social and democratic institutions, must rethink their contents, methods, and educational actions in order to provide practice activities that will contribute to students' active education as citizens.

Campos and Siqueira (2013) warned that, despite the advances in high school admissions, students' critical thinking skills were still limited; according to Arruda (2007), a considerable part of the student population was not prepared to study in an organized way, since they encountered teachers who were unprepared to conduct the teaching-learning process. Furthermore, Campos and Cunha (2013) highlighted that students developed themselves by performing interesting and motivating activities; such activities are often introduced by teachers during classes. However, without interesting classes, students can find it difficult to maintain attention.

Diesel, Baldez, and Martins (2017) highlight the need for teachers to seek new teaching methodologies that can promote the critical, reflexive, and autonomous formation of their students. Paiva et al. (2016) suggest that learning must be built by the student and not simply reproduced in a mechanical way. Thus, the traditional teaching methodology can interfere with student formation; Santos and Schnetzler (2010) reported that, from a perspective based on a constructivist conception of teaching, the best teaching strategies were those that enabled students' active participation and developed their decision-making abilities.

Based on these considerations, Diesel, Baldez, and Martins (2017) claim that teachers must seek methodologies that value the interaction between the subjects involved in the teaching-learning process, youth protagonism, and student autonomy, thus providing meaningful learning. The authors place the active methodologies as processes that view the student as an active subject in the construction of knowledge, since the student is valued in the experiences, knowledge, reflections, and opinions involved in these processes. Paiva et al. (2016) argue that procedures such as seminars, workshops, role-play activities, activities with playful dynamics, musical interpretations, and commented readings may also constitute active teaching-learning methodologies.

Macedo, Petty, and Passos (2005) concluded that valuing the playful dimension in school activities enabled students to be protagonists in their own activities and fostered their understanding of the processes involved in development and content learning. Brougère (2014) stated that, when a playful activity is conceptualized, the cultural context into which it is inserted must be interpreted to give meaning to that activity. Finally, during the selection of the playful material, the following factors must be taken into account: the time and scope of application, the standards of activity performance, the knowledge of the public in question, the educational potential of the resource, and the activity's aim (content support, review, or memorization) (Garcez, 2014).

Diesel, Baldez, and Martins (2017) highlight that choosing a methodology does not guarantee the efficacy of the teaching-learning process unless a well-defined teaching aim has been outlined by the teacher and that the teacher should be able to engage the students and achieve the desired results. Thus, the

High School National Curriculum Guidelines (HSNCG) decreed that the various teaching approaches regarding content must be carried out through activities devised with the aim of triggering speculation regarding ideas and their construction and reconstruction, thus achieving active and meaningful learning (Brazil, 2006). The PCNEM also highlighted the importance of diversifying resources and teaching materials such as experiments, dynamic activities, software, and games.

Regarding the teaching of Chemistry, Zuliani and Angelo (2010) stressed the need for activities that prioritize the students' creative and cognitive processes and thus aid the construction of their own knowledge. According to the HSNCG knowledge that is meaningful to students' lives must be prioritized in order to aid the construction of their citizenship (Brazil, 2006). However, Palharini and Zanon (1995) claimed that students encountered difficulties in contextualizing contents such as Chemistry into their daily lives, thus making their learning process difficult and demotivating.

Thus, Santana and Rezende (2008) reported that students could not understand the purpose of studying Chemistry because it was complex and lacked content contextualization. Campos and Cunha (2013) stated that the way content about the periodic table was presented in textbooks hindered the teachers' presentation and the students' scientific interpretation. According to Santos (2009), the students found it difficult to understand and utilize contents such as the periodic table because they could not consider it as a tool for understanding chemical phenomena; to them, it was an abstract reality.

Regarding this abstraction, Godoi et al. (2010) emphasized that the teaching of lesson content such as the periodic table focused on theoretical aspects in a way that was too complex for the learner. According to these authors, the search for new accessible, modern teaching strategies is a challenge to the teacher. Based on this perspective, Klein and Pátaro (2008) highlighted the need for meaningful learning, through which students can transform school content into knowledge related to their daily lives.

Thus, educational practices must form dynamic, creative, and collaborative individuals who will able to monitor scientific and technological advances and meet the demands of a knowledge society; for this, academic and technological scientific production determines significant intellectual and economic development (ICE, 2017). Moreover, schools must create effective ways to stimulate students' creativity through different classes and projects (ICE, 2017).

Soares (2013) claimed that playful activities were ones that involved the use of teaching materials that could provide good experiences and fun. However, the playful component in the production of knowledge depends on the objectives established by teachers, the educational character of the activities, the social interaction, and the skills developed (Pena & Neves, 2013). Thus, the use of practical activities in Chemistry aids the students' personal and social development, thus presenting them with motivation regarding school contents (Lima, Mariano, Pavan, Lima, & Arçari, 2010). In conclusion, this experience report aims to describe a proposed playful learning activity involving the construction of a periodic table by high school students in a public school; it also aims to contextualize basic concepts involving the content on the periodic table.

2. Method

This experience report records a descriptive study, which included a qualitative approach and a case study. Prodanov and Freitas (2013) suggested that the case study could include individuals, institutions, groups, community members, or others and that the research process should seek to analyze the theme under investigation in order to observe all the factors and aspects related to it. Lüdke and André (1986) stated that the qualitative research approach was implemented between researchers, the environment, and the situation being analyzed in order to reveal the participants' point of view.

This study was developed after a practice activity was conducted between June and August 2018. It involved 27 first-year high school students from a state public school in the municipality of Morrinhos-Goiás, Brazil. This school provides full time assistance to ninth-year junior high and high school students (from 7:30 a.m. to 5 p.m.). The students have classes consisting of the common curricular core and the diversified curriculum.

The choice of participants and the subject of investigation were determined during an informal conversation with the pedagogical coordinator of the school. In this talk, some academic subjects in which the students had low scores were mentioned. After the low-performance subjects were selected, we verified the teachers' availability to participate in the proposed educational practice activity. We decided to a first-year chemistry class because the teacher showed an interest in the activity and offered to let us implement the activity in some of the classes.

We administered an open-answer questionnaire to the participating teacher in order to characterize the class and identify any learning problems the usual contents presented in that class, and the teaching methodology used. Through analysis of the questionnaire responses, we determined that, among the contents provided, the periodic table deserved special attention because of the low student performance reported by the teacher. After that, we established that a practical activity related to the periodic table content would be created because it is a crucially important content, and students need to grasp it in order to understand the next lessons to be taught.

We attended a review class for a remedial test in which the teacher orally presented several summarized contents. During the class, there was no student participation, and the class remained silent; the students looked demotivated because of the amount of information presented to them. At that moment, there was no content contextualization, but the teacher did show concern for her students as she tried to make them understand the exercises required for the test.

Based on the examination of the class and teacher reports, a practical activity of a playful nature was proposed (i.e., the construction of a periodic table with accessible materials) in order to promote students' understanding of the periodic table in a way that was related to their daily lives. After that, the proposed activity was divided into three stages. Between one and two hours were allocated to each stage.

2.1. First Stage: Presentation of the Proposal and Training of the Work Groups

The first stage included presenting the proposal to the teacher and the students, highlighting the periodic table subject, and explaining the aim and importance of the activity for content understanding. We explained to the students that, with the researcher's guidance, they would voluntarily participate in the construction of a periodic table along with their teacher. It was proposed that the students would create Ethylene Vinyl Acetate (EVA) files containing the name of each chemical element, its symbol, atomic number, and atomic mass. They would also have to investigate the main characteristics of these chemical elements, discuss and evaluate the application of some of these elements in their daily lives, and construct the periodic table together.

To achieve this, based on a raffle and the number of team members, we divided the class into six groups, and each group was placed in charge of two or three chemical elements. After creating the files, the students were expected to be able to put them in the correct positions in the periodic table. The background of the periodic table was printed at a printing service shop and provided by the researchers. The students were expected to create the files with the data about the chemical elements and construct the table that would present the information they had analyzed. This initial stage of the activity was developed in a one-hour class.

2.2. Second Stage: Research and Preparation of Frames

In the computer lab, we conducted research concerning certain aspects of the chemical elements that compose the periodic table: the name of each element, its symbol, and its atomic number and mass as well as the everyday characteristics of some of these elements. In this stage, the students were allowed to use their textbook and the computer lab because internet was available. The data found were typed into a standardized frame model by the researcher and printed out to be used in the next stage.

This stage was carried out through two one-hour classes, and it examined the students' individual skills in relation to their use of computers. After the execution of this stage, the groups were observed with regard to their organizational capacity, teamwork, interaction, and determination or flexibility.

2.3. Third Stage: Constructing the Periodic Table in the Science Laboratory

At this stage, the files that would be fixed on the table were created. The files were made with EVA of different colors in order to separate the chemical elements according to their classifications. The material necessary for constructing the files was provided to each group: information containing the measurements of the periodic table's frames, EVA of several colors, scissors, glue, a ruler, and adhesive tape. The files were cut out with a size of 11 cm × 11 cm as reference, and a frame was glued onto each one of them; the frames featured information from the previous stage. Each mounted record was fixed by the groups (with the help of the textbooks) in the corresponding spaces in the periodic table and corrected by the teacher and the researchers. The EVA records were used to prepare the labels. These actions occurred within the period of two one-hour classes, a period that was necessary for analyzing the harmony of the teams.

After the activities were completed, the students were provided with an open-answer questionnaire that contained three questions so that they could evaluate the educational practice that had been applied. According to Chizzotti (1995), the questionnaire should comprise a set of questions related to the research theme in order to obtain answers from the informers on subjects regarding which they can comment or provide information. Thus, these questions sought to identify students' learning reports, their opinions on the methodology used, and the presence of difficulties in the work execution.

To maintain confidentiality and the respondents' privacy, we asked the students to not identify themselves in the questionnaire. The evaluation was applied by the class teacher in order to avoid any interference from the researchers. To facilitate the analysis of the answers, the questions were listed from one to twenty, and the information was grouped in answer categories. The results were made available in tables or in a descriptive way.

3. Development and Results

This experience report aimed to describe the outcome of a playful periodic table construction activity for high school students at a public school; the activity was carried out in a contextualized way. To this end, the educational practice was divided into stages, and the development of the activities occurred as described in the selected theoretical methodology. Of the 30 students enrolled, only 27 participated in the activities, since two had not returned from their vacation, and one was on sick leave. All the other attending students voluntarily agreed to participate in the proposed activities.

Thus, at the stage where activities were presented and study groups were formed, we observed that the students understood the proposal but displayed resistance toward forming groups, since this group organization was delegated to them and not imposed on them by the researchers. Zorzan and Ecco (2004) suggested that, in the educational process, learning to live with each other is one of the most important challenges in learning, since the economic system values competition as a means of increasing productivity. Zorzan and Ecco (2004) highlighted that, to overcome the economic domain and promote democracy, solidarity, and equal opportunities, education must enable individuals to learn to live with each other by considering their diversity as a means to construct a common good. Zabala (1998) highlighted that, through the social function of providing a complete education to students, teachers must utilize learning contents that enable the development of motor, emotional, interpersonal relationship, and social inclusion skills.

During the execution of the research at the computer lab, we found that the groups managed to organize themselves and interact with each other to develop the proposed activity. However, since the practice included conducting research and typing in the Microsoft Office Word program, we found that some students had difficulties in carrying out the required activities. They required guidance with regard to basic computer knowledge. Regarding this aspect, one of the groups that had already completed their work asked us if they could assist their classmates with the computer knowledge tasks, a request that we accepted. We were surprised to find that they had already started to overcome the resistance toward working in teams that they had presented at the initial stage.

According to Damiani (2008), group activities facilitate better assimilation of the contents and develop student autonomy, thus enabling them to strengthen values such as sharing and solidarity—values that have been lost in a competitive and individualistic society. According to Lima et al. his colleagues (2010), the incorporation of playful activities in basic education enables students' personal development, the construction of cognitive, physical, and psychomotor knowledge, and the development of cooperation in the social medium they inhabit. Thus, working in teams enables students to participate in problem solving, and they share ideas, concepts, and strategies in the process (Fernandes, 1997).

A limitation our research encountered was the restricted availability of material resources, since the computer lab did not have enough individual computers for all students. As a result, we required some additional time to conclude the research. As mentioned in the technical summary of the basic education census (Brazil, 2014), school infrastructure is essential to the learning process. This document also highlights that a proper infrastructure standard is required in order to provide students with resources that will facilitate their learning, help them improve their in-class performance, and make the school environment a pleasant place.

In the final stage of the current education activity, while students were creating the files that they would use to construct the periodic table (**Figure 1** and **Figure 2**), we found that the organization and interaction capacity among the group members had increased; this emphasized their teamwork skills in terms of flexibility and the ability to complete the activities. During this stage, we noticed the enthusiasm with which they carried out the tasks and their satisfaction in constructing a periodic table (2.20 × 1.40 meters) within their respective groups. Santos and Jesus (2011) reported that one of the ways to promote learning, contextualize learning contents with students' daily lives, and stimulate students' thinking was to perform various differentiated educational activities, including playful ones. These activities enable students to socialize with others and stimulate their affective, cognitive, social, moral, cultural, and linguistic reactions

Figure 1. Start of the construction of the periodic table—making the files.

Figure 2. Constructing the periodic table.

(Santos & Jesus, 2011).

Gomes, Nascimento, and França (2014) clarified that using alternative teaching resources engaged students' curiosity and participation in playful activities in a relaxed way. Barcelos, Felicio, and Lima (2017) warn that, when using a playful environment, certain limits should be established between fun and cognitive learning so that the formative potential of the playful resources and the intention of the actions do not lose their educational objectives. According to the authors, playful activities provide support so that teachers can provide a dynamic and contextualized classroom environment, thus fostering greater interest among students. Thus, playful activities break with the traditional teaching model, since they develop student autonomy, group work, content contextualization, and individuals' critical and reflexive ability.

In general, the responses obtained from the administered questionnaire were consistent with the observations made during the development of the activities. Thus, the provided answers were organized into categories based on the contribution of the educational activity in relation to students' assimilation of the periodic table content, the development of the activity, and any difficulties encountered during the activities. The answers that best expressed the main idea of each category were transcribed.

Regarding the contribution of the playful activity toward students' assimilation of the periodic table content, all the students reported that there was a positive contribution. Two answer categories were identified: classification of the chemical elements (Category 1—**Figure 3**) and element application and features (Category 2—**Figure 4**). Thus, Santos and Schnetzler (2010) explained that teaching Chemistry must provide students with an understanding of the content so that they can participate in and change their living environments. Moreover, Santos and Schnetzler (2010) highlighted that contextualization of the chemistry content allowed students to apply knowledge in their daily lives.

The students' opinions on the way the activity was developed are represented in two categories: teamwork (Category 1—**Figure 5**) and activity dynamism (Category 2—**Figure 6**), respectively.

As for the way the activities were conducted, Soares (2013: p. 11) stated, "When games and playful activities are proposed, a way of having fun is proposed together with learning to break a certain formality between students and teachers, thus socializing them and making them work together." Santos and Jesus (2011) added that playful activities are an essential resource to build knowledge and skills and facilitate personal improvement. Considering that the Nature

Student 02 - "*Yes, since we started constructing the table, we gained a better understanding of the positioning of the elements in their respective places. This was a fun, dynamic way to memorize the contents that we see in the classroom.*

Student 08 - "*Yes, this study provided the names of elements, some atomic numbers, and even some trivia on the subject.*"

Student 24 - "*Absolutely. The method, used in a practical way, helped me learn more about how the table is defined and its composition.*"

Figure 3. Students' answers regarding the contribution of the activity toward educational practice—Category 1.

Student 11 - "*Yes, the activity that was carried out contributed toward my assimilation of the content. Thanks to the activity, I learned about some characteristics of some elements that I did not know before; therefore, this was a very interesting and promising experience.*"

Student 14 - "*Yes, since we learned more about elements—such as their order and some trivia about them. We also memorized and learned about their many characteristics, and we worked in teams while performing several functions.*"

Student 20 - "*Yes, since this educational practice helped me understand a little more about the elements of the periodic table; in my case, I worked on some elements that I had very little knowledge of.*"

Figure 4. Students' answers regarding the contribution of the educational practice—Category 2.

Student 1 - "*The methodology contributed toward the interaction and participation of all students in the project, thus providing benefits such as team work, respect, and effort.*"

Student 12 - "*The activity was very inclusive because group work was used, and everyone was allowed to participate.*"
Student 13 - "*The union of the groups and the divisions of families were good; we can say that this was a well-prepared work, and it engaged many people's interest.*"

Figure 5. Students' answers on the development of the activities—Category 1.

Student 2 - "*I liked it because it was dynamic and fun, and we were able to participate in each stage in a comprehensive way by helping to construct the table and learning a little more about each chemical element.*"

Student 9 - "*In my opinion, the activity was developed in a very dynamic and constructive way that facilitated our learning.*"

Student 20 - "*I found it very interactive and easy to understand. The activity was carried out through a pleasant learning method.*"

Figure 6. Students' answers on the development of the activities—Category 2.

Sciences subject area is based on objectivity due to the nature of its contents, Barcelos, Felício, and Lima (2017) conclude that different methods for teaching such content must be created in a more effective and interesting way, thus highlighting the potential of playful activities to lower students' lack of interest and school evasion.

Finally, a descriptive analysis was conducted to assess whether there were any difficulties during the activities. Among the respondent students, 24 said that they found no obstacle while executing the actions, especially because of teamwork; two students encountered complications when they started to construct the table, and only one said that he found using the computer difficult. These answer data are inconsistent with the observations made by the current researchers at the beginning of the activities; at that time, the students had experienced difficulties in using the computer.

As for constructing the table, initial complications may have occurred based on the difficulties students encountered with regard to understanding and relating the contents of the table to their daily lives (Godoi, Oliveira, & Codognoto, 2010), but the help provided by fellow students and the interactions among the group members enabled students to continue performing the activities. The inconsistencies between the answers obtained and the observation may have occurred because of the researcher's intervention in the computer lab; she had clarified the questions of students who had no knowledge of basic computer concepts.

Thus, Lakatos and Marconi (2003) claimed that observation presents researchers with the advantage of obtaining data that are not addressed in the questionnaires. Nevertheless, they state that the presence of the researcher may cause changes in the behavior of the observed subjects, and unforeseen factors can thus interfere with the researcher's task. Indeed, when the researchers clarified questions regarding the use of the computer, the students understood the information provided to them and reported that they had no further difficulties after that stage.

4. Final Remarks

The methodology used in this study enabled students to review the chemical elements of the periodic table and its distribution and classification in groups. The analyses indicated that contextualization of the content (to make it relevant to daily life) provided students with a better understanding of the theme, thus reducing abstraction and making the knowledge seem "more real." Thus, active methodologies are well accepted by the students because such methodologies allow for their engagement and participation in knowledge building.

The answers obtained and the observations made during the activities highlighted the importance of teamwork, the interaction between the group members, the need to learn to live with each other, and discussions and reflections for students' learning and progress. As for socialization, Behrens (1999) reported that society needs professionals who are capable of working in groups, who are cooperative, and who can develop autonomy to make decisions. To this end, Sant'Anna and Nascimento (2011) claimed that teachers must opt for a teaching methodology that enables them to use the potential of playful activities to improve students' skills; this ensures that learning does not become mechanical.

The speed with which the students managed to adapt to the activities presented during the study and the interest that they exhibited during the course of the activities highlighted the importance of including different education approaches—especially with regard to fostering interaction among students and strengthening their learning. We also observed that the students considered the activity to be important, since they intensified their commitment to it as the activity continued to develop. Finally, schools must consider the importance of such playful aspects in the evolution and interaction of students and provide situations that can enable teachers to diversify their teaching methods, thus creating more dynamic and differentiated classes.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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