

Chemistry Clubs as Pedagogical Strategies: Potentializing Learning and Teaching in a Brazilian High School

Pedro Henrique Pereira Munhoz, Pedro Henrique Rodrigues Campos, and Mayker Lazaro Dantas Miranda*

Instituto Federal de Educação, Ciência e Tecnologia do Triângulo Mineiro, *Campus* Uberlândia Centro, Rua Blanche Galassi, 150, Morada da Colina, 38411-104 Uberlândia, MG, Brazil

Abstract: High School Science clubs have been considered spaces of collaborative learning where curiosity and the investigative spirit are stimulated to understand students' reality. They are non-formal educational spaces that are strategically effective in the process of scientific initiation in High School. Firstly, the proposal was to start the Chemistry club at the Instituto Federal do Triângulo Mineiro-*Campus* Uberlândia Centro (IFTM-UDICENTRO), in Uberlândia, MG, Brazil. Secondly, it aimed to potentialize chemistry learning. The IFTM-UDICENTRO Chemistry club, whose meetings take place once a week in the afternoon, is monitored by two teaching assistants who are High School sophomores. Both improve learning on themes that result from needs, doubts, and curiosity brought up by freshmen who are members of the Chemistry club. In meetings held by the club, students ask teaching assistants questions about content taught by their chemistry teacher in traditional classes and use the opportunity to strengthen learning. The teaching assistants created an Instagram account for the club and have posted issues related to Chemistry every Wednesday. Instagram was an excellent way to bring students close to Chemistry since its posts are introduced with simple and accessible language. In short, this case study (CS) of a Brazilian Chemistry club showed that this pedagogical proposal could develop students' skills and help them learn scientific concepts and contents.

Keywords: Case-based Learning; Case Study; Chemical Education; Chemistry Teaching Assistance; IFTM-UDICENTRO.

1. Introduction

Brazilian High Schools have long required educators to search for spaces enabling students to develop actions that may impact their future, thus leading to learning beyond traditional school evaluation^{1,2}. Society has gone through changes affecting schools directly, making teachers look for methodologies that account for student's current and future wishes. In the light of restlessness resulting from the pedagogical practice and challenges posed by school teaching, Brazilian basic education teachers must establish school spaces that may meet these peculiarities. We mainly refer to situations involving students in active, autonomous, and creative ways to disseminate and popularize the area of Sciences of Nature, thus making students enjoy Chemistry, specifically^{1,2}.

Increasing High School students' interest in Science is a goal that must constantly be pursued by all Science teachers not only to make citizens who are aware of their need for knowledge to improve their quality of life in society but also to train

professionals in area³. This goal is not always achieved. It may happen because contents taught in schools have been introduced as if they came from "ready and memorized" Science, which allows no space to discuss its phenomena; as a result, students tend to lose interest in it⁴.

To understand such reality, a recent study listed several factors: teachers' lack of training, inadequate training, current work conditions, and students' lack of interest. However, the crisis in Brazilian High Schools poses new challenges and perspectives to Chemistry Teacher Education's search to implement much more significant teaching⁵.

Chemistry and Science clubs play a fundamental role in learning and teaching processes since they sustain a more dynamic Education⁶. They are seen as auxiliaries in students' development of scientific initiation, which teaches and enables debates about several practical and theoretical concepts of Chemistry⁶. Science clubs are essentially non-formal spaces in which scientific education takes

*Corresponding author: Mayker Lazaro Dantas Miranda
Email address: maykermiranda@iftm.edu.br
DOI: <http://dx.doi.org/10.13171/mjc02401031755miranda>

Received August 20, 2023
Accepted October 28, 2023
Published January 3, 2024

place to stimulate curiosity and develop their members' investigative spirit. Scientific divulgation processes started in Brazil in the 1950's when data collected by research centers were made available to the whole population, mainly in Elementary and High Schools that implanted Science clubs ⁶.

According to Tomio and Hermann (2019) ⁷, Science clubs are essential spaces to diversify pedagogical methodologies in terms of scientific divulgation and students' learning: "[...] Science clubs become educational spaces composed of students who are freely associated and organized as a group that shares interest in Science and the wish to be together. Therefore, their members and a Science teacher develop investigative, cultural, cooperative, and dissemination activities related to their themes of interest" ⁷.

The relaxed environment experienced in a Chemistry club enables students to develop their creativity and triggers their search for discoveries in the Science field. From a pedagogical perspective, group work makes it easier to solve tasks proposed by the club, and the methodology helps to consolidate scientific literacy ⁸. While students work in groups, they explore new skills, such as argumentation, reading, material handling, and searching for information outside of school, which are important to their social background ⁸. The connection between informal learning (Chemistry club) and formal learning (classroom) is also observed ⁸.

Case studies have become increasingly common in formal teaching spaces like schools and universities ⁹. The methodology is a variation of the Problem-based Learning (PBL) method, whose guided approach promotes students' active participation so that they may construct their own knowledge ⁹. As a result, CSs not only engage students but also put them in the center of learning and teaching processes and make them actively search for new knowledge. They have to analyze and discuss information taught by their teacher and find new sources to solve problems if needed ⁹.

Based on this theoretical framework, this study aimed at evaluating a Chemistry club in learning and teaching processes in a Brazilian school, the Instituto Federal do Triângulo Mineiro - *Campus* Uberlândia Centro (IFTM-UDICENTRO), in Uberlândia, MG, Brazil (Fig. 1). In addition, an official Instagram account was created for the Chemistry club to post issues related to Chemistry in simple and accessible language once a week. In short, we believe that constructing knowledge about Science and Chemistry clubs – that enable learning about these educational contexts – is relevant to the scientific community in Science teaching since experiences with Science clubs may be shared and contribute to interinstitutional exchange and internationalization regarding cooperative actions related to production and socialization of school knowledge.



Figure 1. Facade and main entrance of the IFTM-UDICENTRO (Source: authors)

2. Methodological Procedures

This CS examines the IFTM-UDICENTRO Chemistry club, which opened on April 1st, 2023. The idea originated from a teaching project funded by the school and registered under no. 23468.000869/2023-67. After the official

registration, two second-year scholarship students in High School (sophomores) were selected by the Chemistry teacher to be teaching assistants in charge of the Chemistry club. Afterward, the teacher asked them to create a logo and an Instagram account where interesting facts related to Chemistry could be posted (Fig. 2).



Figure 2. Logo of the Chemistry Club and its Instagram page (in Brazilian Portuguese)

Afterward, the teacher – and coordinator of the teaching project – asked the teaching assistants to post some information on Chemistry every

Wednesday in simple language to be understood by people who did not have technical knowledge in the area (Fig. 3).

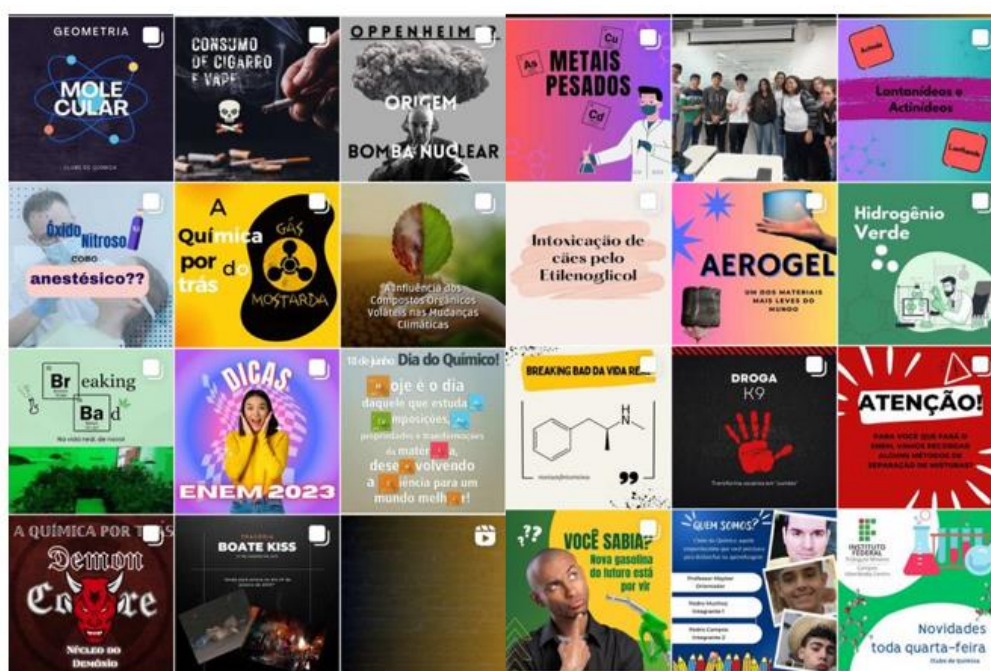


Figure 3. Some Instagram posts of the IFTM - UDICENTRO Chemistry club with colorful identities to call students' attention

Both teaching assistants also created a WhatsApp group called "Chemistry Club" to enable fast communication among its members. In this educational scenario, the nature of our study was qualitative and essentially characterized as a CS.

A CS was the methodology chosen for this study because it is student-centered, i.e., club members can actively develop their learning. Using a case, which is an actual or fictitious story in everyday life, students are asked to solve a dilemma and, as a result, develop superior skills such as critical thinking, communication, problem-solving, and collaborative work ^{10,11}.

3. Results and Discussion

Science clubs emerged in Brazil in the 1970's. However, the proposal was discredited because most

teachers and principals were unfamiliar with going on field trips, collecting data, carrying out investigations, and conducting similar activities. Several educators thought it was not severe and promising work. It was hard to convince people that an attractive pedagogical space could also be developed out of classrooms. Thus, Science clubs emerged prematurely and in a discredited way but conquered trust as they showed their production ¹². Our Chemistry club has 21 members who were 14-15-year-old freshmen at IFTM - UDICENTRO. In 2023, there will be 120 freshmen in the institution and 30 per class, on average (4 groups in technical courses in System Development, Commerce A and B, and Digital Game Planning). Twenty-one students (17.5%) participate effectively in the club. Regarding Instagram, 90% of all High School students enrolled

at IFTM - UDICENTRO follow the page of the Chemistry club.

The following Chemistry contents were chosen to be discussed by the club members: Chemistry and transformations of matter; Nature of matter; Methods of separating mixtures; Atomic structure; Electronic structure of atoms; Periodic table; Periodic classification of chemical elements and periodic properties; Ionic bonds; Covalent bonds; Metallic

bonds; Polarity and molecular geometry; Intermolecular interactions; Inorganic functional groups and their basic principles; Inorganic reactions and reaction balancing; The atomic molecular theory; and Stoichiometry.

Fig. 4 shows photographs of teaching assistants and some club members about the periodic table at the end of the meeting.

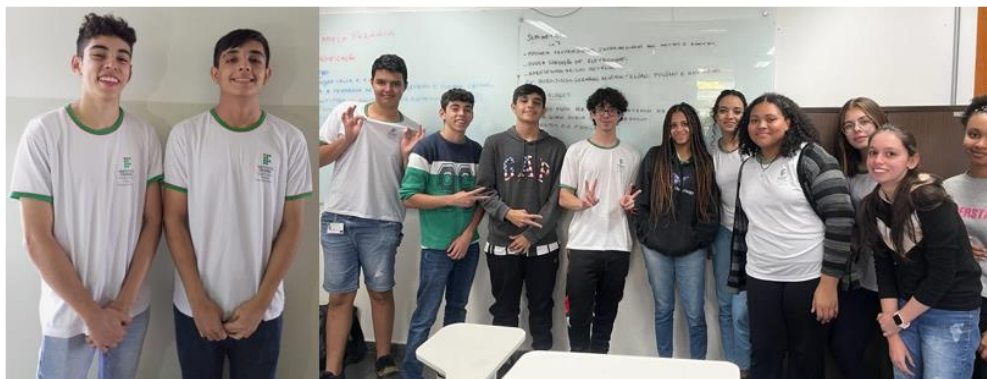


Figure 4. Both teaching assistants of the teaching project and some students of the IFTM-UDICENTRO Chemistry Club. (Source: authors)

The IFTM-UDICENTRO Chemistry Club is involved in planning and organizing activities, mainly experimental ones, about a specific theme based on a set of materials given to students. The club provided:

- Conditions to deepen students' previous knowledge so that they could construct new learning;
- Opportunities to construct and present their ideas;
- Discussions with teaching assistants to clarify Chemistry contents taught in the first year in High School;
- Description of their spontaneous knowledge as a way to achieve scientific knowledge;
- Conditions to understand that previous generations may have structured several ideas, knowledge, and discoveries;
- Spontaneity to question with no fear of committing mistakes.

The IFTM-UDICENTRO Chemistry Club has always aimed at socially relevant activities to promote contextualization in students' everyday life. Thus, several contents were better analyzed to lead to deep discussions about students' lives. A study of Chemistry teaching reinforces that it should be the true essence of Chemistry and Science clubs ¹³.

It is worth mentioning that, even during the COVID-19 pandemic, Science clubs were called remote Science clubs and did not interrupt their educational activities. Different strategies were fundamental to keep them operating to encourage students to follow learning and teaching processes, strengthen interpersonal relations, and boost feelings

of competence and autonomy throughout difficult times worldwide ¹⁴.

In Brazil and other Latin American countries (Argentina, Uruguay, Chile, Ecuador, and Peru), teachers work hard in their Science clubs and dare to break traditional forms of time and space organization that schools conventionally propose ⁷. This study shows that the Science club differs from other alternatives for scientific education because its activities are always developed in a dimension that privileges cooperative work carried out by a group in a school. Students are "club members", i.e., they have a place characterized by relations with other members and mediated by Science knowledge, thus, composing the "club". From this perspective, we advocate that the Science club may become a privileged context to include participants in the search for a common goal – to learn Science in school – while they experience the diversity of establishing relations with the world in the world ⁷.

History reports that Chemistry clubs started their activities timidly and were restricted to meetings that few influential guests attended. They were called small scientific dining clubs ¹⁵. A recent study stated that Science clubs must be encouraged and become part of schools. They are needed to help the learning process since students develop creative skills and may become problem solvers ¹⁶. In Brazil, a recent study also stated that writing and drawing in Science clubs can trigger the learning of scientific concepts ¹⁷. Regarding teachers' practice and didactic development, the literature points out that Science clubs are good opportunities for beginning teachers to improve their teaching skills ¹⁸.

Improvement in scientific education is potentialized by Chemistry clubs since teachers and teaching assistants may calmly address issues that could not be debated in class because of lack of time. Schedules of regular classes are limited, and some students may not commit to plans and contents¹⁹. The IFTM-UDICENTRO Chemistry Club enables teachers and teaching assistants to go beyond those schedules and spaces and help students learn more and better, even with contents they would not be taught in their traditional classes. As a result, the Chemistry club was highly satisfactory.

Besides, it is essential to report what students wrote about their experiences as members of the IFTM-UDICENTRO Chemistry Club. Thus, three students' comments are fully reproduced below:

1) **Student A:** "I think classes are excellent because they reinforce contents we learned in the first year; posts and material used in class and the dynamics used by teaching assistants to teach us make it easier and make us come back in the following weeks to keep up with a theme in Chemistry again."

2) **Student B:** "Classes are well-taught, with good dialogue among all participants and teaching assistants. Instagram posts of the Chemistry club are informative and interesting."

3) **Student C:** "Regarding classes, I think they are excellent; teachers explain the content very well, which is very interesting, but they erase the board too fast (Fig. 5). Regarding Instagram posts, I sincerely like them. They are informative and bring up issues that are close to everyday life. It helps people feel close to the theme and get more interested."

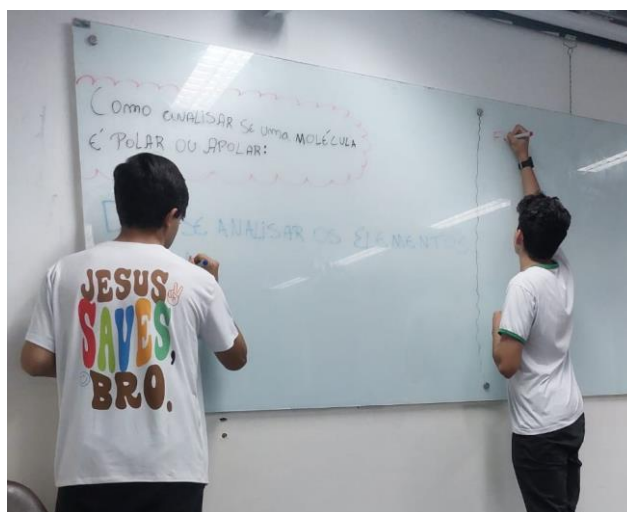


Figure 5. Teaching assistants explaining concepts of basic Chemistry. Theme: how can we analyze whether a molecule is polar or apolar? (Source: authors)

In addition, a 5-question questionnaire was posted on the WhatsApp of the Chemistry Club so that its 21 members could anonymously answer:

- Which activities offered by the Chemistry Club provide more support to your learning?
- Is the involvement of the two assistants in teaching and learning satisfactory compared to the conventional teaching method in traditional chemistry courses?
- Can you notice the support given by the institution and by the principal to activities carried out by the club?
- Regarding the quality of material used by the club, what would you improve?
- How does the club impact your Chemistry learning?

Students' answers were clear and objective. All interviewees stated that activities conducted by the Chemistry Club led to better evaluation performance. They also highlighted the important help both

teaching assistants gave to solve tasks assigned by teachers and get concept A. All participants praised both teaching assistants, while some added that their profiles would enable them to become chemistry teachers and researchers. Regarding question C, all students were dissatisfied with the institution since it does not have a Chemistry or Natural Sciences laboratory.

On the other hand, they were very grateful for the teaching assistants' efforts regarding practices that could be conducted in traditional lessons. The answers to question D were similar to the ones given to question C. All students reinforced that a laboratory would encourage more student participation and increase the quality of practical activities. All students closed their questionnaires by mentioning the positive and remarkable impact of the Chemistry Club in school. Despite the institution's physical and structural limitations, learning happens due to students' effort and dedication.

We have faced several challenges since the implantation of the IFTM-UDICENTRO Chemistry

Club, mainly because the school has no laboratory. Lack of funds is another challenge since buying the materials and equipment that students need to develop their scientific projects is crucial. Some practical activities carried out by the club were based on this problem, i.e., lack of adequate physical space. However, even in this, at times, adverse context, its members have been enthusiastic and interested in the activities that happen every Wednesday, a fact that makes us reflect and evaluate it as a successful teaching project.

It is worth commenting on students' sincere opinions about the Chemistry club (previously reproduced). Reading their opinions shows that the construction of scientific concepts is based on discussions about problem situations, which intertwine what is learned in school and everyday life ²⁰. Students also highlighted the importance of the support of both teaching assistants whenever they had doubts about chemistry. Besides, this study reinforced two crucial aspects, i.e., teaching based on repetition of concepts does not make students learn Chemistry and the fact that students may construct knowledge by developing competencies that complement Chemistry ²⁰. Data on the extra class club show that its advantages lie in the possibilities of proposing and solving students' problems and doubts, deepening their topics of interest, and developing their scientific thinking, skills, and potentialities, such as logical thinking and reasoning ^{21,22}. In short, the club members learned to observe, think, clarify concepts, compare, and develop essential attitudes, such as self-confidence, decision-taking, and friendship.

4. Conclusion

This study showed that science and chemistry clubs can stimulate students' curiosity and improve their critical thinking skills. As a result, they contribute to "making Science". It should be highlighted that both teaching assistants (Pedro Campos and Pedro Munhoz), good Chemistry students before joining the club, became increasingly better students, enthusiastic and committed to learning and teaching processes. The clubs also re-signify science teaching, mainly chemistry teaching, since they aim to join several actions to develop dynamic activities and lead to complete and interesting scientific education.

Acknowledgments

The authors thank IFTM - *Campus* Uberlândia Centro for its financial support.

References

- 1- A. Villani, V.S. Dias, J.M. Valadares, The development of science education research in Brazil and contributions from the history and philosophy of Science, *Int. J. Sci. Educ.*, **2010**, 32, 907-937.
- 2- A.V. Gomes, C.T.W. Rosa, M.L. Darroz, Clube de ciências decolar: da implantação à prática de atividades científicas investigativas, *Ens. Tecnol. R.*, **2022**, 6, 51-67.
- 3- E.M. Leal, L.M.F. Gomes, R.R. Pires, S.F.P. Pereira, R.A. Costa, A.M.F. Sousa, P.M.S. Junior, C.S. Silva, H.C. Costa, Everyday actions in science teaching: a case study in public and private school, *Res. Soc. Develop.*, **2022**, 11, e56111536899.
- 4- K. Adu-Gyamfi, lack of interest in school science among non-science students at the senior high school level, *Prob. Educ. 21st Cent.*, **2013**, 53, 7-21.
- 5- G.R. Gonzaga, D.C. Paiva, M.L. Eichler, Desafios e perspectivas atuais na formação do professor de química: expectativas sobre o mestrado profissional em química em rede nacional (PROFQUI), *Quim. Nova.*, **2020**, 43, 493-505.
- 6- E.B. Filho, L.A. Gomes, J.M.S. Maia, G.M.R. Martins, C.F.S. Barreto, Clube de ciências: a importância da extensão universitária na formação docente de graduandos de licenciatura em química, *Rev. Ext. Cult.*, **2020**, 4, 61-75.
- 7- D. Tomio, A.P. Hermann, Mapeamento dos clubes de ciências da América Latina e construção do *site* da rede internacional de clubes de ciência, *Pesq. Educ. Ciênc.*, **2019**, 21, e10483.
- 8- M. Behrendt, Examination of a successful and active science club: a case study, *Winter*, **2017**, 25, 82-87.
- 9- B. Aidoo, S.K. Boateng, P.S. Kissi, I. Ofori, Effect of problem-based learning on students' achievement in chemistry, *J. Educ. Pract.*, **2016**, 33, 103-108.
- 10- F.M. Bernardi, M.S. Pazinato, O estudo de caso no ensino de química: um panorama das pesquisas na área, *Rev. Ins. Sci.*, **2022**, 5, 221-236.
- 11- C.A. Dewi, S. Rahayu, I.W. Dasna, Case-based learning (CBL) in chemistry learning: a systematic review, *J. Penel. Pend.*, **2022**, 8, 2219-2230.
- 12- N.P.R. Sousa, R.H.O. Viana, G. Ferreira, L.C. Nogueira, Clube de ciências: um olhar a partir das teses e dissertações brasileiras, *REAMEC*, **2021**, 9, e21079.
- 13- N.M. Karkaz, Z.K. Ellala, The effectiveness of science club in the creative skills of students in the elementary grades, *Int. J. Educ. Psych. Studies*, **2017**, 1, 72-95.
- 14- A.M.M. Dantas, V.P. Soares, E.J.L. Toledo, Clube de ciências remoto: proposta motivadora em tempo de pandemia, *Rev. Exitus*, **2022**, 12, 1-25.
- 15- A. Lacey, The chemical club: an early nineteenth-century scientific dining club, *AMBIX*, **2017**, 64, 263-282.
- 16- P. Hidayat, I. Megawati, Penanaman kreativitas di ekstrakurikuler science club SD Muhammadiyah Pakel program plus, Trihayu:

- J. Pendidikan Ke-SD-an, **2023**, 9, 116-130.
- 17-B.D. Rodrigues, J.M.S. Malheiro, A escrita e o desenho na promoção de aprendizagens em um clube de ciências, *Ciênc. & Educ.*, **2023**, 29, e23019.
- 18-C. Wegner, N. Issak, K. Tesch, C. Zehne, Science club-a concept, *Eur. J. Sci. Math. Educ.*, **2016**, 4, 413-417.
- 19-P. Mupa, T.I. Chinooneka, Factors contributing to ineffective teaching and learning in primary school: why are schools in decadence?, *J. Educ. Pract.*, **2015**, 6, 125-132.
- 20-P. Buckley, P. Lee, The impact of extra-curricular activity on the student experience, *Act. Learn. High Educ.*, **2021**, 22, 37-48.
- 21-A. Magaji, G. Ade-Ojo, D. Bijlhout, The impact of after-school science club on the learning progress and attainment of students, *Int. J. Instruct.*, **2022**, 15, 171-190.
- 22-A.I. Borges, M.L.D. Miranda, The role of chemistry in environmental education: learning and constructing knowledge through research in high school, *Indonesian J. Educ. Res. Rev.*, **2022**, 5, 460-468.