VIDEO EXPERIMENTATION AS A METHODOLOGICAL TOOL IN CHEMISTRY TEACHING

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INTRODUCTION

According to Maldaner (2006), in recent decades science education has revealed numerous learning difficulties among students. Fagundes (2007) argues that experimental practice should be understood as a means to achieve learning rather than an end in itself. In this sense, Ausubel (2000) emphasizes that theory is composed of concepts that constitute abstractions of reality, highlighting students' difficulties in relating theoretical knowledge to their surrounding environment. This reinforces the importance of practical activities as mediators of learning (Camargos *et al.*, 2018; Mariz *et al.*, 2024a; Mariz *et al.*, 2024b).

The absence of experimental classes integrating theory and practice intensifies the challenges faced by students in chemistry education (Giordan, 1999). The effectiveness of experimentation lies in the student's active participation as a central subject in the learning process, fostering discussion, reflection, and decision-making (Cachapuz; Praia; Jorge, 2004). The *Parâmetros Curriculares Nacionais* (National Curriculum Parameters) recommend that chemistry experiments adopt contextualized approaches to make chemical knowledge socially meaningful (Brasil, 2006).

Several educational researchers have demonstrated the benefits of experimental learning. Many teachers employ laboratory activities as teaching strategies since handling experimental apparatus allows students to connect theoretical content to everyday phenomena (Séré; Coelho; Nunes, 2003). However, experimental activities should not be reduced to prescriptive "cookbook" procedures with predetermined outcomes (Tamir, 1977; Domin, 1999). Such traditional methods lack problem-posing elements that encourage students to think critically, formulate hypotheses, and draw evidence-based conclusions. Conversely, investigative experimental activities involve students directly in problem-solving processes.

Zanon and Freitas (2007) state that, in the investigative method, teachers act as facilitators who pose problems to spark students' curiosity and hypothesis development. Consequently, the experiment transcends simple manipulation of materials and reagents, becoming a reflective activity in which students become aware of their actions and seek explanations for observed phenomena (Carvalho, 1999).

During the COVID-19 pandemic, when in-person classes were suspended throughout Brazil, experimental video lessons emerged as an innovative pedagogical tool in chemistry education. The integration of audiovisual resources with experimental practices enabled the creation of so-called experimental video lessons, which gained prominence through advances in digital technology. Almeida, Castro and Cavalcanti (2014) highlight that these technological advances represent a break from traditional teaching models.

According to Watanabe, Baldoria and Amaral (2018), videos can serve as tools for observing and analyzing simulated experiments, particularly in the absence of laboratories or experimental materials. This audiovisual resource complements theoretical instruction, stimulating student engagement and learning development. Li Q. *et al.* (2020) and Li J. et al. (2020) also note that experimental videos constitute viable alternatives when hands-on experimentation is not feasible, as was the case during the COVID-19 pandemic.

Therefore, one of the objectives of this study was to produce experimental video lessons aimed at assisting high-school students in learning chemistry content. The laboratory practices were developed and recorded by undergraduate students from the Federal University of the Jequitinhonha and Mucuri Valleys (UFVJM) in their homes due to social distancing measures. Subsequently, the videos were made available to high-school students via the YouTube platform, and the effectiveness of this educational strategy was assessed through online questionnaires administered with the collaboration of the chemistry teachers responsible for the participating classes.

MATERIALS AND METHODS

The experimental activities were conducted in a home environment under the guidance of the supervisors and with remote monitoring by the project team, aiming to produce audiovisual educational materials for Chemistry teaching. These activities were integrated into the academic routine of the participating undergraduate students, who planned, performed, and recorded the experiments following good laboratory safety practices. One introductory video and six experimental videos were produced and later made available on YouTube, on the project's channel entitled *Experimentation in Chemistry Teaching*.

The project targeted high school students from the first, second, and third years. The experiments selected and developed so far were: (1) more resistant soap bubbles; (2) soda battery; (3) quicksand; (4) acid–base indicator using red cabbage; (5) polyurethane foam; and (6) fog in a can. The following materials were used in the experiments: water, pan, sieve, pitcher, cups, spoons, labels, milk, vinegar, detergent, table salt, sodium bicarbonate, bleach, washing powder, soft drink, copper, zinc, and rubber plates, electric wires with alligator clips, voltmeter, calculator, wire, corn syrup, transparent container, and cornstarch.

After performing and recording the experiments, students from the Federal University of the Jequitinhonha and Mucuri Valleys (UFVJM) prepared online questionnaires (initial and final) using Google Forms. Each experiment was carried out over the course of one week. During this period, the teachers administered the initial questionnaire, shared the video link, and then applied the final questionnaire. Two teachers participated in the project, one from each state school, holding degrees in Chemistry and Biology, respectively.

Four experimental videos have been made available to students: (1) acid–base indicator using red cabbage; (2) soda battery; (3) more resistant soap bubbles; and (4) quicksand. In addition, nine questionnaires were created: one introductory and eight corresponding to the initial (IQ) and final (FQ) stages of each experiment, all composed of multiple-choice questions.

The initial questionnaire (IQ) for experiment 1, classified as low complexity, contained five questions related to content previously taught on the chemical behavior of acids and bases. The final questionnaire (FQ) included seven questions, comprising the same five from the IQ plus two related to the experimental procedure. The IQ for experiment 2, of medium complexity, contained five questions on electrochemistry, while the FQ presented nine questions — the same five from the IQ plus four concerning the experiment itself. For experiment 3, also classified as low complexity, the IQ had five questions on intermolecular forces and carbohydrates, while the FQ contained five questions, four of which were identical to the IQ and one specific to the experiment. Finally, experiment 4, of high complexity, addressed the concepts of fluids, density, viscosity, and pressure. Its IQ included five theoretical questions, and the corresponding FQ consisted of five questions directly related to the experimental activity.

RESULTS AND DISCUSSION

The project was developed in partnership with two state high schools in the municipality of Unaí, Minas Gerais, focusing on high school students with the purpose of stimulating their interest in chemistry and contributing to their educational development. Student participation was recorded through evaluation forms (Table 1), which revealed variability in engagement levels. This irregularity may be attributed to limited internet access, as evidenced by students' reports describing difficulties with connectivity due to the geographic location of their homes. Similar situations were observed among other participants, which restricted their ability to complete activities requiring internet access. These findings align with those of Gomes and Moraes (2022), who highlight that digital inequality exacerbates educational disparities between public and private schools.

Experiments	School 1	School 2
Introductory questionnaire	63%	18%
IQ 1 – Soft drink battery	17% ® 7%	9% ® 6%
IQ 2 – Acid-base indicator using red cabbage	11% ® 8%	6% ® 4%
IQ 3 – Stronger soap bubble	18% ® 24%	10% ® 9%
IQ 4 – Quicksand	27% ® 8%	4% ® 2%

Table 1 – Number of students participating in the initial and final questionnaires by school.

Source: Author's elaboration (2025).

The administration of eight experimental questionnaires, each consisting of a pre-test and a post-test, enabled the comparative assessment of students' learning performance. As shown in Table 2, a modest improvement was observed, with the most significant gain recorded in the acid–base indicator experiment using red cabbage, which demonstrated a 6.74% increase in correct responses. All experimental video lessons were made available to first-, second-, and third-year classes, accompanied by pedagogical adjustments implemented by the teachers to ensure conceptual accessibility. For first-year students, additional explanations were provided, given that some of the topics addressed are explored in greater depth in subsequent school years (Pereira *et al.*, 2021).

In contrast, the "quicksand" experiment showed a 13.14% decrease in correct answers between the pre-test and post-test. This decline can be attributed to the conceptual complexity of non-Newtonian fluids, a topic that is not yet fully integrated into early high school curricula. As highlighted by Pereira *et al.* (2021), differences in conceptual maturity across grade levels may affect students' understanding of experimental content, particularly in cases where activities extend beyond the subjects traditionally addressed in each educational stage.

Experiments	Initial Questionnaire (IQ)	Final Questionnaire (FQ)
Soda battery	38.26 %	41.02 %
Acid–base indicator using red cabbage	40.00 %	46.74 %
More resistant soap bubble	46.42 %	50.90 %
Quicksand	51.62 %	38.48 %

Table 2 – Students' accuracy rates in initial and final questionnaires for each experiment.

Source: Author's elaboration (2025).

Similar outcomes were reported by Pereira, Costa, and Nogueira (2021), who found that experimental video lessons increased learning and student motivation. In the present study, however, the same pattern was not observed, as participation decreased (Table 1). This may be associated with the lack of internet access or the students' demotivation toward non-face-to-face activities. In introductory questionnaires, some students expressed dissatisfaction with virtual learning, stating, for instance, that "online classes are not good" or that they "prefer returning to in-person teaching." This observation is consistent with the findings of Silva, Reis, and Araújo (2021), who emphasize the need for appropriate pedagogical and technological support to optimize the use of digital resources in basic education.

Despite these challenges, a slight improvement in performance (Figure 2) indicates the potential of video lessons as a pedagogical tool. One student commented, "During this period, I have faced many difficulties in chemistry," revealing how remote education has affected their learning experience and underscoring the need for more inclusive strategies. According to Cardoso, Ferreira, and Barbosa (2020), educational inequalities highlight the urgency of planning pedagogical actions that take into account different social and school realities. In this context, Faria and Rocha (2022) point out that audiovisual resources can enhance student engagement and offer new cognitive experiences in science education.

Integrating theoretical content with experimental video lessons is essential to promote meaningful learning. Silva and Silva (2011) argue that videos demonstrating experiments capture students' attention and foster active knowledge construction. Similarly, Santos and Menezes (2020) contend that traditional experimentation, focused solely on observation, limits students' autonomy in the learning process. Furthermore, Ausubel, Novak, and Hanesian (2000) emphasize that learning becomes effective when new knowledge is anchored to previous concepts, reinforcing the importance of strategies that connect theory and practice. The absence of direct interaction with experiments—due to structural and logistical limitations—represents a relevant methodological restriction, as

Oliveira and Corrêa (2021) also argue, advocating for pedagogical mediation that values student protagonism.

Therefore, the production and distribution of experimental video lessons proved to be a viable educational alternative, enabling the continuity of teaching activities and the contextualization of chemical concepts. Even with limited infrastructure and connectivity, such resources were useful in stimulating students' interest and expanding their access to scientific knowledge. It is worth noting that these materials can also be employed in schools lacking laboratories or with insufficient supplies, serving as complementary tools for chemistry instruction. Recent studies by Gomes, Santos, and Rodrigues (2023) support this perspective, demonstrating that virtual experimentation can foster collaborative learning and reduce student dropout rates.

CONCLUSION

It is concluded that the applied methodology contributed to improving students' learning and motivation, highlighting the potential of experimental video lessons to integrate theory and practice. This approach proves relevant not only in remote education contexts but also in schools with structural limitations, reinforcing the importance of pedagogical innovation in science teaching.

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