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PRACTICAL TRAINING IN PANDEMIC CONTEXT FOR CHEMICAL ENGINEERING. CHALLENGES, STRENGTHS AND WEAKNESSES

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Abstract: As indicated by Darwin, a species that does not adapt perishes. In the current circumstances of the COVID-19 pandemic, and the corresponding social isolation, the UTN FRLP had to adapt the teaching and learning processes to guarantee educational continuity, through the virtual modality; thus expanding the capacity of the Global Virtual Campus for continuous and indiscriminate use in terms of time for teaching activity. And so significant is the incorporation of knowledge as its application represented by practical training in Chemical subjects for the Chemical Engineering career. That is the challenge of guarding the processes with the correct choice of resources and pedagogical-didactic tools most suitable for their development. So, the objective of this work was to statistically investigate the academic performance of students and the strengths and weaknesses derived from the chosen educational technology. Noting that it was affected, although the existence of other variables could also be responsible, such as connectivity, the quality of Internet service, the equipment used, among others. Social conditions that have also been taken into account from the human point of view and of containment towards the student. Thus, the realization of practical activities through virtual resources was pedagogically beneficial and made it possible to access a tool with clear descriptions, easy to use, without a time limit and inclusive. However, a large percentage of students have a preference for the practical activity in person, as well as the course.
Keywords: educational technology, academic performance, practical training, chemical engineering

INTRODUCTION

Any situation is valued when it is needed and cannot be accessed. Education as a citizen's right, established by the National Education Law No. 26206 [1], and even human has not been exempt from this feeling. However, the non-attendance modality was, is and will be available to all those who show interest in continuing their education, knowing how to manage their learning time in normal conditions or, as currently, in critical circumstances [2].

Currently, humanity is going through a health crisis that calls us from the beginning to remain isolated and change many of its social customs and, as it cannot be exempted, face-to-face education [3].

This, which may seem only a modification, generates a whole manifestation of different methods of approaching knowledge, and among them, Virtual Education (VE) stands out like a titan. However, this teaching modality requires both a teaching style, resources or tools to be used and a student willing and prepared to receive knowledge through this medium. Therefore, the disruption in the face-to-face educational activity forced the system and by extension the educational institutions to look for alternatives given the paradigm shift. Thus, the EV model emerged as a proposal to respond and ensure educational continuity.

Virtuality with its new learning spaces should be observed and applied in initial teacher training. The teaching performance has been located and thought in a physical space determined by four walls, the classroom. Teachers have a different role, they have changed. Therefore, it requires an academic preparation with a framework in the new design for the current learning situation and contexts; with skills as mediator and tutor; skills to apply communicative strategies and computer skills [4].

As for the educational process, this situation is channeled towards a methodology based on the student, since it is he who will interpret and set his own pace of learning. In the process, the student must progressively acquire autonomy; develop the capacity for analysis, comparison and synthesis. All the study strategies considered basic, tools that will facilitate the student's progress in the career. And incorporate other skills applied to research and the work area. Self-management of knowledge will encourage learning to learn [5], [6].

It is for these reasons that we propose the assessment of an indicator inherent to the teaching and learning processes that were affected by the impact of the unforeseen and significant arrival of virtual, compulsory, health and isolation education: practical and experimental training, which require skills and competencies for abstraction, imagination and, like all science nowadays, the use of computer tools.

Thus, the general objective of the present work is to statistically investigate the academic performance of Chemical Engineering students in two subjects, as well as the strengths and weaknesses derived from the chosen educational technology, due to the socially established change, in these circumstances, in society.

DEVELOPMENT

Two groups of the 2020 academic year, with 20 (twenty) students each, participated in the development of this research: one from the first year of General Chemistry (QG) and the other from the second year of Organic Chemistry (QO), both subjects taught for Chemical Engineering, belonging to the Basic Sciences and Chemical Engineering Departments, respectively. As expected, only virtual laboratory activities were used during this year, although they were different for each subject.

It is therefore a comparative research with an experimental design that promotes the use of educational technology, combining procedures for obtaining information and quantitative analysis.

In order to carry out the laboratory activity that is the focus of this research, students were provided with a practical work guide containing the objectives of the laboratory, formulas, necessary calculations, the operating technique and, logically, a web page where they could log in to carry out the activity.

The following tools and techniques were used to collect the information and process it statistically:

a) Preparation of the theoretical framework.

b) QG students: implementation of this activity in Virtual Laboratories of several institutions with free software via Internet.

c) QO students: development of the activity through educational videos of their own making and from other Universities, uploaded on the YouTube platform with free access, or the Virtual Campus that was provided for the Chair.

d) Analysis of the results obtained by the students applied a virtual laboratory environment (QG), with respect to descriptive videos (QO).

e) Preparation of surveys to obtain feedback on the activities developed.

QG LABORATORY ACTIVITY

During the 2020 academic year, the following virtual laboratories were conducted:

- *Experimental verification of gas laws.* Virtual environment of the University of Oregon, free-to-use software via the Internet [7].
- *Heat transfer.* Pearson Education INC. virtual environment, free to use via the Internet [8].

- *Colligative properties.* Virtual environment of the University of Oregon, free use software via Internet [9].
- *pH of aqueous solutions.* Virtual environment of Tema Fantástico S.A., software of free use via Internet [10].
- *Acid-base titration.* Virtual environment of Tema Fantástico S.A., free use software via Internet [11].
- *Electrochemical cells.* Pearson Education INC. virtual environment, free to use via the Internet [12].

In view of the number of practical assignments, the virtual laboratory activity "Heat Transfer" (see Figure 1) will be developed, which is a cross-cutting content with the second year subject (QO), consisting of the following objectives:

1) Analyze heat transfer processes.
2) Compare the heat exchanged by different metals.
3) Find the specific heat of an unknown metal.

Figure 1: Selected virtual laboratory

Thus, once they have entered the virtual laboratory, students must select the metals (iron and copper) and the transfer medium (water) required for the demonstration, and then configure the simulator according to the objectives set (temperature conditions) (see Figure 2).

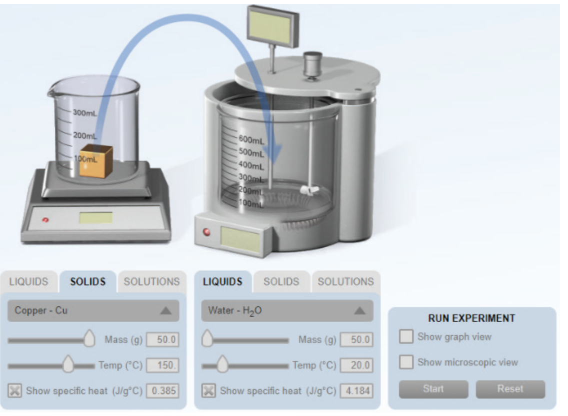

Figure 2: Selection of working conditions and start of the simulation

At this point, students must apply the theoretical concepts learned to perform the requested calculations to obtain the pertinent conclusions.

Next, they should determine the specific heat of an unknown metal, applying the same selection criteria as in the previous steps (see Figure 3).

It should not describe methodology or results obtained, but it is important to describe the motivation for the work, the challenge in relation to the available resources or even the potential impact of the work.

Figure 3: Simulation for unknown metal

With the results obtained, students must analyze and interpret the difference between the heats manifested by each of the selected metals, and justify the specific heat of the unknown metal that has been determined in this way.

QO LABORATORY ACTIVITY

For second year students, a different digital literacy tool was implemented: educational videos, with special attention to the development of an organic synthesis and identification reactions, knowledge that students had to apply effectively in the subsequent writing of a technical report.

This learning tool was chosen for the QO course because, having had the possibility of taking a previous subject with a high experimental training workload (QG - direct correlative), the students had basic knowledge of laboratory material, safety standards, work methodology, among others. On the other hand, since they are experienced students in the university environment, they can benefit from the explanatory videos, which, in addition, given the nature of the subject, address contents that are complex to develop outside the classroom and highly visual.

Thus, this audiovisual medium, used during 2020, represented the practical work that was previously done in person:

- *Liquid-liquid extraction.* Video from the University of Zaragoza, freely accessible via YouTube platform [13].

- *Reactions of aliphatic hydrocarbons.* Video from Universidad Manuela Beltrán, freely accessible via YouTube platform [14].

- *Reactions of alcohols.* Video from the Universidad Nacional de Colombia, freely accessible via YouTube [15].

- *Synthesis and recognition of aldehydes and ketones.* Video prepared by the QO Chair, accessible via the Virtual Campus of the University (UTN-FRLP) [16].

- *Identification of acid derivatives.* Video made by the QO Chair, accessible via the Virtual Campus of the University (UTN-FRLP) [16].

- *Carbohydrates. Characteristic reactions and biotechnological implications.* Video of the ECCSI University freely accessible via YouTube platform [17], and video made by the QO Chair, accessible via the Virtual Campus of the University (UTN-FRLP) [16].

As in the previous section, the practical work "Carbohydrates. Characteristic reactions and biotechnological implications", which was developed by means of two explanatory videos, having the following objectives:

1) Analyze various reactions for the identification of glucids (monosaccharides, disaccharides and polysaccharides) using different chemical agents.

2) Justify the results obtained from their chemical, optical and structural properties.

3) Compare the yield of the chemical hydrolysis reaction with respect to the enzymatic hydrolysis reaction for a polysaccharide (starch).

The activity begins with a brief synthesis of contents, taking up those that are central to the practical development. The aim is that the visualization not only provides a description of the experimental trials, but also enables a correlation between ideas and concepts, thus going through the identification mechanisms of the simplest carbohydrates (monosaccharides), up to the characteristic reactions of higher carbohydrates (disaccharides and polysaccharides) (see Figures 4 and 5).

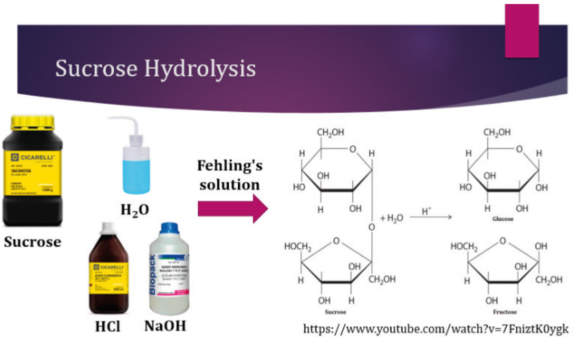

Figure 4: Reactions with disaccharides

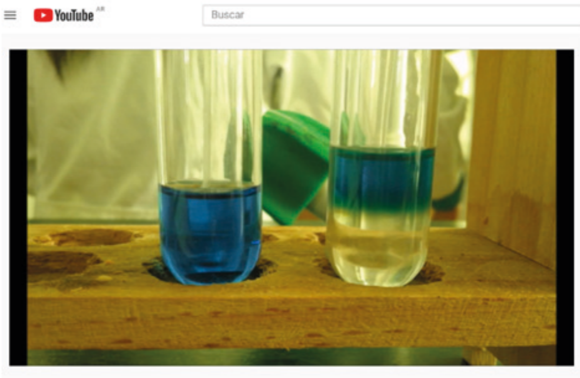

Figure 5: Reactions with disaccharides

Then we proceed to the analysis of a hydrolysis reaction of a biological polymer (starch), applying two different routes for the same. This substance is important in chemical and food engineering, which is why it is studied in this course (see Figures 6 and 7).

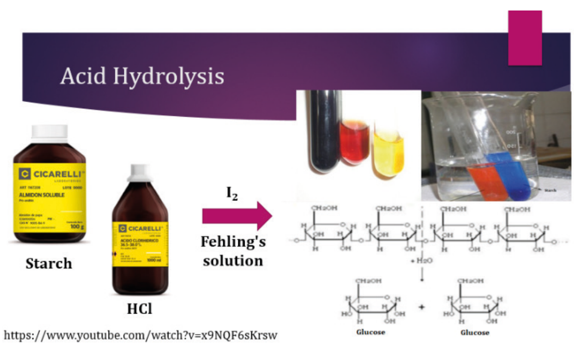

Figure 6: Hydrolysis of starch

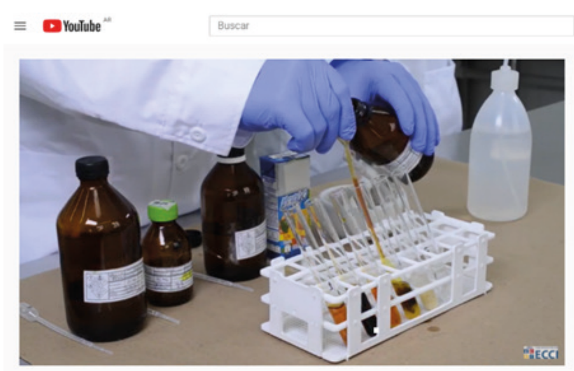

Figure 7: Hydrolysis of starch

At the end of the activity, students must submit a final report. In this manuscript they must develop the main working hypotheses, the objectives pursued during the practical, chemical equations that interpret the phenomena addressed, analysis of results and development of conclusions. On the other hand, for the hydrolysis reaction, they are requested to investigate the mechanisms of industrial production and compare them with the tests at laboratory scale; that is, the applicability and verification of the chemical principles is sought.

VALIDATION OF PROPOSED ACTIVITIES

Considering that many chemical concepts are difficult to explain in the classroom, it is essential to train students in the use of technological tools, so that they can use them as a thread between theory and practice, enabling a better appropriation and consolidation of learning, which allows them to develop skills and attitudes.

After the completion of the practical-experimental training activities, a questionnaire on the subject was included in the formal evaluations that the Chairs carry out on their students, in order to verify the incorporation of concepts and the mastery of the analysis of a concrete situation or a complex procedure, always applied to the subject under study.

Finally, to quantify whether the methodologies used were satisfactory, semi-structured surveys were conducted. The analysis of these surveys was aimed at achieving communication and joint construction of meanings based on a guide of specific questions and subject exclusively to it [18].

Thus, at the time of preparing the questionnaire, the following were taken into account:

i) Questions were clear and understandable to students;

ii) The questions were preferably directed to a single aspect or logical relationship;

iii) The questions did not lead to answers;

iv) In the case of questions with multiple answers, where the student had to choose only one answer, the idiomatic expression was guarded so as not to affect the student's answers;

v) The language used in the questions should be understandable to the student;

Premises taken into account and included in the set of actions programmed by the Chairs.

RESULTS AND DISCUSSION

The performance of the students in the different evaluation instances carried out by the Chairs during 2020 is analyzed (see Figure 8).

It is possible to appreciate a great similarity in the grade point averages for the third evaluation instance (QG: 6.75 and QO: 6.80, respectively). There is also a difference between the first evaluation (QG: 7.0 and QO: 7.2) and the final evaluation (QG: 6.85 and QO: 7.05).

The results obtained reflect a tendency towards a decrease in the academic performance of the students after the first evaluation, although in the subsequent ones a certain linearity is observed, with a notable increase for QO. This may be due to physical and emotional fatigue caused by virtuality, and in some cases, by academic overload and frustration in the face of poor performance [19].

The analysis of the surveys, and the validation of the answers provided by the students of both subjects on the development of the experimental activities, their evaluation and work dynamics, were represented in the following statistical graphs (see Figure 9).

Regarding the use of virtual tools and subsequent performance in the evaluation of the contents, their implementation can be seen as positive in order to consolidate knowledge. However, most of the students expressed their preference for face-to-face activities over virtual ones (88%); even the first year students who did not have the opportunity to compare them. Compared to what was developed in virtual environments, the restlessness and thirst for knowledge by working in the laboratory was reflected in this point.

On the other hand, students were asked to evaluate the activities from a technical and comprehension point of view, as well as the general proposal, where they were satisfied with these items (see Figure 10).

Finally, and to close the questionnaire, they were asked about the problems they encountered during the 2020 school year (see Figure 11).

An analysis of the figure shows a marked trend regarding the availability of computer resources, connectivity and quality of Internet service, which are considered acceptable. However, a large number of students indicated that they did not have the necessary physical space to carry out the activities associated with their training process (38%). Regarding this point, a more detailed explanation was requested in later classes, where the students expressed that since they were at home 24 hours a day with all the members of their families, it was very difficult for them to coordinate activities and to have a space that could be considered as their own to carry out the follow-up of the subjects. Furthermore, they pointed out that this was not a problem when the course was face-to-face, since the teaching and learning processes took place at the University.

CONCLUSIONS

According to statistics, carrying out practical activities through virtual resources was pedagogically beneficial and made it possible to access a tool with clear descriptions, easy to use, with no time limit and inclusive, although it is worth mentioning that a large percentage of students prefer face-to-face practical activities in the laboratory, as well as taking the courses.

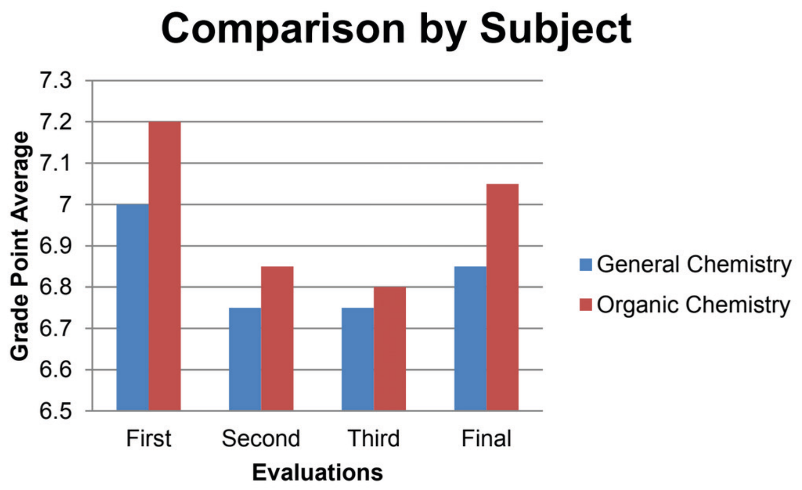

Figure 8: Academic performance (QG and QO)

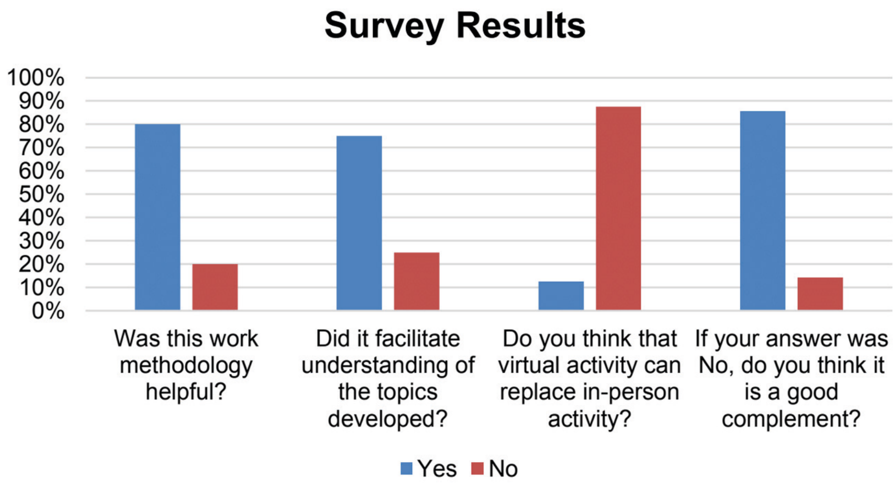

Figure 9: Survey results

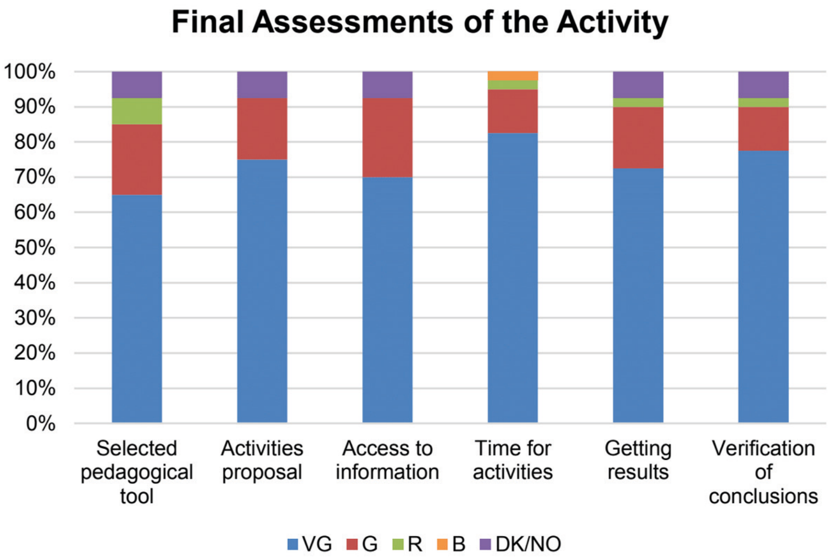

Figure 10: Concluding remarks

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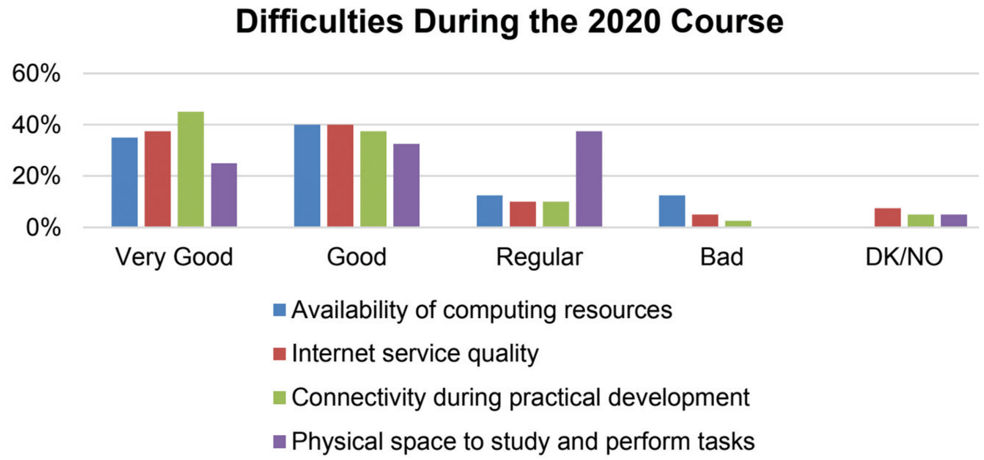

Figure 11: Difficulties in 2020 (QG-QO)

However, the incorporation of knowledge can be difficult because the student acts as a simple spectator. For this reason, it is concluded that the virtual activity is an excellent integrative tool in the teaching and learning processes. However, it is necessary to take into account that, although there are laboratory practices that cannot be carried out virtually, no resource acting alone can achieve the objective of such processes, but rather they complement each other. Let us remember that every resource is a means and not an end in itself.

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