IMPLEMENTATION OF NEW MEASURES TO IMPROVE THE STUDENTS' ACADEMIC PERFORMANCE IN THE ADVANCED CHEMISTRY SUBJECT (CHEMISTRY ENGINEERING DEGREE)

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Abstract

Advanced Chemistry is taught during the first semester of the second year in the Chemistry Engineering Degree at University Jaume I. In the last years, there has been a decrease not only in students' grades but also in their learning attitude.

This subject was not directly affected by the SARS-CoV-2 pandemic, but indirectly since in the 2020/21 academic year, many students passed from first to second year with a deficient level because of a very poor assessment, due to the exceptionality of the situation. In the next academic year 2021/22, the same perception continued after taking the first exam, where only 11 students passed (3 with compensable mark) out of 36 presented (for a total of 50 students).

It was then necessary to take new actions in order to improve the academic performance of the students as well as their motivation. It is essential that the professor put him/herself in the student's skin, detect their concerns, and see the things with their eyes to understand their situation, which is what finally is reflected in their academic performance.

Their learning must not only be academic but also personal. Both are related and indivisible. Then, in this sense, the present work aims a personal involvement of the students, and a closer treatment. New activities (such as step-by-step solved problems and personal tutoring, among others) have been done during the academic year 2022/23. The aim of this work is to evaluate and discuss the obtained results.

Finally, to check the students' satisfaction, they filled a questionnaire that asked about these activities, so that they could evaluate this work. In addition, every student had the opportunity to make any observation of interest for the development of the subject.

Keywords: Advanced Chemistry, Chemistry Engineering degree, teaching, learning quality, students' academic performance.

1 INTRODUCTION

Since the results were not good in the subject of Advanced Chemistry, it was necessary to take some actions.

The first goal was to improve the student yield rate. Last year, the yield rate was 30%. Out of 50 enrolled students, 32 did the exam and only 15 succeed the subject. These data are quite low that needed to be improved. The general mark of student satisfaction obtained from the teacher evaluation survey was 4.5 (26.5% participation), which suggested that the students were happy with the task developed by the faculty.

In order to improve this performance, several new activities are proposed:

1 A collection of solved problems, explained step by step and in full detail that would be uploaded to the virtual classroom

2 Self-assessment tests through the virtual classroom so that students can detect their weak points.

3 Personalized tutoring that addresses the learning difficulty of each student in particular, as well as, their external problems that directly affect their performance, if possible.

4 Carry out some reinforcement class outside the subject's timetable at the request of the student body.

This way, it is possible to detect the students' academic shortcomings and emphasize the explanations in the next courses. In addition, it is also important to detect the emotional shortcomings of our students and support them when they need it. The pandemic lockdown has left younger people very affected, and this affects their performance considerably. The teaching staff must transmit knowledge but at the same time also connect with the students. This symbiosis must guarantee students' personal growth, and be reflected in their performance.

This is intended to achieve the sustainable development goals (SDGs) or global objectives related to teaching [1-3]. We want to guarantee inclusive and equitable quality education where no one is left behind. SDGs aim to transform our world. They are a call to action to end poverty and inequality, protect the planet, and ensure that all people enjoy health, justice and prosperity. In 2015, all the countries in the United Nations adopted the 2030 Agenda for Sustainable Development. It sets out 17 goals, which include 169 targets. Goal 3 is to ensure healthy lives and promote well-being for all at all ages. However, it is also cross-cutting, so that progress in its implementation contributes to progress towards other goals, and action on other goals in turn contributes to attaining goal 3. Most goals also have some direct health targets. All of them have indicators by which progress can be measured.

The 2030 Agenda [4] and its Goals offer a comprehensive vision for sustainable development that:

- Is global, rather than limited to "developing" countries as was the case with the Millennium Development Goals (mdgs);
- Is based on values such as equity and respect for human rights;
- Relies on approaches such as sustainable financing, scientific research and innovation, and monitoring and evaluation;
- Requires a new way of working, involving intersectoral action by multiple stakeholders;
- Aims to strengthen health systems towards universal health coverage (UHC).

Thus, it is necessary to consider the student environment and the impact it has on them. Activities 1 and 2 aim to promote lifelong learning activities. If these goals are achieved at the educational level, we are opening the door to facilitate the rest of the SDG goals among our students. Good training together with good personal growth are the keys to improving the future.

Finally, the effectiveness of these measures will be studied, and academic results will be compared with those of previous courses.

2 METHODOLOGY

Currently, the Advanced Chemistry subject for the degree in Chemical Engineering (Analytical Chemistry block) is divided into the following topics:

1 Introduction to volumetric analysis

2 Application of acid-base equilibrium. Titrations.

3 Application of solubility equilibrium. Titrations.

4 Application of complex equilibrium. Titrations.

5 Application of redox equilibrium. Titrations.

6 Gravimetric methods of analysis

7 Spectroscopic methods of analysis. Chromatographic methods. Electroanalytical methods.

The four activities indicated in the Introduction were mainly carried out.

A collection of solved problems was compiled and self-assessed tests prepared that were uploaded. As theory topics were explained, solved problems and the corresponding self-assessed tests gradually became available to students. In addition, more self-resolution problems were proposed by following the model of the previously resolved problems. Students were also requested to solve these problems on the blackboard in front of their classmates.

At the end of each block, a resolved problem assessment, similar to the final exam, was developed. Finally, students corrected their problems, so they found the errors they have made.

These learning outcomes should ensure that on successful completion of Advanced Chemistry students will be able to:

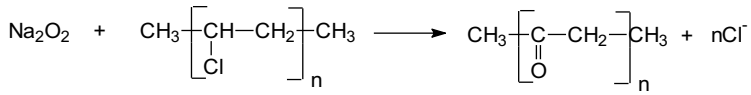
- Define the scope of volumetric methods and describe their rationale, highlighting the features the reactions must have if they are to be used in these methods.
- Describe the fundamentals of direct and back titrations, highlighting the differences in the experimental procedures.
- Carry out the necessary calculations in order to draw titration curves for acid-base, complex formation, precipitation and oxidation-reduction systems.
- Describe the features that primary and secondary standards should have.
- Select the appropriate chemical indicator and calculate the titration error.
- Explain the basis for the main applications in volumetric analysis.
- Determine the analyte concentration in a sample by titrimetric analysis.
- Describe the features that must be met in a chemical reaction if it is to be used in gravimetric analysis.
- Describe the steps involved in a gravimetric procedure.
- Describe the characteristics of the precipitates and the factors that influence a gravimetric procedure.
- Explain the basis for the main applications of gravimetric analysis.
- Determine the analyte concentration in a sample obtained by gravimetric analysis.
- Describe the fundamentals and instrumentation of spectroscopic, chromatographic and electroanalytical methods.

Below is an example of a step-by-step solved problem.

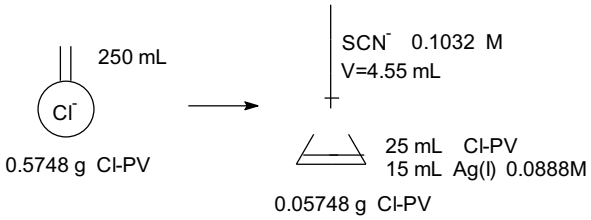
A sample of 0.5748 g of a polyvinyl chloride plastic melts with Na_2O_2. The residue is dissolved in water, being destroyed the excess of oxidant by boiling for 15 minutes. Then, it is acidified with nitric acid and topped up to 250 mL. To a 25 mL aliquot, 15 mL of Ag(I) 0.0888 M are added. The excess of Ag(I) is titrated according to the Volhard method with SCN^- 0.1032 M, being consumed 4.55 mL. Calculate the percentage of chlorine in the polyvinyl chloride.

Solution

The reaction is:



The titration is:



The reactions of the titration are:

$Ag^+ + Cl^- \leftrightarrow AgCl\downarrow + Ag^+_{excess}$

$Ag^+_{excess} + SCN^- \leftrightarrow AgSCN\downarrow$

The volume excess of silver is calculated taking into account the stoichiometry of the titration reaction. Since the reaction is mole to mole:

$$mole\ Ag^+, excess = mole\ SCN^- \rightarrow V_{Ag,excess} * M_{Ag} = V_{SCN} M_{SCN} \rightarrow V_{Ag,excess} * 0{,}0888 = 4{,}55 * 0{,}1032$$

$V_{Ag,excess} = 5{,}29\ mL$

Thus, to neutralize the chlorides, Cl^-, it is required to add the following volume of Ag(I):

V_{Ag} =15 - 5,29 = 9,71 mL

Next, the chloride concentration in the 25 mL aliquot is calculated:

$$mole\ Cl^- = mole\ Ag^+ \rightarrow mole\ Cl^- = V_{Ag} * M_{Ag} = 9{,}71\ 10^{-3} * 0{,}0888 = \ 8{,}62\ 10^{-4} mole\ Cl^- in\ 25\ mL$$

In 250 mL:

$$8{,}62\ 10^{-4}\ mole\ Cl^- \frac{250mL}{25mL} = 8{,}62\ 10^{-3}\ mole\ Cl^-$$

$$8{,}62\ 10^{-3}\ mole\ Cl^- \frac{35{,}453}{1mol\ Cl} = 0{,}3056\ g\ Cl^-\ in\ the\ sample\ of\ Cl - PV$$

Finally, the % Cl^- in the sample is calculated:

$$\%Cl^- = \frac{g\ Cl^-}{g\ mostra} * 100 = \frac{0{,}3056}{0{,}5748} * 100 = 53{,}17\%$$

From the beginning of the course, students were called to give them personalized tutoring, being asked about the difficulty they found in the development of the syllabus, and looking at how to improve weak points. In addition, they were offered to be heard at any level. Many times, they wanted to speak but were not heard. This is something common in our education system and that needs to be changed urgently. We have to see things from their perspective in order to help them and not just demand more and more work. Students have feelings and are not soulless machines.

With all the information collected from the previous sections, the appropriate reinforcement classes were held at the request of the students.

A brief questionnaire has been formulated to know the students' opinion about the measures taken to improve their performance. Twenty-one students participated in this study. Th~~is~~ questionnaire is shown in Section 3.

3 RESULTS

Right now, we have only results from a first partial exam, which was not mandatory. We must point out our concern about students' attitude in the classroom. Many of them did not take notes in class but pictures of the solved problems on the board. We think this is not very helpful as their understanding has to be accompanied by the corresponding explanation instead of photographs. This worrying situation needs to be evaluated and turned around. Speaking with repeaters, it is an attitude that the new second year students have in all subjects and it is not an isolated fact.

The results of the first partial exam were not optimal, but they reflected the situation in the classroom discussed above. A total of 36 students did the exam, with a yield rate of 30.1% and a success rate of 44%. This included passed and compensable marks (> 4).

The carried out activities were:

1 Compilation of a collection of solved reinforcement problems, explained step-by-step and in full detail.
2 Personalized tutorials
3 Reinforcement classes.

Students think that the collection of solved problems are helpful, but they requested exam problems for a better understanding. In addition, the personalized tutorials had great acceptance among students since they could share their concerns about the subject and the way they are learning it. Sometimes, they need simply a preliminary orientation, and be focussed on the hot topics on the different lessons. Finally, the reinforcement classes helped to point it out some theoretical and practical concepts.

3.1 Comparison of results

Table 3.1 shows the yield rate and the success rate in the last academic courses.

Table 3.1. Yield and the success rate in the 2020-2022 period.

Academic year	*Yield rate (%)*	*Success rate (%)*
2019-2020	55.2	48.5
2020-2021	36.7	43.9
2021-2022	30.0	46.9
2022-2023*	30.1	44.4

**provisional results*

As can be observed, the results in the period 2020-2023 are very similar. The results in the academic year 2019-2020 correspond to the lockdown during the pandemic, so it is not representative.

After the application of the project, it would seem that good results are still missing, but it has to be taken into account that just one exam has been done, so the results are not definitive.

3.2 Students' Survey

A survey (21 responses) was conducted where the following three questions were included:

1. Did you keep the subject up to date? Why Give reasons (academic, familiar, etc.)

Only 19% kept the subject up to date, and 23% more or less. The reasons were mainly academic. Students had too many subjects (theory and laboratory).

2. Which part of the subject do you think is more ~~complicated~~ difficult to learn and why?

There was no unanimity in the answers. Students found some parts more difficult than others.

3. What can the professor do to facilitate the more difficult parts of the subject?

In this case, they mainly indicated doing exam problems in class (even uploading them in the virtual classroom). This answer was surprising since this kind of exercises were doing in the classroom, although they were not presented as exam problems. Students also ask for more exercises. They currently have a collection of 42 problems plus 16 solved step-by-step.

4 CONCLUSIONS

Not definitive conclusions can be obtained so far since the academic year is not yet finished, and more exams have to be done in the future, so the results are provisional.

Students thank the effort made by the professor to facilitate the learning of the subject, but unfortunately, the preliminary results were not as expected, maybe due to their working attitude in the classroom and also at home. Only a 30.1 yield rate is not enough, and this must grow.

Thus, more actions will be taken in the 2023-24 academic year to continue improving the student's performance:

1. More step-by-step solved problems will be added to the current collection, including exam problems.
2. Weekly assessable activities in the classroom will be done, so the students have to follow the subject day by day.
3. Continue with personalized tutorials.
4. Carry out some reinforcement class outside the subject's timetable at the request of the students.

Finally, apart from the studied concepts, it is also expected that students will be able to know in this subject how to apply the knowledge learned to guarantee an inclusive, equitable, and quality education and promote learning opportunities for everyone, to acquire a special sensitivity for sustainable management of water, raw materials and energy sources, as well as for an environmentally friendly and sustainable development, in addition to being able to design, select and/or develop efficient chemical products, processes and/or analytical methodologies that minimize their impact on the environment, using alternative raw materials and reducing wastes.

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REFERENCES

[1] Duncan French, Louis J. Kotzé (Eds), *Sustainable Development Goals*, Edward Elgar Publishing, London, United Kingdom, 2018.

[2] Narinder Kakar, Vesselin Popovski, Nicholas A. Robinson, *Fulfilling the Sustainable Development Goals On a Quest for a Sustainable World*, Routledge, London, United Kingdom, 2022.

[3] P. Pradhan, L. Costa, D. Rybski, W. Lucht, J.P. Kropp, "A Systematic Study of Sustainable Development Goal (SDG) Interactions." *Earths Future* 5 (2017)1169-1179.

[4] Alicia Bárcena, Mario Cimoli, Raúl García-Buchaca, Rolando Ocampo, Ricardo Pérez, *The 2030 Agenda for Sustainable Development in the new global and regional context*, United Nations, 2020. https://repositorio.cepal.org/bitstream/handle/11362/45338/4/S2000207_en.pdf (last access date 1.2.2023)