DESIGNING A FLIPPED CLASSROOM IN AN INDUSTRIAL ENGINEERING MASTER SUBJECT

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Abstract

Flipped classroom is a methodology mainly based on delivery instructional content to be used outside the classroom. This methodology was applied in “Chemical Process Design” subject, corresponding to the first course of the Master’s in Industrial Engineering. This course has 3 ECTS distributed on master classes, computer lessons and seminars. The main objective of this course is to provide students with the fundamentals and technologies applied in the field of Chemical Process Design. This course is evaluated by continuous and final assessments. In the continuous assessment, students simulate a chemical process using Aspen Plus, a powerful simulation software. This is the first time that students work with this software and different problems were detected regarding the practical skills with the simulator. To improve the skills students learn about the simulator, different video lessons were prepared combining videos and traditional computer lessons. The aim of this work is to analyse the effect of these video lessons in the students’ learning needs. Thus, students’ marks of this academic course were also analysed and compared to the previous ones. Results were highly positive for most of the students. Hence, it seems flipped classroom is an effective tool for the knowledge embracement in the area of the chemical process simulation.

Keywords: flipped classroom, learning, methodology, videos.

1 INTRODUCTION

The flipped classroom concept does not deal only with recording a section of the lesson or a specific subject in a video. It has more to do with employing that video tutorial as a media for achieving an effective transmission to students, fostering critical-reflective reasoning. In this way, more time can be devoted to: i) interacting with students, ii) increasing motivation, iii) improving performance through formative feedback and iv) differentiating the needs of each student, as well as carrying out activities specific to the project developed with PBL methodology [1]. Authors such as Mingorance et al. [2] also establish that this methodology reduces drastically the number of students that do not take the exam.

This learning model presents four basic keys [3]: i) the generation of flexible environments in the pace of learning, ii) the change in the learning culture more centred on the student and generating more learning opportunities in the classroom in a more personal way, iii) the design of intentional material, appropriate to the characteristics of the course, the subject and the students; and iv) professors or groups of qualified professors, who observe and evaluate the work developed by the students.

One of the tasks carried out in this work has been to evaluate the impact of audiovisual resources prepared for students. Next, the results obtained are compared with the different methodologies analysed and evaluated by the faculty in order to establish the strengths and weaknesses of the learning processes. Ultimately, in this work the objective is to achieve the involvement and collaboration of students through the use of a flipped learning, as well as teaching and learning on-line engineering careers, which is not very usual but with satisfactory results where it has been tested [4], freeing space to delve into active learning through PBL methodology that is already done in the subject.

1.1 Starting situation

The flipped classroom has been applied to students of the first course of Master’s degree in Industrial Engineering for the subject of “Chemical Process Design” in which currently active methodologies are being employed. This subject consists of 3 ECTS distributed in master classes (15 h), computer lessons (9 h divided into 6 sessions of 1.5 h) and seminars (6 h). It is taught to 4 groups in 3 different languages (Spanish, Basque and English), with about 240 students per academic year.

In each academic year students have to design an industrial chemical process from a real scenario, using a powerful and realistic chemical process simulator, and at the same time complex, such as
Aspen Plus. The realization of this open project is carried out in a dynamic and cooperative way through active methodologies – the students have to look for information and apply it in the design of their process. In previous years, problems in the design of the chemical process related to software were detected, as they did not develop deep technical aspects of the project.

Up to now, during the first 3-4 sessions the basic aspects of Aspen Plus and the levels of work required to students, by the end of the subject, were explained. The material that the students had for this purpose were some PowerPoint presentations, in addition to the oral explanations given by the professors during the lessons. This learning rhythm allowed the students to use the last two face-to-face sessions to develop the project.

During the last years, it had been observed that the material required to teach in those first sessions was a lot. Both the students and the teaching staff had the feeling of going fast and without time to assimilate important concepts or to enter into aspects that are more complex. This could allow the students to design a process much in line with real industrial processes. In addition, the huge possibilities of the software make it complex, and the students had many management doubts when carrying out their project.

As a response to this problem, the way of teaching the classes has been modified during the initial face-to-face sessions, where, until now, the knowledge about the software that the students need to manage to carry out a successful project was taught. Throughout the last academic year (2018-19), a series of short audiovisual resources (video tutorials) were used. In each one a specific topic is explained, so that when students have doubts they can go directly to the video tutorial. In addition, they still have the presentations that were employed in previous years, the explanations of the professors and the notes that they have been taking during the face-to-face sessions. The video tutorial is a very suitable tool for learning a software, since it is much more natural to see how something is done, than to read pages and pages with screenshots of a software. They can be paused whenever you want and allow you to repeat once again what is shown in the video tutorial. The videos include both images and oral explanation, which favours the understanding and assimilation of the operation with the software. In this way, at the beginning of the session the students already know what they will work with during that class. In this way, instead of spending most of the time on these explanations, it can be used directly to perform practical exercises and analyse software peculiarities when performing those calculations, make variants of the same exercise so that they can analyse different simulation options, etc.

1.2 Objectives

The main objective of this study is based on the improvement of autonomous and active learning including the flipped classroom method and combining it with the current structure of the subject. In this way, the goal is to have a teaching model focused on the students and on their learning needs, transferring part of that learning process to the outside of the classroom. In this way, classroom hours will not be dedicated to the explanation of the operation of the simulator, but to work more technical aspects [5].

1.3 Expected improvements in learning outcomes

With the incorporation of “flipped learning” methodology, it is expected that the students acquire the basic knowledge of the use of the simulator before the face-to-face sessions. In this way, these sessions will be used to assimilate concepts, to deepen knowledge of the simulator exploring some advanced tools that students may require during their learning process [6]. Therefore, it is expected that the inclusion of the inverted class will help to:

- Have a greater conceptual load in the face-to-face sessions, extracting much more profit and being able to analyse issues that are more complex. Thus, a deeper, more progressive and much more meaningful learning of the Aspen Plus simulator can be achieved.
- Avoid that the lack of any background in working with the simulator is an obstacle when designing the project.
- Increase the involvement, collaboration and motivation of students by encouraging them learning outside the classroom.
- Greater degree of use of face-to-face hours.
As a result of all these improvements, it is expected that the design of the chemical process to be developed by the students will be more complete and will possess deeper characteristics and degree of detail.

2 METHODOLOGY

In order to achieve the aforementioned objectives and expected improvements, the following actions were carried out.

1 Preparation of audiovisual material for students. The video-tutorials are accessible on the eGela platform (Moodle) through private links to YouTube, so they can be visualized from any device. Note that a new topic has been introduced in the last academic year in which audiovisual material will not be used to try to analyse this effect.

2 Preparation of documents that certify a good operation of cooperative work (group formation contract, minutes of meetings and self and co-evaluation).

3 Preparation of questionnaires to be answered by the students. These quizzes will give valuable information about the learning process with the video-tutorials (to know their opinion, if it has served them to be more autonomous and analyse the strengths and weaknesses of the flipped classroom design).

4 Evaluation of the final work carried out by the groups.

5 Comparison of students’ learning results obtained when using the flipped classroom with respect to the results of previous years without flipped classroom.

6 Study the feedback received from the students and study if corrective actions must be adopted in the design of the flipped classroom for following academic years or to extend its development.

The evaluation of the projects has been carried out continuously be means of different deliverables and with personalized tutorials. Mention the use of a rubric through which the students know from the beginning how the project will be evaluated. The eGela platform also allows seeing who watches the videos before each face-to-face class helping to the teaching staff to know if the students have prepared the material.

3 RESULTS

The obtained results from flipped classroom are analysed from two different points of view:

a) Results obtained from the student-questionnaires realized before and after using flipped classroom.

b) Quality of the students’ projects and the comparison with the quality of the projects of previous academic years.

In the previous questionnaires students had to answer some questions about the previous knowledge of the software Aspen Plus, their knowledge about flipped classroom, and the advantages and disadvantages of the flipped classroom methodology that they foresaw. Table 1 summarizes the results obtained in this first questionnaire. Most of the students did not know neither what Aspen Plus is, nor flipped classroom is. But after the explanation of what this methodology involves, lots of them realized that they have used this methodology sometimes during bachelor or/and Master. It should be pointed out, that initially students think that this type of methodology could be helpful for their learning process; in fact, the 92.2% of the students think that the prepared audiovisual material could be highly or very highly helpful for their leaning outcomes acquisition.

Among the advantages of the flipped classroom methodology, the students emphasize that the availability of the audiovisual support is a key factor since they are able to view the video tutorials anywhere and anytime, being able to prepare the topic at their own rhythm. The main disadvantage of the flipped classroom is the resolution of doubts when the students are watching the audiovisual material. This problem can be improved by promoting the use of tools such as "forums" in the eGela platform (Moodle) or by attending face-to-face tutorials with the professor.
Table 1. Previous questionnaire results about their knowledge in Aspen Plus Software and Flipped Classroom.

<table>
<thead>
<tr>
<th>Knowledge about software</th>
<th>Knowledge about flipped classroom</th>
<th>Knowledge about similar methodologies</th>
<th>Audiovisual supports and their importance on learning outcomes acquisitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>6.9</td>
<td>3.7</td>
<td>52</td>
</tr>
<tr>
<td>No</td>
<td>93.1</td>
<td>96.3</td>
<td>48</td>
</tr>
<tr>
<td>Very little</td>
<td></td>
<td></td>
<td>2.6</td>
</tr>
<tr>
<td>Little</td>
<td></td>
<td></td>
<td>5.2</td>
</tr>
<tr>
<td>Highly</td>
<td></td>
<td></td>
<td>45.9</td>
</tr>
<tr>
<td>Very Highly</td>
<td></td>
<td></td>
<td>46.3</td>
</tr>
</tbody>
</table>

Regarding the questionnaires made to the students after the end of the classes (after finishing the project), it has been verified that the students watch the videos in the university (51.1%) or at home (46.5%). The personal computer is the most used device to see this audiovisual material (78.3%), being the set of tablets and smartphones the other two most used tools. This confirms that the students can develop different skills at their own pace. In fact, half of the students (50.9%) always watched the videos before each session. This percentage increased to 79.7% if we take into account students who admit having "almost always" used audiovisual material before each session. Only 2% of students admit that they never saw audiovisual material before the sessions. These data coincide with the access to the material detected by the professors, since the eGela platform allows seeing who accesses the material and at what time, being able to instigate the students to their previous viewing when a lack of involvement has been detected. 

Table 2 analyses the self-confidence/security level of students in different moments:

i) After watching the videos.
ii) After watching the videos and attending to the face-to-face session.
iii) After a face-to-face session of the topic that does not have video.

Table 2. Results of the student questionnaires after the end of the Project.

<table>
<thead>
<tr>
<th></th>
<th>After watching videos</th>
<th>After watching videos and after class</th>
<th>After class (without video)</th>
<th>Previous preparation (with video)</th>
<th>Previous preparation (without video)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very highly confident</td>
<td>44.4</td>
<td>69.2</td>
<td>32.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Little confident</td>
<td>51.0</td>
<td>26.0</td>
<td>56.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unsafe</td>
<td>4.6</td>
<td>3.8</td>
<td>11.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nothing</td>
<td>7.7</td>
<td></td>
<td>28.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 1 h</td>
<td>64.3</td>
<td></td>
<td>50.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between 1 and 2 h</td>
<td>26.0</td>
<td></td>
<td>17.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>More than 2 h</td>
<td>2.0</td>
<td></td>
<td>3.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

After seeing the audiovisual material, 44% of the students felt very sure of the knowledge acquired before going to class, while 51% felt little confident and 4.6% felt unsafe. These values improved after face-to-face computer sessions, where 70% felt confident of the skills acquired compared to 26% and 3.8% that felt little or no safe at all, respectively. As mentioned in the methodology section, only one of the computer sessions did not have audiovisual material. In this case, the competences to be acquired were developed only in face-to-face sessions and with non-audiovisual material that they previously possessed. For this topic only 32.4% felt highly confident. From these data it can be concluded that students take much more advantage of face-to-face classes having previously worked on the video and therefore with prior knowledge. It is also noteworthy that the use of this flipped classroom
methodology favours previous work at home. The previous use of audiovisual material means that the number of students that do not prepare the class decreases from 28.8% to 7.7%.

Table 3. Academic Results of the different courses.

<table>
<thead>
<tr>
<th>Course</th>
<th>Course 18-19 (Flipped classroom)</th>
<th>Course 17-18</th>
<th>Course 16-17</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (9-10)</td>
<td>35.0</td>
<td>37.9</td>
<td>37.6</td>
</tr>
<tr>
<td>B (7&lt; 9)</td>
<td>43.2</td>
<td>46.1</td>
<td>46.2</td>
</tr>
<tr>
<td>C (5&lt; 7)</td>
<td>20.2</td>
<td>16.0</td>
<td>15.1</td>
</tr>
<tr>
<td>D (&lt; 5)</td>
<td>1.6</td>
<td>0.0</td>
<td>1.1</td>
</tr>
</tbody>
</table>

As it can be observed in the Table 3, the use of flipped classroom did not improve the academic results, in fact, the number of A and B marks were reduced. However, it should be noted that the difficulty of the project increased in the last academic year having included a new topic. The fact of applying the flipped classroom methodology has implied a better use of the classes both from the point of view of the student and from the point of view of the professor, being able to include new topic and raising the level of demand in the projects. However, to see a real trend, results of more academic courses are required.

4 CONCLUSIONS

The main conclusions of this work are the following ones:

- Students dedicated greater time to prepare the computer lessons, improving their motivation for the learning process.
- Reinforcement of students’ certainty in their learning path.
- The flipped classroom is not a substitute of the face-to-face classes.
- Better knowledge of the software, hence they are able to develop more complex and realistic chemical processes.
- Motivating experience for both students and professors.
- Higher professors’ satisfaction due to the quality of the projects obtained.
- Larger professor-student interaction as described by Murray et al. [7]

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