CHANGING THE WAY OF TEACHING TO EMPOWER STUDENTS’ LEARNING

Georgina B. Rodriguez, Marta G. Caligaris, Natalia C. Cabo, Lorena F. Laugero
Grupo Ingeniería & Educación, Facultad Regional San Nicolás, Universidad Tecnológica Nacional (ARGENTINA)

Abstract

Technologies and communications existing in today’s world have changed people's lifestyle, both in their personal life and in their work environment. The amount of information available today, as well as the means of access to information, was unimaginable some years ago. Education in general, but mainly Universities, must adapt to these changes, developing in their graduates skills and competences that will let them face the future world.

Today’s students adapt better to change, because they have grown up in a world that is constantly changing, and have been practically born with technology. This fact should improve students learning when teaching, as a basis to develop competencies and skills that they will later use in their professional lives.

Therefore, it is necessary to make changes in the way of teaching, by introducing innovation, modifying the dynamics of the classes, taking into account the interests of the students, and attending to their different styles of learning.

These changes are being attempted in numerical analysis courses at Facultad Regional San Nicolás from the Universidad Tecnológica Nacional, from Argentina, applying the flipped classroom model which implies an outright change in the way of dealing with face-to-face classes, as well as in the activities students have to deal with at home.

This paper presents the innovations made in the development of the issue “Nonlinear Equations” during the current year and the obtained learning outcomes in two courses, one with less than twenty students, and the other with almost sixty.

Keywords: innovation, flipped classroom, learning outcomes.

1 INTRODUCTION

Nowadays students are very different from the ones that their professors used to be at university. They grew up surrounded by tech gadgets, they carry devices and stay connected wherever they are. They adapt better to change, because they have grown up in a world that is constantly changing, and have been practically born with technology. This fact should improve students’ learning when teaching, as a basis to develop competencies and skills that they will later use in their professional lives. Do nowadays classes take advantage of this changes?

The methodology of Flipped Classroom does take advantage of these changes nowadays, as students learn theory by watching videos and doing activities at home requiring actions of remembering and understanding. Meanwhile activities that require superior levels of reasoning are left to be done in the classroom.

Besides, the fact of knowing the predominating learning styles of students contributes to the improvement of their learning process, as faculties can propose appropriate methodologies to fit the styles found.

Some changes are being attempted in numerical analysis courses at Facultad Regional San Nicolás from the Universidad Tecnológica Nacional in Argentina (FRSN). It was decided to apply the flipped classroom model in two courses. This decision implies an outright adjustment in the way of dealing with face-to-face classes, as well as in the home activities students have to deal with. Also, a change in the assessments performed by students was made, following the requirements of the University.

This paper presents the innovations made in the development of the issue “Numerical Methods for Nonlinear Equations” during the current year, students’ opinion and the obtained learning outcomes in two courses, one with less than twenty students, and the other with almost sixty.
2 THEORETICAL APPROACH

2.1 Flipped classroom

Flipped classroom is a pedagogical approach which tries to change the traditional model where teachers give direct instruction in the classroom and students make activities at home, to a different one where students learn content outside the classroom and work procedures inside it [1]. Thereby, students deal with passive tasks at home, and do in the classroom activities that require participation and interaction, producing active learning. As See & Conry [2] say, the flipped classroom model can be thought as a proposal that suggests moving outside the classroom content placed in the lower levels of the revised Bloom’s Taxonomy [3], understanding and memorizing, in order to use the class-time for the upper levels, creation, evaluation, analysis and application.

Flipped classroom allows students to follow their own pace. In the traditional classroom some students get bored and others cannot follow the professor. Moreover, in the flipped classroom they can have control over the contents by studying when and where they decide, pausing and rewinding. In face to face time active learning is promoted, increasing collaboration and participation, even making faster students help the others.

2.2 Learning styles

According to Felder, students whose learning styles fit the teaching style of academics, tends to hold information longer and use it more efficiently, besides having positive attitudes towards issues being studied [4].

Felder & Silverman, presented a model to measure learning styles designed for Engineering students. In this model, the students’ learning styles are classified according to four dimensions which at the same time are composed of two categories. Each dimension refers to the ways in which people collect and process information [5]. The first dimension is related to the type of information that the student prefers to work with (perception: sensing - intuitive); the second analyzes in which modality sensory information is most effectively perceived (input: visual - verbal); the third relates to the actions that the student generates from the information received (processing: active - reflective) and the fourth indicates how the student builds his thinking from the organization and structuring of information (understanding: sequential - global). Below a description of a student of the two categories in each dimension is given [6].

In the first dimension, active students tend to better hold and understand information when they manipulate it, by discussing, applying or explaining it, and like team work. On the other side, reflexive students prefer to think before doing, and they prefer to work on their own.

In the second dimension, sensing students like to learn based on facts, to solve problems with given methods, they don’t like unforeseen. Instead, intuitive students prefer to discover relations, like innovations and don’t like repetition. They acquire concepts easily and they like mathematical abstractions.

In the third dimension, visual students remember better what they see (figures, videos, animations, etc.). Instead, verbal students better hold information if it comes from words (oral or written explanations).

In the fourth dimension, sequential students tends to better understand following ordered steps, one by one, and they follow logical procedures to solve problems. On the other side, global students tend to learn processing material randomly, without connecting parts; they are good in solving complex problems quickly, but they have difficulties when they have to explain how they proceeded.

3 THE EXPERIENCE

The experience was carried out in two courses of Numerical Analysis at FRSN, during year 2017. Students’ learning styles were determined by the model of Felder & Silverman, to be taken into consideration when selecting the activities to modify the way of teaching.

The model of flipped classroom was introduced in the two courses, taking into account the results of the experiences carried out during the previous year. Moodle was the learning management system selected for this experience, as it has many resources useful for this model. Videos to be seen at home were prepared and embedded in Moodle, and material on websites designed by the
Engineering & Education Group (GIE) were linked there. The issue selected was the first in the syllabus, Numerical Methods for Nonlinear Equations.

Also, some activities to engage students were tried, to make the face to face classes more active, like think-pair-share and instant polls designed on Poll Everywhere [7], to raise discussions.

### 3.1 The groups and their learning styles

The groups selected for the experience were two courses of Numerical Analysis, one of Industrial Engineering and the other from Electrical Engineering.

These groups have many differences, the main is that the first has almost sixty students, and the second, less than twenty, so student-teacher ratios are different. As classes are developed in computer labs, also student-computer ratio are also very different.

Students answered an online questionnaire to classify their learning styles according to the model of Felder & Silverman.

#### 3.1.1 Industrial Engineering group

Numerical Analysis is situated in the third year of the syllabus of Industrial Engineering at FRSN. The 2017 course is an exception, with more than 50 students attending classes. The media in previous years was 30.

Students´ learning styles following Felder’s model are shown in tables 1-4 for this group.

<table>
<thead>
<tr>
<th>Table 1. Industrial engineering students classified by active-reflexive dimension</th>
<th>Table 2. Industrial engineering students classified by sensorial-intuitive dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balance</td>
<td>61%</td>
</tr>
<tr>
<td>Moderately active preference</td>
<td>25%</td>
</tr>
<tr>
<td>Moderately reflexive preference</td>
<td>7%</td>
</tr>
<tr>
<td>Strongly active preference</td>
<td>7%</td>
</tr>
<tr>
<td>Strongly reflexive preference</td>
<td>0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 3. Industrial engineering students classified by visual-verbal dimension</th>
<th>Table 4. Industrial engineering students classified by sequential-global dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balance</td>
<td>50%</td>
</tr>
<tr>
<td>Moderately visual preference</td>
<td>23%</td>
</tr>
<tr>
<td>Moderately verbal preference</td>
<td>4%</td>
</tr>
<tr>
<td>Strongly visual preference</td>
<td>23%</td>
</tr>
<tr>
<td>Strongly verbal preference</td>
<td>0%</td>
</tr>
</tbody>
</table>

This group of students shows an active-sensing-visual-sequential preference, so flipped learning fits to the learning styles of the group.

#### 3.1.2 Electrical Engineering group

Numerical Analysis is situated in the second year of the syllabus of Electrical Engineering at FRSN. Generally this is a moderate course. In 2017 there are about 15 students attending classes.

Students´ learning styles following Felder´s model are shown in tables 5-8 for this group.

<table>
<thead>
<tr>
<th>Table 5. Electrical engineering students classified by active-reflexive dimension</th>
<th>Table 6. Electrical engineering students classified by sensorial-intuitive dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balance</td>
<td>62.5%</td>
</tr>
<tr>
<td>Moderately active preference</td>
<td>25%</td>
</tr>
<tr>
<td>Moderately reflexive preference</td>
<td>0%</td>
</tr>
<tr>
<td>Strongly active preference</td>
<td>1%</td>
</tr>
<tr>
<td>Strongly reflexive preference</td>
<td>0%</td>
</tr>
</tbody>
</table>
Table 7. Electrical engineering students classified by visual-verbal dimension

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balance</td>
<td>12.5%</td>
</tr>
<tr>
<td>Moderately visual</td>
<td>37.5%</td>
</tr>
<tr>
<td>Preference</td>
<td></td>
</tr>
<tr>
<td>Strongly visual</td>
<td>25%</td>
</tr>
<tr>
<td>Preference</td>
<td></td>
</tr>
<tr>
<td>Strongly verbal</td>
<td>25%</td>
</tr>
<tr>
<td>Preference</td>
<td>0%</td>
</tr>
</tbody>
</table>

Table 8. Electrical engineering students classified by sequential-global dimension

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balance</td>
<td>62.5%</td>
</tr>
<tr>
<td>Moderately sequential</td>
<td>12.5%</td>
</tr>
<tr>
<td>Preference</td>
<td></td>
</tr>
<tr>
<td>Moderately global</td>
<td>12.5%</td>
</tr>
<tr>
<td>Preference</td>
<td></td>
</tr>
<tr>
<td>Strongly sequential</td>
<td>0%</td>
</tr>
<tr>
<td>Preference</td>
<td></td>
</tr>
<tr>
<td>Strongly global</td>
<td>12.5%</td>
</tr>
<tr>
<td>Preference</td>
<td></td>
</tr>
</tbody>
</table>

This group of students shows an active-sensing-visual-global preference, but there is a group that has moderately verbal preference. Also flipped learning fits to the learning styles of this group.

3.2 Materials

3.2.1 The virtual platform

Learning management systems are being used in Numerical Analysis courses from the beginning. The first environment was Pizarrón, developed by GIE [8]. There students could find material prepared by faculty, assignments to be done and uploaded, online assessments, and grades obtained in written and online assessments. Although there were also available tools for synchronous and asynchronous communication, like chat, forums and mail, they were not used. In this platform it was not possible to insert or link directly videos here.

Therefore, last year we changed to Moodle, because it has a wide set of tools that makes the platform more versatile for activities required in flipped classroom. Many links related to useful sites were included. Lessons were prepared about each method studied, and a quiz was prepared, containing multiple choice and short-answer questions, the latter had to be corrected by professors. Forums were not used by students by themselves, only responses to issues asked by professors appeared. What is remarkable in this environment is the activity log of the students: whatever they do inside the platform is registered, so it can be seen for example if they had seen a video and how much time they spent doing that. Students receive notifications by mail when a new activity is added, and they use the message system of the platform to send requirements to professors.

3.2.2 Website about Nonlinear Equations

The use of websites on teaching processes contributes to enhance and empower the teaching given in the physical classroom in many aspects. The use of didactical resources represented by hypertextual and/or multimedia material lets the approach to the issue studied be enriched and, at the same time, obtain a better adaptation to the students’ different learning styles [9].

The site about Nonlinear Equations, the same as the other sites developed, contains theoretical concepts, solved exercises and exercises to solve, links to other interesting sites, some tools developed with Scilab and a quiz.

![Fig. 1. The Website of Numerical Methods for Nonlinear Equations](image-url)
3.2.3 Videos

The Web has many repositories of videos, and many about numerical methods for nonlinear equations were found, but none of them satisfied our requirements, as it happened in previous experiences [10]. The main obstacle was the language: we need videos in Spanish, but most of them are recorded in English, and we could not find videos fitting the way of our approach to the issue, so we decided to make our own videos. Different kinds of video-tutorials can be found on the Web. Some are just real classes recorded, where the whole class can be seen, others are focused on the board and the professor, and others even don’t show the person who talks, only what is being written or slides of PowerPoint are shown [11].

In this case, most videos were designed with the app Doceri running on an iPad, using the tablet as a board and recording the voice while explaining what is being written. Making a video with these tools is like writing on a board in the classroom. Also some videos made using PowerPoint were used, recording voice while doing the presentation, so as to have the opinion of students about the different techniques used.

![Fig. 2. Images of the videos prepared. On the left using Doceri, on the right using PowerPoint.](image)

3.3 Measuring instruments

3.3.1 Surveys

A survey was conducted in both groups asking about the experience. It was divided in three sections. The first asked about the course, gathering students’ opinion about the way that classes were approached, the amount of material offered and the virtual platform available. The second part was related to the material: how they used the website and about the videos, if they were useful and their preferences between the two kind offered. The last part of the survey asked about assessments.

3.3.2 Assessments

Learning outcomes, exposed to the students in the first class, were measured by performing an assessment including conceptual questions and numerical exercises.

To calm students’ anxiety, as it was the first assessment of the course, simulations were performed before. One of them was a real simulation, as students came prepared to do it as if it was the examination. The other was made online, in a quiz settled in Moodle, to be done at home but with restriction of time. Then, real assessments took place in face to face classes for each group.

3.4 Development of the experience

The development of the classes was the same for both groups. The first class the syllabus, the objectives and general learning outcomes of the course were presented. Also, the methodology of flipped classroom was briefly explained, and the virtual platform was presented. Then, a theoretical explanation of the first method studied took place, as this was the first meeting, and students were asked to do some exercises. But the development was a little different from those of previous years. Interruptions were made to make students think, with activities like Think-Pair-Share, and the class finished with a question in poll - everywhere, where students had to answer the question “Do you think that bisection method converges?”, to prepare the next class. This caused a revolution in the class, because as they were seeing the results while answering, some discussion arose and changed the opinions of those who did not answer yet. During the second class, the convergence was demonstrated.
In the second class, a video prepared for flipped classroom was seen in the class, so as to teach them how they should watch videos. They were suggested to make stops, to take notes as if they were in class, and to rewind the video if it was necessary. It was remarked that they should write doubts and questions in case they arose, and to send them by the forums or take them to the next class. They were also told that they could watch the videos as many times as they need, an advantage from the live class! In this class, the assignment to watch videos for the next class was done.

Since the third class, we were really flipping the classroom. At the beginning, not everybody watched the videos, but during the development of the course, they felt the necessity. Moodle gives the time that students spend on lessons and watching videos, and this was shown to students, to let them know that we know if they do it or not.

4 PERCEPTION OF THE METHODOLOGY ADOPTED

Data gathered in the different sections of the survey is exposed here.

About the modality of the classes, most of students said they were active. Only two of them expressed disconformity in the bigger group, one said that classes were accelerated, and the other expressed his disconformity with the number of computers.

All students said that the material was sufficient. Some of the opinions expressed were:

- I liked the idea of the videos
- I found the material concise and more than enough, I found useful to use videos explaining the different methods.
- Using videos is attractive, and makes learning more bearable.
- I liked the virtual platform and the interactive classes.
- I do really like the proposal of the videos (specially, the development of the methods), because what perhaps I loose in class, it is available to be seen at home. It helps to study.
- With regard to the videos available in Moodle, they are well explained, and if I don’t understand something, I can watch it as many times as I need.
- The material is complete and dynamic.
- The material is interesting because it has examples of real life.
- The material is easy to understand.
- The material is well explained, it is easy to understand with the explanations given in the classroom.

With regards to the virtual platform, only two students expressed difficulties when using it. Most of them felt comfortably.

In the industrial Engineering group, only two students said they did not use the website, but everyone in the Electrical Engineering group did. They expressed they visited it for consulting theory, for seeing solved exercises and for making the self-evaluation.

When talking about the videos, only the 30% of the groups said they had seen them more than once. In general, they preferred the ones made by handwriting, not based on PowerPoint slides. Some of the reasons expressed are:

- It seems that you are in class, I like them because they do not consider obvious some details on the explanations.
- They are easier to understand.
- Because while the writing appears, explanations are given step by step.
- It simulates a real class.
- It has what I would include in my notes.
- In some way, it draws my attention.
I prefer handwriting, because in slides information appears embodied, so some details may be lost.

Most students of the two groups agree with the methodology of watching videos containing the theory at home and do exercises and analyze results in class. Some of them expressed their opinions:

- I agree if then in class doubts can be expressed and a general review of what it was studied is done.
- I agree, although many times it is complicated for me to watch the videos.
- I agree. It would be also good to interact between us.
- It is very important because when you have to apply theory to make exercises, you can see it in the videos available.
- In my particular case I work, so I do not have much time, that’s the reason why I prefer to do everything in the classroom.

All students, except one of each group, considered that the questions of the evaluations were aligned with the learning outcomes presented at the beginning. They considered that the assessments were appropriate.

5 RESULTS OF ASSESSMENTS

Results of the assessments were satisfactory. More than 60% of students in both courses have achieved grade 6 in the assessment (the minimum for approval).

![Results of assessment on numerical methods for nonlinear equations](image)

**Fig. 1. Results of the assessment**

Compared with courses in 2016, Electrical Engineering grades behaved similarly, but in Industrial Engineering the rate of approval was incremented in 20%.

6 CONCLUSIONS

The experience was satisfactory from the point of view of the learning outcomes obtained, as it can be seen on the results of the assessments. The fact of knowing the learning outcomes expected and performing a simulation of the assessment, just face to face or online, helped the students in their performance, as these groups achieved better qualifications than the same courses in previous years.

The flipped classroom fitted the learning styles of the groups. The way that the approach to this new methodology was made helped for its acceptance, as students showed in the survey conducted. Besides, it was demonstrated that it is a methodology that worked in big courses. Some of the next issues will be approached using the traditional methodology, to contrast with the inverted class, and the students’ opinion will be collected, so as to inquire about their preferences.

From the academics’ point of view, the material used in this experience, videos and the website, lets the students to achieve autonomy in the study of theory, making it possible to change the way of working in class. The way that face to face classes were approached helped to develop the critical thinking of students, as they could discuss with their pairs and faculty doubts and questions that arose when solving problems.
REFERENCES


