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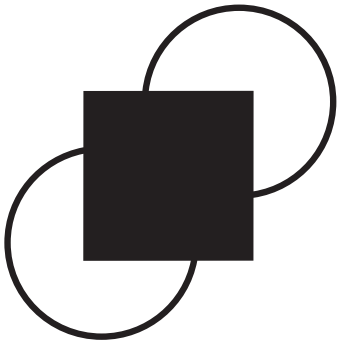

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INTRODUCTION OF FLIPPED LEARNING IN TEACHING TECHNICAL DRAWING AND GRAPHICS AND COMPUTER AIDED DESIGN

V. Pérez-Belis, C. González Lluch, V. Gracia-Ibáñez, M. Vergara, M.J. Bellés Ibáñez

Universitat Jaume I, Department of Mechanical Engineering and Construction (SPAIN)

Abstract

Students of the Degree in Industrial Design and Product Development Engineering of the University Jaume I of Castellón (Spain) received an integrated training in the subject of Technical Drawing and Graphics (TDG) and Computer Aided Design (CAD) through 4 one-semester courses: Technical Drawing and Graphics I & II of 1st year and Computer Aided Design I and II (CADI and CADII), completed in 2nd and 3rd year respectively.

While the first subject (TDGI) focuses on the fundamentals of representation systems and on the knowledge of volumetric forms and elementary surfaces, the following three subjects (TDGII, CADI and CADII) are focused on developing the abilities needed to sketch (TDGII) and create engineering technical drawings with CAD applications. TDGII deepens the sketch, focusing on proportionality, language and graphic representation techniques for engineering technical drawings, being these skills extended in CADI and CADII through the use of 2D and 3D CAD systems.

Considering this framework, TDGII, CADI and CADII courses have been coordinating for several years, sharing a general structure of the common teaching-learning process. The original structure of these classes included a standard lecture format and practical sessions where students worked different types of exercises, including the development of a graphic project.

Teachers' experience over the years and students' opinion have allowed authors to recognize main drawbacks of the standard class structure. Firstly, standard lecture format is not attractive for students. Secondly, due to the differences in the previous training of students (some have already used some CAD software) the levels with which they start the classes may not be homogeneous, which means that some of them may arrive to get bored in class while others take more effort to understand contents.

Flipped learning is a methodology used in teaching that helps teachers to prioritize active learning during class by using that time for group activities and individual attention. This model allows modifying the standard class structure of sessions where the content of the subject is presented by the teacher in the classroom. In this new model the content of the subject is viewed at home or outside the classroom through the use of tools and resources classified within the Information and Communication Technologies (ICT).

As a first step in the analysis of experiences in learning Technical Drawing and Graphics and CAD, this study shows the results of an academic experience that compares the classic methodology of standard lecture format versus flipped classroom in teaching Technical Drawing and Graphics (TDGII). Students from standard lecture format received the lesson in the traditional way, while students from the flipped classroom had to prepare themselves before attending the class, by using this time to complete questionnaires and team activities. Both groups filled a knowledge assessment test before and after class. Student involved in flipped classroom had to complete as well a survey on their perception of the method.

The results obtained show that the level of knowledge after the class is slightly higher for those students involved in the flipped classroom. In addition, the students' opinion on the methodology is quite positive. They consider that it is a more effective method than the standard lecture format, since it has allowed them to better understand the content and to significantly increased their knowledge

Keywords: Flipped learning, Technical Drawing and Graphics, Computer Aided Design.

1 INTRODUCTION

The concept of the flipped classroom (FL) proposed by Bermann and Sams 2012 [1] has become in a powerful movement that has turn education into something newer and more effective. Flipped learning

shows that teachers are not the only source of learning, as teachers became an instrument that helps students to reach sources of knowledge.

In the literature some studies have indicated that if a student is not stimulated during classroom lessons, students leave aside creative thinking, critical learning and complex reasoning skills (Arum and Roska 2011 [2]; Garrison and Kanuka 2004 [3]; McLaughlin et al. 2014 [4]). Therefore, the interest to this topic has led some authors to develop FL design models to create effective guides to design and implement process of flipped learning in higher education [5]. Other authors have compared the application of flipped learning versus traditional teaching since the first years of learning to young ages [6]. Furthermore, FL is applied in higher education [7, 8] and shows benefits as the students increase satisfaction and grades [9, 10]. However, although the literature shows the suitability of this way of teaching, many subjects in the university environment are still taught in a traditional way.

At present, in the Degree in Industrial Design and Product Development Engineering of the Universitat Jaume I of Castellón (Spain), students are trained in the subject of Technical Drawing and Computer Aided Design through subjects coursed during the 1st year, with two courses -Technical Drawing and Graphics I & II- and other two courses in the 2nd year -Computer Aided Design I (CAD I) and II (CAD II)-. In recent years, one of the authors has introduced FL methodology in a different course with good results [11].

During the Technical Drawing and Graphics II course, the teaching methodology consists of two hours of theory (traditional lecture) and two and a quarter hour of practice, taught in smaller groups, where students apply the knowledge exposed at the theory class through practical exercises. So, in theorical classes the teacher is the central figure in the learning model – the sage on the stage –, while students take notes and are assigned homework at the end of the lesson. Teachers of the subject want to increase motivation of the students in order that they assimilate technical drawings knowledge.

To this end, to implement FL methodology, the teachers supplied sources of information to the students with the finality they used it and released time for more significant learning activities such as discussions, exercises among others to encourage collaboration among the students themselves.

The aim of this study is to determine whether the flipped learning methodology has led to a greater increase in the knowledge of the students compared to the master class in the Technical Drawing and Graphics I coursed during the first year of the Degree in Industrial Design and Product Development Engineering (Universitat Jaume I). The results of the study show that students considered FL a more effective and motivator method that let them understand and get better their knowledge versus a traditional class. Furthermore, students who were asked to find out their opinion about the FL methodology, preferred it over the traditional way.

2 METHODOLOGY

The educational innovation experience was carried out during the 2019/2020 academic year in in Teaching Technical Drawing and Graphics (TDGII) as a first step in the application of the method in this type of subjects. This subject is from the first year of the Degree in Industrial Design and Product Development Engineering, which is coursed by 157 students.

The experiment was applied to one lesson of the course. To select the lesson, teachers selected one topic that was considered easy to understand by students, without containing too much concepts requiring a high level of abstraction. Considering that TDGII is focused on developing the abilities needed to sketch, the topic selected to developed the experience was the principles for presentation of dimensions, which includes basic concepts such as the elements that have to be drawn for dimensioning (centre line, dimension line, extension line, angular dimensions, and others) as well as their correct use in technical drawings.

The theoretical lessons are taught in two groups of 88 and 69 students. To develop the experience, these two groups (A and B) were used. A different experience was carried out in each of the two existing groups. The methodology followed is shown in Figure 1.

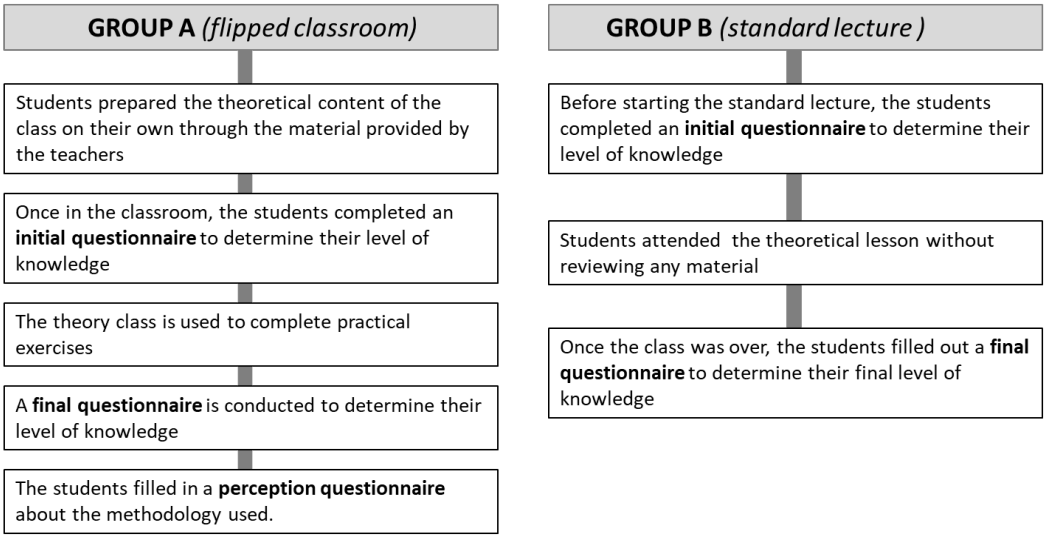

Figure 1. Methodology followed by different groups.

The students of group A prepared the content of the lesson on their own. The required information was provided through the virtual classroom (a pdf file previously complete by teachers). The students had to consult the information before attending the class, in order to have time previously to work on exercises in a practical way. Once in the classroom, the students completed an initial questionnaire to determine their level of knowledge (22 questions). After that, students completed practical activities with the aim of consolidating previously acquired knowledge. Once the activities were finished and commented, they filled out the same questionnaire in order to determine whether their level of knowledge had increased from the beginning of the session. The final questionnaire included as well two questions (23-24) on their perception of their knowledge). Finally, the students filled out a questionnaire about their opinion on the methodology used, comparing this with the traditional methodology (master class) followed for years in the subject.

To the students of group B attended a traditional class (master class) being the teacher the central figure in the learning model. They did not review any material before attending it. Before starting the traditional class, the same initial questionnaire to determine their initial level of knowledge was complete by students. After filling the questionnaire, the teacher began explaining the contents of the session step by step. Once the class was over, the students filled out the same questionnaire of knowledge (same questionnaire of group A), to determine if their level had changed from the beginning of the class.

Principles of dimensioning is a simple topic based on the explanation of the dimensioning rules. Questionnaires on determining the level of knowledge contained specific questions in which the students could demonstrate whether or not they have understood the content of the lesson.

Table 1 shows the questions corresponding to the knowledge questionnaires, created from practical questions containing key information representative of the unit. It contains a total of 24 questions, where 1 to 9 question, were theoretical ones showing the possible answers through text, 10 to 22 question were practical ones showing the dimensioning answers through images and finally two questions related to the level of knowledge that the student thought to have before and after the session. These two last questions (23-24) were only shown in the final questionnaire.

Table 1. Questions to test students' level (questions 1-22) and perception (questions 23-24) of knowledge.

Nº	*Question*	*Answer*
1	What is the meaning of dimensioning?	Multiple answer (one true sentence)
2	We talk about dimensioning when…	
3	According to dimensioning, hidden lines…	
4	If an arc of an angle is not greater than 180°, indicate which of the following dimensions is correct	

5	If an arc of an angle is greater than 180°, indicate which of the following dimensions is correct	
6	Dimensions wil be located…	
7	All dimensions should be shown	
8	The dimensions of each element will be located…	
9	The extensión line…	
10-22	Select the correct answer from the image shown	Image-based responses Multiple answer (one true sentence)
23	How much do you think you know NOW (after doing exercises/after the standard lecture) about dimensioning?	Nothing Basic knowledge (basic concepts and without going in depth) Advanced knowledge (I consider that I know enough, more than average of my colleagues)
24	How much do you consider that your knowledge has increased compared to the beginning of the class?	0% 25% 50% 75% 100%

Once the practical session was over for Group A and the final questionnaire determining the level of knowledge was completed, the students completed another questionnaire on their perception and opinion of the session, with the questions shown in Table 2.

Table 2. Questions to know the opinion of students.

Have you consulted the available material?	Yes, No, Others
Where have you prepared the session?	At home, at university, others
How long did it take you to prepare the topic?	Less than 15 minutes 30 minutes aprox. One hour 1-2 hours Other
How have you worked the session?	I have read the available material I have made diagrams and summaries after reading it I have searched for information in addition to what is available Others
Did you understand the content?	nothing little bit something quite A lot
I consider the flipped classroom methodology to be a more effective method than the traditional master class	
It has allowed me to better understand this part of the subject	1. Completely disagree
Flipped classroom methodology allow more interaction with your classmates	2. Mostly disagree 3. Slightly agree
It seems to me a more motivating method to study	4. Mostly agree
I consider that my learning has significantly improved	5. Completely agree
I prefer the traditional method (master class) than the flipped classes	
General opinion, other comments	Open answer

3 RESULTS

The experience involved 53 students of Technical Drawing and Graphics II (TDGII). According to their initial level of knowledge, it is observed that for those students of group A, who previously had prepared the content, the percentage of correct answers at the beginning of the lesson is higher than those students for group B (84% of correct answers group A versus 73,11% of correct answers group B), as shown in Figure 2.

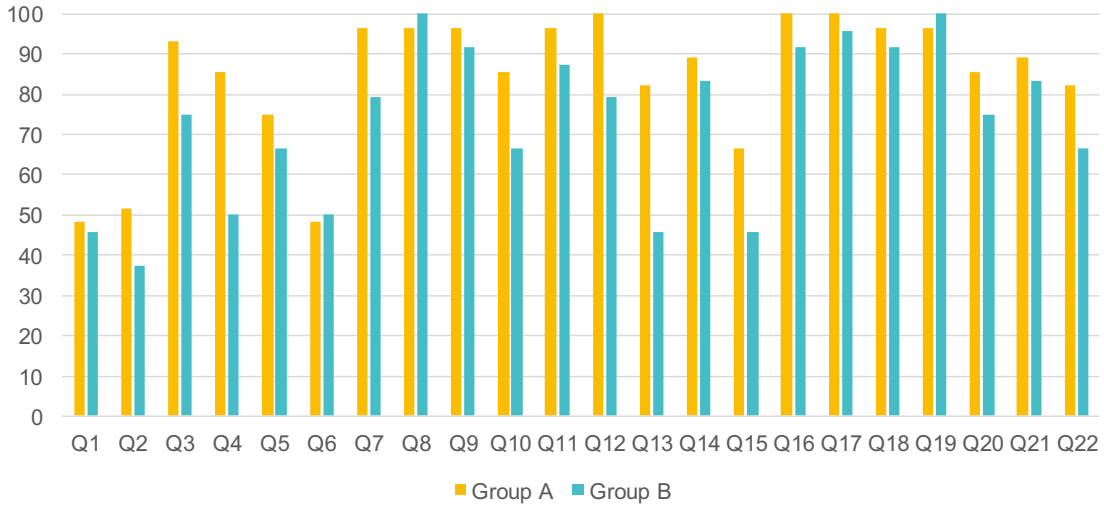

Figure 2. Percentage of correct answer by group at the beginning of the session.

Once the session was over, results from the questionnaire analysing final level of knowledge shows that for students of Group A, the percentage of correct answers is higher than those students for group B (88,25 % of correct answers from group A versus 78,35% of correct answers from group B), as Figure 3 shows.

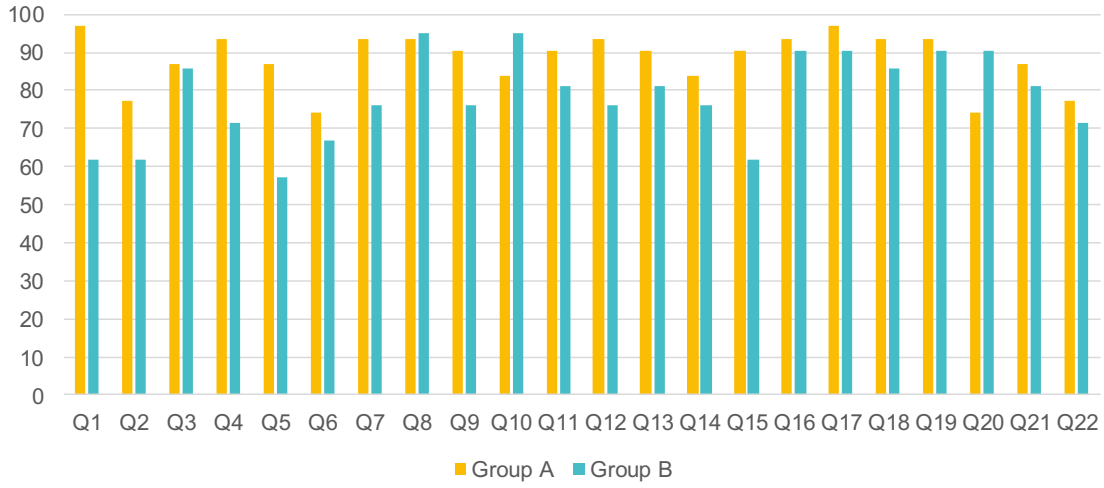

Figure 3. Percentage of correct answer by group at the end of the session.

The level of knowledge of group A is initially higher than for the group B, as expected because students of group A had previously reviewed the content of the session. Although the level of initial and final knowledge of group A is higher than group B, the increases within each group are similar, as Figure 4 shows. However, the final knowledge of group B is under the initial knowledge of group A.

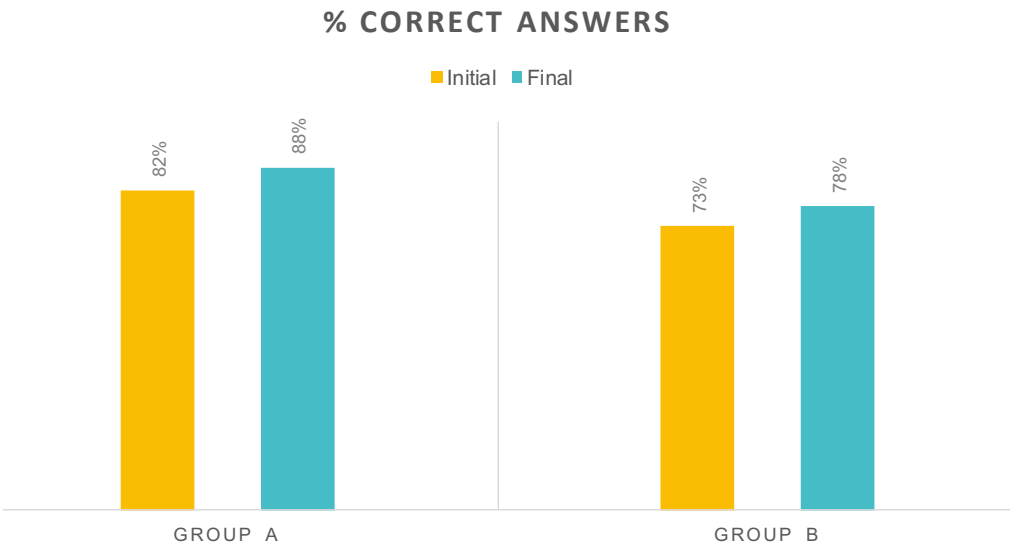

Figure 4. Percentage of correct answer (initial and final) by group.

In reference to the perception of increased knowledge, students from group B, who attended the traditional lesson (standard lecture), considered that their level of knowledge had highly increased after the session, while students from group A, that prepared the content by themselves and worked in the classroom different exercises, considered that their level of knowledge had not increased that much during the class. This perception may be due to the fact that students could feel that information is more reliable if they attend a traditional lesson where the teacher explains the content rather than if they prepare the content by themselves. It would be also possible that students who have not practiced with exercises have not realized what they can actually do. Considering that the content was easy to understand, they feel that it will be easier for them. Results are shown in Figure 5.

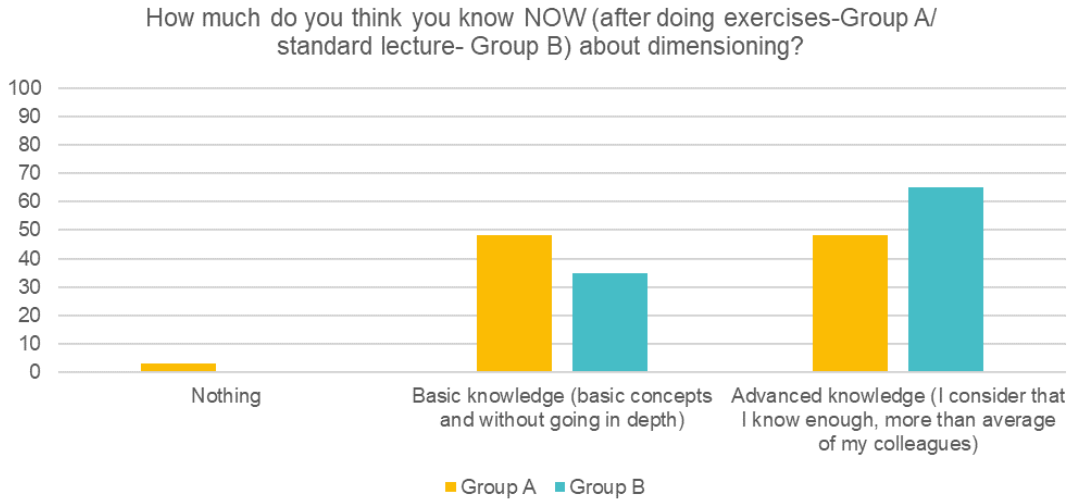

Figure 5. Percentage of answers by group related to the perception of their knowledge after the session.

In respect to the usefulness or effectiveness of the class, 35.5% of the students in group A considers that their knowledge has increased by 75% compared to the beginning of the class, while 50% of the students of Group B, thinks that it has increased by 50%. Figure 6 shows the results.

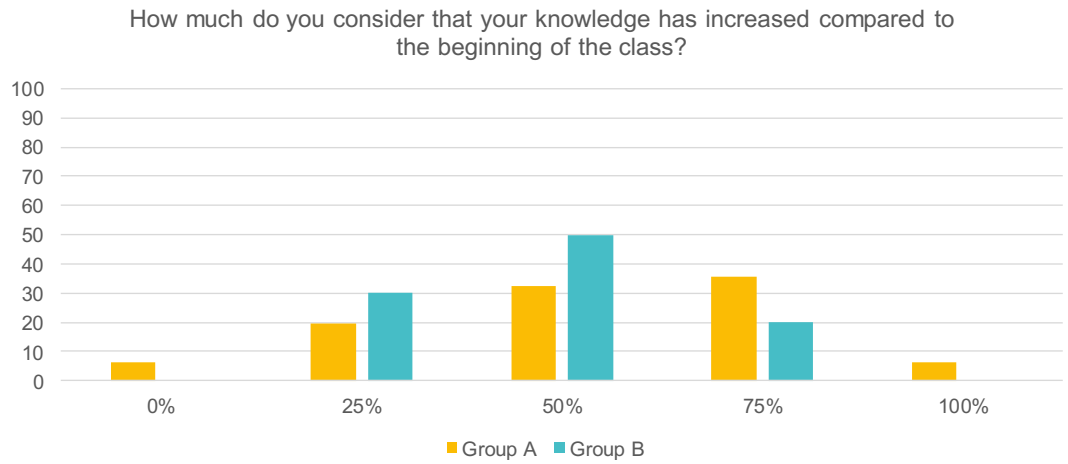

Figure 6. Percentage of answers by group related to the perception of their level knowledge after the session.

3.1. Opinion of students of flipped learning methodology

According to the initiative of students, it is observed that 93.3% of the students of group A worked the content of dimensioning before attending the class. Students worked the content by themselves, taking to them between half an hour (44.8%) and an hour (27.6%). Only 13.18% of students spent between one and two hours to do it and 10,3% took them less than 15 minutes.

According to the preparation of the session, 82.6% of students read the available material while 13.8% claims to use diagrams, figures and summaries to better understand the content. While asking students about their own comprehension of the information, 79.3% claims to completely understand it and 13.8% has only understand something.

In reference to questions related to the perception of the methodology (answers based on Likert scale: 1. Completely Disagree; 2. Mostly Disagree;3. Slightly Agree;4. Mostly Agree; 5. Completely Agree) Figure 7 shows the main answers of students.

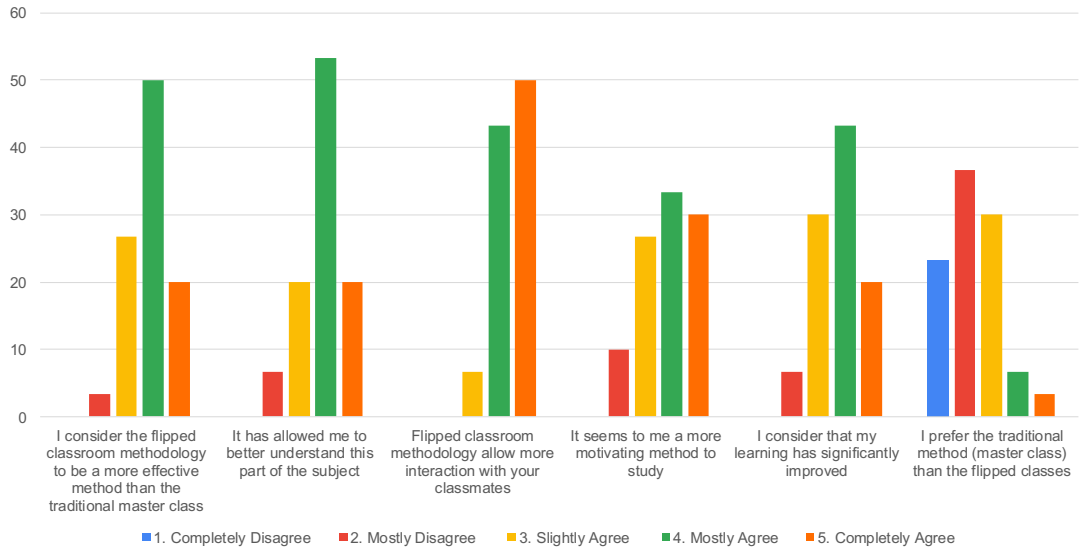

Figure 7. Opinion of students of group A regarding flipped learning experience.

Over 70% of the students considered flipped methodology as an effective one, being preferred to the traditional lesson (master class) by 60% of the students. More than 70% admit the effectiveness of the FL for understanding the content, helping as well to the interaction to other colleagues (more than 90%). This method is more motivating for the students (63.3%), and the students considered that their learning had significantly improved (63.3%). Last question shows that 60% of the students do not preferred the traditional method to the flipped learning methodology.

Finally, some opinions collected from students show the success of the experience:

- “In my opinion, I think that flipped learning methodology works well”
- “I think it is a good method, as long as the students commit to preparing the class on their own, which is difficult for the students. So, the only weak point that I consider is that you don't really know if students are going to review the content”
- This type of method works much better for me than a traditional lesson, since I am more attentive, and I think I learn much more”
- “I consider it much better than a traditional class”
- “I think that it becomes more enjoyable! In addition, the level of comprehension of contents is higher than with other methods. Using this method seems a very good idea!”
- The master classes are quite boring and sometimes you even disconnect from teachers, so it seems like a good idea to spent time doing exercises. More entertaining than a normal class!

4 CONCLUSIONS

This study shows the results of an academic experience that compares the classic methodology of standard lecture (master class) format versus flipped classroom in teaching Technical Drawing and Graphics (TDGII), as a first step in the analysis of experiences in learning Technical Drawing and Graphics and CAD.

Students from standard lecture format received the lesson in the traditional way, while students from the flipped classroom had to prepare themselves before attending the class, by using this time to complete questionnaires and team activities.

Results showed that the level of knowledge both before and after the class is slightly higher for those students involved in the flipped classroom. And the final knowledge is higher for the flipped lecture. Since experience was developed during one lesson one day, it should be recommendable to be repeated with some other lessons, in order to increase the robustness of results.

According to the questionnaires collecting opinion of students, the flipped learning methodology helps students to better understand the content, to significantly increased their knowledge, as well as their participation and interest, which is in line to some other studies (7).

However, it has also to be considered that despite all the benefits, the flipped learning method can also generate some difficulties for the student, especially in situations related to the access and management of teaching platforms or when dealing with concepts that require a high level of abstraction.

Considering this approach, some other experiences will be developed from this pilot experience, increasing the level of difficult of contents or even the format of the material provided (video, books, tutorials, etc.). It is quite positive that meaningful small changes may result in a noticeably improved learning experience. So, in the future, teachers consider the introduction of FL in other part of the subject of Technical Drawing as well as CAD.

ACKNOWLEDGEMENTS

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