

# Flipped Classroom as a Learning and an Evaluation Strategy in a Pharmaceutical Quantitative Analysis Course at the Pharmacy Faculty of the Universidad de Costa Rica

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## Abstract

The flipped classroom is an active learning strategy in which what normally is done at home is flipped or switched with what is done during the classroom time. The objective of this work was to use the flipped classroom for the students learning improvement in the Pharmaceutical Quantitative Analysis Laboratory at the Pharmacy Faculty of the Universidad de Costa Rica. For this purpose, students were divided in groups, and a laboratory practice with its respective support material was assigned to each one. This information was explained to each member of the group, as well as other aspects that were considered pertinent. At the end of the groups' presentations, a survey was given for the evaluation of each student about this didactic strategy. In this experience, from the total enrolled population, 94.23% approved the course. As a complement, the students' opinion revealed that for 86.54% of the didactic strategy improved their academic performance and/or learning process. This positive impact was due to the contents explanation by their peers, the learning deepening to teach the lesson in the best possible way, having the study material since the course beginning, and the acquisition of tools and/or skills necessary to make public presentations. Nevertheless, the most frequent negative comments were that there is no difference between this flipped classroom and traditional lectures. In addition, the complexity found for the class preparation was not well received.

**Keywords:** flipped classroom, student-centered learning, Bloom Taxonomy, Pharmacy, Pharmaceutical Quantitative Analysis Laboratory, curriculum, evaluation.

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## INTRODUCTION

Enhancing learning experiences of students, and meeting their needs and expectations have been some of the primary concerns over the last decades [1]. Traditional teaching methods are focus on the professor; meanwhile, students have a passive learning, because the information is provided only in a professor-to-student direction. Besides, because all students receive information simultaneously, professors cannot attend them at distinct levels or with diverse learning speeds [2]. Flipped classroom is a teaching technique that is achieving popularity and is transforming the traditional ways of teaching [3, 4]. It represents a paradigmatic shift in education from professor-centered to learning-centered instructional strategies sessions [5]. Through them, students can have learning experiences through direct access to their classmates, and professor's feedback and scaffolding [6].

Flipped classroom (also called inverted classroom) has been the focus of attention since 2007 [7]. There are different definitions of a flipped classroom. However, it is based in the introduction of active learning to the classroom [8]. Bergmann and Sams describes the flipped classroom by mention that what is done at home as a traditional learning is done during the classroom time, and what is done during the classroom time as a traditional learning, is done at home [9]. Therefore, it requires that students have to study the content (information and instruction normally given inside the classroom) [10] prior to class. In class, problem solving, group discussions, and written assignments are done under the professor guidance [11]. In addition, it offers opportunities to build relationships with peers and with the professor [12].

Still, a re-ordering of the teaching and learning activities (interpreting the strategy as a narrow and

simple process of inversion) is inadequate to show the importance of this approach [13] [14]. That is why there are some key elements around a flipped classroom. They include [15]:

- Opportunity to study information prior to class.
- Incentive to prepare for class.
- Mechanism to assess student understanding.
- In-class activities related with higher-level cognitive activities.

Some studies have compared learning outcomes between the flipped classroom and traditional methodologies. Results have revealed better learning outcomes in the first one [16]. For example, in medical education the pre-class task can create a framework of core knowledge, while the active learning work can insert the knowledge in the students [17]. That is why this strategy has been implemented at health professionals' education at the universities. Professors at pharmacy schools have integrated this strategy into their curriculum [18]. Related with the curriculum, the flipped classroom has its basis in the constructivism and the social learning theory [19]. In the constructivist model, people integrate their prior knowledge, experiences, beliefs, and values to construct with new information, generating novel knowledge [20]. Therefore, the student is seen as an active participant [21], and the professor participates as a facilitator and an applied learning coach [22, 23].

Flipped classroom are separate into three stages. First, in the preclass learning preparation, students are involved in autonomous learning through online learning platforms. Next, students and professor complete participatory learning activities during the in-class learning activities. They discuss, debate, and present, simulating the lesson content. This improves teaching quality and learning efficiency. Finally, during postclass learning consolidation, students review materials, increasing learning outcomes, and allowing them to learn outside of classrooms, use what they learned in class, work with others, and get feedback from professors [2].

In the presence of active learning, students have a higher performance [24]. This also allows them to interrelate and develop higher-level cognitive skills [2]. Bloom's Taxonomy considers six categories in the cognitive domain: knowledge, comprehension, application, analysis, synthesis, and evaluation [25].

The lower-level skills of remembering and understanding are executed before the class without any guidance, while the higher-level skills are applied during the class work [26].

In the flipped classrooms, professors are showed as efficient (use time effectively), reflective (monitor themselves, contributing to their teaching skills in regard with content and pedagogy), and masters at relationships (enables them to construct relationships between students) [27].

Therefore, the objective of this work was to use the flipped classroom for students' learning improvement in the Pharmaceutical Quantitative Analysis Laboratory (FA-2008) at the Pharmacy Faculty of the Universidad de Costa Rica.

## MATERIALS AND METHODS

The students were divided in four groups of six persons and four groups of seven. A laboratory practice procedure with its respective support material, which included the theoretical foundations and the procedure for such practice (found in the laboratory manual), was assigned to each group. This information was explained to the students, as well as other aspects that the group considers pertinent, such as the uncertainty calculation of the required values and other practical problems related with the practice. The presentation lasted between 40 and 50 minutes, and then 10 minutes were given for students' and/or the professor's questions. For the evaluation (2.75 % of the course grade), the third part of the grade corresponded to the professor's hetero-evaluation, another third was the self-evaluation by the group in charge of the class and the rest represented the other groups' coevaluation (the assigned points were added and the total divided by 7). In order to carry out these evaluations, the rubric appreciated in Figure 1 was available.

At the end of all presentations, a survey was given with the purpose of knowing each student's perception about this didactic and evaluation strategy used. This has been previously used [28].

Universidad de Costa Rica  
Faculty of Pharmacy  
Pharmaceutical Quantitative Analysis Laboratory (FA-2008)  
Group: \_\_\_\_\_

**Flipped class evaluation**

Evaluation criteria	Assigned points
Class content	
Class organization and sequence	
Theme clearness and domain	
Security during the class	
Use of technological and didactic resources	
Time use	
Voice tone and diction	
Points obtained	

The assigned score is 0 to 3, with 0 being the lowest grade and 3 the highest grade possible.

Figure 1: Evaluation rubric for the flipped class during the FA-2008 subject (first semester of 2016).

## RESULTS AND DISCUSSION

The flipped classroom is an alternative strategy to use instead of traditional classroom without forfeiting information [29]. In this case, it was used in the FA-2009 subject. This course was going to be taught for the last time during the first half of 2016, because the new curriculum of the Pharmacy Faculty of the Universidad de Costa Rica came into effect from 2017 and that one was no longer part of it; therefore, it was desired to increase, as far as possible, student approval. At the time the learning and evaluation

strategy was carried out, 52 students were enrolled in the course. At the end of the course, 94.23% of the enrolled population managed to approve it (equivalent to 49 students).

In addition, there was a similarity between the grade provided by the professor and the working groups for each of the activities. These ratings are shown in **Table 1**. The final grade is calculated by the formula: (Mean points obtained/21) \* 100.

**Table-1: Groups' grades for the flipped classroom activity in the Pharmaceutical Quantitative Analysis Laboratory during the first semester of 2016.**

Evaluation type	Points							
	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8
Hetero-evaluation	21.00	21.00	19.00	20.00	20.00	20.00	20.00	21.00
Self-evaluation	20.00	20.00	19.00	20.00	21.00	20.00	21.00	21.00
Coevaluation	19.71	20.43	18.43	20.14	19.14	20.00	20.29	20.57
Mean points	20.24	20.48	18.81	20.05	20.05	20.00	20.43	20.86
Final grade	96	98	90	95	95	95	97	99

These evaluations allowed assessing whether there was any comparison between the grade provided by the professor and the students. As a complement to the academic results of the students' group, to whom this didactic strategy was applied, it was decided to know their opinion about it. Therefore, the questionnaire in Figure 1 was applied. First, there was a population that ranged between 19 and 26 years. The percentage of students associated with each age is shown in Table 2.

**Table-2: Students' surveyed age in the Pharmaceutical Quantitative Analysis Laboratory during the first semester of 2016.**

Age	Number of students	Percentage
19	6	11.54
20	10	19.23
21	13	25.00
22	9	17.31
23	5	9.62
24	5	9.62
25	2	3.85
26	2	3.85
Total	52	100.00

The surveyed group consisted of 40 females and 12 males, representing 76.92 and 23.08%, respectively. This shows the existence of a significant difference between both sexes for this particular group. The information obtained should be considered, as it has been appreciated in previous studies that the differences in learning styles between men and women in the Pharmacy career are subtle. In addition, it suggests that the use of this didactic strategy in particular would not have any problem with this students' population [30].

In question three, it was requested to indicate whether the flipped classroom strategy had been used prior to this course. The 71.15% said they had never used it. Therefore, the flipped classroom is a new strategy, with its priority being established on student-center learning [31].

As for the people who answered affirmatively to this question, the subjects in which they had previously used it included: Human Physiology, Quantitative Pharmaceutical Analysis (theory), Macroscopic Anatomy, Biopharmacy and Pharmacokinetics, Humanities, National Reality

Seminar II, and General Organic Chemistry. The above is a sample of the acceptance that its employment is receiving every time within the possible strategies to be used by university professors [32, 33] and that more people decide to utilize it [34].

Another question asked was whether the didactic strategy had improved the academic performance and/or learning process of each student. Given this question, 86.54% of the people who completed the questionnaire mentioned that it improves positively, while 13.46% said it did not help them improve these aspects. This confirms the evidence that indicates that students' perceptions are positive when referring to the flipped classroom [35], with an increase in the capacity to learn and retain information in an improved way in relation with traditional instruction [36].

With regard to the positive responses in favor of the use of this didactic and evaluation strategy, there is the improvement of the student's learning process when their own classmates are in charge of the class. Twelve people mentioned that when other students explain the information to them, it is easier to understand and allows them to deepen the aspects required to carry out the activities in the laboratory in a better way. In addition, because they are their peers, it increases the student-student relationship [37] and favors to solve learning difficulties [38]. In this way, there is greater confidence to ask questions about ideas or concepts that were not entirely clear, which is a bit intimidating when the professor is consulted. Some of the comments issued are shown below:

"Students explain to each other how we understand, so it is easier (sometimes) for another classmate to explain to us. They (the partners) explain from the level of one, do not assume knowledge and explain from the most basic, do not skip details, on the contrary, they emphasize them, which helps one to understand the practice and the information as well as tools and tips for the moment to execute the practice."

"It is easier to understand the procedure, the reagents, the reactions, because when you sit down to understand the things for the presentation, doubts arise and those doubts arise not only to those who make the exposure, but to everyone in general. Then in the presentation each person clarifies things that are general doubts that perhaps for the professor does not look like something that can generate confusion."

"Fellowship was noticed at the time of the explanations, and understanding, since being all in the same situation we could understand each other. I think it is easier to understand each other between peers. Partners tend to explain in a way perhaps more similar to our understanding and emphasize things that are perhaps more confusing to us."

One aspect that is constantly mentioned is the learning deepening to teach the lesson in the best possible way. This deepening implies the need to search beyond the study material, rising the metacognition skills [39]. Besides, there is also the responsibility to study more so that when explaining the subject, it is understandable for the rest of the public. Therefore, a student's comment point out that: "when it is necessary to do the oral presentation, it encourages us to learn the subject well, its details, and to how to explain it, therefore positively improves academic performance."

Another point refers with the study material. Because it has been delivered from the beginning of the course, the students are able to learn at their own pace. The flipped help students' self-learning according to their strengths and individual requirements [9]. Therefore, each person studies at home at their own pace and arrives in the classroom to clarify concepts, thus facilitating the work of learning within it. This aspect was referred by 10 students. They bring comments such as the fact that with the flipped classroom it was possible to "make sure to bring the information well studied and come to the class to answer questions, not to see it for the first time." Also it helped to "understand the information before arriving at class and one must be well prepared to explain." In this way, one of the most complicated aspects when working with large groups manages to be solved to some extent with the use of this didactic and evaluation strategy, specifically the fear that people have of not understanding the information at the speed at which the professor is providing it to the whole group.

A final majority idea among people who found positive aspects regarding this strategy was the acquisition of tools and/or skills necessary to make public presentations. This is an important aspect, because currently students not only need to have knowledge, but also the ability to express them to other people with different knowledge levels on the subject (in the case of pharmacists, from a patient to another health professional). So, it is important when you read that the flipped classroom was valuable because "it teaches one to know how to prepare a lesson and know all its details and to prove to oneself that one can". Likewise, "it generates in the student the ability to prepare to discourse in public, and understand on their own and according to what I have already seen about the information." Finally, a student contributes that "helped her analyze ways to allow other people to better understand, which at the same time helped me to learn and helped me in communicative terms." After this, there are clear benefits of this strategy, reflected through the increase in critical thinking, self-learning, communication skills, and cooperation among students [9].

Regarding the people who responded negatively to question four, three people indicated that it did not influence either positively or negatively. Even one person mentioned that this was a product of "which is similar to having a professor." However, this comment can also be considered something positive, since it is achieved that the strategy allows classmates to be considered other professors, which is part of being seen the flipped classroom as an active learning technique [40].

As a complement, three people mentioned that this strategy was not received in a positive way because of been the same as having a professor to provide the information. In this regard, a student explained: "It seems to me that in the same way that my classmates give the lessons, if the professor had given them I would have received the same information and processed it in the same way." This is an example of what It has been appreciated in previous research, because although most people provided positive opinions, also have expressed a desire to return to traditional lessons, because any value is appreciated in active learning, with the inconvenience of a workload increase [29]. However, the same student later mentions, "The only difference was that for the lesson in which I exposed you knew things in a little more detail." The latter is one of the objectives sought with the flipped classroom, as it facilitates the students' learning and allows them to put themselves in the professor's place in terms of the preparation required for the class development. In spite of this, what is salvageable is the fact that before beginning its implementation, you must explain the intentions of its employment, because sometimes using it is not fully understood and students prefer a traditional class, because "the professor explains it better."

A final aspect indicated was related to the complexity found for the class preparation, since a given opinion was: "there are many variables of a presentation that sincerely a student cannot explain as well as the professor would have done." This is an idea that must also be worked on in future strategy uses, because effectively in the case of oral dissertations, the professor, in most cases, has more resources for its development. In this way, work should be done on a rubric regarding the evaluation of the work to be done, given that this change affects the functions and responsibilities of both professors and students [41].

In question five, it was requested to know aspects that were not liked by the students. The first detail to consider is related to their oral expression, since for nine people there were aspects that people should correct, including speaking very low and very fast. One of them expressed that: "Not all people have the facility to transmit their knowledge, so it is a bit tangled." Despite this, he concludes his comment by saying: "But among the other colleagues the doubts

were clarified." This is one objective of this activity, to ensure the integration of some abilities into real-world activities [42], related to their future profession. Therefore, despite the commentaries by two students that "some presentation styles were not the most attractive" and that "certain students do not have teaching facilities," oral expression should be worked during the university years. The shortcomings found can be solved to some extent in courses prior to this one.

Another aspect to consider is a greater participation by the professor during the development of the activity, because of the fact that "the classmates do not handle the information very well and leaving many details in their hands generated that confusion." At the same time, it is established that there should be a more active participation by the professor. One student advises that:

"I would have liked intervention by the professor when doing the exercises, because I feel that the classmates did not prepare very well or maybe they fought for it, but it is not the same to go out and explain theory to go out and explain an exercise."

Eight other respondents express these comments. Such a situation is really an opportunity for personal improvement, because it was the first experience when using this type of strategy. The conception was that the professor was only to make a final intervention and any correction necessary to avoid confusion among the members of the course. However, it is clear the need for more intervention before, during, and after the activity, so that the student feels accompanied by the professor, and does not generate insecurity, so the professor's presence ensures that they will be guided and helped if there is confusion during this process [27].

Another detail to consider is the working complexity with such a large group, since it requires that the work have to be done among a considerable number of people, so "agreeing is more complicated." In addition, it is difficult to have homogeneity in the oral presentation. In fact, a student warns "there was no uniformity in the presentation style." Finally, we must find a way not to lose interest as indicated in a comment: "It is monotonous that the whole course consists of that, it is better to focus on a part of the subjects." Such a situation arises as a need that all evaluations have to be similar for all groups and to avoid discrepancies in them. But, as a result of these comments, the idea is to look for differences between one group activities from another. However, despite this, group work in the flipped classroom is of great value, because the collaborative learning processes provide opportunities for the students to generate individual and group understandings. The power of this process resides in the ability of peers to take the



meaning of difficult concepts to the rest of the group more effectively than the professor [35].

To conclude with these features, six students indicated that a greater value should be given at the evaluation, since “the presentation is worth the same as a quiz and it requires more time than studying for a quiz.” Therefore, the request that “the percentage could be a little higher, since more time is spent than studying for a quiz,” in addition to “it takes a lot of time to organize in a group” is completely share.

Other aspects indicated in a minority manner were suspicion that the peers do not perform the coevaluation objectively, the need to seek exercises in other teaching sources outside the material delivered, and the pressure generated by giving a class. It should be noted that 16 students did not mention characteristics that they disliked about the use of the flipped classroom in this course.

In the next question, they were asked if they would recommend the use of the classroom strategy invested in future career courses. Pleasantly, 92.30% answered affirmatively. The reasons why they would recommend it are diverse, but some of them are remarkable. First of all, it was indicated that “it improves the learning process,” which was one of the objectives from this strategy since its inception. In fact, generating deeper learning in comparison to a master class is mentioned, reaffirming the reference to this technique in terms of reaching the highest levels of Bloom's Taxonomy [43, 44]. Subscribed to this, the class becomes more dynamic, since as indicated by a person:

“It becomes less tedious than listening to the same person talking for two hours (professor), is more entertaining and is understood (sometimes) better. As well as they show videos and information of situations that could be presented, and how it should be at the time of practice (tools and advice).”

In addition, it's seen as an innovative learning way, reinforcing what was found in question three. However, part of the students made the caveat that not all courses can apply the flipped classroom, because its use will depend on the complexity, whether or not you have prior knowledge, among other details. In fact, most of the studies have reported the practices in higher education and the findings are mixed, especially aspects related to activities to promote active learning, which are at a nascent stage [45].

In contrast, three people would not recommend its use in the future. They mentioned that it is not good to entrust the contents of the courses to classmates. In fact, one of the comments expresses that the classmates:

“Don't have a good preparation, so they don't understand the same and you don't learn the same. It is not good for colleagues to explain the information of the career that will be exercised for the rest of their lives. The professor who has a great preparation explains much better and the classmates don't.”

This comment is valid, because it again brings up the need for further intervention by the professor from the beginning to the end of the activity. A purpose of this strategy is to increase professor-student engagement during class time [46].

Another issue was about the time requirement to carry it out, because “the time spent to prepare and understand the themes and the material is a lot, so I prefer to spend time studying everything and the professor to explain it”. Given this, it must be evaluated in future occasions if a higher percentage will be assigned in the evaluation, achieving a better coherence between the effort invested and the percentage of course associated with that effort. It should be noted that a person did not answer this question.

Finally, it was requested to indicate aspects that would help improve the flipped classroom application on future occasions. The first (mentioned by seven students) is to increase professor supervision, participation, and intervention (especially in the practical exercises developed by each group). We consider it essential to have a more active mediator role during the group preparation and presentation, indicating relevant aspects about what people is communicating to their peers and then, if it has been a doubt about the topic developed. All this can be summed up in the opinion of a student who expresses:

“I wanted to feel that although the person in charge is not the professor, I would have liked to feel that there is more guidance on his part. For example, indicating a date for a previous meeting or at least indicate in advance the presentation important objectives. Because in some cases I felt that they didn't speak important things, but a lot of theory that could be avoided.”

As a corollary, it is requested a scheme developed by the professor with the topics to be addressed, the presentation format, and the exercises to be included in it (to avoid that it is all free, as happened in this case). Also, additional guidelines incorporation such as an initial introduction to the teaching staff's position, a summary delivery of the presentation (including formulas and calculations), and a question proposal for the quiz by the lecturer group, under professor supervision are needed.

Another aspect is to increase the exposure time, as five people point out the need to give more minutes for people to be able to exhibit more calmly, because “some presentations require more dedication” and because a longer period is needed in terms of exercises resolution.

In addition, four students recommend improving the presentation interactivity in, avoiding that only Power Point® is used, and achieving greater communication between the speakers and the rest of the public. Also, it will be useful to include resources such as videos, that are very convenient when you need to review the way of carrying out a laboratory procedure and that have been essential in the development of flipped classroom strategies [47, 48].

Likewise, four persons requested that they will like to form their own groups and that they should be smaller. In this occasion, it was decided not to do this, because it was the first contact with this group of students, which made it difficult to leave the option open for them to make the job teams.

Finally, the topic of increasing the presentation percentage in the course evaluation, providing advice for a better oral expression and having recommended exercises to know the elements to focus were discussed.

Of all the respondents, 17 did not give suggestions on this matter, since they had no idea or considered that the way it was implemented had no aspects to improve.

## CONCLUSIONS

In this flipped classroom experience, there was a similarity between the grade provided by the professor and the working groups for each of the activities. From the total enrolled population, 94.23% approved the course.

As a complement, the students’ opinion revealed that for 86.54% the didactic strategy improved their academic performance and/or learning process. This positive impact was due the contents explanation by their peers, the learning deepening to teach the lesson in the best possible way, having the study material since the course beginning, and the acquisition of tools and/or skills necessary to make public presentations. In fact, 92.30% would recommend the use of this classroom strategy in future career courses.

Nevertheless, the most frequent negative comments were that there is no difference between this flipped classroom and traditional lectures. Also, the complexity found for the class preparation was not well received.

Because of these situations, students recommend to increase professor supervision,

participation, and intervention, a scheme developed by the professor with the topics to be addressed, the presentation format, and the exercises to be included in it, and increasing the presentation interactivity and time along with the evaluation percentage.

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