Designing the pre-class and class to implement the Flipped Learning Model in a Research Methodology Course

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***Title*— Diseño de la pre-clase y la clase para implementar un modelo Flipped Learning en un curso de Metodología de la Investigación.**

***Abstract*— The use of new technologies in university education is indispensable for promoting the autonomous work and motivation of a new generation of students who use technology frequently and skillfully. For these reasons, integrated technology into teaching-learning processes is needed. Our study focused on the implementation of the Flipped Learning model (FL) in the Research Methodology course. The content and the activities for the Pre-class and class were designed to develop the skills and competencies in the students and to propose a research design. For the first execution, open-access videos were used. After analyzing the first execution, the results showed the need to make personal videos, that include the exact content, making them more attractive for the students as well as to use strategies to ensure that the students prepare the pre-class appropriately. In conclusion, the model encourages students to include technologies as learning tools, adapt their schedules to take better advantage of classes, and apply the knowledge taught in videos to their classwork.**

***Index Terms*— flipped learning, blended learning, research methodology, student-centered learning, university education.**

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I. Introduction

UNIVERSITIES should be capable of incorporating new technologies into the teaching-learning process to adapt to society's new requirements. Emerging technologies like smart devices make it possible and even compel education to shift towards a new student-centered paradigm [1], [2]. Digital native students are accustomed to using new technologies and expect to use them in their studies [3], [4].

An alternative to the traditional model is the Flipped Learning model, an emerging form of Blended Learning [5], [6]. Flipped Learning (FL) is a student-centered pedagogical focus that proposes to bring instruction from the collective space to the individual space and to use the remaining space for collaborative, dynamic, and interactive learning [7]. Briefly, individually, and before class, students should access class content online (generally in video formats) instead of waiting for the class. Then, during class, they can participate in learning activities in which classmates and professors interact; applying the knowledge acquired in the pre-class work [5], [8]. In this way, students can personalize their learning time, remember and understand their pace, and review the content as needed. However, FL's strength extends beyond these features. Studying videos outside of class space can be considered a form of self-learning. Student-centered learning occurs when class time is used in activities in which students are encouraged to apply, analyze, evaluate, and create based on lessons they learn individually [9]. In terms of Bloom's taxonomy, this process means they conduct the lowest level of cognitive work (acquire knowledge and understand) outside of class, and during class, they perform higher forms of cognitive work (applying, analyzing, synthesizing, and/or evaluating) together with their classmates [10].

To apply FL, the four pillars of F-L-I-P should be considered: a flexible environment, a learning culture, intentional content, and a professional educator [7]. According to the Flipped Learning Network, a flexible environment refers to professors having the freedom to adapt spaces to make them better suited for active student-centered learning. A learning culture refers to a change in the traditional professor-centered model as a source of information to a student-centered model. In this new model, the student participates in the construction of his/her own knowledge. Intentional content refers to the idea that

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professors should select which content they will transmit to students and which materials they will use to this end. Furthermore, they should prepare and orient class activities to enable students to acquire more in-depth knowledge. The professional educator should provide feedback during active learning and be capable of directing activities in class [7]. Studies have proposed that three letters should be added to the proposed F-L-I-P research model and design to complete the experience, P-E-D —progressive activities, engaging experiences, and diversified platforms— forming the new abbreviation "FLIPPED" [11].

The FL model has been successfully used in higher education in courses such as English, Biodiversity and the Global Environment, Clinical Practicum, Liberal Arts and Introduction to Communication, Linear Algebra, Radiology Clerkships, Information Technology, and Medical-Surgical [12]–[19]. In evaluating the model, student participants indicated that they felt more motivated during classes, more sure of what they learned, and more responsible for their learning [12]–[17], [19]. Furthermore, better performance and retention were found in students in the groups in which FL was applied compared with students who attended traditional classes [17], [18]. Among the disadvantages were students' lack of familiarity with the model and their feeling that preparing for class involved more time than usual [15].

Among the challenges that accompany this model is getting students to review the theoretical content developed for pre-class work and getting professors to choose content and activities that will direct students to use the previously acquired knowledge [1]. To incentivize students to review content, various studies suggest strategies such as using short videos with essential information [20], [21]. Videos should be a maximum of 10 minutes to maintain attention and retention [20]. Questions should be incorporated between videos to improve attention and interest in the videos [21]. A second aspect less studied is the influence of the experience of the teacher in the class subject and in the use of the FL model in the effectiveness of the application.

Although studies have explored the implementation of the FL pedagogical model in higher education, few studies have analyzed the elements of design of the pre-class and class. For instance, studies on higher education report the activities during the class as well as the pre-class video content; but do not describe the resources used and the reception of such element for the students [12], [19]. Most studies on the FL model are quasi-experimental; they aim to compare the FL class against the traditional class [16], [17]; or evaluate effectiveness and acceptance of the FL model by students [13]–[15], [18].

The goal of the project was to implement the Flipped Learning model (FL) in the Research Methodology course taking into account the design elements of the pre-class and class.

II. METHODOLOGY

A. Planification and design

The class was designed for the course Scientific Research Methodology for two-degree programs of the University of Cuenca, Ecuador—Chemical Engineering, and Industrial Engineering—according to the guide based on the FL pedagogical model shown in Table 1. The activities for the pre-class and class were designed and organized by the professors and experts in FL pedagogy to develop in students the skills to propose a research design. The course lasted one semester and was offered separately by degree. The course was executed over two semesters for each degree. The same professor taught the course for both degrees over the two semesters.

TABLE I
GUIDELINES TO DESIGN CLASS USING FLIPPED LEARNING MODEL

Flipped Learning model	
Before class	– Identify goals and competences of the module. – Plan the pre-class with low-level cognitive tasks according to Bloom such as remember and understand: 1) Select the content to be studied by the students. 2) Choose or prepare the videos (and/or other format) with the content of the topic to be studied by the students. 3) Design activities in order for the students to review the videos and learn the content. – Plan the class to include higher mental activities according to Bloom's taxonomy such as application, analysis, evaluation, and creation: 1) Prepare tests and/or reinforce activities of video contents. 2) Plan active and collaborative tasks. – Plan formative and summative assessments.
During Class	– Promote active student-centered learning. – Guide the learning process. – Share additional content.

The main objective of this course is to teach students to design a research plan correctly with all its parts. The course included the following modules: 1) philosophical trends: epistemology and ontology; 2) research approaches: qualitative, quantitative, and mixed; 3) general concepts: science and scientific research; 4) the research problem and the research question; 5) information and its sources; the state of the art; 6) research objectives, variables and their operationalization for implementation, and the hypothesis; 7) the research design and the methodology; 8) the sample and sampling; 9) the data-processing approach; 10) research funding; 11) final research protocols; 12) conducting research; and 13) the presentation and dissemination of results. Two professors of the subject selected and prepared the content of each module together in mutual agreement. The syllabus content was taught in pre-class with videos selected from the YouTube channels, university web pages, etc. for each topic, and these were uploaded to the Google Classroom platform, with the disadvantage that statistics on video usage could not be accessed. Different video types were chosen such as animated videos, panel discussions; those that included audio

and text, those that included only text or only audio, and those that contained either examples or theoretical content. With the exception of the video regarding the population and sample (24 min), none of the videos exceeded 15 minutes. After each module, the platform was used to ask students' opinions regarding the videos and other content used in the Google Classroom. Based upon this information, content and video formats were chosen to create our own materials, which were applied for the second intervention. The videos that were used were created by our team at the University of Cuenca's MediaLab, following scripts generated by the department professors. The video scripts were designed for generic content, so they could be used for any degree program. The videos can be viewed through our account on YouTube's platform: https://goo.gl/KQH1Na, see figure 1. Students had access to these videos on the Moodle platform which was enabled for these classes. At this stage, the video transcription was included on the Moodle platform, in PDF format.

For the Pre-class, activities such as online knowledge tests and forums were prepared for the students after viewing and studying videos. During the first intervention, the professor noted that many students did not watch and/or study the videos, so in the second intervention it was determined to include a pre-class content test at the beginning of each class. For the class, activities were designed in order for the students to apply the concepts contained in the videos for the development of each part of the research plan as well as the full research plan.

B. Application

At the beginning of the course, the professor explained the syllabus to the students; as well as the FL pedagogy (Table 2). Furthermore, a video tutorial of the FL model was introduced, to explain the work methodology and the online tools. Briefly, students were explained that before each class they should watch and study the videos as well as carry out the activities of the platform; so that during the class, they will carry out the planned group activities using the concepts included in the videos.

TABLE II
PHASES OF THE FLIPPED LEARNING MODEL APPLICATION DURING THE COURSE

Flipped Learning model		
	Pre-class	Class
Professor	– Uploads videos and activities to reinforce the video contents.	– Preparing the tests and reinforces the knowledge acquired from the video. – Explains and guides the in-class activities.
Student	– Enters the platform to view and study videos and/or educational materials. – Performs the reinforcement activities to strengthen the knowledge obtained from the videos	– Takes the test and makes questions about theme content. – Perform group activities to create, apply, analyze, and evaluate studied content.

In the first class, the students had to work in groups and choose a research theme according to their interests. Throughout the course each group had to develop all aspects of the research protocol of their theme such as state of the art, objectives, hypothesis, variables and their operationalization, methodology, sample and data-processing design.

In a typical class, as an initial activity, ideas about video content were shared. Later, the teacher explained and expanded the concepts and indicated the tasks that the students had to develop in groups during the class. Next, each working group should apply their knowledge in developing the part of the research protocol assigned for that day. Then, each work group had to expose what worked during the class. The other groups had to give their opinion and be analytical about the work of their peers. Finally, the teacher made suggestions on the progress of the groups so that students make corrections and improvements in their work. The students had the possibility to share an improved version of the activities carried out on the platform, to receive more recommendations and comments before the presentation of the final work.

At the end of the course, the groups presented the complete research protocol to a panel of experts who evaluated the work carried out during the semester. Furthermore, they presented the project in a poster format and a blog as strategies to publicize their work to the general public. In other words, to approve the course, the students had to complete the different activities and tests as well as presenting the final task which was a research protocol of a theme of their choice.

In order to evaluate the students' opinions regarding the FL model and content, they were asked about these aspects. During the first intervention, upon completing the reinforcement activities put on the platform, such as questionnaires and forums regarding the subject matter, the students were required to participate in an opinion forum regarding the videos and FL model; these results were used to design and make the videos for the second intervention as previously explained. Lastly, at the end of the second intervention, two focus group sessions were conducted separately with the chemical and industrial engineering students; the professor was interviewed to understand their perceptions of the pre- and in-class work, including the contents and activities used. The focus group sessions lasted approximately 1 hour and were organized in two parts. The first component was dedicated to establishing an activity to generate trust in the participants, and the second component consisted of questions about their perceptions regarding the video: type and content as well as questions about their perception regarding the class and pre-class and FL model. In response to these questions, the students formed groups of 3 or 4 people and were instructed to give their answers only after discussing the questions in the group. A representative from each group tacked sticky notes with their responses on the board, and the facilitator took note of all significant data that emerged during the discussion. Qualitative data was analyzed manually.

To evaluate the effectiveness of the application of the FL model in the teaching-learning process of the Research

Methodology course, students were tested upon their theoretical knowledge. Furthermore, the research plan designed for the students was evaluated by two professors to obtain the level of skill achievement in each task. The professors used a format with the rubrics to evaluate the final task. The rubric was made and evaluated for research experts. Briefly, professors should grade from 0 to 100 the following aspects of the protocol: 1) scientific writing, grammar, and the use of quotations; 2) coherence between the structures; e.g. title, variables, objective, hypothesis, and methodology; statement of the objectives; statement of the hypothesis or the research questions; variables and their correct operationalization; appropriateness and relevance of state of the art; adequate proposal of methodology; correct planning and use of resources. Regarding each statement, the professor had to justify their grade. Quantitative data was analyzed with the 3.5.2 version of the R statistical program.

As a limitation, the application of the FL model could not make the comparison between the students' knowledge about the concepts regarding the subject before and after the course since it could not retrieve the questionnaires due to a technical failure of the Moodle platform and the linked Google form questionnaire.

III. RESULTS AND DISCUSSION

The full course was executed over two semesters, September 2016–February 2017 and September 2017–February 2018 for each degree. The demographic characteristics of the participants are shown in Table 3. The students' average age was approximately 22 ± 2 years. More than 20 % of Industrial Engineering students worked. In the first intervention, 38 students participated while in the second intervention 42 students participated.

TABLE III
DEMOGRAPHIC DATA OF THE PARTICIPANT PROCESS

Semester	September 2016–February 2017		September 2017–February 2018	
Degree Program	Chemical Engineering	Industrial Engineering	Chemical Engineering	Industrial Engineering
Age $\bar{x}$ (SD), years	22.82 (2.52)	22.13 (2.52)	22.89 (1.53)	22.81 (2.17)
Male, n (%)	6 (54.55)	22 (81.48)	10 (66,67)	17 (62.96)
Female, n (%)	5 (25.25)	5 (18.52)	5 (33,33)	10 (37.04)
Disability, n (%)	1 (9.09)	0 (0)	0 (0)	0 (0)
Working, n (%)	2 (18.18)	11 (40.74)	1 (6.67)	6 (22.22)

Only one student presented a disability. The student was asked if it would be an inconvenience to take classes using the FL model; the student indicated that it would not be a problem for him/her

A. Pre-class

As stated in table 2, students are expected to study the video content of the topic as well as do the reinforcement activities online, such as completing online questionnaires and participating in forums. Substantial participation was observed in completing the questionnaires and engaging in forums; around 90 % of the students, as has been found in other studies [21]. Nevertheless, the professor realized that many students did not adequately learn the video content due to their poor intervention when they were asked to explain the concepts of the pre-class. During the second execution (September 2017-February 2018), a strategy was implemented to avoid this situation and to ensure that the students review and study the videos at home and in class; tests were included regarding the video content. The tests were graded; the average of the tests represents 20 % of the total grade.

Such tests complemented the reinforcing activity of completing online questionnaires regarding the content of the viewed video. This strategy leads to more students strongly reviewing the pre-class content before attending class.

In the first execution (September 2016–February 2017), the students were interviewed regarding each video. The opinions and suggestions of the students encompass 5 aspects: 1) short and concise videos, "videos that are short and clearly explain science and the scientific method"; 2) videos that explain the subject matter with applied examples; 3) fast and dynamic videos (this conclusion can be assumed from the following statements: "The video that I liked the most was the hypothesis and variables video [6 min], because it explained each concept; both conceptual aspects and examples. I like it better when they give an example. I also liked the last animated science video [4 min] because they make you put into practice what you learned in the other videos. The one I didn't like was the third video. It was really long, and the woman spoke very slowly [8 min]". "The video that I found most interesting was the last one that focused on research methods. Even though it lasted 7 minutes it was educational and original and pointed out the differences between each type of research design".); and 4) animated videos that were not recorded lectures (for example, "Regarding the different videos that we have seen, I'd say that the video on 'population, sample and sampling' [24 min] was too long, so you lose interest. I would recommend the video be shorter, and the information better resumed. However, it did provide relevant information regarding the subject. I didn't like it because it was too long, but it was really useful because it provided good information. With regard to the 'funding and budget' video [14 min], it was similar to a class that is normally given, so I didn't entirely like it because these classes don't provide the necessary information, and you only see slides with a text".). In conclusion, videos should be short, concise, dynamic, use theoretical content that includes examples. Videos longer than 10 minutes, recorded lectures, or slides should be avoided. These results are similar with other studies, in which short

videos are recommended [12], [20]. This feedback means that when deciding which videos to use, the length should be considered a between 8 to 10 minutes, as seen in other studies [20]. Preferably, the videos should be animated; the individuals who intervene should be dynamic, and they should use different tones of voice and provide examples.

Once these recommendations were evaluated and after an analysis by the research group and teachers, it was decided that the best option was for teachers to make their own videos with content designed according to the needs of the class.

According to research, this also makes the students feel that the teacher is more involved in the pre-class [22]. These videos were used in the second execution (September 2017–February 2018); the videos were posted on Moodle as well as YouTube, see figure 1

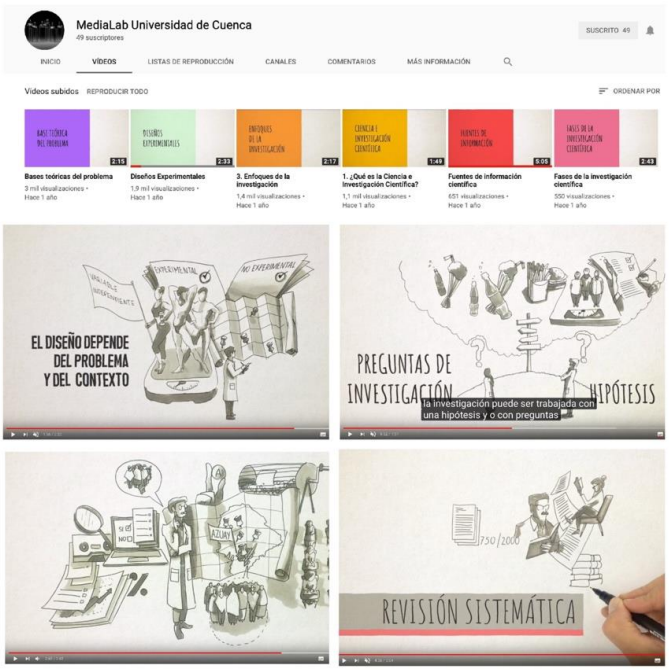

Fig. 1. Video examples created by the research team, available on YouTube page, https://goo.gl/KQH1Na

The videos are short and dynamic and include theoretical content and examples. The video transcriptions in PDF format were uploaded to Moodle. When our own videos were used, the students considered them complete and dynamic. Through watching these videos, it encouraged them: “Yes, because the graphics make it easier to understand”. However, some students felt more comfortable reading the content, saying, “It was necessary to read the PDF [file] to completely understand the video”, or “No, because we are accustomed to learning by reading”. At the end of the course, the students were asked which videos they remembered the most and they recalled remembering videos focusing on the application of activities or concerning specific tasks. Students repeatedly referred to the videos regarding bibliographic references or sampling, those they used in their final projects, or those about research objectives related to proving a hypothesis in class. Furthermore, they also remembered the hypothesis videos because of the graphics that were used.

In general terms, the students indicated that the pre-class work was helpful because they understood the theoretical part of the subject. Among the reasons they shared, there were statements like, “They were linked to the course and we could watch them several times”. When we asked the students if the content was relevant to the class, all of the students agreed that it was, among their answers we found statements like, “Yes, because they were directly related to what we worked on with the professor. We had a sense or knowledge of the subject matter that was going to be addressed”, or “Yes, it was relevant because we had to apply them to the project”. The majority of students also acknowledged having felt more prepared when they reviewed the videos because the content eased the understanding of the concepts reviewed in class. This feedback confirms one of the model’s advantages, which is to increase motivation [5]. With this model, students become more autonomous and do not content themselves with memorizing the theoretical content. Unlikely, they think about it and apply it. The FL model seeks to increase students' motivation by encouraging them to become active participants in their own learning process [12]–[17], [19]. This process enables them to become more independent and concerned in trying to understand, as opposed to simply memorizing the theoretical content to gain a course credit. Last of all, in response to the question “How can the pre-class experience be improved?” students recommended upgrading the platform; attaching supplementary content such as glossaries, bibliographies, and questionnaires; and including activities like didactic games. Regarding the content, they suggested more examples and these to be linked to other materials related to their study areas; discussion forums should be included and used after watching the videos.

B. Class

At the beginning of the class in the first execution or after the test in the second execution, the professor asked the students about the concepts studied in pre-class and explained the misunderstandings. Regarding the lessons applied to guarantee that students prepared their pre-class work, most of them pointed out that the daily tests were a source of stress: “We were stressed out by the daily tests”. One option might be to show the videos in class and discuss them immediately afterwards. However, with this alternative, the adaptation of resources according to their learning needs would be lost; the students would not be able to watch the videos or other resources as many times as necessary to understand the concepts. According to the professor, applying the tests was worth it due to the fact that students were better prepared for pre-class which allowed them to use their understanding for the class. After the test and reinforcement, the students formed groups to develop each part of the research plan of a theme chosen by them during class. At the end of the class, each group presented their work carried out during class for it to be discussed and improved. Assignments were graded in each class. At the end of the semester, each group presented a full research plan. Moreover, a final individual test about basic

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concepts was applied. Regarding the experience obtained from the forums and focus groups, the students indicated that they enjoyed the classes because they could use class time to apply the knowledge acquired from the pre-class. According to the professor, the fact that class time was not used to give a master type class to explain concepts and examples, this allowed the professor to help the students during the development of their tasks. The professor however, indicated that this model is more demanding because in some way the teacher is removed from his or her comfort zone where he or she is the one who dominates the concepts and explains them to the students; the professor considers that this is an enriching model that allows students to acquire appropriate knowledge and makes learning more dynamic and practical.

C. Performance Evaluation

Regarding academic performance results, both groups showed evidence of having acquired enough knowledge and skills during class and were capable of developing all the tasks efficiently. Comparing the grades obtained from the students of each intervention, this is, September 2016–February 2017 and September 2017–February 2018, the students from the second group achieved better grades than the students from the first group. From September 2016–February 2017 the average obtained is 6.53/10 with a standard deviation of 1.806. Meanwhile, from September 2017–February 2018 the average obtained is 7.53/10 with a standard deviation of 0.794. These variations are significant according to T-student with a difference of (3.15); p (0.001) < 0.01. In addition, the variation was shorter in the second intervention in comparison with the first intervention, see figure 2.

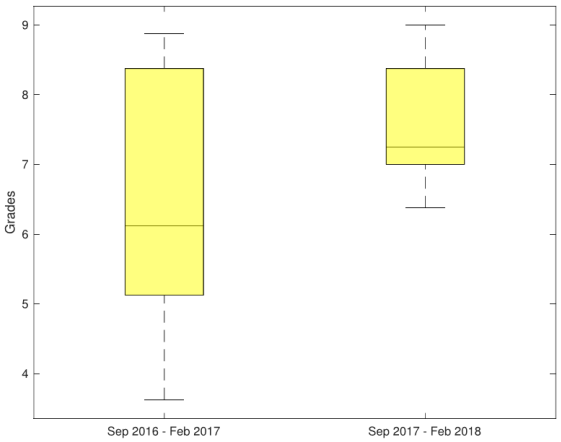

Fig. 2. Boxplot of research plan grades in both interventions

One possible explanation is due to the fact that in the second intervention some changes were made to the model, for example, shorter and dynamic videos were used with the necessary contents for the intervention. In addition, despite the unpopularity of the tests before the beginning a class, they make the students really studied and understood the pre-class contents. Another change was that the working groups could not be formed by more than 4 people, making sure that everyone participates in the work.

Regarding the focus group, the students emphasized that they enjoyed this learning experience in which they used the resources and technology within the learning process. They stated that it made them more independent: “The course has led me to look for more information on my own, to look for contents of interest, and to find them”. They also indicated that now they consider it more important to learn the theoretical content instead of memorizing it to pass the exam: “I think that now, instead of memorizing certain things, I am more concerned about the logic of how it works, and in this way, I get to acquire more knowledge without forgetting what I learned”. Hence, Flipped Learning was a suitable way to teach the subject at the University. From these experiences the need of a flexible environment, a learning culture, theoretical content, and a professional educator was evident [7]; as well as, progressive activities, engaging experiences, and diversified platforms [11, 23]. In addition, for pre-class and class, it is necessary to include activities that lead students to achieve the established achievements; For example, tests on the content of the previous class and reviews on the activities carried out during the class.

IV. CONCLUSIONS

FL is a model that enables educators and students to take learning to another level by using class time to engage in tasks at a higher cognitive level. Students become more independent and participate in their own learning. However, the context of implementation should be considered. For example, in Ecuadorian universities, students frequently spend many hours in the classroom, which means that they arrive home tired and with homework to be done. Given these circumstances, when implementing the model, pre-class tasks should be meted out, using more effective content such as short, concise and dynamic videos. Likewise, the same content should be provided in various formats, for example, scripts and audio, so that students acquire the information in a flexible way. Due to the recommendation to make short and concise videos, it is highly recommended to add complementary content such as the transcriptions and other sources to extended information – articles, books, verified web pages with more information to expand the students’ knowledge.

Professors should carefully consider how to ensure that students complete pre-class tasks because in-class lessons or tests are the most effective but also the most stressful strategies. During classes, students should work in small groups to ensure the participation and active contribution of all group members. Additionally, professors should verify equal participation by using strategies such as: oral presentations and individual writing assignments. Last of all, this model can be used to merge common classes at the university by decreasing the amount of time spent at the university and providing students with more time for pre-class activities, in which the attendance will be required only for group work.

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