Impact of the b-Learning Model on University Teaching

Antonio Cedillo-Hernandez and Lydia Velazquez-Garcia

***Abstract*—In this work, the impact of the implementation of B-Learning and traditional face-to-face models is analyzed, by comparing the academic results achieved by four groups of university students in the electronics course, by using objective and subjective measurements. Analysis of the results based on objective data demonstrated a lower student dropout rate and an improvement in the general grade point average under the B-Learning model. The subjective comparison collects student's opinions through a formal evaluation instrument. This analysis concluded that students perceive the teaching-learning process under the B-Learning model more motivating, more useful and that it meets their expectations in a better way. Finally, the Student's t test is carried out to demonstrate that the analyzed research variables present statistically significant differences.**

***Index Terms*—B-learning, information technology, higher education, educational innovation, professional education.**

I. Introduction

At the beginning of the 21st century, there was a relevant increase in the registration of domains on the Internet related to education, which resulted in an excessive offer of distance educational courses that led the rise of the online learning model (e-learning) [1]. The trend in educational institutions was to develop online learning courses that would provide the opportunity for students to obtain knowledge from different geographical locations, in a flexible schedule and with the reduction of some costs. However, completely transforming face-to-face courses to meet the specific attributes of online learning environments was an effort and resource-intensive activity. Learning quality and objectives were affected when students exclusively used e-learning as a teaching method, principally due to a) lack of motivation to read all the online learning material, b) procrastination and c) lack of interaction with the teacher and other students. In this way, the practical use of e-learning model generated serious questions about its effectiveness and efficiency, and it was the implementers themselves who detected the need to combine technological resources implemented with face-to-face reinforcements to encourage and motivate the development of professional skills of students. [2]. The offering of e-learning model together with face-to-face activities was reflected in greater efficiency, which made possible a new model for the specific needs of the teaching-learning process: hybrid learning or Blended Learning model (B-Learning). At present, both terms are used without distinction [3]. In the literature we can find different definitions of the B-Learning model. There are two definitions of B-Learning that are most frequently cited in the literature. Graham [4] defines B-Learning as "a system that combines traditional face-to-face learning with computer learning". Garrison & Kanuka [5] define B-Learning as "the reflective integration of face-to-face learning experiences in the classroom with online learning experiences". As can be observed, there is general agreement that the key components of B-Learning are face-to-face learning and online learning supported by information technologies. In this way, we can define the B-Learning as a model that combines virtual and face-to-face teaching and is a valuable tool to improve the learning process by using information technologies [6]. However, as we can see in Fig. 1, this model begins from two possibilities, the first is to incorporate face-to-face activities to E-Learning model, but it also arises when virtual activities supported by information technologies are included to the face-to-face education [7].

Fig. 1. The b-learning model can result from adding face-to-face to the e-learning model or adding virtual activities to face-to-face education.

Pinpoint the exact moment of appearance of B-Learning model is not easy, nor is it easy to specify its first execution. The B-Learning model has been established as an emerging educational option, whose evolution has occurred naturally, based on constant experimentation to achieve improvements and perfect educational techniques from a personal and group perspective. The implementation of the model responds to a social and cultural context that goes hand in hand with the evolution of information technologies. In this way, this new technological context merges with the need to renew the pedagogical organization and make educational innovations.

The B-Learning model is a topic of great current interest that implies a change of paradigm where the emphasis shifts from teaching to learning [8]. A great challenge is how the information technology tools are used while the participant engagement is successfully ensured considering individual characteristics of students [9]. According to previous studies, the B-Learning model can bring several advantages to the teaching-learning process, among which are the following: a) This model provides flexibility to the student, allowing the student to access the online content and develop the academic activities available within the course at his own pace. Not all students will be able to learn at the same pace, it depends on multiple individual factors, and this model allows knowledge to be consumed at a convenience, b) One of the most tangible

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advantages is the possibility of accessing online resources from anywhere (ubiquitous learning) and through different mobile devices with Internet connection, such as a desktop computer, a laptop, a tablet or a smartphone, c) The coverage of attention to a larger number of students becomes possible through educational platforms, which allow programming activities with targeted evaluation and feedback. In this way, the platform allows several students to interact at the same time with the different contents of the course, d) Through the management of contents arranged in technological platforms, it is possible to establish levels of depth in the knowledge that the student will be able to consume considering his individual requirements, e) The student eliminates some transportation expenses, since it will not be necessary for him/her to attend all face-to-face academic sessions. This represents some cost savings, as well as time savings due to the transfers that can be used for other academic or personal activities, f) From the point of view of the administration of academic resources, different types of learning content can be stored and accessed in an equitable manner and through different media, which will allow better results to be obtained, and g) B-Learning model privileges the interaction among students, in whether face-to-face or virtual. For this purpose, the final objectives of this interaction must be considered, and the necessary pedagogical tools must be made available to the students for this purpose. In the case of virtual tools, the model relies on information technologies to include communication forums, blogs, chats, e-mail, and asynchronous message posting [10]. Nevertheless, only few of these studies are focused on higher education and do not consider the effects of B-Learning from the perspective of students. It should be considered that users who experiment complications with technology can result in the abandonment of the learning program and the eventual failure of technological applications. Students are important partners in any learning model and thus their backgrounds and characteristics influence their ability to continue learning effectively. This work focuses on resolving these two current issues. The objective is to compare the implementation of the B-Learning and traditional face-to-face models in university teaching. Since a desirable indicator in the teaching-learning process is that students develop knowledge and skills that are reflected in better results in their evaluations, the academic results achieved by students are analyzed, particularly the degree of dropout and grades achieved during the course, which are considered objective measurements. On the other hand, derived from the fact that one of the most important aspects in the implementation of a teaching model is the experience of the students, a collection of information is carried out to measure the way in which the students perceive the implementation of the B- model. Learning, which is considered a subjective measurement.

II. Methodology

This research evaluates the academic results obtained in the Electronics course, taught in the third semester of the Information Technology Engineering educational program, at the Tecnologico de Monterrey University. Four groups of students divided into two sets are evaluated, two groups under the traditional face-to-face model and two under the B-Learning model. The data obtained oscillate between the years 2017 and 2021, where the traditional face-to-face model corresponds to the courses taught in 2017 and 2019, and the B-Learning model corresponds to the courses taught in 2020 and 2021. It is important to note that the study plans of the subject were not modified during the research period, therefore, the learning topics are the same in the application of both methods.

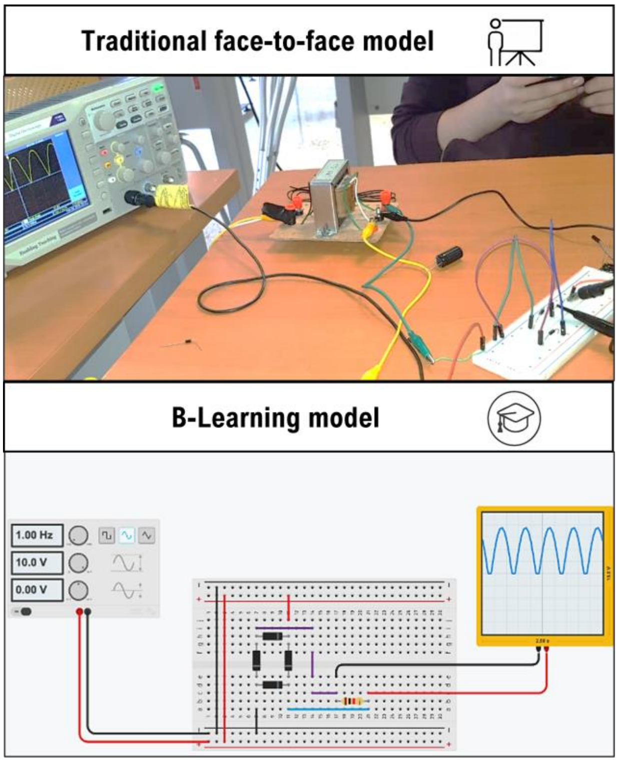

Fig. 2. Laboratory practice applied in traditional face-to-face model (above) and b-learning (below).

The B-Learning model integrates educational activities organized for individual and group work, supported using information technologies, with the aim of consolidating the knowledge of face-to-face lessons. The teachers encouraged the execution of these activities, highlighting the objectives of the approach and its relationship with the face-to-face lessons. In general, we can classify the activities carried out as part of the B-Learning model, such as laboratory practices, creation of support videos, and participation in virtual spaces for collaboration and evaluation activities. Fig. 2 illustrates an example of the activity “Module 2 / Practice 2: Circuits with diodes”. The upper part of Fig. 2 shows an example of the work carried out in a traditional face-to-face class making use of the laboratory facilities and equipment for the design of a full-wave rectifier circuit, while the lower part shows the same activity, but carried out with the Tinkercad ® simulator, which is a free online tool that, among other functions, allows to model circuits with great realism. The use of the tool is preceded by an explanation of the subject to be dealt with, in face-to-face mode, and its use allows students to get a virtual, ubiquitous, safe laboratory with unlimited material; and from which they can get the results and acquire the expected skills on the operation of the rectifier diodes.

Finally, in the implementation of the B-Learning model, not only the traditional face-to-face activities were modified, but also the way of presenting course contents to the students.

For this modality, a series of support videos were created for all the course topics, and they were posted on the YouTube ® platform (Fig. 3). Several studies have shown that the use of educational videos takes advantage of the communicative potential of images, words, and sounds, for the construction of meaningful knowledge through the construction of an experience that promotes the stimulation of the human senses and the different types of learning of students [11]. However, the teacher will be the one who must determine how, when and for what purpose to use the concepts and thus give them meaning and educational value.

In general, this type of material is very well accepted by the students. This can be proved through a feedback exercise on the course, where students were asked what aspects, they liked most about the B-Learning model and it was found that 14 out of 20 comments allude to videos as a desirable content within the classes.

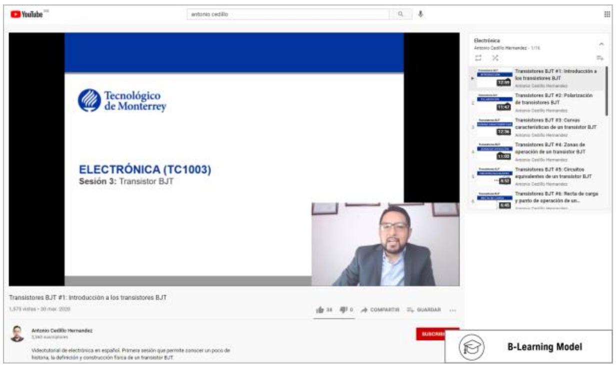

Fig. 3. YouTube® playlist with supporting videos (https://bit.ly/3DQZ9ZR).

A. Sample Selection and Variables

The total sample corresponds to a total of N = 55 students. This sample is divided into two data sets. The first set N1=27 corresponds to students who took the Electronics course with the traditional face-to-face model and the second set N2=28 to those students who took the same course but using the B-Learning model. Regarding the research variables, two hypotheses were generated to be evaluated according to the obtained results:

1) Hypothesis 1: The application of the B-Learning method has a positive effect on the student's academic results.
2) Hypothesis 2: Students perceive their experience in the course in a more positive way with the application of the B-Learning method compared to the same course under the traditional face-to-face modality.

To evaluate the first hypothesis, we use two variables: 1) the non-dropout rate (TASA_ND), denoted by the percentage of students who remain from the beginning to the end of the course and calculated as the ratio of students who present the final exam of the subject against those originally enrolled and; 2) the average of grades obtained in each school year (PROM_CALIF), in which all students who take the final exam are considered regardless they pass or not the course.

Regarding the second hypothesis, we use an institutional instrument applied to students of Tecnologico de Monterrey University at the end of each school year to evaluate their perception of the teaching-learning process, which is known as the Student Opinion Survey (ECOA). The ECOA is divided in three blocks of two questions each to determine the SATISFACTION, MOTIVATION and UTILITY, perceived by the students. Each question has a scale of 5 to 10, where 5 indicates the lowest level of evaluation and 10 the highest level. Table I shows the elements that set up the evaluation instrument proposed for this research.

TABLE I: VARIABLES OF THE PROPOSED EVALUATION INSTRUMENT

Variable	Question ID	Description
SATISFACTION	ETEVA	Regarding the evaluation system, the course was
	ETESA	Regarding the interaction and the help received, the course was:
MOTIVATION	ETAPR	Regarding the learning guide, the course was:
	ETRET	Regarding the level of intellectual challenge, the course was:
MOTIVATION	ETMET	Regarding the methodology and learning activities, the course was:
	ETPRA	Regarding the understanding of concepts in terms, the course was:

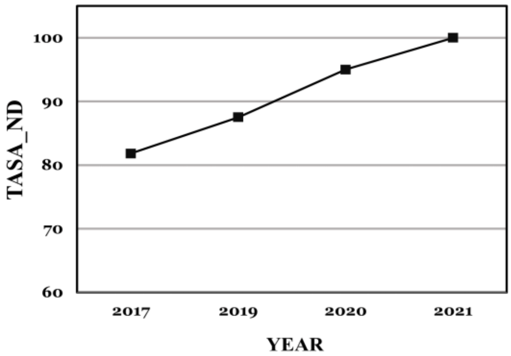

Fig. 4. Non-dropout rate (TASA_ND) for the years 2017 – 2021.

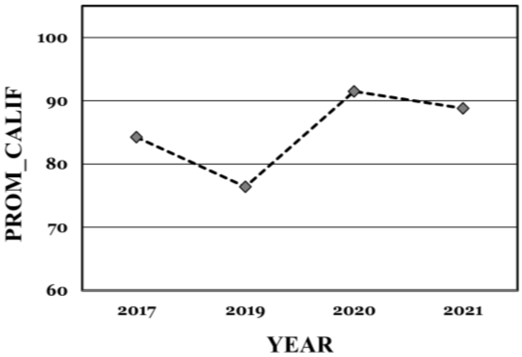

Fig. 5. Grade point average (PROM_CALIF) for the years 2017 – 2021.

III. RESULTS AND DISCUSSION

The non-dropout rate (TASA_ND), is represented as the percentage of students who remain throughout the course and is measured as the ratio of students who take the final exam, against those originally enrolled in the course. It should be remembered that within the educational model of TEC de Monterrey, students have the possibility of withdrawing or withdrawing subjects during the first six weeks of the course, for the reasons that the student considers necessary and that is convenient for him. Historically, it has been determined that these reasons are usually due to the desire to lighten a high load of subjects by choosing to drop out of those where there is minimal motivation or the worst learning experience. It can also be due to personal, family and/or financial problems, but this occurs to a lesser extent. Fig. 4 shows that B-Learning model has a notable contribution to the non-dropout rate of the course. In 2020, which was the first year of incorporation of the B-Learning model, there was a non-dropout rate of 95%, which meant the absence of only one student to the final exam of the subject, and for 2021 the rate was 100%, that is, there were no dropouts. This data shows an important improvement compared to the years 2017 and 2019 where there were non-dropout rates of 81% and 87% respectively.

Subsequently, the average of grades obtained in each school year is calculated. This data allows to know the level of knowledge acquired by students in the field of Electronics. Fig. 5 shows that results obtained in the implementation of the B-Learning model are much higher compared to the traditional face-to-face model. It should be noted that grade point averages consider the results of all students who take the final exam, even if they do not pass the course.

To measure the students' perception regarding the teaching-learning process, the results of the application of each model should be compared from the questions formulated within the ECOA. In this sense, it is necessary to process the data obtained to determine the contribution of each question of the ECOA survey towards the research variables and to standardize the research variables in the evaluated periods.

It should be noted that the ECOA establishes the results for each question of the survey applied to the students, but not for the research variable. For example, the ECOA returns the results of the ETEVA and ETASE questions, but these must be combined to calculate the SATISFACTION variable. In this specific example, this is accomplished by combining the mean and standard deviation values from the ETEVA and ETASE ID questions. To do this calculation, the mean and standard deviation values of the ETEVA and ETASE questions are considered as values from two different populations. Thus, to combine the mean values of two different populations, we use the following formula:

$$\bar{X}_C = \frac{n_1 \bar{X}_1 + n_2 \bar{X}_2}{n_1 + n_2} \quad , \tag{1}$$

where n_1 y n_2 corresponds to the total to the total samples of the first and second population respectively. The result, which is denoted as $\bar{X}_C$ corresponds to the combined mean between both populations. In the case of standard deviation, a similar process is carried out, expressed by equation (2):

$$Sd_C = \sqrt{\frac{Q_C - (n_1 + n_2) \times (\bar{X}_C)^2}{n_1 + n_2 - 1}} \quad , \tag{2}$$

where $\bar{X}_C$ is the combined mean determined through equation (1) and Q_C represents the composite sampling variations to calculate the standard deviation of combined samples (Sd_C) and is calculated as follows:

$$Q_C = Q_1 + Q_2 \quad ,$$
$$Q_i = (n_i - 1) \times (Sd_i)^2 + n_i \times \bar{X}_i^{\,2} \quad , \tag{3}$$

where n_i is the total sample, $\bar{X}_i$ the mean and Sd_i the standard deviation of the population i. Note that the term $(Sd_i)^2$ is also known as the variance. Once the mean and standard deviation values of two questions have been combined, these values will match to the research variable. Specifically, combining the mean and standard deviation values obtained for the ETEVA and ETASE questions will give us the mean and standard deviation of SATISFACTION variable, ETAPR and ETRET questions give us the values of the MOTIVATION variable and the combination of the ETMET and ETASE questions will give us the values for the UTILITY variable.

Once you run this procedure, you will get two mean and standard deviation values for each variable. These two values will correspond to each educational period evaluated. To standardize these results and find a single value of mean and standard deviation, the procedure is applied a second time. The result is presented in Table II, where we can observe the values of each research variable for each educational model. In this case, the average (M) of the students' opinion is consolidated, as well as its standard deviation (S). To carry out a simpler comparison, Fig. 6 graphically shows the result of the mean for each research variable, in each educational model applied.

TABLE II: COMPARISON OF RESULTS OBTAINED FOR EACH MODEL

	N	M	S
Traditional face-to-face model			
SATISFACTION	N1=27	9.425	1.003
MOTIVATION		9.095	1.326
UTILITY		9.301	0.908
B-learning model			
SATISFACTION	N1=28	9.902	0.522
MOTIVATION		9.095	0.142
UTILITY		9.885	0.471

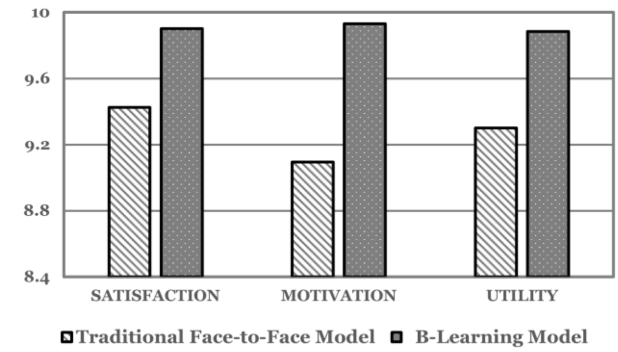

Fig. 6. Mean value of the research variables for each educational model.

Fig. 6 shows that the B-Learning model obtains a lot better results for the three research variables in comparison with the application of the traditional face-to-face model. It is relevant to note that the variable with the greatest difference in this comparison is MOTIVATION. The difference between the motivation generated by the application of the traditional face-to-face model and the B-Learning model is very noticeable if we consider that the difference between the values of both variables is close to twenty percentage points. Even though both models considered the same thematic content, the incorporation of information technologies generated greater motivation in the students. This finding can be related to the results obtained in the non-dropout rate and the grade point average, since when there is motivation the learning results are increased.

Regarding the UTILITY variable, the results indicate that students understand the relevance of the electronics course under the B-Learning model has for their university studies and their professional trajectory. The use of information technologies in the B-Learning model allows the student to use a laboratory with unlimited material and in a ubiquitous way by using computer simulators. Also, collaborative work platforms and the creation of videos on the content of the laboratory practices, allow the student to reflect on the knowledge acquired. The difference found between the perceived utility in the traditional classroom model and the B-Learning model represents ten percentage points.

As for the SATISFACTION research variable, it reflects the well-being that students experience in relation to the academic expectations of the course. In this case, the activities carried out under the B-Learning model allowed these expectations to be met and this is reflected again, in better results for this model compared to the traditional face-to-face model.

Finally, the data obtained for each research variable in the models were statistically analyzed with the Student's t-test to formalize the research results and determine the existence of significant statistical differences. The Student's t-test is used as a statical tool to evaluate the mean value of one or two groups through hypothesis tests. Conceptually, the value obtained through this test represents the number of standard units that are separating the means of the two groups evaluated. At the time to calculate the Student's t-test, it is assumed continuous data, that have homogeneity variance and have normal distribution. An important note is that the Student's t-test requires that the populations to be compared have the same length and originally in our research we have that the population of students who received the electronics subject under the traditional face-to-face model is N1 = 27 and the total of students who received the same subject using the B-Learning model is N2 = 28, therefore, we have that N1≠N2. To solve this problem, it was necessary to standardize both populations by randomly removing a data from the N2 population. The significance criterion used to perform the Student's t-test was p <0.05 and this was carried out using the Minitab ® version 19.2020.1 software for Windows ®.

TABLE III: RESULT OF THE STUDENT'S T TEST

Variable	gl	t	X_{MPT}	X_{MBL}	p
SATISFACTION	52	2.21	9.425	9.902	0.031
MOTIVATION	52	3.65	9.095	9.931	0.001
UTILITY	52	2.53	9.301	9.885	0.014

Table III shows the result of the Student's t-test. We can observe that there is a statistically significant difference for all the research variables since the initial condition established p <0.05 is met in all cases.

IV. CONCLUSION

Educational innovation implies a notable improvement in teaching-learning process that promotes changes in aspects such as pedagogy, academic tools, didactics, processes, and people. Consequently, students should feel motivated in the usage of improved academic resources, perceive that the expectations of the expected value are satisfied, and perceive the utility and relevance that this innovation will bring to their professional lives. In this context, within this research we analyze the academic impact of the implementation of the B-Learning model, as part of an educational innovation in the subject of Electronics in the third semester of the Information Technology Engineering educational program, at the TEC de Monterrey University.

In this research, it has been verified in a practical way that the integration of B-Learning model in the teaching-learning process provides several advantages through the addition of educational practices in the field of Information Technology. It has been confirmed that the application of the B-Learning model generates a positive impact on the average of grades obtained by students in contrast to those obtained in the traditional face-to-face model, which reflects a higher level of success and skills acquired by students during the course.

Also, it was found that students perceive the teaching-learning process by using B-Learning, as a more motivating model, more useful and that better meets their expectations, compared to the traditional face-to-face model. This reflects that the students positively perceive their learning experience and feel more satisfied under B-Learning model.

CONFLICT OF INTEREST

The authors declare no conflict of interest

AUTHOR CONTRIBUTIONS

Antonio Cedillo-Hernandez was responsible for teaching, led the execution of the entire project, and wrote the paper; Lydia Velazquez-Garcia guided the research orientation, perform the data analysis, and complete the paper review process. All authors had approved the final version.

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