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# The use of online learning environments in higher education as a response to the confinement caused by COVID-19

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**Abstract**

In Colombia, a developing country, higher education has a gross coverage rate of about 40% (supply concerning the entire population). However, although this value is low, ten years ago this rate barely exceeded 20%. The increase in coverage is largely due to a policy that has promoted training by cycles. This model allows education by levels with the granting of professional degrees at each stage, which allows for rapid employment. Even so, places are limited, particularly for medium and low economic levels (which concentrate the majority of the population), and access to them in public universities (those with state-funded enrolment) is very restricted. Access to education is a major concern for institutions and the state, in particular for vulnerable social groups, and has been further depressed by the security and control measures implemented to slow down the spread of the COVID-19 virus. In a short time, and with limited resources, institutions have had to adapt their models to guarantee continuity and quality in academic processes. In this context, digital platforms have come to play a fundamental role by allowing access while reducing social interaction. However, the use of these platforms implies the development of specific learning environments adapted to academic, economic, and social conditions. This paper explores the design, development, and impact of some of these learning environments in the process of technological training of students from low economic strata in the most important public university in the Colombian capital. The initial results of this study show that the distance learning model adopted as a response to social isolation does affect students' academic performance. Besides, the results also show that there are effects on the students' interaction schemes and their motivational levels towards their training process.

**KEYWORDS:** Cycle-oriented Training, COVID-19, Learning Environments, Online Learning.

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## 1. Introduction

One of the key factors for the development of a country is the level of education of its individuals. In Colombian society, it is widely accepted that the economic development of the new generations, and their family groups, is strongly linked to the level of education. In particular, higher education is considered to be a path of development since it makes it possible for people to work at a professional level. However, access to higher education institutions is limited, partly because of the majority of the population from lower economic strata, unable to finance studies in private institutions, and partly because of the low coverage offered by state-funded institutions.

Among the national policies aimed at increasing coverage in higher education, there are programs aimed at funding private institutions for young people with high academic performance, as well as the implementation of minimum quality standards for educational institutions, both public and private. One of the policies that have had the greatest impact in the last 10 years in increasing the coverage rate has been the ones oriented to support propaedeutic formation by cycles (Perez, Mena, Hoyos, & Perez, 2010). It is a cycle-oriented training in which a traditional undergraduate program is structured along with two or

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three training cycles, each one a prerequisite for the next one, with its own rules for admission and graduation, as well as a professional degree at the end of each cycle. Based on this strategy, academic programs were designed mainly in technical areas such as engineering, in which the traditional five-year programs were divided into two or three cycles, granting professional qualifications at the end of each cycle. These cycles were designed in such a way that the training in technical and technological tools was prioritized in the first levels, allowing a fast labor linkage of the young people, and impacting more quickly the economic development of their families (Arias, Ruiz, & Henao, 2012).

Among the first programs with this structure are the engineering programs offered by the Technological Faculty of the Universidad Distrital Francisco José de Caldas, the most important public university in the Colombian capital (Jirón, 2014). This characteristic is important because many of the city's low-income students attend this institution, and because the model it uses has an impact on other institutions in the city and the country. The campus of this faculty was built 25 years ago in Ciudad Bolivar, one of the poorest areas of the city. Among its policies, it decided to focus its training programs on areas identified as priorities for the city, which create real needs in the labor market. Also, it designed its admission scheme that considers not only academic results but also prioritizes the young people of the area. This is a social development project that has been consolidated over the years due to the high quality of its graduates, its social commitment to highly vulnerable populations, and its training paradigm. However, in recent months the restrictions imposed by the national government aimed at slowing the spread of the COVID-19 virus have created new conditions of inequality that add to the social ones.

Institutional policies prioritize the need for equitable access to quality education for the city's poorest young people. To guarantee this principle, the Universidad Distrital complemented its programs of food support and psychological follow-up with others of access and communication, made visible in the distribution of digital tablets with wireless connectivity for its most needy students. These programs sought to reduce the impact of not having access to the resources of the university campus, and the inability of young people to acquire computer resources. However, access to education has several additional aspects that involve the adaptation of content and processes to this new training strategy, and the development of new distance learning skills by students (Halimi, Salzmann, Jamkojian, & Gillet, 2018; Huang, 2020; Jotikabukkana & Sornlertlamvanich, 2019).

These new structures achieve their objective of distance ordered by restrictions. However, on the other hand, they also bring many new positive elements to the training process, with verifiable results in the short, medium, and long term (Ospina & Galvis, 2017). Properly oriented online training promotes discovery learning, with less distraction, and greater motivation and interaction among students, and between students and teachers (Y. Wang, 2019). With great savings in travel time, and less distraction for students due to grouping restrictions, there is greater dedication, and dialogue and interaction is promoted throughout the training and evaluation process (J.-H. Kim, Park, Cho, & Kim, 2012).

It is, therefore, necessary to develop the strategies for students to generate their learning outcomes in coherence with the new social conditions, which according to institutional and national projections will extend throughout the year (Raga & Raga, 2018). It is expected that some of these strategies will be maintained even after health emergencies have been overcome. These strategies must be formulated and structured based on the objectives of the training process, and the integration of technologies and tools not traditionally used in classroom training schemes (Choi & Cho, 2018; Zhao, 2020). Online education becomes a fundamental tool for these strategies since it allows access to resources and teaching activities in coherence with current interaction restrictions (Bright, 2012). This also occurs at a time when technological evolution places in the hands of individuals low-cost ubiquitous computing that enables access to specialized digital platforms (social and digital inclusion) (Cho & Kim, 2016; Sánchez & De Los Ríos, 2015; Wood, 2006).

The new national policies in education promote the development of learning outcomes that can be evidenced in the professional development of graduates. It is a labor approach that favors social and economic development. In this sense, skills strengthened by distance training such as communication and collaborative work should be reinforced in these digital platforms (Arooj, Farooq, Umer, Rasool, & Wang, 2020; Y. Kim, Cho, & Chong, 2014). The electronics, control, and instrumentation area of the Technology in Electricity program of the Universidad Distrital structured a set of digital platforms as specific training tools to support some of the program's courses. These platforms were conformed with an active learning model with the support of PBL (Project Based Learning) (Jacinto, Martínez, & Martínez, 2016; D. Kim & Kim, 2014; Martínez, Montiel, & Jacinto, 2016; Zhu et al., 2020). Each of these tools allows students to actively analyze basic concepts, work on projects structured in groups, and design their solutions based on the proposals of the teachers (Kang, Oh, & Woo, 2009; Liu, Huang, & Wosinski, 2016).

This study w as conducted on three courses of the technology cycle at different stages of the training

process. The objective of this study is to evaluate the impact of the distance learning scheme strengthened with technological tools in aspects such as educational performance, critical discussion, project development, and collaborative work (Laberge & Lin, 2015; Matsumoto & Kashima, 2012; C. Wang et al., 2017). Additional elements of the study consider the capacity of democratization of knowledge of our institution under the new conditions of isolation and the robust against possible reductions in equity and quality (Awofeso & Bamidele, 2016; Hayes & Johnson, 2019; Kargutkar & Chitre, 2020).

## 2. Materials and Methods

The following null hypotheses were tested in the study:

- $H_1$: There is no significant effect of the distance learning scheme on students' academic skills.
- $H_2$: There is no significant effect of the distance learning scheme on student interaction.
- $H_3$: There is no significant effect of the distance learning scheme on student motivation.

This study retrieves information recorded in the years 2018 and 2019 during a process of monitoring the performance of students in the electronics area of the Technology in Electricity program. This follow-up is carried out as part of the improvement plans promoted by the Colombian government. These data allow us to form control information, and therefore structure quasi-experimental research. The data matrix was completed with an additional level, corresponding to tests applied during 2020 to students at equivalent academic levels but with a distance training model supported by digital platforms. The data contains information related to motivation levels, performance, and results of collaborative work.

The sample in the control group consists of a total of 40 students in two groups. The sample in the test group consists of 37 students in three groups. The students are mostly male (86.5%), but this study does not consider gender incidences on the parameters. Table 1 shows the characteristics of the students in the study concerning the parameters that define the population.

| Academic population | Ages | Academic Program | Duration of the Academic Program | Course | Training type |
|---|---|---|---|---|---|
| Undergraduate students | From 16 to 25 years old | Technology in Electricity | Three years | Dynamic Systems Analysis, Digital Circuits, and Deep Learning | Propaedeutic cycles |

**Table 1 -** Typology of students involved in the study.

This measurement instrument was designed to consider both the students' social environment and their emotional response to the dynamics of the training process. At the emotional level, we included indicators related to the open expression of ideas, communication with classmates and lecturers, the dedication shown in the development of the projects, the questions asked during the sessions, and the attendance at the online sessions. Regarding the social environment, indicators such as students' initiative to collaborate, level of participation during synchronous activities, integrated presentation of proposed projects, and familiarity of social interaction were considered. The performance evaluation focused on assessing the level of apprehension of the course concepts. The data were structured in a matrix, for which a code was generated for each group of students:

- Control group 1: PEC1 MLC1 CLC1
- Control group 2: PEC2 MLC1 CLC1
- Experimental group 1: PEE1 MLE1 CLE1
- Experimental group 2: PEE2 MLE2 CLE2
- Experimental group 3: PEE3 MLE3 CLE3

Where:

- PEC1 = Performance evaluation control group 1
- PEC2 = Performance evaluation control group 2
- PEE1 = Performance evaluation experimental group 1
- PEE2 = Performance evaluation experimental group 2
- PEE3 = Performance evaluation experimental group 3

- MLC1 = Motivational level weighting control group 1
- MLC2 = Motivational level weighting control group 2
- MLE1 = Motivational level weighting experimental group 1
- MLE2 = Motivational level weighting experimental group 2
- MLE3 = Motivational level weighting experimental group 3
- CLC1 = Collaborative level weighting control group 1
- CLC2 = Collaborative level weighting control group 2
- CLE1 = Collaborative level weighting experimental group 1
- CLE2 = Collaborative level weighting experimental group 2
- CLE3 = Collaborative level weighting experimental group 3

The distance learning courses were implemented using four digital tools. Google Classroom and Google Meet were the platforms for the synchronous meeting between students and teachers. They were used to set up meetings and record the progress of the courses. They were also used to provide feedback to students. The material of the courses was developed in Python on Google Colab, there were designed interactive worksheets with live code and rich text, the material with which the students interacted during and after the sessions. The teaching-learning process was developed synchronously with face-to-face classes by the lecturer on the conference platform. Students had to attend in a similar way as in the face-to-face classes. During these sessions, three basic training strategies were developed: direct work, consisting of the instructor's lectures where the central concepts were explained and exemplified, cooperative work developed from laboratory exercises proposed by the instructor for the students to solve by simulation in groups of two, and autonomous work where the student had to develop autonomously the reading of texts, online lectures, and research in the style of a flipped classroom. Each of these moments had its methodological processes and forms of interaction, for instance, during the lectures, examples are made and exercises are proposed to the students to be presented to the rest of their classmates, all laboratories were supported online to the teacher and other students, and autonomous progress controls were carried out through forums and joint assessments. Finally, all the course material is made available to students through a public repository in GitLab, this resource is continuously updated according to the dynamics of the sessions (Fig. 1).


**Figure 1** - Interactive electronic platform used during the study.

The PEXX groups were used to establish differences in performance, the MLXX groups were used to apply the assessment of changes in motivational level, and the CLXX groups were used to assess the elements of social interaction. The groups marked XXCX correspond to the control groups evaluated during 2019, while the groups marked XXEX correspond to the students evaluated under distance learning due to confinement. The performance evaluation considers purely academic aspects reflected in the intermediate and end-of-course academic assessments. The students' answers to the survey questions correspond to the input used to evaluate the emotional and social aspects.

The study with the experimental group was developed for over 16 weeks. In the courses of Analysis of Dynamic Systems and Digital Circuits, an intensity of six hours per week was developed, distributed in sessions of two hours every two days. In the case of the Deep Learning course, an hourly intensity of four hours per week was implemented, in two weekly sessions of two hours each. This intensity of work is the same applied to the students of the control groups, but with a traditional classroom training strategy. When we talk about traditional training strategy, we refer to the training model that was being developed with students in the classroom before the confinement forced by COVID-19, the readings corresponding to this dynamic that make up the control group were carried out during the year 2019. In both cases (control and experimental students) the students were continuously motivated to dedicate more time and work to the course on their own. A similar academic performance test was used to evaluate all students. To prove the null hypothesis, we applied statistical analysis to the data, we performed covariance analysis with a significance level of 0.05.

## 3. Results

### 3.1 Hypothesis $H_1$

According to the results, hypothesis $H_1$ is rejected. Although it is necessary to repeat the tests on a larger number of groups, the results of this study show that if there is an effect on students' skills and academic performance attributable to the variable parameter, the training scheme (classroom or distance). This effect indicates that the latter modality (distance learning) has a positive impact on students' academic performance ($F_{(2.28)} = 2.21$, $p < 0.05$, $\eta^2 = 0.19$, $R^2 = 0.71$).

Initially, these results can be explained by a bigger dedication in the time and effort of the students to the courses, parameters also consulted in the student survey (Fig. 2).

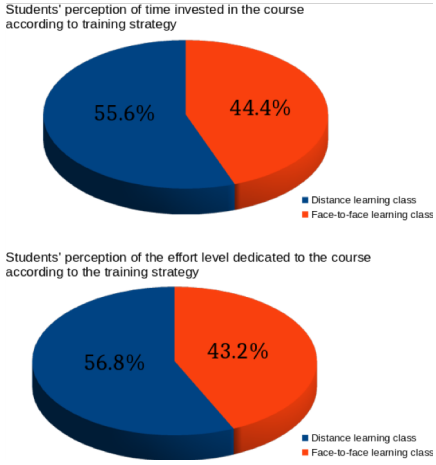


**Figure 2** - Students' perception of dedication to academic courses before (face-to-face classes) and after confinement (distance learning classes).

### 3.2 Hypothesis $H_2$

Again, the results show that the hypothesis is rejected ($F_{(2.28)} = 14.52$, $p < 0.05$, $\eta^2 = 0.28$, $R^2 = 0.71$). There is a strong indication that the distance learning strategy considerably reduces student interaction, which has had an impact on competencies related to teamwork, assignment of responsibilities in the development of joint activities, and communication of ideas (Fig. 3).

The results show that the distance learning scheme has a statistically significant effect on interaction patterns for this student population used to high levels of social interaction.

### 3.3 Hypothesis $H_3$

In this last case, the hypothesis is also rejected. The results reveal that there is an interaction effect of the distance learning scheme on student motivation in terms of dedication to the courses ($F_{(2.28)} = 3.44$, $p < 0.05$, $\eta^2 = 0.22$, $R^2 = 0.71$). The data show a markedly greater effort in the courses, with a greater number of hours dedicated and a greater interest in the contents. This may be a consequence of the increased availability of time due to confinement, and/or greater willingness to study given the lower number of external elements that distract the student.

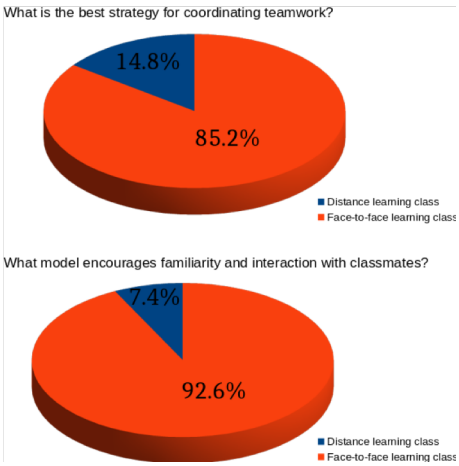


**Figure 3** - Students' perception of interaction with classmates before (face-to-face classes) and after confinement (distance classes).

Table 2 summarizes the statistics measured for each hypothesis.

| Hypothesis | $E_{(2.28)}$ | $\eta^2$ | $R^2$ |
|---|---|---|---|
| $H_1$ | 2.21 | 0.19 | 0.71 |
| $H_2$ | 14.52 | 0.28 | 0.71 |
| $H_3$ | 3.44 | 0.22 | 0.71 |

**Table 2** - Statistics summary ($p < 0.05$).

## 4. Discussion and Conclusions

Colombian universities have implemented in a very short time distance education strategies on digital platforms for their students to allow the operation of their training processes in line with national policies of social confinement and distance as a result of the spread of the COVID-19 virus. The Universidad Distrital Francisco José de Caldas, a public university in the Colombian capital, also implemented these measures during the first academic semester of 2020. The design of the training tools fell mainly on the professors in charge of each course.

Our study focused on the analysis of the impact of the use of online learning environments on undergraduate students from the poorest economic strata in the city, characterized by a dynamic and very close social behavior, with a history of daily work with high social

contact, and with only previous experience in traditional classroom training.

The study showed that social isolation, and the obligation to continue educational processes through the use of online environments on digital platforms, had a significant effect on the dynamics of students, both academically and socially and emotionally. These results are valid for the social group studied, and in the specific academic areas of the group.

In terms of academic performance, there was a slight increase in the group's capacities compared to the control group, in terms of reasoning, appropriation of concepts, creativity, and critical thinking. These results are in line with those reported by similar studies such as the one by Moreira (2017). However, an unreported negative impact was observed in terms of collaborative work and communication skills. It remains to be determined whether the causes of these negative effects lie in the pedagogical tools used, in the profile of the group of students, or in the way in which the change in training strategy was developed.

The evaluation of the students' perception also showed some negative results at the social and emotional level. Based on the data, it can be concluded that the transition from a model of classroom training to a model of distance learning took place abruptly, breaking basic patterns of social interaction, which, while increasing parameters such as dedication and interest, from the student's perspective, reduces his or her capacity for action because they do not have spaces, resources and social support that were very familiar and basic to them. Our findings in this sense coincide with others reported in studies such as Krystle (2016).

The most important results, however, relate to the ability of these digital tools to create a favorable study environment away from distractions, which seems to promote student interest, dedication, and critical thinking about the course content and the teaching processes designed in it. Although students show less interaction, from the teacher's point of view, there is more active participation and a higher level of student interest and dedication.

According to these perceptions, we can conclude that these pedagogical strategies allow a high level of training, critical development, and conceptual appropriation even higher than that observed in the traditional classroom strategy. The university even increases its social role by increasing access to training processes. However, given the abrupt form of the process, there were negative elements at the social and communicative level that affected the overall performance of students. It is necessary to create alternative strategies to support these skills and to shape a true model of integral formation.

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