

Impact of COVID-19 on generic skills development of students from a university in a developing country

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ABSTRACT

The COVID-19 pandemic has caused an unprecedented crisis in all socioeconomic areas, including education. Throughout the world, universities have been forced to shift their traditional teaching techniques towards implementing a variety of emergency remote teaching approaches. This study aimed to determine the effect that remote education has had on the development of generic skills in a university from Colombia, South America. This study's dataset comprised the generic skills scores (from a standardized test) during the 2018-2020 period. This research used an exploratory analysis, a differential analysis (between the No COVID vs. COVID scenarios), and a comparative correlation analysis. The results showed that the skill-wise scores increased significantly during the COVID scenario, indicating that the overall generic skills were strengthened. Such enhancements could be attributed to the strategies designed and implemented to tackle the pandemic-driven crisis, demonstrating that the crisis can be overcome with correct and opportune measures.

Keywords

Pandemic; education quality; communication technologies; education system; generic skills

Introduction

The COVID-19 pandemic has posed a significant challenge to sectors involved in the diverse aspects of social life, politics, work, and economics [1], and the education sector is not the exception. The COVID-19 pandemic's effects on the abovementioned sectors are yet to be fully quantified as the world remains beneath this crisis. The world witnesses an economic collapse that will severely impact the well-being of a large part of its population within the upcoming years [2]. One of the sectors worldwide jeopardized the most is the education sector, endangering the learning process, health, and well-being of children and teenagers, as the schools and universities have been shut down or shifted to remote classes, and the economic recession has led to higher desertion rates [3].

In developing countries, the situation becomes more complex due to the large number of families relying on informal jobs to get their incomes. The job loss, income reduction, and COVID-19-related health problems limit the families' ability to keep their children within the education system [4]. The economic recession increases the probability of

desertion and threatens the education quality to be offered [4].

Colombia (South America) is a developing country that has been working on the promotion of new policies that guarantee the reduction of poverty and inequality for the last decades. Nevertheless, during the COVID-19 pandemic, poverty reduction has led to creating a growing, fragile middle class, comprising households with incomes slightly above the poverty threshold [5]. Among the strategies to control the COVID-19 transmission, the Colombian government has pulled out emergency policies consisting of the temporal suspension of classes and their further shift to a remote-lecturing approach via information and communication technologies [6].

The COVID-19 pandemic has offered the opportunity to set out the path to the introduction to digital learning [7]. The 'new normality' makes society search for new ways of living and working, as well as novel education approaches. Thus, understanding the role of all the factors affecting the education quality will help design integral policies to mitigate the crisis in the short term and set the bases to improve the education system's quality and efficacy in the mid and long terms [2]. Moreover, one of the main challenges

that this new education model poses for developing countries is closing the socio-economic inequality gap among students. The most vulnerable see themselves at a disadvantage to learn through remote classes, which might further increase the gap.

In Colombia, the learning gap, i.e., the difference between what students must have learned and what they have learned, portrays the socio-economic inequality that leads to differential opportunities to receive good-quality education [2]. Hence, educators and students are under high stress levels. Research on this matter shows that educators are challenged by such a sudden change in the teaching approach, along with the limitation of contact with colleagues for the academic and pedagogical planning, the inequality regarding internet connection, and the complex home issues faced by some students with whom professors must follow up [2]; [8]. Universities and professors have made considerable efforts to propose and implement novel and innovative teaching and learning strategies. However, about a year since the COVID-19 outbreak started, the education sector continues struggling to offer alternative learning methods that guarantee education quality [9].

The transition from traditional, in-person education to remote education can be an experience sensed differently by professors and students, as both are forced to adapt to it with few or no available alternatives [9]. The generation of a body of knowledge regarding the education quality during the pandemic allows proposing strategies to compensate for its adverse effects and providing educators and students with aid to assimilate such a transition. Therefore, this research aims to assess the impact of the COVID-19 pandemic-driven global crisis on developing generic skills in university students from Colombia. The study focuses specifically on: *i*) analysing the current status of education in Colombia, and *ii*) determining, quantitatively, the effect remote education has had on the development of generic skills in a university from Colombia, south America.

Literature Review

This section addresses: *i*) the characterization of higher education's current context, giving special

focus to Latin America, the Caribbean, and Colombia in particular, identifying the strategies implemented by Colombian universities during the 2020-2021 period, their impact on students, and the challenges and opportunities identified for the teaching-learning process; *ii*) the description of the strategies designed and implemented by Universidad de la Costa (a university located on the north coast of Colombia) to face the COVID-19 pandemic.

The COVID-19 pandemic-related situation has elucidated the worldwide inequity regarding the universities' technological infrastructure. Universities that had been leaning towards virtualization before the pandemic showed a good response adapting to the unexpected, sudden change. On the other hand, those universities with little or no experience with virtualization have faced hardship in migrating to digital platforms and continuing the learning process [10].

Langegård et al. [11] conducted surveys at the Gothenburg University to characterize and assess the nursing students' experience regarding the use of digital tools and platforms. They found that only one third (1/3) of the surveyed population preferred the remote education with digital tools. The pandemic-driven transition to remote education deprived students of the natural social interactions during their learning process, disrupting the experience, and diminishing motivation. Conversely, some of the surveyed students suggest that a hybrid learning approach would retrieve the benefits of using digital platforms while maintaining a reasonable level of social interaction. On the other hand, a study conducted by the faculty of Telecommunications Engineering at Universidad Politécnica de Madrid (Spain) showed a rise in the students' performance when shifting to remote learning, as considerable planning and organization efforts were displayed. Those results support the idea that organizational factors can contribute to successfully implementing remote learning [12].

Although there is a significant body of knowledge on education's virtualization and online learning, to date, there are no standards for the preparation students must go through to partake in real-time, online education [13]; [14]. Tang et al. [15] conducted a study including students from three

higher academic institutions in Hong Kong: The Hong Kong Polytechnic University, the Hang Seng University, and the College of Professional and Continuing Education of the Hong Kong Polytechnic University. They evaluated the factors influencing students' motivation to learn, preparation for learning, and self-sufficiency to engage in the educational process during the COVID-19 outbreak, considering gender and academic level, i.e., whether they are undergraduate or graduate students. Their main findings suggest that the preparation for online learning was significantly differential when comparing undergraduate and graduate programs. On the other hand, the study showed that educators played a major role in the online classes implementation and design, aiming to motivate students through more dynamic and immersive activities.

Roman & Plopeanu [16] conducted yet another study, in Romania, to identify the determinant factors for effective online learning while facing the COVID-19 pandemic, and determine which learning approach (in-person, online, or hybrid) is preferred by students. The study retrieved information from a 1415-student sample from 5 economy faculties, regarding the following variables: depression, anxiety, worry, lack of hope, irritability, stress, and loneliness. Moreover, they proposed a psychological distress indicator. An ordinal, bivariate logit regression model was used to predict the proposed indicator using the abovementioned variables as covariates. The model revealed that the pandemic had a negative effect on the students' learning efficacy as they constantly feel under pressure and stress. Additionally, the study revealed that students frequently have limited access to the internet, family conflicts, and inappropriate working spaces, and the male students exhibited a lower likelihood of effectively adapting to the online learning.

Higher Education Institutions (HEIs) from Latin America and the Caribbean have worked jointly to define measures and standards to mitigate the virus's impact while ensuring the universities' autonomy, including the temporal suspension of lectures. Almost all of the HEIs report their lectures are carried out remotely using technological platforms, and some of them lack

effective remote learning strategies targeting institutions with little or no previous experience with this working approach [17]. For instance, through the National Interuniversity Council, Argentina decreed the in-person classes suspension, launched COVID-19 prevention campaigns, and created a special commission comprising several universities. Through its website, the commission offers resources to provide universities with procedures and materials for proper remote learning. Furthermore, the commission offers technical aids to non-experts in digital communication tools, including tutorials and step-by-step directions to get started and use the tools available on the internet [17]. In Brazil, the National Association of Federal Higher Education released a document with directions and measures to prevent COVID-19 infection, including the transition to remote and hybrid classes [17]. In Chile, through the Chilean Council of University Rectors, 30 universities jointly pulled out a series of measures to give continuity to the learning processes, focusing on meeting the connectivity necessities of those students lacking proper internet access [17].

As of the beginning of 2020, the predominant lecturing modality in Colombian universities was the in-person class, comprising 85% of the country-wide offered courses [18]. Nevertheless, the COVID-19 pandemic led to a public health alert declaration in the country, making all universities switch to remote, online classes for a considerably long period. That was later relaxed, and other approaches arose, as will be shown further in this subsection. Such sudden change forced universities to modify the educational methods and adapt their resources to fit the new reality.

According to Iglesias-Pradas et al. [12], currently, the learning approaches in Colombian universities fall into one of the following three groups: *i*) In-person classes keeping social distancing, *ii*) hybrid approaches combining both in-person and remote classes, and *iii*) remote, online classes only. The transition from in-person classes to hybrid or remote-only classes is managed under carefully planned directions. In most cases, such transition requires help from education experts as this process must consider human, technical, financial, and intellectual resources. For a course to adapt to

be offered online, the planning, preparation, and development can take up to 6-9 months [12]; [19]. However, there is not much understanding on how to quickly implement such sudden transitions and their potential effects on education quality. Thus, this sudden transition means venturing into unknown ground [12]. Some experts have argued that the education approach offered due to the COVID-19 pandemic-driven transition to classes in digital spaces cannot be labeled as “online learning.” Instead, a new concept to define the current education approach has been introduced, and it has been named “emergency remote teaching” [19]; [20]; [21]. The main difference between online education and emergency remote teaching is that online learning is the outcome of carefully designed and planned online courses, relying on a thorough body of aids and tools for the students that takes a long time to be built. The emergency remote teaching, on the other hand, arises as a response to a crisis, forcing educators (and education workers) to create and provide students with instructions and learning materials that would have been otherwise used for in-person or hybrid classes, and which were not carefully designed and planned for online learning ([19].

Through the Association of Colombian Universities (Spanish: Asociación Colombiana de Universidades), also known as ASCUN, Colombia issued a bulletin with recommendations to adopt contention measures against the COVID-19 within the HEIs, including the creation of a committee to track the COVID-19 pandemic evolution, a series of webinars to instruct students and universities’ educators and staff, and recommendations regarding work directions. Among the strategies pulled out by ASCUN, there was a series of webinars denominated “Interuniversity dialogs between executives and leaders of management in higher education: progress and challenges in virtual support strategies for face-to-face care due to the Coronavirus emergency in HEIs” (translated from Spanish), in order to foster an opportune and appropriate use of technological and pedagogical tools to face the situation, considering that not all HEIs have the same infrastructure [22].

The Colombian HEIs with in-person programs had to give continuity to developing academic activities aided by Technologies of Information

and Communications (TICs) [23]. Hence, institutions were forced to adjust their syllabi, propose new collaborative, online work strategies, and develop activities to strengthen the students’ skills and foster their comprehensive education [24]. On the other hand, governmental policies have been implemented to ensure educational continuity. These policies include: *i*) Broadcasting lectures to reach for the most vulnerable population using different media (e.g., television, radio, social networks, among others); *ii*) supervised self-learning approaches; *iii*) robust learning, i.e., tackling small, progressive goals, and providing students with real-time feedback; *iv*) planning and creativity, i.e., use creative teaching methods as a learning strategy for student; and *v*) one-on-one online tutoring [25]. Such strategies aim to promote development in the education system, with the educators using the technological tools and pedagogical methodologies, following up with students, and being flexible to encourage students to remain engaged in the process [25].

Universidad de la Costa’s Pedagogical Strategies to face the Pandemic

Universidad de la Costa, aiming to enhance its students’ generic skills, has implemented a novel evaluation system in which students take a semesterly test known as the “Generic Skills Test” (translated from Spanish) [26]. The test features a questionnaire structure similar to that outlined by the Colombian Institute for the Promotion of Higher Education, also known as ICFES, in the Colombian standardized test for undergraduate students, known as the Saber Pro [27]. Universidad de la Costa materialized the Generic Skills Test taking the international Tuning Project as a reference [28]. The Generic Skills Test assesses the following generic skills: reading comprehension (RC), quantitative reasoning (QR), citizen skills (CS), English proficiency (EP), and written communication (WC), as outlined by the Colombian Institute for the Promotion of Higher Education (ICFES) [27]. The university considers that all citizens should develop such generic skills to foster their further employment perspectives and engagement in the productive sector, and, consequently, the abovementioned evaluation strategy aims to strengthen the students’ generic skills. The Generic Skills Test was designed and

implemented before the COVID-19 outbreak in Colombia, but it has served as a sensing instrument to measure the students' performance before and after this happenstance.

In addition to the institution-level Generic Skills Test, the Engineering Faculty developed strategies at the curricular level, among which the following can be mentioned: *i*) For CS, RC, and WC, they proposed reading articles and books (semesterly), writing essays, workshops, and infographics; *ii*) For QR, they proposed activities related to graphics interpretation and workshops on numeric problems interpretation; and *iii*) for EP, they proposed activities to stimulate text writing (in English) based on the prior reading of articles, manuals, glossaries, and other reading materials. Additionally, students prepare reports and slides presentations, attend reading clubs, and there is an English Culture Immersion Week, offering a diverse pool of activities in English. All these strategies were traditionally developed in the classrooms or auditoriums. However, since the COVID-19 outbreak took place at the beginning of the 2020-I period, the strategies shifted to a remote approach using the platform Moodle (<https://moodle.org>), which also supports the assignments and, to some extent, the tests and online lectures.

As of March 16, 2020, complying with the recommendations issued by the Colombian Health Ministry (Circular No. 21, 2020) [23] to prevent the COVID-19 spread in the country, Universidad de la Costa shifted to remote learning using platforms such as Moodle, Microsoft Teams, and Outlook. The transition was immediate, and classes continued uninterrupted as the planning for the synchronous, remote learning scheme was swiftly developed (in parallel) during the week of March 16, i.e., the first week under the remote-only learning. To face this sudden transition, the university had to undergo a transformation process of digitalizing and creating large amounts of class materials, e.g., virtual learning objects, infographics, creative presentations, and virtualized lectures. The technological tools aiding the process included Moodle, Microsoft Teams, Camtasia, and simulation software (e.g., Arena, Matlab and Simulink, R, and Python). Moreover, with informed consent from students and professors, all synchronous lectures are recorded

for their use by students with connectivity issues that may occur.

On the other hand, Universidad de la Costa simultaneously trained the teaching staff on virtualization affairs. Professors have intensified the attention to students, supporting them with online, swift attention to solving doubts, answer questions, and provide them with synchronous online lectures and recordings. Working under this new paradigm, the university and the teaching staff have found technological tools of significant help for the learning process, such as the so-called collaborative blackboards, Canva, Jamboard, and Forms applications.

Although the restrictions imposed by the Colombian Health Ministry were later relaxed, and a hybrid approach (combining remote and in-person lectures) was temporarily implemented, these restrictions have come back and forth responding to the pandemic dynamics and evolution, and, for now, the education continues to be mainly remote. The strategies described in this section have been of significant help for professors to follow up with students, keep them motivated to attend the synchronous lectures, and strengthen their general skills. It is worth mentioning that Universidad de la Costa had accumulated a background regarding the remote learning approach before the COVID-19 pandemic, as it offered online subjects since 2018. This previous know-how certainly soothed the transition to the remote and the hybrid learning approaches under which Universidad de la Costa and all other universities in Colombia are currently working.

Methods

First, the study gathered the results of an institution-level test, known as the Generic Skills Test, applied at Universidad de la Costa, a university located in Barranquilla, on the north coast of Colombia. Data for the 2018-2020 period was available and gathered. The Generic Skills Test assesses the following generic skills: RC, QR, CS, EP, and WC. Each of the abovementioned skills is assessed with a 0-5 scale, where 0 is the lowest score, and 5 is the maximum. Finally, an average score is calculated

with a simple arithmetic mean of all the skill-wise scores.

Data Analysis

Once the data was gathered, we conducted an exploratory data analysis using the following univariate descriptive statistics: means, standard deviations, minimum and maximum values, medians, and quartiles. Means and standard deviations are summarized in tables, while the remaining statistics are summarized through boxplots. All these statistics are calculated discriminating by period and generic skills.

As the COVID-19 outbreak took place during the first semester of 2020, we split the data into two datasets: No COVID (2018-I to 2019-II) and COVID (2020-I, 2020-II), respectively. The Shapiro-Wilk test [29] was performed (variable-wise) to assess normality. Then, we conducted univariate differential analyses to compare the skill-wise means and standard deviations, using the Welch’s two-sample t-test [29] and the F-test [30], respectively. Moreover, we computed the correlation structure for both the No COVID and COVID datasets and presented these results graphically. Furthermore, we constructed undirected weighted correlation networks to provide a tool to qualitatively compare the correlation structures more easily. Finally, we compared the correlation structures quantitatively with the Jennrich test [30]. All the analyses were performed in the software R [31].

Results

This section presents the main findings of the exploratory data analysis, the univariate differential analysis, and the correlation analysis for this study’s dataset.

Exploratory Data Analysis: Descriptive Univariate Statistics

This subsection presents the univariate descriptive statistics performed on the General Skills Test data, discriminating by period and generic skills. The dataset used for this study, $X \in \mathbb{R}^{29346 \times 6}$, comprised 29346 observations of six continuous variables, corresponding to the scores for each generic skill (RC, QR, CS, EP, and WC) and the average score, respectively. Moreover, the dataset included metadata regarding the test’s periods of application, academic programs to which students belong, and the students’ deidentified IDs. The statistics used were the following: means, standard deviations, minimum and maximum values, medians, and quartiles.

First, the abovementioned statistics were computed for the test’s average scores for each period. Table 1 summarizes the results for the means and standard deviations.

Table 1. Period-wise means and standard deviations for the Generic Skills Test’s average scores

Statistic	Period					
	2018-I	2018-II	2019-I	2019-II	2020-I	2020-II
Mean	2.323	2.619	2.311	2.579	3.457	3.202
Std. Deviation	0.495	0.545	0.472	0.561	0.449	0.654

Figure 1 summarizes, graphically, the minimum and maximum values, medians, and quartiles for the average scores for each period through boxplots.

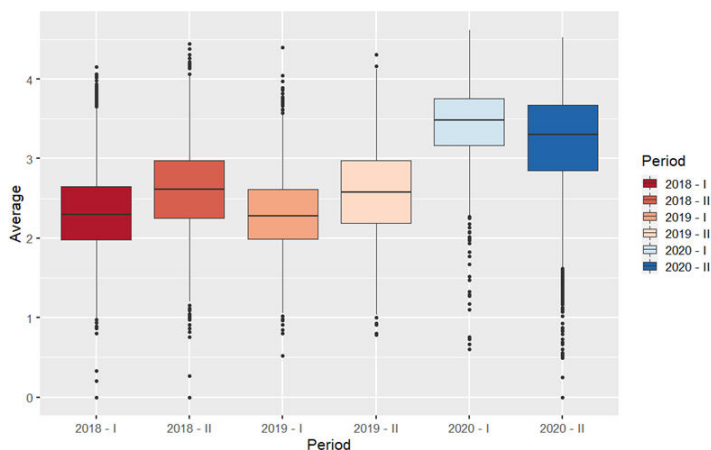


Figure 1. Period-wise boxplots for the Generic Skills Test's average scores

Table 2 summarizes the means standard deviations for each skill and period, while Figure 2 summarizes, graphically, the minimum and maximum values, medians, and quartiles for each skill and each period through boxplots.

Once this exploratory analysis was performed, it is noticeable that the scores (average and skill-wise) during the 2020 year have risen compared to what is observed during the 2018-2019 period. Therefore, in the following subsection, the dataset will be split into two datasets, corresponding to the test's results before and after the COVID-19 outbreak in Colombia, to be further analyzed.

The same univariate descriptive statistics were calculated, period-wise, for each generic skill.

Table 2. Period-wise means and standard deviations for the Generic Skills Test's scores

Skill	Statistic	Period					
		2018-I	2018-II	2019-I	2019-II	2020-I	2020-II
RC	Mean	2.626	2.563	1.825	2.656	3.405	2.646
	Std. Deviation	0.697	0.748	0.703	0.788	0.459	1.001
	Deviati						
QR	Mean	2.428	2.216	2.689	2.462	3.548	2.988
	Std. Deviation	0.798	0.765	0.908	0.825	0.487	0.864
	Deviati						
CS	Mean	2.464	2.832	2.238	2.351	3.591	3.638
	Std. Deviation	0.806	0.987	0.773	0.790	0.556	0.857
	Deviati						
EP	Mean	2.300	2.393	2.049	2.615	3.531	3.439
	Std. Deviation	0.759	0.845	0.808	0.892	0.607	0.842
	Deviati						
WC	Mean	1.794	3.093	2.751	2.811	3.208	3.300
	Std. Deviation	1.049	1.294	0.921	1.508	1.425	1.368
	Deviati						

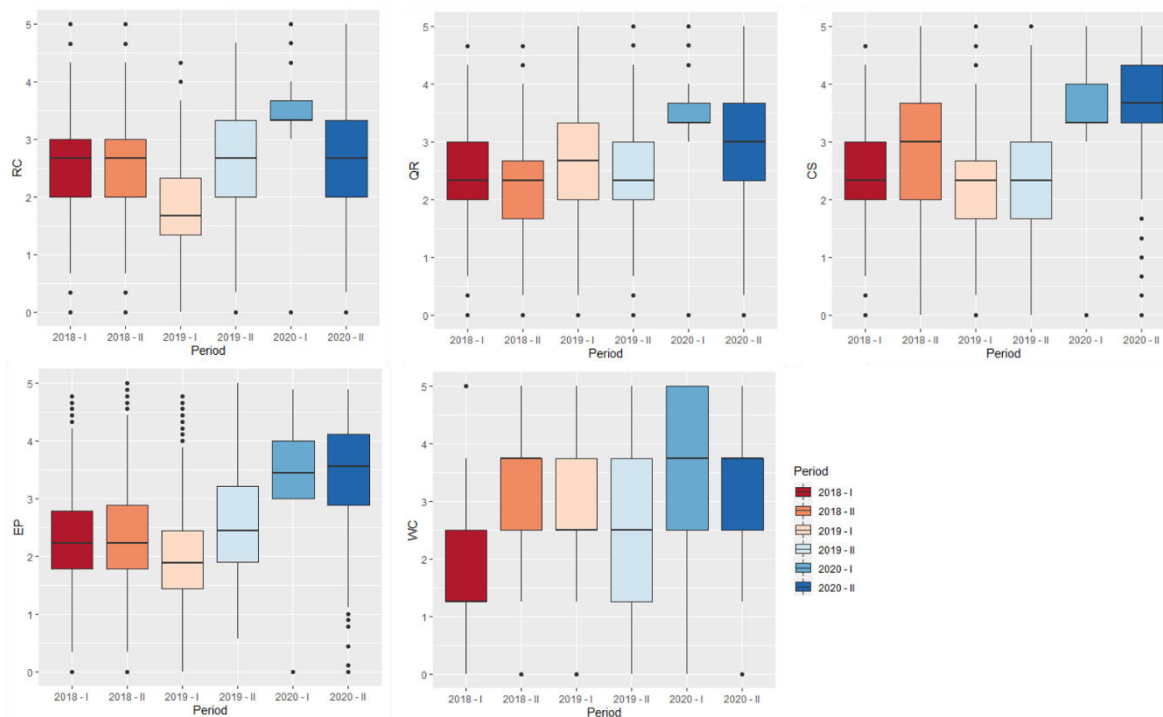


Figure 2. Period-wise means and standard deviations for the Generic Skills Test’s average scores

Univariate Differential Analysis

In this subsection, we present the univariate differential analysis to compare the General Skills

Test’s scores before and after the COVID-19 outbreak in Colombia. First, we split the data into two datasets: $X_{No_COVID} \in R^{20393 \times 6}$ and $X_{COVID} \in R^{89533 \times 6}$, corresponding to No COVID (2018-I to 2019-II) and COVID (2020-I, 2020-II),

respectively. Normality was tested (variable-wise) with the Shapiro-Wilk test, finding no rejection of the null hypothesis (i.e., the data is normally distributed). We computed the skill-wise scores’ mean and standard deviation for both datasets (No COVID and COVID). Moreover, we tested (skill-wise) the mean equality through the Welch’s t-test, and we tested (skill-wise) the standard deviation equality using the F-test. The mean and standard deviation comparison results are summarized in Table 3.

Table 3. Period-wise means and standard deviations for the Generic Skills Test’s scores

Statistic/metric	Scenario	Skill				
		RC	QR	CS	EP	WC
Mean	No COVID	2.4114	2.4528	2.4686	2.3346	2.6059
	COVID	3.0207	3.2647	3.6156	3.4846	3.2551
t-test’s p-value		0	0	0	0	2.02×10^{-293}
Standard deviation	No COVID	0.8125	0.8442	0.8710	0.8515	1.3049
	COVID	0.8697	0.7578	0.7254	0.7376	1.3974
F-test’s p-value		1.821×10^{-14}	1.572×10^{-32}	4.889×10^{-88}	1.408×10^{-55}	1.288×10^{-14}

As observed in Table 3, the univariate differential analysis reveals, that the skill-wise scores’ mean, and standard deviation changed significantly when comparing the No COVID vs. COVID scenarios.

The implications of these results are discussed in detail in the Discussion section.

Correlation Analysis: No COVID vs. COVID Scenarios

Again, datasets X_{No_COVID} and X_{COVID} were analysed. This subsection addresses the pair-wise Pearson correlation [32] analysis performed to said datasets. For each dataset, the entire correlation structure was obtained. Figure 3

summarizes the No COVID dataset’s correlation structure, while Figure 4 shows the COVID dataset’s correlation structure. Additionally, we built undirected weighted correlation networks, aiming to provide a graphical representation that allows easier qualitative comparison between the computed correlation structures. Figure 5 shows these correlation networks.

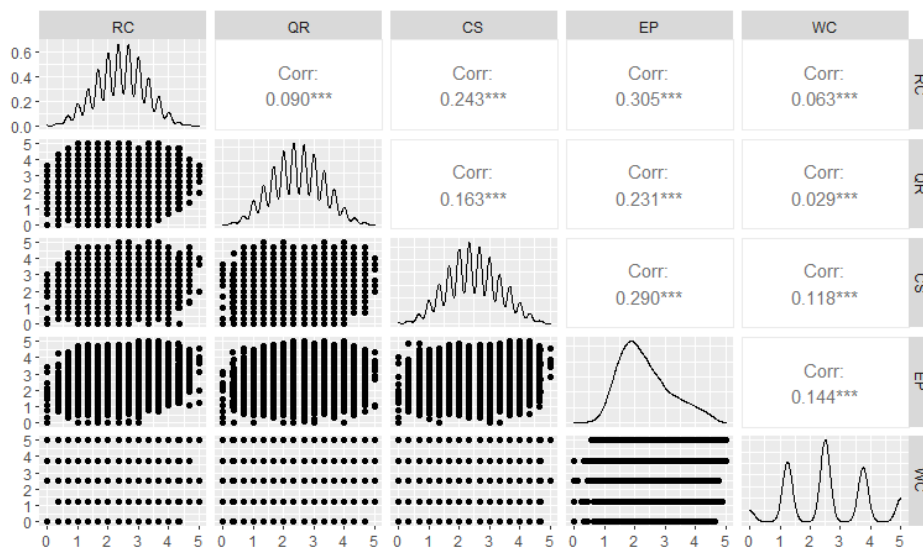


Figure 3. Correlation structure for the No COVID dataset

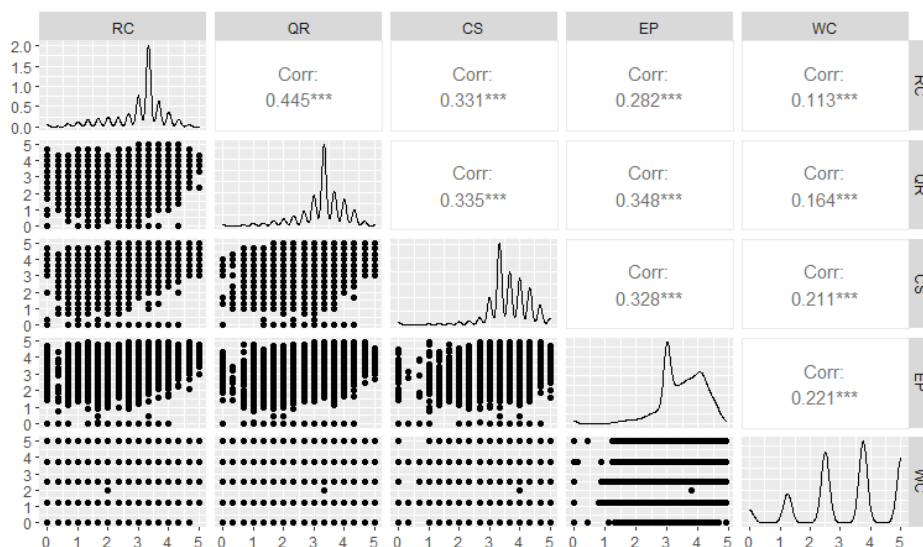


Figure 4. Correlation structure for the COVID dataset

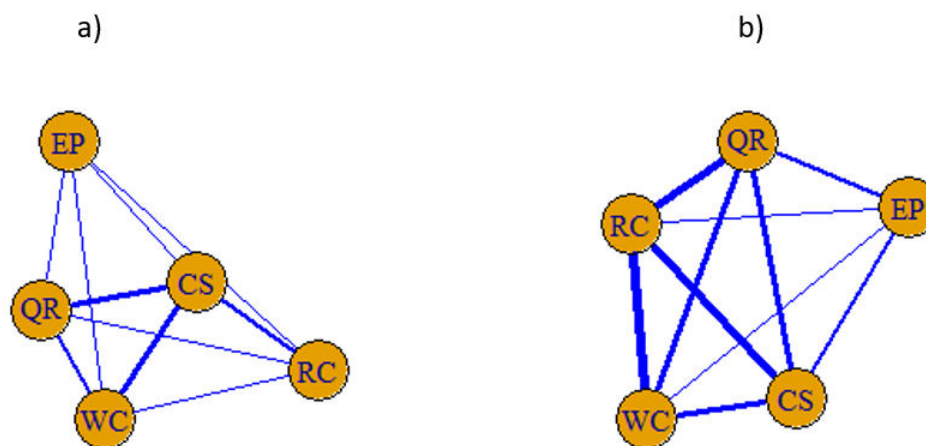


Figure 5. Correlation Networks: a) No COVID, b) COVID

From Figures 3 and 4, it is noticeable that all the pair-wise correlations among all the general skills' scores are positive for both scenarios, but they are greater in the COVID scenario. That can also be noticed when looking at the correlation networks (Figure 5), where the blue color in the vertexes indicates a positive correlation, while the vertex thickness is related to the correlation magnitude.

Although Figures 3-5 allow qualitative comparisons between the correlation structures, they do not inform whether the observed differences are statistically significant. Hence, we performed a multivariate test to compare both correlation structures, known as the Jennrich test [30]. The Jennrich test yields a p-value of 5.0034×10^{-248} , rejecting the null hypothesis that the compared correlation structures (No COVID vs. COVID) are statistically equal. The implications of the correlation structure difference found when comparing the No COVID vs. COVID scenarios are discussed in the Discussion section.

Discussions

The literature review on education's current status in Latin America, the Caribbean, and particularly in Colombia motivated this article's authors to conduct a retrospective statistical study to quantify the COVID-19 pandemic's effects on the performance of students from Colombia regarding five generic skills (RC, QR, CS, EP, and WC)

outlined by the Colombian Institute for the Promotion of Higher Education (ICFES).

As previously mentioned, the study cohort consisted of students from different academic programs from Universidad de la Costa's engineering faculty. 29346 observations were retrieved. This section discusses the results obtained at the three analysis stages (as explained in the methods section): *i*) Exploratory data analysis (using univariate descriptive statistics); *ii*) differential analysis (using univariate statistics) between the No COVID vs COVID scenarios; and *iii*) comparative correlation analysis.

The exploratory data analysis exhibited notorious differences between results from periods before and after the COVID-19 outbreak, as observed in Tables 1-2 and Figures 1-2. Nevertheless, the exploratory analysis alone lacked the statistical means to prove the differences significant. Thus, the dataset was split into the No COVID and COVID subsets. The univariate differential analysis compared the skill-wise means and standard deviations from the No COVID dataset with those of the COVID dataset, using the t-Student and the Fisher tests, respectively. The tests found that, for every skill, there were significant changes in both the means and standard deviations when comparing the two datasets.

It is noticeable that all the skill-wise (score) means exhibited a greater value for the COVID dataset. Such outcome indicates that the overall performance was enhanced in the 2020-I – 2020-II period as the individual skills were strengthened. Although this outcome might seem counterintuitive, as the performance was expected to decay due to the pandemic's effects, it reflexes Universidad de la Costa's response capacity to design and implement (at short notice) the strategies discussed in section 3. Moreover, from the exploratory data analysis (see Table 1 and Figure 1), it is noticeable that the scores during the 2020-I period were greater than those for the 2020-II period. That can arise because the 2020-I period featured a hybrid approach, combining in-person classes with remote learning, while the 2020-II period was utterly remote, disfavoring the learning process with respect to that of 2020-I. Conversely, the standard deviations for three out of the five skills (QR, CS, and EP) dropped for the 2020-I – 2020-II period, while the standard deviations for the remaining two skills (RC and WC) exhibited an increment. Such changes show a partial trend to decrease the variability of some of the dataset's variables, but that trend was not completely consistent.

As the univariate differential analysis did not consider the pair-wise interactions between the variables (i.e., the skill-wise scores), a comparative Pearson correlation analysis between the No COVID and COVID datasets was performed. The correlation analysis found that 9 out of 10 pair-wise correlations (between skills' scores) increased when comparing the COVID dataset against the No COVID dataset. The RC-EP correlation was the only one dropping from 0.305 to 0.282 (see Figures 3-5). The overall correlation structures were found to be statistically different when using the Jennrich test. In addition, it is noticeable that, for both datasets, all correlations were positive. These results suggest that not only individual skills improved, but also the positive, greater correlations indicate that students show a more balanced set of general skills instead of developing them asymmetrically, i.e., favoring some skills significantly more than the others.

Overall, the data analysis results show that the generic skills were strengthened during the 2020-I – 2020-II period, as evidenced by the students' performance improvements. Such enhancements can be attributed to the strategies designed and implemented to tackle the pandemic-driven crisis, showing that the crisis can be overcome with correct, opportune measures.

Conclusion and Future Studies

A literature review was conducted focusing on characterizing education's current status in Latin America and the Caribbean, particularly in Colombia. This literature review revealed that most countries in the region are facing significant challenges for their educators and students, which are enduring hardship after the COVID-19 pandemic-driven crisis.

This research further addressed a statistical analysis to quantify the pandemic's effects on the performance of a cohort of students from the engineering faculty of Universidad de la Costa, a university located on the north coast of Colombia. The performance was measured through the so-called General Skills Test. This instrument is a standardized test complying with the outlines issued by the Colombian Institute for the Promotion of Higher Education (ICFES), and it is applied on a semesterly basis.

The approach to assess the pandemic's effects on Universidad de la Costa's students' performance comprised three stages: i) An exploratory data analysis using univariate descriptive statistics; ii) a differential analysis, using univariate statistics to compare the No COVID vs COVID scenarios; and iii) a comparative correlation analysis. The exploratory data analysis suggested differences between scores before and after the COVID-19 outbreak in Colombia, leading the researchers to split the dataset into No COVID and COVID subsets and further conduct differential analysis to compare them. The univariate differential analysis showed that the skill-wise scores increased significantly during the 2020-I – 2020-II period, indicating that the general skills were strengthened. Additionally, the correlation analysis indicated that students showed a more

balanced, symmetrical skills profile for the 2020-I – 2020-II period, as the pair-wise correlations between skills were strengthened and remained positive.

Overall, this study shows that, despite the COVID-19 pandemic-driven crisis for the education sector in Colombia, students can achieve improvements in their generic skills if effective, robust strategies are designed and implemented to overcome the shifting to remote learning. Therefore, the current remote learning approach is proved feasible and enriches the know-how for future post-pandemic remote education programs that can offer more flexibility to students from remote regions without compromising the education quality. Future works could focus on developing innovative learning strategies for the post-pandemic remote education programs. Moreover, the digital gap (i.e., the lack of internet access of many vulnerable students) should be addressed by future works, aiming to propose strategies to close that gap.

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Data and Code Availability

Data used for this study and the code implemented in R are freely available at <https://github.com/iportnoy1/General-Skills-Test-Dataset-and-Source-Code>. The students' IDs were deidentified to protect their private information, and the metadata regarding the programs to which they belong was removed due to Universidad del Costa's privacy policies.

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