Impact of socio-demographic variables on university students' perception of online education post-COVID-19

Impacto de variables sociodemográficas en la percepción del alumnado universitario sobre la educación en línea post-COVID-19

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ABSTRACT

The digital transformation of present-day society has, along with the impacts of COVID-19, led university students to prefer online education, and the need to recognize the factors that influence its effectiveness and perceived quality has, therefore, emerged. The objective of the present study was to determine the effect that the socio-demographic variables of academic level, gender, area of residence and age have on the perceptions of online Bachelor's degree students at the Technical University of Manabi with regards to the components "pedagogical, technological and social organization of the online teaching-learning process" (PC1), "learning achievements" (PC2), "assessment and feedback" (PC3), and the "design of the course or subject" (PC4) in the Post-COVID-19 context. Descriptive-correlational-type research with a quantitative focus was developed, in which 545 students responded to a questionnaire adapted to and validated for the context of Ecuador. The results of the *PERMANOVA* and the pairwise effects evidenced the statistically significant impact of socio-demographic variables such as academic level, gender and age on the students' perceptions of the principle components of online education. Specifically, academic level had an influence on PC1 and PC3, while gender affected PC4. Finally, the main finding of this study was that students of 26 years of age and over have a more favorable perception when compared to that of those who are younger. The results obtained provide an empirical basis on which to improve online education in the Post-COVID-19 era, making it more effective, inclusive, equitable and adapted.

Keywords: socio-demographic variables; online education; students' perceptions; permutation ANOVA; higher education.

RESUMEN

La transformación digital de la sociedad actual, sumada a los impactos de la COVID-19, han generado preferencias del alumnado universitario hacia la educación en línea, emergiendo la necesidad de reconocer los factores que influyen en su eficacia y calidad percibida. El objetivo del estudio fue determinar el efecto de las variables sociodemográficas nivel académico, sexo, área de residencia y edad en la percepción del alumnado de carreras en línea de la Universidad Técnica de Manabí sobre los componentes "organización pedagógica, tecnológica y social del proceso de enseñanza aprendizaje en línea" (CP1), "logros de aprendizaje" (CP2), "evaluación y retroalimentación" (CP3), y el "diseño del curso o la asignatura" (CP4) en el contexto Post-COVID-19. Se desarrolló una investigación de tipo descriptivo-correlacional con enfoque cuantitativo, donde 545 estudiantes respondieron un cuestionario adaptado y validado para el contexto ecuatoriano. Los resultados del *PERMANOVA* y los efectos por pares evidenciaron el impacto estadísticamente significativo de las variables sociodemográficas como nivel académico, sexo y edad en las percepciones estudiantiles sobre los componentes principales de la educación en línea. Específicamente, el nivel académico influyó en el CP1 y el CP3, mientras el sexo afectó el CP4. Por último, el principal hallazgo de este estudio evidenció que la edad impactó en los cuatro componentes, demostrando que estudiantes de 26 años o más poseen una percepción más favorable, en comparación con aquellos de menor edad. Los resultados obtenidos brindan una base empírica para mejorar la educación en línea en la era Post-COVID-19, haciéndola más eficaz, inclusiva, equitativa y adaptada.

Palabras clave: variables sociodemográficas; educación en línea; percepción estudiantil; ANOVA de permutación; educación superior.

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INTRODUCTION

The digital transformation of contemporary society has promoted flexible online training and education, and provided access to a variety of resources and activities (Pelletier et al., 2023), thus increasing university students' demand for virtual education at a distance (Ramírez et al., 2021).

That stated above, together with the urgent need to provide an effective and attractive online education adapted to students' preferences that appeared as a result of COVID-19 (Wang et al., 2022; Yan et al., 2022) led to the development of research concerning education mediated by digital technology at a worldwide level. The Spanish-speaking countries leading this type of research have been Spain, Ecuador, Colombia, Peru, Mexico, Venezuela and Chile. Scientific production emphasizes topics related to students' teaching, learning, academic achievement, motivation and satisfaction with both education (Cruz, 2023) and university services (Colvin et al., 2024).

Education via digital technologies has been tackled from different angles and perspectives in the case of Higher Education, and has been assigned various terminologies in published literature. Some of those most frequently employed are "distance learning" (Carbonell et al., 2021; García Aretio, 2020), "online education" (Arslan et al., 2023; Colvin et al., 2024; Yan et al., 2022) and "virtual education" (Crisol-Moya et al., 2020; Gómez-Arteta et al., 2024; Ramírez et al., 2021). However, for the purpose of the present study, the term "online education" will be used to refer to the non-face-to-face educational distance-learning process, which takes place in the form of a didactic dialogue via a telematic connection, during which teachers and students do not share a physical space when new knowledge is imparted either individually or in a group (García Aretio, 2004, 2020).

This study method integrates the intensive use of interactive multimedia technologies, virtual learning environments and digital educational resources (Higher Educational Council, 2023; Crisol-Moya et al., 2020) with didactic strategies that are appropriately planned, executed and self-regulated via controls (Rivera et al., 2023). The results of this integration promote: the time-space flexibility of studying; autonomy and self-management for learning; access to a wide variety of digital educational resources and information sources 24 hours/day; savings in time and money; a positive environmental impact owing to a reduced use of transport and infrastructure; the possibility of being able to reach a greater number of students; motivation; communication; collaborative work, and innovation as regards the assessment of learning (Arslan et al., 2023; Barrientos et al., 2022; Cramarenco et al., 2023; Dinu et al., 2022).

In spite of all of the aforementioned benefits and advantages, there are also challenges and limitations that must be overcome if a quality online education is to be developed. Of these, it is possible to highlight the following: the problems related to connecting to the Internet; an insufficient teacher-student and student-student interaction; the lack of the technical equipment and infrastructure and educational resources required for teaching; the scant development of digital skills in teachers and students; the high cost of the infrastructure, which widens the digital gap and educational and socio-economical inequality; the lack of credibility as regards assessment and the effectiveness of the teaching method, and the problems related to the concentration required for learning (Amaning, 2024; Cabero-Almenara et al., 2023; Carbonell et al., 2021; Martín-Párraga et al., 2024; Vásquez et al., 2023).

One essential criterion for the evaluation of the quality of online education is the students' perceptions of and levels of satisfaction with the design, organization and assessment of online learning (Rahmatpour et al., 2024). In the Latin American context, several dimensions into which to group the variables that contribute to the evaluation of the quality of online education have been established. Of these, it is possible to highlight:

- The design of the course or material, the characteristics of the classes, the quality of the teaching, the teacher's technological and social capacities, and learning (Avendaño et al., 2021).
- Experience as regards learning, perceived usefulness, the instrumentality of the course, ease of use, and the quality of the service (Estrada & Paz, 2022).
- Institutional commitment, the quality of the teaching-learning processes, the quality of class-planning, the quality of relationships with partners, the quality of the relationship with the teacher, and perceived self-efficiency as regards virtual education (Lobos et al., 2022).
- General educational services, technological resources, the teacher's performance and attitude, and the virtual teaching-learning process (Gómez-Arteta et al., 2024).

As will be appreciated in the paragraph above, there is a tendency to group the variables regarding the evaluation of students' perceptions of and satisfaction with the quality of online education into dimensions related to the design of the course or subject, the pedagogical-technological and social organization of the online teaching-learning process, assessment and feedback and the students' learning achievements. These aspects are taken into consideration in the present research, together with the criterion of the existence of an association between the students' perceptions of the quality of online education and their socio-demographic, academic and context variables such as gender, age, area of residence and academic level (Avendaño et al., 2021; Estrada-Araoz et al., 2023).

There is an awareness in the Higher Education system in Ecuador of the need to evaluate the quality of online education, as is evidenced by the study developed by Remesal and Villarroel (2023), which compares the perceptions of teachers and students from Chile, Mexico and Ecuador as regards the pedagogical and emotional aspects related to online education during COVID-19. The results of this study highlight the importance of evaluating the instructional design, the teacher-student link, significant and realistic assessments and the opportunities for feedback in online education, along with their association with gender, place of residence and academic level in the Post-COVID-19 era.

The present study was, for all of the aforementioned reasons, designed with the objective of determining the effect of the socio-demographic variables of academic level, gender, area of residence and age on the perceptions of students studying online degrees at the Technical University of Manabi as regards the components "pedagogical, technological and social organization of the online teaching-learning process" (PC1), "learning achievements" (PC2), "assessment and feedback" (PC3), and the "design of the course or subject" (PC4) in the Post-COVID-19 context.

METHODOLOGY

The research design employed was transversal non-experimental, supported by a quantitative methodological approach for the development of a descriptive correlational-type study (Hernández & Mendoza, 2018).

Context and participants

The research was carried out in the context of the eight online degrees offered by the Technical University of Manabi in 2024. Online education on these degrees is developed in alignment with the guidelines laid down in the Academic Regime Regulations (Ecuadorian Higher Education Council, 2023), which establish that the total number of learning components will be measured for the use of interactive multimedia technologies and virtual learning environments. A teaching-learning virtual environment was, therefore, created using the Moodle platform, whose instructional design integrates digital educational resources with learning activities in a sequential and planned manner for the development of autonomous learning components and experimental practice, with asynchronous contact with the teacher (tutorials). The asynchronous contact with the teacher component was implemented via hour-long telematic sessions using the Zoom videoconference platform.

The study sample was obtained from the total population of 9127 students enrolled on online degree courses in the 2023-2024 academic year. It was calculated that the size of the sample would be 370 students, although it was eventually possible to survey 545 for the present study. The participants were selected in a random manner by the vice deans of each degree, to whom the research team sent the link to the questionnaire constructed in *Google Forms*. The inclusion criteria were that the participants must: be students enrolled on online degrees in the study-object period and be over 15 years of age, similar to those established by Avendaño et al. (2021). From the socio-demographic point of view, 69.9% (381) of the sample were male and 30.1% (164) were female, and the predominant age group was 21-25 44.6% (243). The data were collected after the students had signed informed consent forms during the month of May, 2024, following approval by the Technical University of Manabi Ethics Committee (CEISH-UTM-INT_24-04-22_ALP).

An attempt was made to ensure that the sample selected for Higher Education Institutions that develop online education processes in Ecuador was representative by taking into account three fundamental aspects. The first of these was conditioned by time-space flexibility, which made it possible for the 24 provinces in the country to be represented by students enrolled on these courses. The second took into consideration the fact that the Technical University of Manabi is one of the top three universities in the country, offering the highest number of online degrees (SENESCYT, 2024), thus guaranteeing that the proportion of students enrolled from the various regions appropriately represented the data at a country level, despite being obtained from only one university. With regard to the third, it is important to mention the fact that the Technical University of Manabi appears in the *QS World University Rankings* and *Times Higher Education World University Rankings*, making it a reference institution for online education in Ecuador.

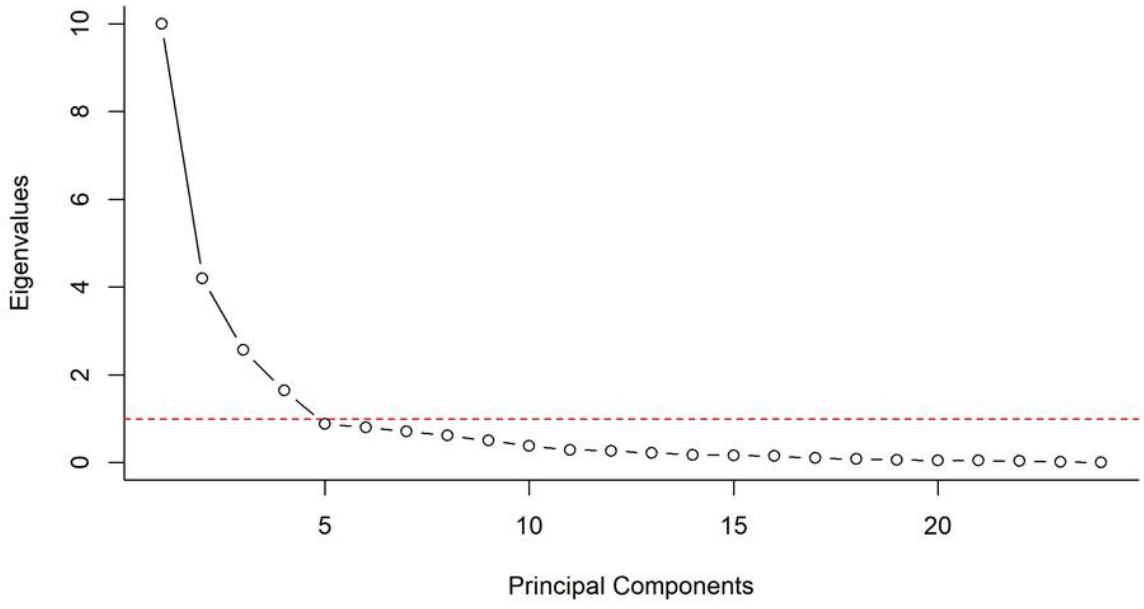
Instrument

The instrument employed was a questionnaire designed by Avendaño et al. (2021) for the analysis of virtual education by means of the perceptions of Columbian university students. The data required for the present study were collected by structuring the instrument in two sections: one concerning the socio-demographic variables (academic level, gender, area of residence and age) and another regarding the construct of the students' perceptions of the quality of online education, represented by 24 items distributed in five factors: "design of course or material" (5 items), "characteristics of classes" (5 items), "quality of teaching" (6 items), "teacher's technological and social capacities" (3 items) and "learning" (4 items). These items were measured using a 5 point Likert scale, on which 1= greatly disagree and 5= greatly agree.

Validity and reliability of the instrument for the Ecuadorian context

Despite having been validated with university students, by means of expert judgment and in a pilot study, thus giving it a high level of reliability and validity (Avendaño et al., 2021), it was kept in mind that the structure of online education in Ecuador may differ to that of Columbia, and the instrument was, therefore, validated using the principle component analysis (PCA) method. The KMO index was 0.97, which is greater than the value of 0.6, and the Bartlett sphericity for the polychoric correlation matrix of the instrument was significant, with a p-value < 0.05. The PCA was consequently carried out by considering the Varimax rotation with the aim of maximizing the variance of the squared elements of each factor. As a result, and according to the Kaiser criterion, it was concluded that there were four principal components (Figure 1).

Figure 1
Number of principal components with eigenvalue > 1



Source: created by the authors.

As will be noted when observing the construction of the principal components, the contribution that each item makes to its components is over 0.50. Moreover, the first component is represented by 63% of the items, followed by the second component with 21%, and the remaining 16%, which represents components 3 and 4 in equal parts (Table 1).

Table 1
Maximum factorial loads of principal components, per item

Item	PC1	PC2	PC3	PC4
Organization and sequences				0,78334
Rhythms				0,67948
Level of academic demand			0,73685	
Commitments/tasks			0,74937	
Bibliography	0,56674			
Teacher's explanations	0,75840			
Student's interest	0,76850			
Motivation	0,74320			
Participation	0,65253			
Resources and means	0,68096			
Teacher's attitude	0,71018			
Empathy	0,70494			
Contents and information	0,71847			
Organized procedures	0,65782			
Teacher's discourse	0,72809			
General class management	0,63373			
Management of platforms	0,60548			
Use of networks	0,63920			
Virtual and digital resources	0,58784			
Student's autonomy		0,71390		
Effective learning		0,77202		
Skills and competences developed		0,77767		
Emotions		0,73844		
General satisfaction		0,71265		
Proportion	**63%**	**21%**	**8%**	**8%**

Source: created by the authors.

The dimensionality is, therefore, reduced to four principal components, corresponding to the characteristics of the items that they represent, which are denominated as: "pedagogical, technological and social organization of the online teaching-learning process" (PC1), "learning achievements" (PC2), "assessment and feedback" (PC3) and "design of the course or subject" (PC4). Moreover, it was possible to identify the existence of *outliers* that were assigned to the edges, where 50% of the data around the mean of the box diagram were grouped, with the aim of not losing observations from the sample.

The consistency of the instrument was validated using the Cronbach's Alpha (α) and Macdonald's Omega (ω) coefficients. The results of α for each factor were: 0.97,

0.93, 0.78 and 0.70 respectively, while those of ω were: 0.97 and 0.94 for factors PC1 and PC2, respectively. No values of ω were attained for factors PC3 and PC4, since this coefficient can be determined only with a minimum of three items per factor. As PC3 and PC4 contain two items each, their reliability was evaluated only by applying the α (Roco-Videla et al., 2024). The findings indicate a reliability that oscillates between acceptable and high for the factors examined.

Data analysis

The data were processed by means of descriptive and inferential statistical analyses, using RStudio version 4.3.2 software.

The influence of the socio-demographic variables (independent) on the four principal components extracted (dependent) were evaluated by applying an ANOVA of permutations, aka a *permutational multivariate analysis of variance* (*PERMANOVA*). This nonparametric approach was chosen because the suppositions of normality required by the traditional ANOVA were not completely fulfilled. The Shapiro-Wilk and Jarque-Bera tests corroborated this choice, providing sufficient evidence to be able to reject the null hypothesis concerning the normality of the data, since a p-value of less than 0.05 was obtained (Harpe, 2015; Norman, 2010; Sullivan & Artino, 2013).

The *PERMANOVA* is a robust test when confronted with violations of suppositions, such as a lack of normality, and is an appropriate means to analyze complex data. Moreover, it is a flexible way in which to analyze the effect of multiple independent qualitative variables, and even considers their interactions in the model when it is relevant to do so (Anderson, 2001; Good, 2000; Higgins, 2004).

It is important to consider that the *PERMANOVA* was estimated by carrying out 5000 permutations in order to generate a null distribution under the hypothesis that the socio-demographic variables had no influence on the principal components. The p-value resulting from each analysis made it possible to evaluate whether the observed differences among the principal components in the different levels of the socio-demographic variables were significant.

When carrying out the non-parametric analysis of variance it is, therefore, fundamental for the selection of an optimum model to take place from the outset in order to ensure robust interpretations and prevent over-parameterization. This is done using information criteria such as Akaike's Information Criteria and Bayesian Information Criteria (*AIC* and *BIC*, respectively), both of which are widely used in statistical modeling (Burnham & Anderson, 2004).

Keeping that proposed above in mind, the *PERMANOVA* was estimated for each dependent variable with all of the aforementioned independent variables, considering the cases in which there was and there was not an interaction among them. The *AIC* and *BIC* criteria were consequently evaluated in order to determine which model best adjusted to each of the principal components. Table 2 shows that, with regard to the principal components, the models with no interaction consistently attained the lowest *AIC* and *BIC values*. This indicated that incorporating interactions into the models led to an unnecessary complexity without implying a significant improvement to the adjustment.

Table 2
AIC and BIC criteria for models of each principal component regarding socio-demographic variables, considered with and without interactions among them

Criteria / Model	PC1		PC2		PC3		PC4	
	Without	With	Without	With	Sin	Without	With	Without
AIC	1444,30	1476,04	1346,21	1382,68	1421,44	1439,17	1406,69	1444,13
BIC	1500,61	1675,29	1402,52	1581,93	1477,75	1638,42	1463,00	1643,38

Source: created by the author

Given that the *PERMANOVA* without interactions was better, it was necessary to evaluate the *AIC* and *BIC* criteria in order to define which socio-demographic variables adjusted best to the models. The *PERMANOVA* was, therefore, generally specified in the following manner:

$$Y\_ijk = \mu + A\_i + B\_j + C\_k + D\_l + e\_ijkl$$

Where:

- Y_ijk represents the value of the principal component.
- μ is the global mean.
- A_i is the effect of the level of education.
- B_j is the effect of gender.
- C_k is the effect of area of residence.
- D_l is the effect of age.
- e_ijkl is the error term.

In order to determine which of the four socio-demographic variables best adjusted to the models, we estimated all the possible combinations of the *PERMANOVA* for each of the principal components, obtaining a total of 60 models (15 for each component). This analysis is facilitated by Table 3, which presents the optimum models for each of the principal components studied.

Table 3
AIC and BIC criteria for models of each principal component regarding relevant socio-demographic variables, considered without interactions among them

Components	Model	*AIC*	*BIC*
CP1	PC1 ~ Academic level + Gender + Age	1443,41	1495,39
CP2	PC2 ~ Gender + Age	1344,92	1370,91
CP3	PC3 ~ Academic level + Age	1417,84	1465,49
CP4	PC4 ~ Gender + Area of residence + Age	1402,09	1432,41

Source: created by the authors.

A pairwise permutation was also carried out in order to identify which specific groups in each socio-demographic variable were significantly different as regards the principal components. This analysis was carried out using the pairwise permutation

method, during which all the levels of the independent variables (such as academic levels that were different from each other) were compared individually. This method is ideal when data do not fulfill the supposition of normality (Ernst, 2004).

Given the high number of comparisons among the levels of the independent variables (academic level, gender, area of residence and age), the adjustment of the *False Discovery Rate* (*FDR*) was employed in order to control the type I error and avoid false positives in the multiple tests (Benjamini & Hochberg, 1995; García & Herrera, 2008).

We carried out 5000 permutations for each pair of combinations with the objective of attaining a null distribution and estimating the corresponding p-values. This made it possible to identify which combinations of levels were significantly different as regards the principal components, thus providing a detailed evaluation of the variations among pairs for each socio-demographic variable.

RESULTS

This section shows the statistically significant results and the most important models proposed. It is divided into two sub-sections, the first of which provides a description of the results of the *PERMANOVA*. The second presents the results of the pairwise permutations. Both approaches make it possible to evaluate the influence that the socio-demographic variables (academic level, gender, area of residence and age) have on the principal components obtained using the questionnaire.

Results of PERMANOVA

The results obtained after using the PERMANOVA method are shown in Table 4. These demonstrate that, below a level of significance of 5%, the variable academic level has a significant effect on the students' perception as regards "pedagogical, technological and social organization of the online teaching-learning process" and "assessment and feedback", while the variable gender has a significant effect on their perception of "design of the course or subject".

Table 4
P-values of independent variables per model

Model	Academic level	Gender	Area of residence	Age
CP1	0.002 **	0.17		0 ***
CP2		0.0848		0 ***
CP3	0.0318 *			0.0018 **
CP4		0.016 *	0.2213	0 ***

Note: Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' '
Source: created by the authors.

The variable age, meanwhile, has a significant effect on all the components analyzed. One of the most relevant findings of this study is consequently evidence of the positive marginal effects on the perceptions of students aged 26 or over in comparison to those who are younger, as is shown in Figures 2, 3, 4 and 5.

The marginal effects estimated for the variables academic level, gender and area of residence are presented below for each component. These results evidence possible significant effects that will be confirmed in the second sub-section of the results.

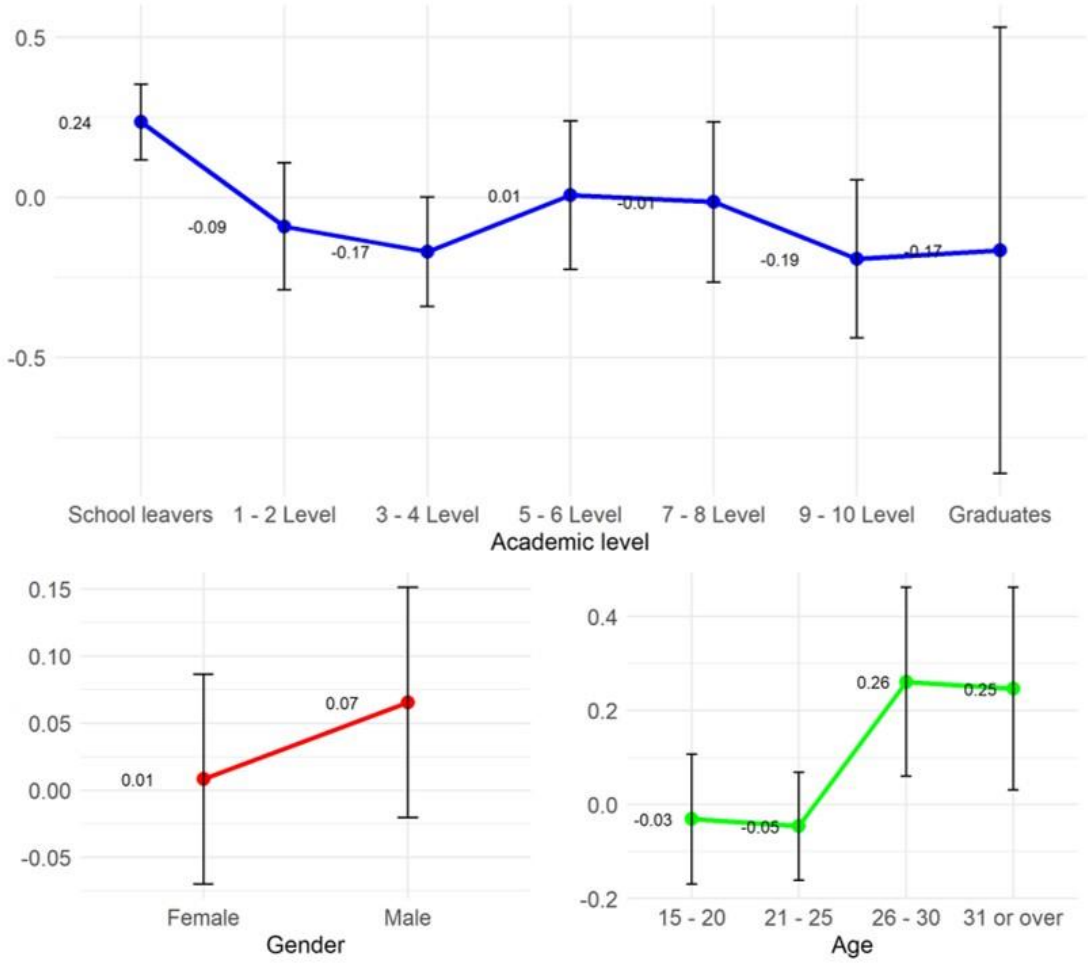
Component 1: Perception of "pedagogical, technological and social organization of the online teaching-learning process"

Upon analyzing the marginal effects of each factor on the "pedagogical, technological and social organization of the online teaching-learning process", Figure 2 shows, although not conclusively, that the perception of those students at the school leavers academic level is greater and positive when compared to those at the levels after it. It is not yet possible to clearly state that all of these effects are significant, since some of the confidence intervals of the factors overlap with others.

Furthermore, the variable gender is fairly similar to the other that it represents, also evidencing that the confidence intervals are superposed, which is why it is not significant in the *PERMANOVA*.

Figure 2

Marginal effects of the socio-demographic variables on the perception of "pedagogical, technological and social organization of the online teaching-learning process"

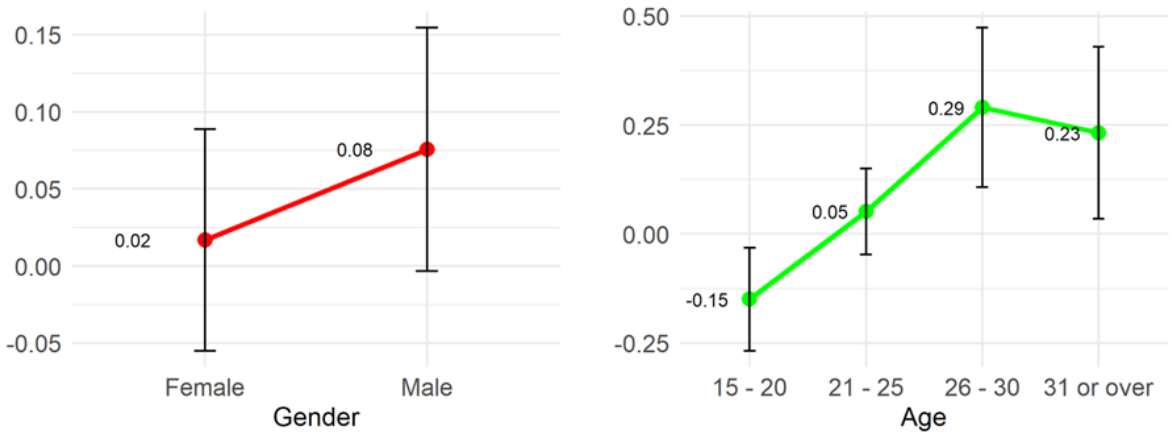


Source: created by the authors.

Component 2: Perception of "learning achievements"

Figure 3 shows that the male students' perception of "learning achievements" is greater than that of their female counterparts, although upon comparing pairs this might not be significant, because the confidence intervals overlap only partially.

Figure 3
Marginal effects of the socio-demographic variables on the perception of "learning achievements"

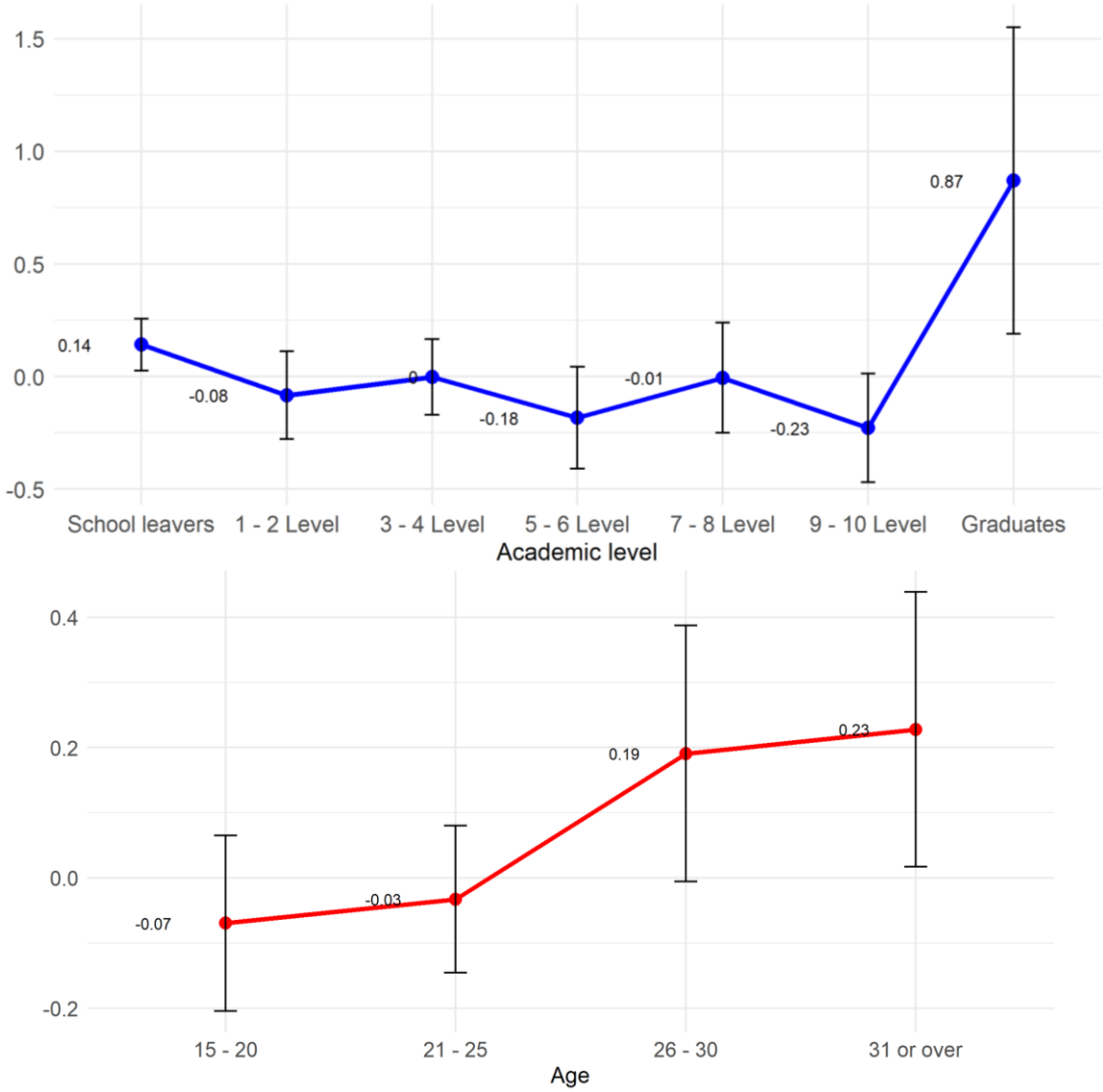


Source: created by the authors.

Component 3: Perception of "Assessment and feedback"

As Figure 4 shows, albeit inconclusively, the students with a graduate's academic level have a positive and presumably significant perception of "assessment and feedback" when compared to that of the other academic levels, since their confidence intervals do not overlap with those of any other academic level. Note also that the students in the school leavers academic level had relatively significant effects on the levels 1 – 2, 5 – 6 and 9 – 10.

Figure 4
Marginal effects of the socio-demographic variables on the perception of "assessment and feedback"

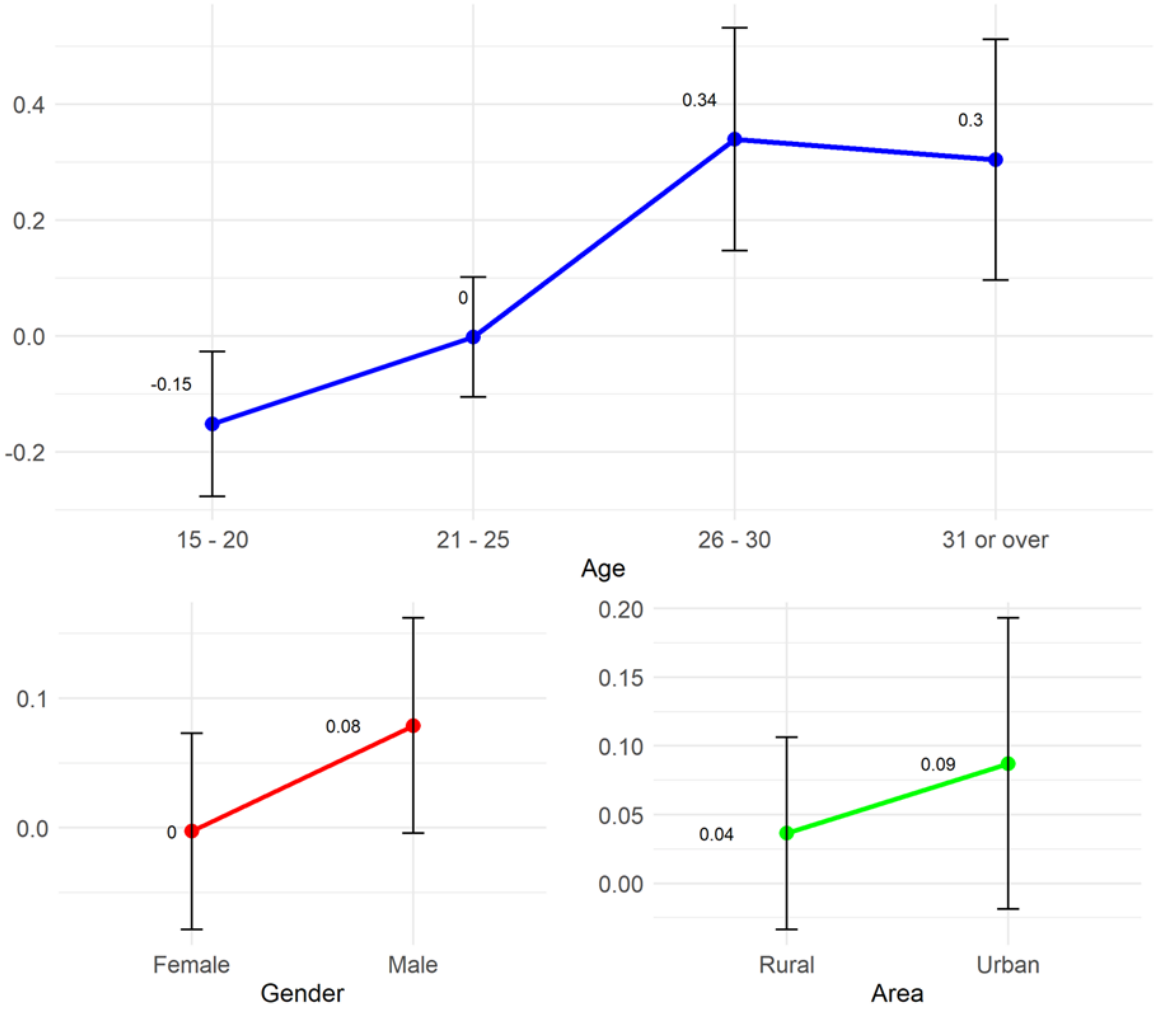


Source: created by the authors.

Component 4: Perception of "design of the course or subject"

Finally, with regard to the perception of "design of the course or subject", Figure 5 shows that only the effects obtained for the variable gender do not totally overlap as regards their confidence intervals, and although the *PERMANOVA* shows that there are significant differences among the groups for this variable, it is not completely clear whether this is actually the case. However, the variable area of residence significantly overlaps with the confidence intervals of each factor, which is why they are not significant.

Figure 5
Marginal effects of the socio-demographic variables on the perception of "design of the course or subject"



Source: created by the authors.

Results of pairwise permutations

Below are the results obtained for the pairs that were significant below a significance of 5%, thus making it possible to reject the null hypothesis that there was no difference among the averages obtained for the dependent variables analyzed given certain socio-demographic characteristics of the students surveyed.

Component 1: "pedagogical, technological and social organization of the online teaching-learning process"

Table 5 shows the results of the comparison of the academic-level pairs. As will be noted, the magnitude of the average difference as regards the students' perception of the "pedagogical, technological and social organization of the online teaching-learning process" is greater for the school leavers students than for those in levels 1 - 2, 3 - 4 and 9 - 10, with a magnitude of difference of 0.33, 0.41 and 0.43, respectively.

Furthermore, an examination of the variable age evidenced that the students in age groups over 26 had a more favorable perception when compared to those who were between 21 and 25 years of age.

Table 5
Results significant to 0.05 as regards perception of "pedagogical, technological and social organization of online teaching-learning process"

Comparison	Magnitude of difference among means (ΔM)	Statistic	Adjusted P Value	Significance
	Academic level			
School leavers - 1 - 2 Level = 0	0.33	-3.36	0.00539	***
School leavers - 3 - 4 Level = 0	0.41	-4.09	0.00046	***
School leavers - 9 - 10 Level = 0	0.43	-4.10	0.00046	***
	Age			
[21 - 25] - [26 - 30] = 0	-0.3074568	3.36	0.00474	***
[21 - 25] - [31 or over] = 0	-0.2926446	2.87	0.01238	**

Note: Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' '
Source: created by the authors.

Component 2: "learning achievements"

In the case of component 2, the pairs of the variable gender were evaluated. Although the *PERMANOVA* rejected the null hypothesis of equality between groups, the pairwise analysis revealed that the differences between the male and female groups was not statistically significant ($p = 0.0735$), although it was close to the typical threshold ($p < 0.05$). This indicates that the difference between the groups could be a coincidence, and there is not sufficient evidence to reject the null hypothesis that they have similar effects on the perception of "learning achievements" (Table 6)

Nevertheless, the data concerning age revealed that the different means in the age range 15 – 20 (minimum admissible age) was significant in comparison to all its pairs, in addition to indicating that the higher age ranges had, on average, a greater magnitude of difference of means as regards the perception of "learning achievements".

Table 6
Results significant to 0.05 as regards perception of "learning achievement"

Comparison	Magnitude of difference among means (ΔM)	Statistic	Adjusted P Value	Significance
	Age			
[15 - 20] - [21 - 25] = 0	-0.2011647	2.51	0.02422	**
[15 - 20] - [26 - 30] = 0	-0.4395201	3.75	0.00108	***
[15 - 20] - [31 or over] = 0	-0.3815715	3.03	0.00743	***
[21 - 25] - [26 - 30] = 0	-0.2383554	2.38	0.02577	**

Note: Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' '
Source: created by the authors.

Component 3: "Assessment and feedback"

Upon carrying out a pairwise comparison of the perception of component 3, the results attained were similar to those for component 1. The magnitude of average differences was significant, particularly in the case of the students in the graduates and school leavers academic levels, and for the 15-20 and 21-25 age ranges.

The analysis of the results obtained for the post hoc of the PC3 with academic level showed that the graduates' students were significantly different with regard to all their pairs. The significantly higher values were specifically attained for the following levels: 1 - 2 ($\Delta M = -0.95$) and 5 – 6 ($\Delta M = -1.05$).

With regard to the variable age, it was evidenced that the students between 26 and 30 attained higher values for PC3 when compared to the younger students of between 15 and 20 ($\Delta M = -0.26$). Another analogous tendency was observed for the 31 or over group ($\Delta M = -0.30$). Likewise, the 21 to 25 group attained significantly lower values when compared to those in the over 26 group. The values for the differences between the pairs are shown in Table 7.

Table 7
Results significant to 0.05 as regards perception of "assessment and feedback"

Comparison	Magnitude of difference among means (ΔM)	Statistic	Adjusted P Value	Significance
Academic level				
School leavers - 1 - 2 Level = 0	0.22	-2.31	0.04898	**
School leavers - 5 - 6 Level = 0	0.33	-2.59	0.03994	**
School leavers - 9 - 10 Level = 0	0.37	-3.26	0.0236	**
School leavers - Graduates = 0	-0.73	2.45	0.0429	**
1 - 2 Level - Graduates = 0	-0.95	2.65	0.03994	**
3 - 4 Level - Graduates = 0	-0.87	2.49	0.0429	**
5 - 6 Level - Graduates = 0	-1.05	2.91	0.031	**
7 - 8 Level - Graduates = 0	-0.88	2.35	0.04898	**
9 - 10 Level - Graduates = 0	-1.10	2.85	0.031	**
Age				
[15 - 20] - [26 - 30] = 0	-0.26	2.13	0.0492	**
[15 - 20] - [31 or over] = 0	-0.30	2.15	0.0492	**
[21 - 25] - [26 - 30] = 0	-0.22	2.88	0.01304	**
[21 - 25] - [31 or over] = 0	-0.26	2.85	0.01304	**

Note: Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' '
Source: created by the authors.

The results obtained are undoubtedly interesting, particularly as regards the graduates, who have undergone two crucial steps in education in Ecuador: 1) Pre-COVID-19 and 2) Post-COVID-19. Their positive perception may be owing to the fact that they lived through the evolution of the design of online classes, particularly in the case of that concerning "assessment and feedback", along with those factors that may be associated with maturity.

Component 4: "design of the course or subject"

Finally, with regard to component 4, there were significant differences in perception according to gender and age, as is shown in Table 4 of the *PERMANOVA* analysis. Upon carrying out the pairwise permutations for the variable gender, it was found that there was only a small difference between the means attained for males and females ($\Delta M = -0.08$), but that it was significant (Table 8). The fact that this is a negative adjusted mean difference indicates that the average value of the dependent variable is less for the females than for their male counterparts.

The variations according to age are, in contrast, more evident and align with the findings obtained for the other components (PC1, PC2 and PC3). As Table 8 shows, the youngest demographic segments (15-20 and 21-25) tend to evaluate "design of the course or subject" less favorably than do those in the older age groups (26-30 and 31 or over).

The most notable differences in means were observed for the 15-20 and 26-30 age groups ($\Delta M = -0.49$), and that of 31 or over ($\Delta M = -0.46$). This indicates that the younger students may note more failings and challenges in "design of the course or subject", in contrast to their older pairs, who probably have more experience or more effective adaptation strategies in the educational context.

Table 8

Results significant to 0.05 as regards perception of "design of the course or subject"

Comparison	Magnitude of difference among means (ΔM)	Statistic	Adjusted P Value	Significance
	Gender			
Female - Male = 0	-0.08	2.35	0.01888	**
	Age			
[15 - 20] - [26 - 30] = 0	-0.49	4.03	0.00034	***
[15 - 20] - [31 or over] = 0	-0.46	3.48	0.00151	***
[21 - 25] - [26 - 30] = 0	-0.34	3.02	0.00504	***
[21 - 25] - [31 or over] = 0	-0.31	2.49	0.01926	**

Note: Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' '

Source: created by the authors.

DISCUSSION

The objective of the present research was to determine the effect that the socio-demographic variables academic level, gender, area of residence and 'age' as regards the perceptions of students on online degree courses at the Technical University of Manabi had on the components "pedagogical, technological and social organization of the online teaching-learning process", "learning achievements", "assessment and feedback", and "design of the course or subject" in the Post-COVID-19 context. A discussion examining the influence that each significant socio-demographic variable had on the perception of online education, measured for each component analyzed, is presented below.

Academic level proved to have an effect on the students' perception of online education, with similar tendencies as regards the components "pedagogical,

technological and social organization of the online teaching-learning process" and "assessment and feedback". In both cases, the school leavers students evaluated online education more positively than those at intermediate or advanced levels did. This finding coincides with that of Remesal and Villarroel (2023), who suggested that students in their initial stages have fewer references with which to compare educational modalities, and are consequently more accepting. Moreover, their enthusiasm and initial expectations may influence this evaluation.

Furthermore, the graduates also had significantly more favorable perceptions of PC3 than the students at intermediate levels did, which may be owing to their experience in both Pre-COVID-19 and Post-COVID-19 education, which has allowed them to evaluate the improvements made to online education in an objective manner (Dinu et al., 2022; Vaca-Cárdenas et al., 2024). The implementation of strategies such as the personalization of learning, collaborative work, more authentic assessments and effective feedback could explain this tendency (Amaning, 2024; Estrada-Araoz et al., 2023; Rivera et al., 2023; Wang et al., 2022; Yan et al., 2022).

These findings highlight the importance of continually adapting pedagogic approaches and technological strategies according to the students' academic level, thus guaranteeing an effective and equitable online education that is adapted to their individual and collective needs.

Gender had an effect on the perception of online education, differentiated by the components "learning achievements" and "design of the course or subject".

No significant differences were found between males and females in the case of PC2 ($p = 0.0735$), which suggests that online education has a similar impact on both genders as regards "learning achievements", coinciding with the findings of Bazán-Ramírez et al. (2023). However, the proximity of the significance threshold indicates that factors such as experience with technologies or the family environment may influence perception, as has been suggested in previous studies that attained varying results (Estrada & Paz, 2022; Estrada-Araoz et al., 2023; Remesal & Villarroel, 2023).

A significant difference ($p = 0.01888$) was found in the case of PC4, since the males had a more positive perception of "design of the course or subject" when compared to the females, a result that coincides with that obtained by Estrada-Araoz et al. (2023), but which contrasts with that of studies reporting that the females had a more favorable perception (Estrada & Paz, 2022; Remesal & Villarroel, 2023). This disparity, although small in magnitude, suggests that the two genders may interact differently with pedagogic design and educational resources, thus highlighting the need for additional studies with which to better understand these patterns.

These findings emphasize the importance of adopting inclusive pedagogical approaches that consider differences in learning experience according to gender, promoting an instructional course design that meets with the student's needs and expectations.

One of the most relevant findings of this study focuses on the significant differences perceived by the students according to their age in relation to the four principal components identified in order to evaluate the quality of online education. Specifically, the younger students (15-20) have less favorable perceptions than their older pairs (26 to 30 and 31 or over). These differences could be attributed to the younger students' absence of experience and self-regulation skills, which hinder their adaptation to the exigencies of the study modality in question. Previous research has indicated that younger students may be hindered as regards administering their time, self-management and self-regulation when learning, which could influence their

perception and performance in virtual contexts (Colvin et al., 2024; Cramarenco et al., 2023; Garzón & Gil, 2017).

The older students may, in comparison, have more academic maturity and experience, which makes it easier for them to adapt to the challenges of online education in a more effective manner. Moreover, it is plausible that these students have developed efficient autonomous learning strategies and time-administration skills, which may contribute to a more positive performance in virtual contexts, as occurred in the study carried out by Ferrer-Cascales et al. (2011).

The evidence found in this study not only provides key information concerning the perception of the quality of online education at public universities in the context of Ecuador, but also has practical and relevant implications for educational managers when designing educational strategies and public policies. One specific contribution is focused on the use of the questionnaire, whose psychometric characteristics ensure its validity and reliability, with the objective of obtaining students' perceptions of the quality of online education at a national level. These findings could, therefore, serve as the basis for the development of adaptive online teaching-learning models that integrate Artificial Intelligence with analytical learning in order to personalize the students' experience according to their academic level. It might, for example, be possible to implement recommendation systems founded on data in order to contribute to the optimization of pedagogical organization and feedback, adapting the content and methodologies to the students' individual needs and learning styles.

CONCLUSIONS

This research, which is based on the findings regarding the validity and reliability of a questionnaire, emphasizes the relevance of taking socio-demographic variables, such as academic level, gender and age, into consideration as predictive factors in the decision-making related to academic administration, along with the planning and execution of public policies, with the objective of fomenting an inclusive and equitable online education that is adapted to university students' circumstances. Keeping these elements in mind, the conclusions reached are the following:

1. *Improve educational planning*: The results regarding the influence that the academic level has on students' perceptions suggest the need to design different pedagogical strategies for students at different levels of their degrees. School leavers and graduates' students have significantly more positive perceptions of the "pedagogical, technological and social organization of the online teaching-learning process" and "assessment and feedback" in online education, indicating that university policies should be focused on adjusting educational methodologies and tools throughout the student's academic trajectory, thus meeting changes in expectations and needs.
2. *Promote inclusion and gender equity:* The finding regarding the male and female genders' different perceptions of "design of the course or subject" highlights the need to adopt policies that promote a more equitable learning environment. Public institutions and universities could use these data to design improvement programs that achieve equilibrium between the perceptions and experiences of both genders, thus ensuring that the structure of online courses and subjects is inclusive and responds to the diversity of ways in which people interact with the digital environment.

3. *Evolution of online education and its impact:* The results obtained concerning the graduates show that these students, who lived through both the Pre-COVID-19 and Post-COVID-19 phases, have a positive perception when evaluating online education, particularly with regard to "assessment and feedback". This finding underlines the need to continue perfecting virtual learning environments by considering the lessons learned during the Pandemic. Educational managers and universities should ensure that the improvements made are maintained and continually adapted in order to satisfy the new demands of the context of digital education.
4. *Contribution to public policies:* This study could serve as a key tool for public management, since the results obtained could be used by educational managers to formulate policies that would strengthen the infrastructure and quality of the online education at public universities in Ecuador. Given the current context of digital transformation in education, the findings allow those responsible for public management to make informed decisions that seek to close digital gaps and improve the accessibility and effectiveness of online learning.

Despite the significant contributions of this study, it also has certain limitations. Although the sample selected for this study is representative and the context of public universities in Ecuador has a minimum structure that ensures a high quality homogeneous online education, this does not prevent each entity from investing in additional resources in order to optimize these conditions. This heterogeneity could limit the generalization of the findings to a national scale, despite the fact that the sample comprises students from all the provinces in the country. Moreover, the inherent characteristics of the online self-evaluation questionnaire may have induced a social desirability bias in the responses.

Finally, it is imperative for future research to contemplate, from a transversal point of view, comparisons among degrees according to their respective fields of knowledge, and among universities according to their geographical region and nature (public or private). Moreover, it would be useful to extend the study to a longitudinal research approach. The findings could also be increased by means of qualitative research using techniques such as interviews and focus groups of students, teachers and educational managers, which would facilitate a more detailed understanding of their perceptions. Another future line of research could focus on evaluating the effect of the adaptive personalization of learning, considering it as a new essential study component to be incorporated into the evaluation of the quality of online education.

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