FACTORS INVOLVED IN HIGHER EDUCATION IN A POST-PANDEMIC CONTEXT

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Abstract
The purpose of this article is to analyze different factors involved in higher education, specifically in three aspects: educational, technological, and economic. To this end, a segmentation of the variables was carried out based on the survey carried out on the students of the Faculty of Agricultural Economics of the Agrarian University of Ecuador (UAE) in its three campuses Milagro, El Triunfo and Guayaquil. The multivalent normality assumption was applied using the factorial model and Varimax rotation to improve the interpretation of the factors. The results evidenced in the educational aspect, three factors that explain the shared variance between the variables studied. These factors were related to teacher quality, active student participation in the classroom, and learning in virtual classes. In the technological aspect, two factors were extracted that represent the relationship between the variables related to access to the internet, electronic devices and the use of the laboratory to reinforce learning. While the economic aspect, a significant correlation was shown between the variables of expenditures on technology and education and the monthly income of the household. After extracting two factors that explain the variance in variables related to household income and expenses.

Keywords: Education, Factor Analysis, Learning, University

Introduction

Throughout history, education has been one of the main engines in the socioeconomic development of countries, which is why it is established as a fundamental human right and it is an unavoidable duty of the state to guarantee it. Various international organizations classify it as the center of a common problem that must be resolved promptly and effectively, for the benefit of humanity (Romero et al., 2021).

Education is defined as a process by which knowledge, skills and competencies are transferred from a certain group to another, thus allowing the continuity of knowledge in people. From ancient civilizations to the present day, education has been evolving and adapting according to the needs of societies. Education in the present is oriented to the new context of globalization since in current times substantial changes in processes are demanded, due to the emergence of new theoretical and practical currents. (León, 2007)(Añaños Bedriñana, 2012)

Access to higher education institutions continues to be a matter of concern, in addition to the constant growth in the number of participants (students and non-students). These problems must be addressed in solutions such as the application of national policies, equity, quality and performance in higher education institutions. The countries of the region have invested in the education sector, from the approach that through knowledge the nations will achieve their growth, increasing their value and quality of life of the population. (UNESCO, 2020)(Osorio Sierra, 2014)

Government institutions have the duty to manage the mechanisms and sources that ensure the education of their population, as the academic demand increases. In the case of Ecuador, education is regulated by the National Government through the Ministry of Education, which is responsible for national education at the initial, basic and high school levels, while the agent that coordinates actions between the executive branch and the institutions of the higher education system is the Ministry of Higher Education. Science, Technology and Innovation (Senescyt).

One of the crucial levels in the training process is that which occurs in higher education, because in this phase more specialized academic and professional training is used, in addition to representing a stage of great significance in intellectual development for the progress of society. Constant changes have forced undergraduate learning to ensure the development of specific skills in order to improve the services of new professionals. (Benítez Chavira et al., 2023).

The expansion of participation in higher education in medium-sized countries has been one of the characteristics to be developed. On the other hand, characters such as Koshy et al., (2023) collected data focusing on the attention of two opposite, but interrelated, trends, the combination of substantial cultural change in many countries and the persistence of traditional values, reflecting a focus on participation and achievement in higher education. In another perspective, Zhu et al., (2018) highlight the role of education as a determinant of the competitiveness of a region, through a comprehensive index and a panel model investigated the influence of the quality scale of higher education on economic growth.

Learning in higher education is oriented towards three types of training, such as technological, undergraduate and master's degrees. They are encompassing a wide variety of institutions, such as universities, institutes of technology, colleges and vocational training centres. The increase in the number of students in higher education has complicated the identification of the variables that influence the institution's permanence decisions. Academic performance is usually a direct measure for this problem since it allows learning to be classified into groups to predict their behavior (Casanova et al., 2018).

The use of technological tools became a fundamental pillar in education, due to the mandatory confinement due to the Covid-19 pandemic, this caused a drastic change in the teaching and learning process. In this sense, authors such as Bajaña and Bohórquez (2022) analyzed the consequences of development on education in post-pandemic times. Likewise, Torrego and Fernández (2022) highlight the impact of the pandemic on higher education institutions, and the problems they experienced due to the sudden adaptability in virtual teaching.

The relevance of the study lies in the connection of factors associated with higher education and student learning in a post-pandemic scenario. Exploring the determining aspects that influence learning in students of the Faculty of Agricultural Economics of the Agrarian University of Ecuador, by which aspects by aspects will be analyzed to delimit its predominance in the student environment.

Method

This article took the approach of the multivalent methodology, for which an analysis of factors is established in order to reduce the variables associated with the education of the students of the Faculty of Agricultural Economics of the Agrarian University of Ecuador (UAE) in its three campuses Milagro, El Triunfo and Guayaquil.

To obtain data, surveys were carried out, which were classified into educational, technological and economic aspects. The following table shows the segmentation of variables by their various aspects.

EDUCATIONAL DATA TECHNOLOGICAL DATA ECONOMIC DATA	
DI	Where does your income come from?
PAE	How many people carry out economic activity in your household? Does the institution have electronic devices for learning?
IAH	How much of your income does it contribute to the household?
IM	What is the monthly household income? Do more than two people connect to the same electronic device that
GMH	What are the monthly expenses at home?
GM	Do you use the ability to practice what you have learned in class? Do you think that what is taught in classes forms skills and
GS	What are the monthly expenses of the household in mobilization?
GET	What are the monthly household expenses on technology and education?
GAL	What are the monthly household expenses for food?

Factor analysis is established as a technique used for the identification of underlying patterns in a dataset by reducing dimensionality. Its purpose is to search for the minimum number of dimensions capable of understanding the data being modeled. The model is valuable when working with multiple variables that aim to establish latent relationships between them, this type of analysis can be applied in various areas, in the case of the study it was applied in the area of education.(Johnson & Wichern, 2007)(Tabachnick & Fidell , 2019)

The article established the exploratory factor analysis (EFA) supported by the maximum likelihood method, since this method finds the values of the factors and their coefficients of the linear combination, in addition to performing the analysis by estimating parameters that maximize the joint likelihood of the latent data and the observed data.(Gómez Mejía, 2020)

Factor analysis is defined as follows:

$$X_1 = a_{11} f_1 + \ldots + a_{1k} f_k + u_1$$
$$X_2 = a_{21} f_1 + \ldots + a_{2k} f_k + u_2$$
$$X_p = a_{p1} f_1 + \ldots + a_{pk} f_k + u_p$$

Where:

$X_1, X_2 \ldots, X_p$ These are the observed variables

$F_1, F_2 \ldots, F_k$ These are the common factors
$U_1, U_2 \ldots, U_p$ These are the unique factors
a_{ij} These are the coefficients
$i=1, \ldots, p;$ These are the factorial loads
$j=1, \ldots, k$

The method of maximum likelihood is based on the multivalent normality hypothesis. The statistical software tool SPSS was used to facilitate the calculation of the factor analysis model, based on the theory of multivariate normal distribution.$x=af+u \Leftrightarrow x=fa'+u$

Results

In order to carry out the analysis of factors, the variables were segmented depending on the aspect they belonged to, these were grouped into three aspects: education, technology and economics. When proceeding to carry out the model, the questions asked in the survey were taken, it is worth mentioning that some variables (questions) were omitted because they did not support the established model, as well as they were not closely related to the study.

Educational Aspects

The following table shows the Kaiser-Meyer-Olkin test (KMO) and the Bartlett sphericity test, these tools are used in the analysis of factors to evaluate the adequacy of the dataset, allowing to compare the magnitude of correlation of the observed variables with respect to the coefficients of partial correlations.

Board 1 KMO and Bartlett Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		,725
Bartlett's sphericity test	Approx. Chi-square	382,224
	Gl	28
	Gis.	,001

On the Kaiser-Meyer-Olkin (KMO) test, your measurement should have a value ranging from 0 to 1. Where a score close to zero indicates that factor analysis is not viable, so its correlations between pairs of variables do not explain the rest of the variables, while a score close to one indicates that the values are adequate for analysis. In this case, the value obtained in the test amounts to 0.725, which shows that the model is acceptable, since the sample has a reasonable suitability for the performance of the factor analysis.

Bartlett's sphericity test estimates the null hypothesis that the correlation matrix is an identity matrix, when the test there are significant correlations between the variables, the factor model is not relevant. Regarding the model, Bartlett's test was positioned as left from the significance value established at 0.05, therefore the null hypothesis is rejected and it is concluded that there is a high correlation between the variables.

The factor matrix table (table 2) shows the factors obtained with their respective loads. This matrix indicates the relationship between factors and variables, and provides valuable information about the underlying structure of the data. The values of the factor matrix represent the factor loads, which indicate the correlation between each variable and the factors extracted.

Board 2 Factorial matrix

	Factor		
	1	2	3
GP	-,294	,512	,262
FCIA	,069	-,224	,150
AC	-,300	,302	,170
ATI	,504	-,075	,320
RDP	,530	-,143	-,003
DT	,622	,119	,209
DR	-,477	-,348	,399
CPL	,567	,100	,101

Extraction method: maximum verisimilitude.
3 factors extracted. 10 iterations needed.

In this analysis, three factors have been extracted by reducing the dimensionality of the variables of the study, the three factors obtained are shown as important since they explain the shared variance between the variables.

The values stipulated in the matrix indicate the relationship between the original variables and the extracted factors. A positive value is related to a positive correlation between the variables and a negative value is related to a negative relationship between the variables, on the other hand, values close to zero are established as a weak correlation. For the interpretation of the factor matrix, the highest values for each factor were considered.

Factor 1 called "teaching and educational relationship" has significant loads in two variables, the variable Do teachers master the subject they teach in class? (DT) has a value of 0.622 and how was your relationship with the teacher in the classes? (RDP) with 0.530. So it follows that the first factor is linked to the two variables.

The variables What is their degree of participation in the classroom? (GP) with 0.512, do you practice what you have learned in the classroom? (AC) with 0.302 and Is the teacher ready to answer any questions? (DR) with -0.348 have an important load in factor 2 called "the incidence of teaching in the promotion of student participation" consequently it is related to the variables.

Finally, factor 3 "the uncertainty associated with virtual learning" has three significant variables, among them is the variable Did you learn the topics taught in virtual classes? (ATI) with a value of 0.302 and the variable Is the teacher ready to answer any questions? (DR) with a value of 0.399. This suggests that factor 3 is mainly associated with the DR variable.

The number of interactions necessary to extract the three factors was ten, this amount indicates the number of times that the extraction process was carried out to obtain the factorial matrix.

The factor matrix shows the resulting factor loads after performing a factor analysis with the maximum likelihood extraction method. This matrix represents the relationship between the original variables and the extracted factors. Each value in the matrix indicates the correlation between the variable and the factor, where a positive value indicates a positive correlation, and a negative value indicates a negative correlation.

Board 3 Factorial Transformation Matrix

Factor	1	2	3
1	,874	-,422	-,242
2	,180	,743	-,645
3	,452	,520	,725

Extraction method: maximum verisimilitude.
Rotation method: Varimax with Kaiser normalization.

The Varimax rotation with Kaiser normalization seeks to simplify the structure of the factors for optimal interpretation. Their values determine the relationship of the original variables and rotated factors, values close to one show a high correlation while those close to zero suggest a zero correlation.

The highest loads in factor one are the first and second variables with values of 0.874 and 0.180 respectively, this shows that both variables have an important positive correlation with factor 1. Regarding factor 2, it presents the most significant burdens for the second and third variables with values of 0.743 and 0.520 respectively, however, variable two contributed to a lesser degree to the factor. Finally, in factor 3, variable three is presented with the highest load with a value of 0.725, the other variables have a minimum proportion.

Technological aspects

To determine the reduction in dimensionality of the variables related to the technological aspects, the adequacy of the data was first evaluated using the Kaiser-Meyer-Olkin (KMO) tests and the Bartlett sphericity test, since these tests allow determining whether the data have an adequate underlying structure.

Board 4 KMO and Bartlett Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		,707
Bartlett's sphericity test	Approx. Chi-square	346,956
	Gl	15
	Gis.	,001

Table 4 presents the results of the KMO and Bartlett tests. In the case of the Kaiser-Meyer-Olkin measure, a value of 0.707 was obtained, evidencing a good adequacy, so the model has sufficient correlation between the variables. Meanwhile, Bartlett's test obtained a high significance, because the value of p is lower than the level of significance established at 0.05, by which the null hypothesis is rejected and it is concluded that there is sufficient correlation between the variables related to the technological aspects.

In the factorial matrix, the resulting factor loads are presented after the analysis by applying the maximum likelihood extraction method. Each value presented in the matrix indicates the correlation between the variable and the factor. Table 5 shows the extraction of two factors from the totality of data, represented by the most important latent factors that explain the shared variance between the variables.

Board 5 Factorial matrix

Factor

	1	2
IIA	,690	-,371
CI	-,507	,299
DEA	,445	-,128
PC	,147	,116
PDI	,404	,193
THE	,734	,374

Extraction method: maximum verisimilitude.
2 factors extracted. 16 iterations needed.

In this analysis, it is understood that each column represents a factor and each row represents a variable and for the interpretation the variables with loads closer to 1 or -1 have a greater influence on each corresponding factor.

The variables with the highest loads in Factor 1 "the usefulness of electronic devices and the internet within the educational system" are; Do you have access to the internet within the Institution? (AII) with 0.690, does the institution have electronic devices for learning? (DEA) with 0.445, have you ever had the need to bring a laptop into the classroom? (PDI) with 0.404 and Do you use the laboratory to reactivate what you have learned in class? (LA) with 0.734. This shows that the four variables represent a high correlation with respect to the factor.

In factor 2 called "the reactivation of knowledge intertwined with the quality of the internet", the variables How do you consider the quality of the internet? (CI) with 0.299 and Do you use the laboratory to reactivate what you have learned in class? (LA) with 0.374, they are already presented with the highest loads. While the variables Within the Institution, does it have access to the internet? (AII), Does the institution have electronic devices for learning? (DEA), Have you ever had the need to bring a laptop into the classroom? (PC) and Do more than two people connect to the same electronic device that the institution has? (POIs) have near-zero charges, indicating a weak correlation with Factor 2.

Table 6 shows the rotated factor matrix, which presents the resulting factor loads after applying the Varimax rotation with Kaiser normalization to the factors extracted by the maximum likelihood method. The matrix is used to improve the interpretation of factors, in order to simplify factor loads.

Board 6 Rotated Factor Matrix

	Factor	
	1	2
IIA	,759	,194
CI	-,576	-,123
DEA	,414	,207
PC	,030	,185
PDI	,167	,416
THE	,287	,772

Extraction method: maximum verisimilitude.
Rotation method: Varimax with Kaiser normalization.
The rotation has converged in 3 iterations.

It is noteworthy that the rotation has converged in only 3 iterations, indicating that the rotation process has been efficient and has quickly reached an optimal solution for the interpretation of the factors.

The highest loads in Factor 1 are of the variables Within the Institution, do you have access to the internet? (AII) with 0.759, Does the institution have electronic devices for learning? (DEA) with 0.414, and Do you use the laboratory to reactivate what you have learned in class? (LA) with 0.287. This determines that three variables are strongly associated with Factor 1 and have a high correlation with it. However, the variables Have you ever had the need to bring a laptop into the classroom? (PC) and Do more than two people connect to the same electronic device that the institution has? (POIs) have near-zero charges, indicating a weak correlation.

In factor 2, the variables with the highest loads and have a high in factor 2 are: Do you use the laboratory to reactivate what you have learned in class? (LA) with 0.772, do more than two people connect to the same electronic device that the institution has? (PDI) with 0.416, and Within the Institution, do you have access to the internet? (AII) with 0.194. Have you ever had the need to bring a laptop into the classroom? (PC) and How do you consider the quality of the internet? (CI) have charges close to zero, indicating a weak correlation with respect to the factor.

Economic aspects

Table 4 shows the Kaiser-Meyer-Olkin test (KMO) and the Bartlett sphericity test, both tests allow us to determine if the data have an adequate underlying structure to carry out the reduction of dimensionality in the variables of the technological aspects involved in education.

Board 7 KMO and Bartlett Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		,809
Bartlett's sphericity test	Approx. Chi-square	1255,150
	Gl	36
	Gis.	,001

The Kaiser-Meyer-Olkin measure of sample adequacy was established at 0.809, which shows that the sample has a reasonable adequacy, in the same way it indicates that it has sufficient correlation between the variables to obtain significant and reliable results.

The value of the approximate Chi-square statistic is 1255.150 with 36 degrees of freedom, and the significance value (Sig.) is less than 0.001. This indicates that Bartlett's sphericity test is highly significant, since a significant correlation is demonstrated between the variables in the dataset, whereby the null hypothesis is rejected and it is concluded that there is sufficient correlation between the variables to perform the factor analysis.

Commonalities are values that are represented by the proportion of the variance of each variable that is explained by the factor model. In this process, two estimates of communalities were made; initial communality and communality after extraction using the maximum likelihood method.

Board 8 Communalities

	Initial	Extraction
DI	,107	,023
PAE	,063	,033
IAH	,137	,034
IM	,457	,695
GMH	,594	,706
GM	,388	,439

GS	,519	,635
GET	,454	,574
GAL	,532	,593

Extraction method: maximum verisimilitude.

Table 8 shows that the extraction commonalities vary in each variable observed. The variables What are the monthly expenses in the home? (GMH) with 0.706, what are the monthly expenses of the household in mobilization? (GS) with 0.635 and What are the monthly household expenses for food? (GAL) with 0.593 are positioned as the highest variables, which arises from the fact that the factors extracted explain a large part of the variance.

On the other hand, the variables Where does your income come from? (DI) with 0.023, how many people carry out economic activity in their household? (PAE) with 0.033 and What is the monthly household income? (AHI) with 0.034 have the lowest communalities, therefore, these factors have a lower capacity to explain the variance.

Table 9 shows the factor matrix, which shows the relationship between the original variables and the extracted factors, also each value in the matrix indicates the correlation and the resulting factor loads after the factor analysis with the maximum likelihood extraction method.

Board 9 Factorial matrix

	Factor	
	1	2
DI	-,094	,120
PAE	,175	-,046
IAH	,160	-,090
IM	,676	-,488
GMH	,817	-,195
GM	,614	,247
GS	,721	,339
GET	,640	,405
GAL	,768	,055

Extraction method: maximum verisimilitude.
2 factors extracted. 5 iterations needed.

The analysis of the factors was interpreted considering the highest factor loads in each column. In factor 1 renamed "economic situation", significant burdens are shown for the variables What is the monthly household income? (IM) with a value of 0.676, What are the monthly household expenses? (GMH) with a value of 0.817, what are the monthly expenses of the household in mobilization? (GS) with a value of 0.721 and What are the monthly household expenses in technology and education? (GET) with a value of 0.640. Demonstrating that the four variables make up factor 1 to a greater extent.

Meanwhile, factor 2 "health consumption and mobilization" has significant burdens for the variables What are the monthly household expenditures on health? (GM) with 0.614 and What are the monthly household expenses in mobilization? (GS) with 0.339. Therefore, it is evident that the two variables represent a high correlation with respect to the factor.

In another sense, factor loads close to zero indicate that the variable has little relationship with the factor. In the case of variables, where does your income come from? (DI), How many people carry out economic activity in their household? (PAE) and What is the monthly household income? (AHIs) have low factor loads in both factors, which shows that they have a weak correlation with the extracted factors and their influence on the formation of the factors is limited. As for the iterations needed, the model indicates that 5 interactions were necessary to obtain the final solution.

Determining factors in education

Table 11 shows the factor matrix for each aspect studied with the maximum likelihood method. The matrix demonstrates the factors extracted in each aspect, which explain the underlying structure of the original variables.

Board 10 Factorial matrix by aspects

		GO ES	Educational Aspects	G O ES	Technological aspects	GO ES	Economic aspects
Extracted factors			3		2		2
Iterations Needed			10		16		5
Significant Loads	**1**	DT	0,622	T H E	0.734	GM H	0.817
	2	GP	0,512	T H E	0.374	GS	0.614
	3	DR	0,399				

In the case of educational aspects, it is shown that the variables that contribute the most by factor are: Do teachers master the subject they teach in class? (DT): How much is your participation in the classroom? (GP) and Is the teacher ready to answer any questions? (RD), being 3 factors extracted from a total of 10 necessary interactions.

The factors extracted in technological aspects coincided with the highest load in the variable is: Do you use the laboratory to reactivate what you have learned in class? (LA), this indicates that the variable contributes with a high correlation with respect to the others.

Finally, in the economic aspect, 2 factors extracted from 5 necessary interactions are evidenced. The variables that contributed the highest percentage are: What are the monthly household expenses? (GMH) and What are the monthly expenses of the household in mobilization? (GM), which suggests that these two variables are strongly associated with the aspect studied and have a high correlation with it.

In summary, this study made it possible to simplify the structure of the factors, and also facilitated the interpretation of the relationship between the original variables and the extracted factors. Each factor is now dominated by a set of variables with high loads, allowing for a better understanding of the underlying patterns in the data.

Conclusion

In this research work, the factors related to the educational field in higher education were analyzed. The study revealed important information about the aspects studied that influence the academic development of university students. The factors extracted from the educational,

technological and economic aspects provide a more accentuated understanding of the relationships between the original variables.
For the educational aspect, the influence that teachers have on the student's training is highlighted, since an active interaction between them fosters an adequate environment for learning. In the same way, it was evident that learning in virtual classes is a significant element as a tool in education.
Regarding the technological aspect, it was shown that access to the internet and electronic devices predominate as one of the preferred factors of students in the educational process. Likewise, the use of the laboratory as a reinforcement tool for learning is highlighted, since it was positioned as a valuable practice in this analysis.
Finally, in the economic aspect, a correlation was found between expenditures on technology and education and monthly household income. Therefore, it is of utmost importance for students to have economic resources that are adequate to support access to education and technology.
In conclusion, the factor analysis carried out in this article provides fundamental information to understand the aspects that influence the learning of university students. The results obtained can serve as a basis for the implementation of strategies that aim to improve academic quality, promote the inclusion of new technologies and address the economic needs of students, in search of comprehensive and equitable development in the education sector.

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