



## Research article

# Keys to managing university reputation from the students' perspective

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## ABSTRACT

University reputation is a decisive factor in the management, positioning, sustainability, competitiveness, differentiation, and success of universities. However, the measurement of university performance is often communicated through international rankings, which are frequently criticized for not considering the student's perception, who is the primary user of the educational service. For this reason, the objective is to analyze how students' experiences and their perceived value of the educational process influence the final reputation of universities in two different contexts: Colombia and Spain. Additionally, the results of these relationships are contrasted with the cultural differences and educational systems of both countries. The methodology used is quantitative by means of the formulation and demonstration of a structural equation model, with 385 surveys collected from undergraduate students in Colombia and 333 from undergraduate students in Spain. The results confirmed that student experience influences both perceived value and reputation, and perceived value influences the reputation of the university, likewise, the student experience has an indirect effect on reputation through perceived value, with consistent findings in both countries.

## 1. Introduction

The university reputation is an intangible key for the management of higher education services [1] with the capacity to influence the decisions of different interest groups. Reputation plays a crucial role in the selection stage of the applicant [2], in the experience with the educational process as well as in the job search after graduation [3]. A good reputation allows universities to attract research and teaching staff with high academic training and an outstanding career, improves financial performance, positioning, media coverage [1], investment attraction, as well as the advantage competitiveness and the success of the university [4].

Likewise, the university reputation has received special attention from the academic administration and management staff, who have focused on understanding the expectations, needs and requirements of interest groups to differentiate the university in a highly competitive and globalized educational context [5]. This differentiation can be achieved either in teaching, research, and in relationships with the community. These differentials are evaluated by international rankings such as the Academic Ranking of World

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Universities, the Quacquarelli Symonds World University Ranking, and the Times High Education, which, despite criticism for the methodologies used, are widely consulted by interest groups and they influence their decisions, which is why universities seek to create reputation through a good classification in international rankings.

Given this panorama, previous research has focused on understanding how to generate, improve, and streamline the construction of a reputation based on its differential values, in order to achieve institutional objectives [6,7]. Reputation is not built in the short term and it is based on the sum of the perceptions that different interest groups have over time. This is how research has focused on understanding what factors make up the construct of university reputation [8], making adaptations of scales that measure organizational reputation to the context of higher education, analyzing some relationships of reputation with other variables such as image [5] and legitimacy [9], among others, see Ref. [10].

Despite previous research, it is necessary to continue delving into how different factors influence university reputation, especially from the perspective of the student body [2], since the studies are still in exploratory stages and the models have been inconclusive due to data analysis, which has made use of first-generation statistics. There is a lack of comparative research that allows a better understanding of what happens in different contexts. In this regard, Jayadeva et al. [11] emphasized that the higher education system and the experiences of both the students and the administrative staff have had an important transformation given the commercialization of education, reason why their roles have changed notably and this differs in the context of each country, affecting the way in which the university reputation is conceived.

This study aims to analyze the relationship between the educational experience of the student body, their perception of value in the process and how these variables influence university reputation. In addition, to compare the behavior of these factors in two different educational contexts, Spanish and Colombian. The choice of these two countries is due to the differences they present in terms of the levels that make up the educational systems, the number of hours of teaching support and the independent work of the student [12], the results and the investment in research, the infrastructure, the teaching qualification, the quality assurance systems, among others [13]. These differential characteristics and the incidence of the cultural variable in the management of the higher education service make the perceptions that the student body has about their experience, the value they perceive of their educational process, and the reputation of the university may be different.

In addition, this study investigates the dual role of perceived value as a mediator and moderator, an approach that adds depth to the existing body of knowledge. The use of advanced statistical techniques such as Structural Equation Modeling (SEM) further distinguishes this research by ensuring methodological rigor. Thus, this study contributes to the literature by offering new avenues for enhancing university reputation through culturally tailored strategies, which is crucial for universities operating in diverse educational landscapes.

The results provide relevant information so that universities can improve their strategic management regarding reputation. Likewise, the modeling of university reputation is strengthened by proposing a conclusive model on the influence of student experience and perceived value. Likewise, contributions are presented on the factors studied from a comparative perspective of two contexts that present wide differences and that allow feedback to those who make decisions, both in the Spanish and Colombian context, on the variables that influence the creation of the university reputation.

In response to the above, this study addresses, first of all, a general review of the concept and the research that has been carried out on these variables in the countries that are the object of this study (Colombia and Spain), and the relationships found between the value perceived, student experience and university reputation. The objectives that guide this research, the methodology, and the measurement models used are presented below. Finally, after the presentation of the results, the discussion and main conclusions of the study are addressed.

### 1.1. Studies on university reputation

University reputation is a concept adapted from organizational reputation [10] and it is defined as the result of the perceptions and experiences that people who interact and communicate with the institution have in comparison with others [14]. According to Walker [15], the definition provided by Fombrun [14] is the most predominant in the literature and focuses on three attributes: perception, stakeholders and comparison. Additionally, Walker identifies that it can be positive or negative, and that it requires time for its construction and consolidation, see Ref. [16]. It also allows communicating the ability of an organization to provide valuable results for a group of stakeholders and meet their expectations [17]. For this reason, the management of this important intangible asset requires administrators to measure and understand how reputation affects consumer behavior [18,19].

Within the university context, reputation becomes the subjective reflection of the actions that an institution takes to create an external image [20]. Therefore, the interaction that different interest groups have with the university is essential to generate perceptions of value [21] and can serve as a significant indicator to evaluate the quality of the university [2]. In this sense, students are one of the most important interest groups in evaluating reputation as users of the service [6].

In Colombia, research has been carried out on the importance of teachers in relations with the public, communication, and strategies to impact educational marketing and reputation [7], as well as on the relationship between legitimacy and reputation [22]. Furthermore, it has been found that the reputation of the university acts as a moderating variable between the communication of university social responsibility practices and the intention of future students to select the university. Likewise, the impact of the university's reputation has been evident in the requests made by students to carry out internships in companies and in the hiring of graduates [23].

In the case of Spain, research has focused on the relationships between image, legitimacy, and reputation [5,5,24,25] as key factors for the competitive advantage of higher education institutions (HEIs) [17]. Similarly, the mediating effects of corporate image and

reputation in the relationship between corporate social responsibility (CSR) and emotional attractiveness were confirmed [26].

### 1.2. Student's experience studies

The student's experience has become a core component of the universities' policies and planning documents. This concept has been widely used in an environment increasingly subject to internal and external modes of measurement and evaluation. Its use has a culturally specific rather than universal nature [27]. The student's experience focuses on three aspects: learning and teaching, student's engagement and their own well-being [28]. Therefore, it is the result of the interaction with the services and programs that are offered by the university [29]. Thus, when the quality of the service does not meet their expectations, students in general have a negative experience that impacts their satisfaction. That is why universities must focus on improving the levels of experiences of their students, providing high quality of services in order to compete in the market and obtain benefits [30].

In Colombia, studies on the experience of students from management are scarce. Authors such as Barragán-Díaz [31] address the experiences of students who must study, work and have a social life at the same time. Gutiérrez and Aguirre [32] considered learning experiences, and Nieto [33] analyzed the pedagogical experiences of a particular group of students.

Studies in Spain analyzed generic academic competencies and their relationship with the experience of both students and graduates, finding a mediating effect of satisfaction on loyalty [34]. Martínez and Toledo [35] identified that the most important factor of the university experience is the quality of teaching, influencing the intention to decide on the choice of the training program. On the other hand, it was found that the non-compliance with the initial expectations of the degree and the traditionalist methodologies affected the student experience [36].

### 1.3. Studies on perceived value

The concept of value has been widely studied and approached from economic and administrative sciences, and especially from marketing [37]. Its relationship with services, and the challenge of its ambiguity and subjectivity, has generated various conceptual approaches [38]. Value is the result of the customer's assessment of the product or service, a product of the perceptions that are created after the resulting exchange between what is given and what is received [39]. It refers to the consumer's evaluation of the balance between the benefits they receive and the resources they invest in the product or service. It has also been found that, in university contexts, the perceived quality of the service received determines the perceived value, which directly influences satisfaction [40].

In Colombia, the research of Gómez-Bayona et al. [41] concluded that universities improve trust, reputation, and positioning with management and planning strategies focused on valuable actions. Serna-Loaiza et al. [42] identified the dimensions of perceived value, finding others additional to those evidenced in the theory [functional, social, emotional, conditional, epistemic, ethical and spiritual]. Veas-Gonzales et al. [43] state that perceived value influences students' satisfaction and that their experience must be good for the evaluation to be positive.

In Spain, studies on perceived value show that social and emotional aspects are the most important dimensions of value in the student's experience [44]. The perceived value is a determining factor in the image, satisfaction and loyalty towards the higher education institution [40]. Besides, motivation is a predictor of the perceived value of duties and academic expectations [45].

### 1.4. Studies on the relationship of the three variables

The relationships between reputation, experience, and the value that students perceive of their educational process have been addressed in previous research, showing bivariate relationships between the student's experience and perceived value [46,47]; student's experience and the reputation of universities [3], and perceived value with reputation [40,48].

Likewise, the results of the comparative study between the universities of Spain, Great Britain and China, regarding university selection, its influence on expectations and perceived value, conducted by Li et al. [49], show that, for the functional value is taken into account the infrastructure and practical methodologies used by teachers, and the quality of education. In terms of social benefits, they materialize in experiences outside the academic environment. The emotional benefits are influenced by the reputation of the university and the relationship with the faculty. Likewise, this study concludes that, in terms of time and effort, the results vary depending on the program, nationality and cultural environment, which is why it is not possible to use the same strategy to generate value from one country to another. Thus, based on this finding, we seek to verify whether these relationships also occur in different cultural and geographical areas, and the following hypotheses are proposed to be contrasted for Spanish and Colombian universities.

- Hypothesis 1: Student experience significantly influences perceived value among students at universities in Colombia and Spain.
- Hypothesis 2: Student experience significantly influences university reputation among students at universities in Colombia and Spain.
- Hypothesis 3: Perceived value significantly influences university reputation among students at universities in Colombia and Spain.
- Hypothesis 4: Perceived value moderates the relationship between student experience and university reputation among students at universities in Colombia and Spain.

## 2. Objectives

Objective 1: Analyze the relationship between the educational experience of the students, their perception of value in the process,

**Table 1**  
Instrument.

<b>REPUTATION (REP)</b>		
Performance	DES1	My university has a high research level
	DES2	It obtains lucrative job placements
	DES3	Has growth perspectives
Innovation	INN1	It adapts quickly to change
	INN2	Uses innovative teaching methods
Citizenship	CIU1	Exerts positive influence on society
	CIU2	Supports good causes
	CIU3	My university cares about their stakeholders' well being
Services	SER1	The formative offer responds to market trends
	SER2	It trains competent students
	SER3	It has good value for money
Governance	GOB1	There is a clear vision of the objectives that guide my university
	GOB2	It is managed with ethics and transparency
	GOB3	It takes into consideration its stakeholders in their management decisions
Workplace behaviour	CLIMA1	My university's professors are competent
	CLIMA2	The administrative personnel is competent
	CLIMA3	In general, my university is a good place to work
<b>STUDENT EXPERIENCE (EXP)</b>		
Student-centred service	SCE1	Teaching is student-centred.
	SCE2	My university provides good service to me.
	SCE3	My university provides enough administrative support to me.
	SCE4	My university cares about the students.
Diversity and global citizenship	DYC1	I am aware of the future state of the hospitality and tourism industry.
	DYC2	I can share with future students some information about the school and university education.
	DYC3	My university helps me develop local and global citizenship.
	DYC4	My university helps me recognize cultural differences.
	DYC5	I have the opportunity to learn from other students.
Co-production of experience and learning	CPEA1	I can express my rights and opinion.
	CPEA2	I contribute to the learning in class.
	CPEA3	I actively participate in group projects and class discussions.
	CPEA4	I teach my fellow students.
	CPEA5	I can play the role of leader.
Teacher dependence	DDM1	Teachers provide suggestions to my personal and life issues.
	DDM2	Teachers motivate me to learn.
	DDM3	The teachers provide me with everything I need to learn.
	DDM4	The teachers use ways which appeal to our generation to teach us.
Responsibility	RES1	I am trained to take responsibilities for other people.
	RES2	I am trained to be responsible for myself.
	RES3	I am trained to fix problems by myself.
Whole-person development	DIP1	My university is a small community where I perform civil responsibility.
	DIP2	My university creates all-rounded students.
	DIP3	My university creates ethical students.
<b>PERCEIVED VALUE (VP)</b>		
Functional value	TYTUC1	My degree will allow me to earn a good/better salary
	TYTUC2	My degree will allow me to achieve my career goals
	TYTUC4	My degree will lead to promotion in my current/future job
Epistemic value	ECDC1	The content of my career keeps me interested
	ECDC2	I learn new things from my career
	ECDC3	My career content contributes to the high value of my education
	ECDC4	The academic guidance I receive from my lecturers has enhanced the value of my degree
Social value	TCROP1	People who are important to me think that taking my course is a good thing to do
	TCROP2	People who influence what I do think that taking my course is a good idea
	TCROP3	My current/future employer will see me in a better light when I have finished my degree
	TCROP6	The support of my friends and family has been important in helping me through my career
Emotional value	TCPS1	I feel proud that I'm taking my career
	TCPS2	Taking my course has boosted my self confidence
	TCPS5	Taking my career has given me a sense of self-achievement
Non-monetary sacrifices	LSHSC2	My studies have reduced the time I spend with my family
	LSHSC3	My studies have reduced the time I spend with my friends
Monetary sacrifices	LSHSC5	The monetary price paid for my career is reasonable when I consider what I am getting out of it
	LSHSC6	When considering the monetary price of my course, I believe that the quality is good
Image	OFRCC2	Study-group work has been a beneficial part of my career
	OFRCC3	The campus and its facilities have contributed to the value of my career
	LPAU1	The reputation of my university influences the value of my degree
	LPAU2	The image projected by my university has an influence on the value of my degree
	LPAU3	I believe that employers would have positive things to say about my university
	LPAU4	I have heard positive things about my university
	LPAU5	I believe that my university has a good reputation

and how these variables influence university reputation.

Objective 2: Compare the behavior of these factors in two different educational contexts: Spanish and Colombian.

### 3. Methodology

The methodology used was a quantitative and cross-sectional approach. Through this methodology, we sought to verify the hypotheses, as well as compare the results between the two countries, Colombia and Spain. On the other hand, the collection of information was developed following the research protocols of each country.

#### 3.1. Instrument

This study took as measurement instruments scales already validated in other countries and adapted to the Spanish language. The instrument was divided into three parts. The student's experience scale (EXP) was originally taken from Xu et al. [48] validated by Amado et al. [50]. This instrument consists of six factors: student-centred service, diversity and global citizenship, co-production of the learning experience, dependence on the teacher, responsibility and integral development of the person and a total of 24 items. For perceived value (VP), it was taken the scale proposed by Ledden et al. [47] and validated by Amado-Mateus et al. [51]. This instrument is made up of seven factors: functional value, epistemic value, social value, emotional value, image, monetary and non-monetary sacrifice, and a total of 26 items. Finally, to evaluate university reputation (REP), the scale proposed by Del-Castillo-Feito et al. [5] was used. It is made up of six factors: performance, innovation, citizenship, services, governance and behavior in the workplace, with a total of 17 items. The complete instrument was composed of 67 items (see Table 1), not including demographic questions. A prior piloting process was also carried out to confirm language and cultural adaptation.

#### 3.2. Sample selection and data collection

The questionnaire was applied in two universities in Spain and Colombia to students enrolled in undergraduate programs (Degree in the case of Spain) and of legal age. The Spanish university is ranked 801–1000 in the QS World University Rankings 2022, and the Colombian university is ranked 751–800. For the application, the support of teachers was requested who invited their students to participate in it and they participated freely. In the case of Colombia, 385 surveys were obtained between July and November 2022. In that same period, data were collected from 333 students from Spain. Demographic information, including age, gender, and socio-economic background, was collected to provide a comprehensive understanding of the sample. Additionally, ethical considerations were strictly adhered to, ensuring that all participants provided informed consent and that their anonymity and confidentiality were maintained throughout the study.

In the case of the Colombian student body, 54.5 % (210 people) were in semesters less than or equal to fourth, and 45.5 % (175) were in fifth to tenth semesters. 80.5 % (310) were women and 19.5 % (75) men. In relation to age, 79.2 % (305) were between 18 and 21 years old, 16.9 % (65) between 22 and 25 years old and 3.9 % (15) over 25 years old. Finally, in reference to the social stratum, 46 students reported to belonging to stratum 2, 132 to 3, 122 to 4, 58 to 5 and 22 to 6.

Now, 35.4 % (118) of the Spanish students reported being in the first year, 27.0 % (90) in the second year, 28.5 % (95) in the third year and 9.0 % (30) in the fourth year. Besides, 80.2 % (267) of the participants were women and 19.8 % (66) men. Regarding age, 81.4 % (271) indicated they were between 18 and 21 years old, 15.3 % (51) between 22 and 25 years old and 3.3 % (11) were over 25 years old. Since in the case of Spain there is no social classification by stratum, this was done based on social class. Thus, 1.2 % (4) claimed to be from the lower class, 5.7 % (19) lower middle class, 39.3 % (131) middle class, 49.2 % (64) upper middle class and 4.5 % (15) were high class.

It is important to note that the issue of social strata or classes in the study was differentiated according to the country. In Spain, social class was defined by factors such as educational level, occupation, and income, and was categorized into upper, middle, and lower classes, with additional subcategories. In Colombia, the social stratification system was employed, classifying the population into six strata based on socioeconomic and housing characteristics, ranging from stratum 1 (the lowest level) to stratum 6 (the highest level). The majority of the Colombian population resides in strata 1, 2 and 3, which represent the lower and lower middle classes.

#### 3.3. Analysis of data

A Structural Equation Model (SEM) has been applied to analyze the data. Given the nature of this type of model, the analysis of the results was divided into two parts. The first one, sought to evaluate the measurement model. The second one, was to verify the structure model and the hypotheses both for the total sample of both countries and separately.

For the development of the measurement model, we started with an Exploratory Factor Analysis (EFA) to observe the behaviour of the scales in relation to the conformed factors. The KMO (Kaiser-Meyer-Olkin) statistics and Bartlett's test of sphericity were analyzed, as well as the explanation of variance of the factors. These analyses were based on the original scales validated by Xu et al. [48], Ledden et al. [47] and Del-Castillo-Feito et al. [5]. The KMO statistic was used to measure sampling adequacy, ensuring that the data were suitable for factor analysis. Bartlett's test of sphericity was used to confirm that the variables were sufficiently correlated for the analysis. Finally, the explanation of variance allowed us to identify how much of the total variability in the data could be explained by each factor identified in the EFA. Subsequently a second order Confirmatory Factor Analysis (CFA) was carried out. It was determined that the data did not fit a normal distribution, in a univariate or multivariate manner in each of the items evaluated. Therefore, for the

development of the CFA, estimates were made based on free asymptotic distribution. The bootstrap method was also used, developing 2000 bootstrap samples with 95 % confidence intervals. The use of the bootstrap is widely recommended in the methodological literature to handle non-normally distributed data and complex models [(52)], thus ensuring the validity and reliability of the results obtained.

The results of the CFA were evaluated using the Chi-square statistic ( $\chi^2$ ), minimum discrepancy ratio ( $\chi^2/df$ ), goodness-of-fit

**Table 2**  
Factor loadings of the instrument and bootstrap method results.

Construct	Factors	Factor loadings	Lower	Upper	Sig	Observable variables	Factor loadings of Observable variables	Lower	Upper	Sig
Rep	Performance	0.933	0.909	0.953	<0.01	DES1	0.853	0.818	0.879	<0.01
						DES2	0.819	0.782	0.855	<0.01
						DES3	0.923	0.899	0.943	<0.01
	Innovation	0.93.6	0.919	0.953	<0.01	INN1	0.946	0.93	0.96	<0.01
						INN2	0.928	0.909	0.944	<0.01
	Citizenship	0.947	0.928	0.964	<0.01	CIU1	0.925	0.899	0.946	<0.01
						CIU2	0.906	0.877	0.93	<0.01
						CIU3	0.93	0.909	0.947	<0.01
	Services	0.971	0.958	0.983	<0.01	SER1	0.895	0.866	0.917	<0.01
						SER2	0.943	0.927	0.956	<0.01
						SER3	0.844	0.815	0.867	<0.01
	Governance	0.953	0.933	0.966	<0.01	GOB1	0.943	0.931	0.954	<0.01
						GOB2	0.959	0.949	0.968	<0.01
						GOB3	0.927	0.905	0.945	<0.01
	Workplace behaviour	0.936	0.908	0.959	<0.01	CLIMA1	0.905	0.878	0.926	<0.01
						CLIMA2	0.87	0.827	0.903	<0.01
						CLIMA3	0.914	0.89	0.932	<0.01
	Exp	Student-centred service	0.873	0.834	0.906	<0.01	SCE1	0.86	0.83	0.882
SCE2							0.885	0.862	0.906	<0.01
SCE3							0.806	0.772	0.835	<0.01
SCE4							0.88	0.855	0.902	<0.01
Diversity and global citizenship		0.898	0.869	0.925	<0.01	DYC1	0.836	0.804	0.863	<0.01
						DYC2	0.893	0.871	0.913	<0.01
						DYC3	0.728	0.678	0.765	<0.01
						DYC4	0.624	0.566	0.676	<0.01
						DYC5	0.68	0.622	0.729	<0.01
Co-production of experience and learning		0.809	0.765	0.854	<0.01	CPEA1	0.823	0.786	0.857	<0.01
						CPEA2	0.691	0.62	0.745	<0.01
						CPEA3	0.787	0.749	0.819	<0.01
						CPEA4	0.7	0.643	0.747	<0.01
						CPEA5	0.705	0.656	0.754	<0.01
Teacher dependence		0.905	0.88	0.926	<0.01	DDM1	0.687	0.641	0.728	<0.01
						DDM2	0.883	0.857	0.905	<0.01
						DDM3	0.866	0.841	0.887	<0.01
						DDM4	0.861	0.832	0.884	<0.01
Whole-person development	0.891	0.849	0.926	<0.01	DIP1	0.768	0.724	0.805	<0.01	
					DIP2	0.912	0.889	0.933	<0.01	
					DIP3	0.873	0.845	0.898	<0.01	
VP	Functional value	0.906	0.879	0.929	<0.01	TYTUC1	0.909	0.886	0.928	<0.01
						TYTUC2	0.914	0.89	0.933	<0.01
						TYTUC4	0.859	0.823	0.882	<0.01
	Epistemic value	0.912	0.885	0.933	<0.01	ECDC1	0.904	0.881	0.924	<0.01
						ECDC2	0.913	0.89	0.93	<0.01
						ECDC3	0.927	0.905	0.945	<0.01
						ECDC4	0.887	0.862	0.908	<0.01
	Social value	0.763	0.697	0.82	<0.01	TCROP1	0.918	0.888	0.939	<0.01
						TCROP2	0.93	0.899	0.951	<0.01
						TCROP3	0.704	0.633	0.768	<0.01
						TCROP6	0.721	0.66	0.777	<0.01
	Emotional value	0.84	0.799	0.88	<0.01	TCPS1	0.872	0.837	0.901	<0.01
						TCPS2	0.867	0.831	0.898	<0.01
						TCPS5	0.894	0.859	0.921	<0.01
	Monetary sacrifices	0.736	0.688	0.779	<0.01	LSHSC5	0.86	0.824	0.892	<0.01
						LSHSC6	0.976	0.949	0.999	<0.01
	Image	0.795	0.707	0.863	<0.01	OFRCC3	0.604	0.514	0.682	<0.01
						LPAU1	0.604	0.808	0.94	<0.01
LPAU2						0.921	0.844	0.961	<0.01	
LPAU3						0.848	0.771	0.902	<0.01	
LPAU5						0.758	0.667	0.828	<0.01	

index (GFI), adjusted goodness-of-fit index (AGFI) and root mean square error of approximation (RMSEA). For this, the following thresholds were taken into account:  $\chi^2$  the smaller the better with  $p$ -value  $> 0.05$ ,  $\chi^2/df$  less than 5, GFI and AGFI greater than 0.8 and RMSEA less than 0.08. These parameters were taken and supported theoretically by Refs. [53,54], as well as by their previous use in social science studies, for example in the work of Amado et al. [51]. In the event that the CFA did not present a good fit, especially the RMSEA, we proceeded to evaluate which variables had normalized regression values less than 0.55 for their elimination, as well as the modification indices of the covariance of the errors of each of the items, covarying those larger and theoretically more parsimonious indices.

Subsequently, the convergent and discriminant analysis of each of the factors of the instruments was carried out. In the case of convergent validity, the Analysis of Variance Extracted (AVE) was determined, the reliability evaluated from the CR statistic (composite reliability), as well as Cronbach's Alpha  $[\alpha]$ . In the case of AVE, values greater than 0.5 were considered acceptable, CR values greater than 0.7, and  $\alpha$  values greater than 0.8. Finally, for the discriminant analysis of the factors, the Maximum Shared Variance (MVS) and the Average Shared Variance (AVS) were calculated, considering them acceptable when the MVS and the AVS were lower than the AVE.

Then, the goodness of fit of the proposed model was evaluated, preserving the statistics and thresholds of the measurement model stage. If necessary, the largest and theoretically more parsimonious modification indices were covaried. The hypothesis contrast was developed with the adjusted model, being accepted when the  $p$ -value of Beta (estimated) was less than 0.05. Likewise, the hypotheses for the group of students who belonged to the Colombian HEIs and the Spanish HEIs were contrasted under the previously described procedure.

#### 4. Results

Before carrying out the hypothesis contrast, the reliability and validity of the scales was guaranteed using the structural model. This was done in order to validate if the factors of each of the scales explained the factors evaluated. The perceived value scale presented a KMO of 0.94 with a Bartlett's test of sphericity of 18,114.95 with a  $p$ -value of  $< 0.01$ . That said, the eight factors that make up the scale managed to explain 77.34 % of the variance, having a clustering behaviour equal to that of the original scale. In the case of the student experience scale, it presented a KMO of 0.95 with a Bartlett's test of sphericity of 12,765.21 with a  $p$ -value  $< 0.01$ . The six factors of this scale explained 66.87 % of the variance. Finally, the reputation scale presented a KMO of 0.97 with a Bartlett's test of sphericity of 15,894.89 with a  $p$ -value  $< 0.01$ . The six factors of this scale explained 83.67 % of the variance.

A second order CFA was used, that said, the constructs related to responsibility and non-monetary sacrifices were eliminated as they

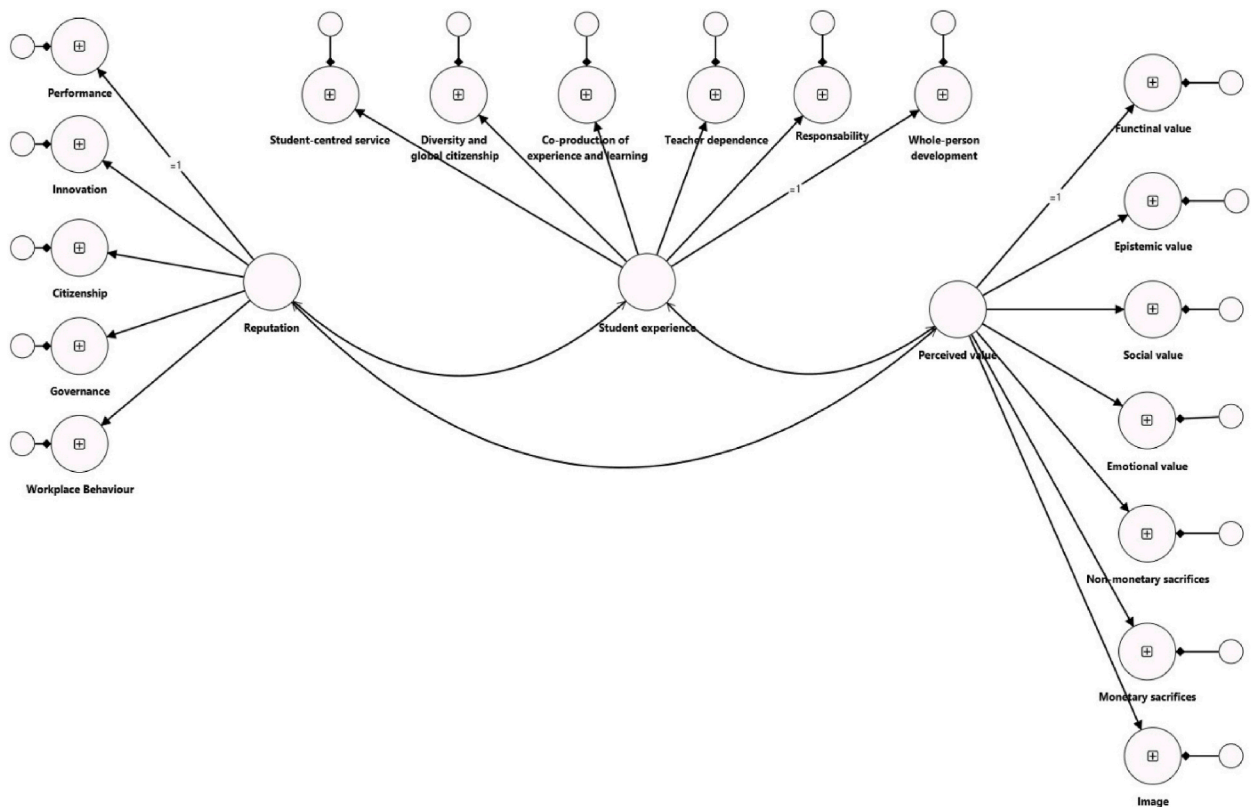


Fig. 1. CFA model.

had factor loadings below 0.60, being 0.49 and 0.22 respectively. In the case of observable variables, LPAU4 and OFRCC2 were dropped because they had a factor loading of less than 0.60. Thus, the goodness-of-fit of the CFA was  $\chi^2/df = 3.34$ , CFI (Comparative Fit Index) = 0.91, NFI (Normed Fit Index) = 0.88, TLI (Tucker-Lewis Index) = 0.91, IFI (Incremental Fit Index) = 0.91, GFI (Goodness of Fit Index) = 0.77, AGFI (Adjusted Goodness of Fit Index) = 0.75, and RMSEA (Root Mean Square Error of Approximation) = 0.05. The factorial loadings of the items of the instrument are presented in Table 2. For a visual representation of the model refer to Fig. 1.

The convergent validity of the instrument was adequate for each of the constructs, given that it presented an AVE greater than 0.5, as well as the reliability evaluated from the CR statistic was bigger than 0.70. Regarding discriminant validity, the values of the MSV and ASV statistics were lower than AVE. Table 3 presents the values of the convergent and discriminant validity statistics for the instrument.

Regarding the adjustment of the structural model, it was considered adequate when the following values were presented for the statistics of  $\chi^2/df = 3.34$ , CFI = 0.91, NFI = 0.88, TLI = 0.91, IFI = 0.91, GFI = 0.77, AGFI = 0.75 and RMSEA = 0.05. For a visual representation of these relationships of the model refer to Fig. 2.

Table 4 presents the results of the contrast of the hypotheses. The analyzes indicate that all hypotheses (H1, H2 and H3) are accepted, due to their significant p-values (<0.01). Consequently, the educational experience of the students positively influences the perceived value of their academic training. Likewise, both student experience and perceived value have a positive impact on university reputation. Compared to the direct effects of the relationships in the reference model, for the case of EXP > VP, it was 0.84; for EXP > REP, it was 0.55; and for VP > REP, it was 0.39. Now, for the indirect relationship of EXP > VP > REP the effect value was 0.32 with a p-value less than 0.01, thus confirming H4.

The R<sup>2</sup> statistic for REP, in the baseline model, was 0.82, which means that the constructs EXP and VP can explain 82 % of the variance of REP. In the case of the influence of EXP on VP, the R<sup>2</sup> was 0.71, meaning that EXP explained 71 % of the variance of VP. The effect size of the relationship was analyzed only for the REP construct, so for H2 the f<sup>2</sup> was 0.02 which is considered low and for H3 it was 0.16 which represents a medium effect.

Likewise, compared to the contrast by countries, H1, H2 and H3 are confirmed. Tables 5 and 6 present the results for each group.

In the case of Spanish students, the direct effects of the relationships were 0.72 for EXP > VP; 0.59 for EXP > REP; and 0.31 for VP > REP. In the case of the indirect relationship of EXP > VP > REP, the effect value was 0.22 with a p-value less than 0.01. Thus, H4 is confirmed for the Spanish student population (See Fig. 1). The R<sup>2</sup> statistic for REP, in this population, was 0.72, which means that EXP and VP explained 72 % of the variance. The effect size of the relationship between EXP and REP was small with a value of 0.001, and between VP and REP was large with a value of 0.357.

On the other hand, the effects of the relationships for Colombian students were 0.88 for EXP > VP; 0.48 for EXP > REP; and 0.44 for

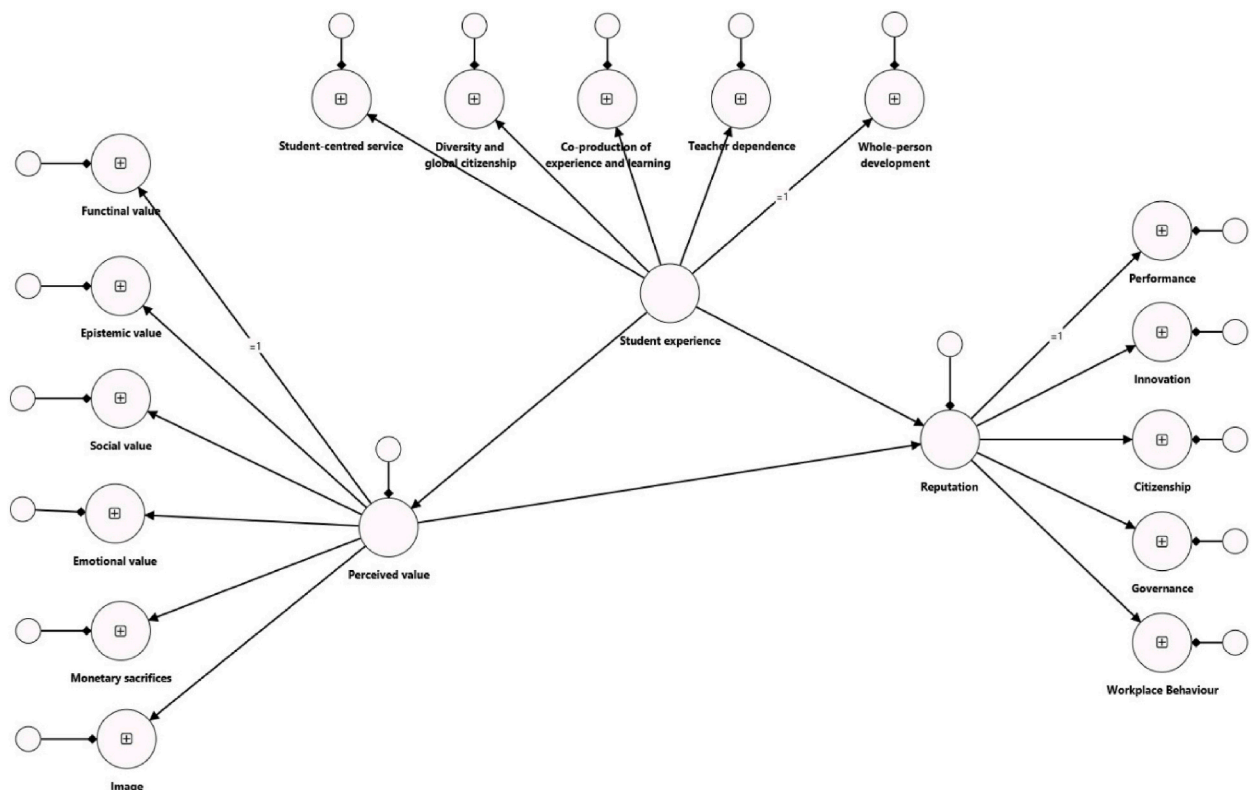


Fig. 2. Adjusted structural model.

**Table 3**  
Convergent and discriminant validity of the instrument.

CONSTRUCT	AVE	CR	MSV	ASV
EXP	0.767	0.943	0.774	0.740
REP	0.895	0.981	0.774	0.749
VP	0.686	0.929	0.672	0.610

**Table 4**  
Contrast of the hypotheses of the reference model.

Hypothesis	Estimated	S.E.	C.R.	p-value	Result
H1 [EXP > VP]	1.25	0.06	20.293	***	Accepted
H2 [EXP > REP]	1.35	0.11	11.545	***	Accepted
H3 [VP > REP]	0.63	0.07	8.63	***	Accepted

Note: H is accepted when p-value <0.05.

Note: \*\*\*represents significance with p-value <0.001.

**Table 5**  
Contrast of the hypotheses of the Spanish student model.

Hypothesis	Estimate	S.E.	C.R.	Lower estimate	Upper estimate
H1 [EXP > VP]	1.32 <sup>a</sup>	0.14	9.26	1.08 <sup>a</sup>	1.636 <sup>a</sup>
H2 [EXP > REP]	1.74 <sup>a</sup>	0.22	7.63	1.33 <sup>a</sup>	2.19 <sup>a</sup>
H3 [VP > REP]	0.49 <sup>a</sup>	0.10	4.86	0.27 <sup>a</sup>	0.72 <sup>a</sup>

Note: H is accepted when p-value <0.05.

Note.

<sup>a</sup> represents significance with p-value <0.001.

**Table 6**  
Contrast of the hypotheses of the Colombian student model.

Hypothesis	Estimate	S.E.	C.R.	Lower estimate	Upper estimate
H1 [EXP > VP]	1.39 <sup>a</sup>	0.09	14.434	1.19 <sup>a</sup>	1.61 <sup>a</sup>
H2 [EXP > REP]	0.67 <sup>a</sup>	0.12	5.61	0.35 <sup>a</sup>	1.04 <sup>a</sup>
H3 [VP > REP]	1.16 <sup>a</sup>	0.20	5.79	0.67 <sup>a</sup>	1.66 <sup>a</sup>

Note: H is accepted when p-value <0.05.

Note.

<sup>a</sup> represents significance with p-value <0.001.

VP > REP. Finally, the indirect effect of the EXP > VP > REP ratio was 0.38 with a p-value less than 0.01. For the  $R^2$  of REP was 0.79, taking this in consideration EXP and VP explained 79 % of the variance. The  $f^2$  was for relationship between EXP and REP 0.01, and for VP and REP it was 0.09, in both cases the effect size were considered small.

Comparing the results between both groups, it is highlighted that Colombian students show stronger direct effects of both the educational experience on perceived value and university reputation, compared to Spanish students. Furthermore, the indirect relationship of EXP > VP > REP is also slightly more pronounced for Colombian students. These differences suggest that while the fundamental relationships between student experience, perceived value, and university reputation hold across both contexts, the strength and nature of these relationships are influenced by cultural, socioeconomic, and educational factors. These factors could contribute to the observed disparities and warrant further research to better understand their impact on student perceptions in different geographic contexts.

## 5. Discussion, conclusions and contributions

### 5.1. Discussion

Regarding H1, it was confirmed that student experience is positively related to perceived value, as observed in previous studies [46, 47]. In the cases of Colombia and Spain, there is a strong direct relationship between these variables, with correlations of 0.88 and 0.72, respectively. This relationship in academic settings is generally assumed as a result of the habits and practices acquired by both teachers and administrative staff in the performance of their duties. However, this study provides empirical evidence that allows for a better understanding of its impact on the university, the factors that comprise it, and a viable and proven way to measure it. Notably, the stronger relationship observed among Colombian students could be attributed to a greater emphasis on personal relationships and

community engagement prevalent in Colombian culture, which enhances the perceived value derived from educational experiences [13].

The effect sizes observed in these relationships suggest important considerations for the generalization of the results. Although the positive relationship between student experience and perceived value is confirmed in both countries, the larger effect size in Colombia indicates that this relationship may depend on specific cultural and contextual factors. This suggests that, while general trends can be identified, the intensity of the relationship between these variables may vary significantly across different educational settings.

Regarding H2, it was confirmed that student experience influences reputation. This finding is consistent with previous research [3]. The results of the direct relationships show that, in the case of Colombia, there is a moderate effect with a coefficient of 0.67, while for Spanish students, this effect is lower, with a value of 0.55. Therefore, individual experience is relevant and a determining factor when evaluating the university's reputation. The management of this experience will impact the learning path of students and the communication strategy developed by the university. The stronger effect observed in Colombia may be influenced by cultural factors where interpersonal experiences and social reputation are more deeply valued, enhancing how educational experiences shape institutional reputation [52].

The analysis of effect sizes in this context reveals that, although student experience influences university reputation in both countries, the magnitude of this effect is moderate in Colombia and lower in Spain. This underscores that student experience depends not only on individual factors but also on how educational institutions manage and communicate these experiences. The differences observed in effect sizes indicate that the ability to generalize these results may be limited by variations in institutional factors, such as university policies and the cultural environment in which they operate.

Regarding H3, it was found that perceived value influences reputation, consistent with findings from previous studies [40,48]. The direct effect of these variables in the case of Colombia was moderate, with a value of 1.16, while in Spain the correlation was lower, at 0.49. This finding, along with the previous one (hypothesis two), allows for the identification that these two variables have a positive impact (with greater or lesser force, depending on the country) on the evaluation of the university's reputation from the students' perspective, who are the users of the educational service and can assess whether the outcome of their training process generates value for them. The differences in these effects could be due to socioeconomic contexts, where students in Colombia might place greater importance on perceived value due to the greater variation in educational quality and resources compared to Spain.

The moderate effect sizes in Colombia and low effect sizes in Spain also reflect that the influence of perceived value on reputation may be conditioned by individual and institutional factors. In contexts where educational quality is more heterogeneous, as in Colombia, students may place more value on the perceived aspects of their education, which translates into a greater influence on the institution's reputation. This finding suggests that student experience and perceived value are complex constructs that depend on multiple factors, which may limit the ability to generalize results and emphasize the importance of considering specific contexts when interpreting these effects.

Regarding Hypothesis 4 (H4), which posited that perceived value would mediate the relationship between student experience and university reputation, the findings demonstrate a significant mediating effect in both Colombian and Spanish contexts. Specifically, for Colombian students, the direct effects were substantial, with coefficients of 1.39 for EXP > VP, 0.67 for EXP > REP, and 1.16 for VP > REP. Additionally, the indirect effect (EXP > VP > REP) was 0.38, with a p-value less than 0.01, indicating a robust mediation effect. These results suggest that in Colombia, student experience not only directly enhances perceived value and university reputation but also indirectly influences reputation through perceived value.

On the other hand, while similar patterns were observed for Spanish students, the effects were less pronounced. This discrepancy may be attributed to cultural and systemic differences between the two countries. The literature supports that cultural contexts significantly impact how educational experiences and perceived value shape institutional reputation [11,49]. For example, the greater emphasis on community and interpersonal relationships in Colombian culture might enhance the perceived value derived from educational experiences, thereby exerting a stronger influence on university reputation [13].

These findings align with previous studies that highlight the critical role of perceived value as a mediator in educational settings [40,47]. The stronger mediating effect observed among Colombian students suggests that universities in Colombia might benefit more from strategies aimed at enhancing the perceived value of educational experiences. This could involve focusing on personalized student services, community engagement, and practical applications of learning, which are highly valued in the Colombian educational context [41].

Since the four hypotheses were tested in both countries, it can be inferred that the fundamental relationships between student experience, perceived value, and university reputation are maintained across both contexts [49]. However, the results also highlight the importance of considering cultural and systemic contexts when analyzing these relationships. While the core findings are consistent, the nuances of cultural and educational differences can influence the strength and nature of these relationships. Additionally, the effect sizes vary, suggesting that, although the relationships exist in general, their intensity and significance may differ depending on individual and institutional factors.

This analysis provides valuable implications for university administrators in tailoring their strategies to enhance perceived value and, consequently, institutional reputation in different cultural settings. The findings emphasize that effective management and enhancement of university reputation require recognizing and addressing these contextual differences to optimize the educational experience and perceived value among students. Furthermore, they underscore the importance of considering how individual and institutional factors influence student experience and, therefore, the ability to generalize the results to other contexts.

## 5.2. Conclusions

This study contributes to the theoretical construction of reputation, perceived value, and experience from the perspective of university students, and its findings can be extrapolated to other HEIs. As mentioned, there is some evidence of similar studies in the higher education sector, but to date, no studies have compared the relationship between these variables across different countries, which confirms the validity and replicability of the study, following appropriate processes of cultural adaptation and effect size analysis in each sample.

Regarding university reputation, it is concluded that it can be assessed in both countries using the factors proposed by Del-Castillo-Feito et al. [5], which include university performance, innovation, citizenship, service, governance, and organizational climate. In relation to student experience, this can be evaluated through the factors proposed by Xu et al. [48], which correspond to student-centred service, diversity and citizenship, co-production of the learning experience, teacher dependence, and whole-person development. It is important to note that the responsibility factor, which was initially part of the scale, was removed after factor analysis. This result aligns with studies such as those by Pötschulat et al. [27] and Matus et al. [28], who do not consider it a common factor in measuring student experience.

Regarding perceived value, the study confirms that the factors of the scale proposed by Ledden et al. [47] include functional value, epistemic value, social value, emotional value, monetary sacrifices, and image. However, the study eliminated the non-monetary sacrifices factor and two items from the image factor. This finding is consistent with previous research by Kubat [56] and Ledden et al. [57], which found that these elements are not essential for adequately capturing the construct of perceived value in the educational context.

On the other hand, the quality of the educational offering is something that students assume as a prerequisite when selecting a university with national high-quality accreditation, in the case of Colombian students, as well as international high-quality accreditation, in the cases of both Spanish and Colombian students. Therefore, one of the main premises of the study is that universities must manage their processes with high quality standards as a key objective that will guide their strategic plan. The accreditation seals are what will confirm that everything is fulfilled.

However, thinking that educational quality is achieved solely through accreditation undermines the importance and impact of educational quality on the training process, outcomes, performance, and the university's reputation. It is crucial to communicate the vision and strategic objectives to all stakeholders, especially students and applicants. The university's communication department must design and manage communication plans and messages, ensuring that the value obtained by each stakeholder is consistently communicated, thereby motivating positive evaluations of the university's reputation.

Universities should focus their efforts on managing relationships with their stakeholders, particularly the student experience at every stage of their educational journey, considering the factors mentioned above. The "student journey map" could be a useful tool, providing a comprehensive and inclusive management model that articulates the steps of the student's journey with the university's areas, processes, procedures, activities, and communication channels. Following Trubnikova and Sharakhina [52,55], universities should identify three important moments related to the roles students adopt during their time at university: attraction and communication with applicants, the development of their training process, and the post-graduate phase, which includes relationships with the business sector for job placement or business development. Recognizing these roles helps managers to effectively guide needs and communication without implying a clientelistic model that diminishes the development of the student's training process.

Regarding perceived value, universities must align their strategic plan with generating value for students throughout their journey. The perception of value should encompass the fulfillment of students' objectives and professional development, as well as the positive perception of their choice by themselves and their close circles, such as family and friends. Managing the university's image among internal stakeholders through communication programs that reinforce the good choice made by students can help achieve these perceptions.

The findings suggest that while fundamental relationships hold across different contexts, the strength and nature of these relationships are context-dependent. This finding is crucial for university administrators, as it emphasizes the need for culturally adapted strategies to enhance perceived value and institutional reputation. Additionally, the dual examination of perceived value as a mediator and moderator provides a more comprehensive understanding of its role. By recognizing and addressing these contextual differences, universities can better manage their reputation and improve student experiences.

It is important to highlight that effect sizes vary depending on the context, indicating that although general relationships exist, their intensity and significance may differ based on individual and institutional factors. This underscores the importance of not only considering cultural and educational differences but also understanding how these factors affect the student experience and, consequently, the ability to generalize results to other contexts.

Future research should continue to explore these differences to develop more effective reputation management practices in diverse educational settings. By doing so, more precise and adapted strategies can be designed to strengthen institutional reputation and optimize the educational experience for students.

## 5.3. Contributions

This investigation has yielded critical insights into the determinants of university reputation, foregrounding the student perspective as pivotal within the reputation management discourse. The methodological robustness, conceptual clarity, and practical relevance of the study collectively signal a meaningful advancement in the academic understanding of institutional reputation.

### 5.3.1. Methodological contributions

The methodological contributions of this study are marked by a layered design and robust analytical techniques that collectively enhance our understanding of the university reputation construct. Employing a cross-national comparative framework, the study critically examines the reputation construct for its universal applicability and its unique manifestations within Spanish and Colombian contexts. The utilization of Structural Equation Modeling (SEM) and Confirmatory Factor Analysis (CFA), replete with a suite of rigorous fit indices (CFI, NFI, TLI, IFI, GFI, AGFI, RMSEA), provides a strong foundation for the validation of the scales, which were carefully adapted to capture linguistic and cultural specificities. This detailed attention to scale adaptation is paramount, safeguarding the psychometric properties across varied educational and cultural landscapes. The substantial sample size from both countries further bolsters the findings, ensuring that the insights gained reflect an authentic representation of student perceptions and extend the generalizability of the results. This methodological rigor, characterized by sophisticated statistical modeling and careful scale adaptation for cross-cultural relevance, underscores the study's dedication to producing reliable, valid, and universally relevant findings.

### 5.3.2. Conceptual advancements

Conceptually, the study extends our understanding of university reputation by elucidating the direct correlations between student experience and perceived value, which, in turn, significantly affect reputation. The validation of this model across two countries, with their distinct educational paradigms, underscores the robustness of these constructs and their interactions. The research underlines the importance of the student experience as the cornerstone of perceived educational quality and its subsequent impact on institutional reputation. Notably, the study's findings indicate that while the constructs are consistent across cultures, the strength of the relationships between them is influenced by the specific educational and cultural context, suggesting a more complex interplay than previously recognized.

### 5.3.3. Practical implications

The study's practical contributions provide university administrators and policymakers with a strategic framework to enhance institutional reputation through targeted improvements in student experience. The research empirically demonstrates that the quality of student experience is a pivotal factor in increasing perceived educational value, which, in turn, significantly impacts the institution's reputation. This critical correlation underscores the need for universities to allocate resources and devise initiatives that enhance the student experience comprehensively.

A key practical implication is the necessity for universities to articulate and communicate a clear value proposition. Ensuring that educational offerings meet student expectations and that the academic environment fosters a positive institutional image is essential. Universities should focus on strategic alignment, developing transparent policies and practices that convey the intrinsic value of their educational programs. This strategic approach will enable institutions to demonstrate their commitment to educational excellence and positively influence their reputational standing. Additionally, leveraging data analytics to continuously assess and improve student satisfaction can further enhance perceived value and institutional reputation.

### 5.3.4. Contributions to educational policy

This study can significantly shape educational policies and management strategies within higher education institutions by emphasizing the critical role of student experience and perceived value in building university reputation. By highlighting the necessity of integrating skill development for future work, the study suggests that policies should prioritize the enhancement of student experiences and the practical value of education provided. Implementing such policies can substantially bolster an institution's reputation, making it more attractive to prospective students and esteemed academic professionals.

According to recent findings, effective reputation management is essential not only for student recruitment but also for fostering international collaborations and partnerships [56]. The development of soft skills, such as communication, critical thinking, and problem-solving, which are highly valued by employers, is crucial for preparing students for the evolving job market [57]. Additionally, the inclusion of work-integrated learning programs and practical experience in the curriculum can significantly enhance graduate employability [58]. By aligning educational strategies with these insights, policymakers can develop targeted approaches that prioritize student satisfaction and perceived value, ultimately leading to a stronger institutional reputation.

### 5.3.5. Other contributions

- 1. Development of Evaluation Tools:** The study contributes to the development of new tools and metrics for evaluating and improving student experience and perceived value. These tools can be used internally and in international rankings and accreditations, providing a more comprehensive view of educational quality. Evaluation tools that measure these aspects help institutions identify areas for improvement and implement more effective strategies [56].
- 2. Focus on Cultural Diversity:** The study highlights the importance of considering cultural diversity in higher education. The findings inspire additional research on how cultural differences affect the perception of educational quality and university reputation, which is crucial for institutions seeking to internationalize and attract students from diverse backgrounds. Recent studies have shown that universities in different regions adopt varied approaches to managing their reputation, adapting to specific cultural contexts. For instance, research has emphasized the positive impact of student exchange programs on developing cultural intelligence and innovative behavior among students [59].
- 3. Communication Strategies:** The study's results guide the design of more effective communication strategies that highlight institutional values and perceived quality. Universities can use these insights to improve their communication with current and

prospective students and other stakeholders, enhancing their national and international reputation. Effective reputation management is essential for universities aiming to maintain a positive image and attract a global audience [60].

4. **Professional Development and Training:** The findings emphasize the need for continuous professional development and training for academic and administrative staff. By improving staff competencies and skills, universities can ensure they provide a high-quality educational experience, which in turn enhances perceived value and institutional reputation. Studies have shown that investing in staff development is crucial for improving student satisfaction and loyalty [59].
5. **Pedagogical Innovations:** The study promotes the implementation of innovative pedagogical practices that enhance student experience. Identifying the practices and approaches most valued by students allows universities to adapt their teaching methods to be more effective and engaging. Integrating technology and interactive methods has proven effective in improving student participation and satisfaction. For example, flipped classrooms and blended learning environments are innovative approaches that have been shown to increase student engagement and academic performance by incorporating multimedia and digital platforms into lesson plans [61].
6. **Implications for Reputation Management:** Finally, the findings offer new perspectives on managing and improving university reputation in a competitive environment. This includes specific strategies for different cultural and educational contexts, particularly relevant for universities operating in multiple countries or with a large population of international students. Reputation management is a key component for universities seeking favorable positioning in global rankings and attracting high-quality students [62,63].

## 6. Future research directions

This study lays a vital foundation for future inquiry into the dynamics of university reputation, signaling the need for an expanded examination of the roles that cultural and educational systems play in shaping student experiences and their perceived value. The research paves the way for subsequent investigations into how these diverse contexts may affect the established model, with a particular focus on the potential moderating effects of demographic variables. Longitudinal studies are also suggested to understand how these relationships develop or change over time. By delving into these cultural nuances and system variations, future studies can enhance our understanding of the intricate relationships between student experiences, perceived value, and university reputation. Moreover, this research advocates for a more detailed exploration of demographic factors and their influence on these relationships, aiming to refine the applicability of the reputation model across global educational landscapes and contribute to a more nuanced and context-sensitive approach to reputation management in higher education. Studies involving sociology and anthropology could provide new insights into the behavior and perceptions of different stakeholders.

## Ethics and consent section

The study with human participants was approved by the Research Ethics Committee of the Universidad del Rosario on September 22, 2021 with code DV005 516 – CS265. Consent was signed online on the form sent, in accordance with national legislation and institutional requirements.

## CRedit authorship contribution statement

**Marelby Amado Mateus:** Writing – original draft, Validation, Project administration, Methodology. **Alfredo Guzmán Rincón:** Visualization, Software, Formal analysis, Data curation. **Fernando Juárez Acosta:** Supervision, Conceptualization. **Irene Ramos Soler:** Writing – review & editing, Investigation. **Daniel Rodríguez Valero:** Resources, Investigation.

## Data availability statement

The data that support the findings of this study are openly available in Figshare at <https://doi.org/10.6084/m9.figshare.22583770>. This dataset includes the results of the factor loadings for the perceived value, student experience, and reputation scales.

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## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.heliyon.2024.e39805>.

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