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PAPER

Validation of the Digital Transformation Model of the Universidad Autónoma de Chile

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ABSTRACT

The emergence and massification of digital technologies are having such an impact on educational systems that universities are being forced to design transformation processes that make it possible to ensure the gradual incorporation of technologies into academic-administrative processes with a view to achieving greater student-centered educational quality. In response to this need and for the specific case of the Autonomous University of Chile, a digital transformation model composed of nine dimensions and 54 indicators was designed, which was subjected to an analysis process through structural equation modeling to check its consistency, reliability, and validity. With the data resulting from the application of surveys to 97 undergraduate students from that university, it was possible to demonstrate that the variables considered, and their corresponding dimensions form a solid construct that can explain the preliminary model of the digital transformation process at the university. Therefore, even recognizing limitations of a methodological nature, the model was intrinsically validated by the data. The findings represent a first approximation for the construction of a new academic-administrative scenario at the Autonomous University of Chile, which is based on the proper use of scientific-technological advances that have occurred in the global context.

KEYWORDS

digital transformation, higher education, factor analysis, structural equations

1 INTRODUCTION

The emergence of digital technologies and the widespread use of them represent a milestone in the socioeconomic evolution of humanity. The paradigm of the digital age, whose beginnings date back to 2002, when the information accumulated in technological tools exceeded the volume of analog information [1], produced a digital divide that is becoming less and less if the global context is considered [2]. However, this new paradigm, which began with the proliferation of data communication and storage, has entered a new stage in which algorithms create automated processes that make it easier to turn information into actionable knowledge.

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This technological scenario has had such an impact on educational systems that Facer and Selwyn [3] went so far as to affirm that digital technologies are an increasingly prominent feature of the provision and practice of contemporary education throughout the world and are fundamental to building the social imaginary about the future of education, which is significantly related to innovation and its contribution to socioeconomic development [4]. This, coupled with the fact that the educational importance of digital technologies has been amplified during the COVID-19 pandemic due to the massive adoption of digital educational resources, has sown hope, albeit cautiously, about the possibility of a profound transformation of education.

Educational structures are shifting towards technological devices [5]. However, it is known that digital technology by itself does not transform education. In fact, despite the increasing visibility of digital devices and online systems, the essence of educational processes seems to remain intact in the absence of substantial changes that could favorably impact training and the student experience. It has also been argued that even though there are many theoretical explanations for the potential learning benefits arising from the use of digital technologies, there is still little solid evidence to validate these claims, and, in any case, the findings are still inconclusive. On the other hand, the reduction of social inequalities using digital resources in education is still a great ambition, having argued that "the use of technology in education continues to be subject to and often reproduces a series of persistent and pernicious inequalities" [3].

The previous elements of judgment point to the need to consider whether any impact that arises after the introduction of these technologies in educational systems is specific to a certain context and closely related to sociotechnical factors that show the multidimensionality of the educational phenomenon in the digital age. Consequently, any attempt to take advantage of digital technologies and generate greater value for the student through the teaching-learning processes and the economic-administrative processes must consider the characteristics of the system in which the educational event occurs. especially in three closely related aspects: (1) strategic focus and organizational culture; (2) the way to use and take advantage of the available technological base; and (3) the skills and abilities that are possessed to manage the technology, as emerged from a study carried out by the author in the year 2022 at the Autonomous University of Chile (UAM).

Based on the above and assuming that the student should be the center of attention in the decision-making process, a preliminary theoretical model was developed for the digital transformation of that university, in order to direct the mechanisms to ensure a process of transformation that takes into account the digital skills (current and desired) of students, teachers, and those responsible for managing the gradual incorporation of technologies in academic-administrative processes and that, in addition, allows anticipating the new scenarios that derive from scientific-technological advances in the global context with a view to achieving a higher educational quality.

The model assumes that there is a close and unequivocal relationship between "digital transformation", understood as a process, and "digital maturity", understood as a result. Both constructs feed each other by understanding that the transformation process determines the degree of maturity reached, which once again impacts the process in search of new transformations.

In this sense, and because it is a preliminary theoretical model, the purpose of this study was to empirically validate said construct by subjecting it to a process of analysis through which its consistency could be evaluated with respect to other previously established knowledge and theories, identify and correct errors or weaknesses, improve their accuracy, ensure their usefulness and reliability to make informed decisions, make accurate predictions, and verify underlying hypotheses.

2 CONCEPTUAL FRAMEWORK OF THE RESEARCH

In the last ten years, the idea of digital transformation has gained traction in the management literature. This concept has transcended the simple fact of measuring how an organization can benefit from the use of information technology to conceive it as an evolutionary process in which said technology becomes an essential element in the daily life of the organization, affecting all dimensions of it, including workers and users. In other words, digital transformation refers to the changes caused by digital technologies that influence various aspects of human life [6].

There is no single interpretation of what digital transformation means. Some authors conceive of digital transformation as an incremental application of information technology to business processes [7]. Other theorists consider that this type of transformation represents an abrupt and disruptive change that can generate chaos in the business world [8]. A less radical definition implies that digital transformation is a progressive process that takes advantage of digital capabilities and technologies to enable new business models and operational processes that impact the consumer experience by generating more value [9]. Digital transformation can also be viewed from the perspective of changes in structure, strategy, and technology; these dimensions, which interact to respond to the needs imposed by the dynamics that are typical of digital environments [10], require the proper implementation of digital skills, which represent the core of professional training and lifelong learning and are essential to improving personal performance, active citizenship, social inclusion, and employability [11].

Although it is true that the concept of digital transformation is not new, its considerable relevance in the contemporary context has been driven by the rapid evolution of technology and the massification of telecommunications networks. This in turn has allowed the emergence of new practices and management models that have changed the way people and companies interact [12]. It has even been argued that, in the educational context, the digital transformation of higher education "determines the future roadmap towards a sustainable education management strategy" [13].

The foregoing is consistent with the general perception that one of the great urgent problems posed by education today is, precisely, the modernization of the system, which must adapt to the requirements imposed by the digital economy, which raises the need to create mechanisms that enable digital transformation [14]. To make this task possible, different approaches have been proposed whose dimensions reveal a fragmented image but which, in any case, according to Teichert [15], reveal the impact of culture on transformational capacities, deducing that the success of any digital transformation process must consider the cultural particularities of the context in which it will take place.

In the case of this research, the dimensions of the digital transformation model to be validated arose because of the operationalizing of a solid theoretical body represented by the contributions of Catlin, Scanlan, and Willmontt [16], Westerman, Bonnet, and McAfee [17], and Valdez-de-León [18], to which were added the contributions of Crespo and Pariente [19], Furedi [20], Gobble [21], Salinas and Vio [22], and Sánchez and Fernández [23]. The model is based on the premise that the maturity of any university's strategic processes can be achieved if most of the factors of each dimension are met, that is, if the level of digitization of each of the dimensions proposed in the construct reaches its highest level [24]. Each of the theoretical contributions that were considered to design the digital transformation model of the Autonomous University of Chile is described below.

Starting with Catlin, Scalan, and Willmontt [16], these authors base their proposal on the McKinsey model, presenting a set of dimensions and factors to measure the digital maturity of a company, which they called the "Digital Quotient Model." In this model, the starting point is the definition of a clear and precise digital strategy that is integrated into the company's corporate strategy and whose alignment is key to the success of the digital transformation. According to the authors, designing a correct digital strategy involves answering three key questions: where are the most relevant opportunities and threats? How fast and at what scale could a digital disruption occur in my sector? And what are the best options to seize opportunities proactively, and which ones to reallocate resources away from the big threats?

In summary, the dimensions and factors that are integrated into the digital quotient model include:

- Strategy: bold, long-term orientation; digital strategy linked to business strategy and focused on customer needs
- Culture: risk appetite, speed and agility, ability to learn from mistakes, internal collaboration, and external orientation
- Organization: roles and responsibilities; talent and learning management; governance and performance indicators; investment in digital technologies
- Capabilities: connectivity, focus on customer experience, decision-making based on data, automation, and information technology architecture

Another theoretical root that was used for the design of the theoretical model of digital transformation at the university corresponds to the proposal presented by Valdez-de-León [18], who designed a model of digital maturity with an approach more like the function of universities, understood as service provider organizations. The model presents the dimensions and factors indicated below:

- Strategy: vision, governance, planning, and management of the processes that will support the execution of the digital strategy
- Organization: changes in culture, structure, training, and knowledge management
- Customer: new benefits created in the customer experience through digital changes in their journeys
- Ecosystem: development and support of ecosystems of partners and allies, which are conceived as fundamental elements in any digital business
- Operations: more digitized, automated, and flexible, which contribute to reaching a higher level of digital maturity based on the capabilities that support the provision of services
- Technology: effective technology planning, including deployment, integration, and its use to support digital business.
- Innovation: new flexible and agile ways of working that will form the basis for an effective digital business

A third theoretical contribution that was key to the design of the digital transformation model of the university corresponds to the Digital Maturity Model (IMD) proposed by Westerman, Bonnet, and McAfee [17], who, after demonstrating the existence of a significant correlation between digitization and competitiveness, designed a model through which any organization could gradually and progressively develop its key capabilities that would allow it to evolve and be successful in the new digital age.

In that model, the authors combined two closely related aspects that could describe how companies are reacting to digital opportunities:

- Digital intensity, or the level of investment in technology initiatives aimed at changing the way the company operates
- Transformation management intensity is understood as the level of investment in leadership capabilities required to create digital transformation within an organization, shaping a new future based on governance and a commitment to implement change based on the technology

As a synthesis, the theoretical contributions that defined the preliminary structure of the Digital Transformation Model of the University that was submitted to empirical validation were those indicated in Table 1.

Table 1. Theoretical contributions considered to design the preliminary structure of the digital transformation model of the Autonomous University of Chile

Theoretical Support	Dimension	Description
Catlin, Scanlan and Willmott [16]	Key Capabilities and Resources	It involves digitizing the aspects that generate value within the organization and that are sources of competitive advantages such as connectivity, customer experience, decision-making based on data, automation, and architecture.
	IT investment	Adequate technical support, digitization of physical machines, virtualization, from analog to digital.
Crespo and Pariente [19]	Institutional strategic framework focused on digital transformation	A comprehensive strategy focused on the service delivered by the university and driven by digital, which involves all the processes that generate value in the long, medium, and short term. It involves adapting the corporate, business, and functional strategy to a digital modality.
Valdez-de-León [18]	Student life cycle	New benefits created in the student experience thanks to digital transformation. It involves the student's passage through the university, promotion, recruitment campaigns, registration, teaching, job search, and follow-up of alumni.
	Ecosystem	Focused on the experience of stakeholders. It refers to the development of a strategic network of allies as a key element for a comprehensive solution for the student.
	Processes	Transform teaching for digital education Transforming the teaching and learning dynamics
Gobble [21]	Organization and structure	Way of organizing functions within the university Roles and responsibilities, talent and learning, form of governance, IT leadership, way of designing work, and adapting it through ICTs
Furedi [20]	Points of contact with the student	Students need to be assisted at any time, from anywhere and on any device. Service points must be digitized.
Salinas and Vio [22]	Flexible and personalized teaching	From a one-size-fits-all teaching to a tailor-made teaching Managing individualized student information through predictive data analysis to offer individualized counseling systems
Sánchez and Fernández [23]	Social networks and profile research	It involves: Educational marketing Recruitment of new students Analyzing click-through rate, which is a digital marketing measure to evaluate the performance of content on the Internet, whether on Google or social media Understand the perception of public regarding the academic programs of the university Identify points of improvement in the service and to create new programs to respond to the needs

Based on the theoretical contributions indicated, the complexity of the aspects that intervene in the digital transformation of the university is observed, which is in harmony with what was argued by Rossman [25] when he warns about the need to develop a set of capabilities linked to different dimensions, including leadership, market, operations, people, culture, governance, and technology, or as Mühlburger et al. [26] point out when relating digital transformation to factors such as organizational values (culture), management capacity, organizational infrastructure, and workforce capabilities.

Given these indications, the structure of the digital transformation model of the university was integrated by nine variables and 54 indicators, as observed in Table 2.

Table 2. Variables and indicators of the preliminary theoretical model of digital transformation of the Autonomous University of Chile

Variables/Description	Indicators
Strategy and culture Strategic basis for the digital transformation of universities, being related to the interactions between people and technologies to satisfy the requirements of people and society. This dimension includes the adoption and implementation of decisions related to university policies and strategies related to obtaining, using and integrating digital technologies.	Mission and vision statement, focused on the digital context Formulation of strategic objectives focused on information technologies Organizational structure adaptable to the demands of the digital environment
Financial resources They affect the way in which digital transformation occurs and represent the basis for improving internal processes and productivity, differentiating from the competition by providing a better student experience, and anticipating the trends of the digital age both in terms of learning platforms as administrative.	Investment in learning platforms Investment in administrative technology platforms
Technological basis It is constituted by the set of equipment, applications and infrastructures that allow the generation or improvement of the academic and administrative processes that derive from its institutional mission, and that are produced using different technologies.	Availability of digitized library Availability of digital technologies in organizational processes Availability of a digital platform to manage student affairs ICT support to promote work groups Digital support for the student-director-secretary relationship Availability of quality technical support in digital processes
Focus on the student experience The digital transformation process must be based on the need to increase the centrality of the student to improve their experience in terms of academic and administrative matters that concern them and optimize communication aspects that allow them to offer timely and real information. This premise must be internalized in the decision-making processes.	Comprehensive approach to the student experience IT focus on student loyalty and university brand Problem solving for students, with an IT approach Accessible services anywhere and anytime Digitization of the student life cycle Incorporation of IT for student satisfaction and retention Incorporation of IT for continuity of studies Integration student life project – teaching strategy Improvement of contact points with students through ICTs
Teaching-learning processes They represent the core of the system that generates value for the student. It includes the interaction between teachers and students with the mediation of digital technologies. In this dimension lies the effectiveness of the pedagogical action and the social justification of the university in accordance with the new training scenarios and the requirements of the labor market.	Use of predictive data to anticipate student needs. Individualized counseling system Academic and pedagogical support with a focus on IT Labor internships and job search with a digital focus Incorporation of IT in the student's study rhythm Teaching model appropriate to the physical location of the student Adaptation of the teaching model to the profile of each student Application of ICTs in the teaching-learning process Incorporation of digital teaching strategies in pursuit of family integration

(Continued)

Table 2. Variables and indicators of the preliminary theoretical model of digital transformation of the Autonomous University of Chile *(Continued)*

Variables/Description	Indicators
Economic-administrative processes They make it possible to ensure the operational and financial sustainability of the university, maintain flexibility to adapt to the socioeconomic conditions of the students, provide study alternatives, optimize the use of resources by improving response time, and facilitate the generation of useful information for the student. Along with the teaching-learning processes, economic-administrative processes impact the student experience and can be a determining factor in decisions about continuing studies.	Digitized administrative processes Integration of the student's socioeconomic level with digital teaching strategies Recruitment of potential students through social networks Student loyalty strategies with a digital approach
IT governance Ability to lead processes aimed at centralizing information to understand and decode it to improve decision-making processes based on data from different sources. From an external perspective, IT governance is related to the management of links with the different entities that make up the university ecosystem. This variable is consubstantiated with the management and control of all processes, mediated by information technologies, which contribute to achieving the strategic objectives of the university.	Analysis of student perceptions in RRSS Analysis of positioning indicators Identification of points for improvement in digital services Digital initiatives aligned with the corporate strategy Promotion of projects on digital issues Automation of teaching services aimed at students Positioning through digital platforms Relations with companies and corporations Relations with communities and social groups Relations with foundations/NGOs Relations with international universities Links with the educational community and professors from other universities
Competencies and abilities Cognitive, emotional, and attitudinal skills required to integrate digital technologies and reduce the technological gap between the people that make up the various levels of the university.	Training focused on digital technologies Training in digital pedagogical strategies Tolerance to changes Continuous learning ability Promotion of collaborative learning in RRSS
Internal process management It covers all the processes that must be carried out to achieve the strategic objectives of the university in a context characterized using integrated digital technologies, both to support workflows and for decision-making related to performance improvement and of relations with students, teachers, administrators, and other interest groups.	Digital technologies in workflows Technologies in back-office optimization of the organization Decision making incorporating IT Data-driven decision making

3 METHODOLOGY

For the validation of the initial model of digital transformation at the university, a three-step methodology was used that allowed us to obtain a definitively adjusted model with sufficient reliability to contrast the preliminary hypotheses.

- Development of the data collection instrument (survey) to find out the students' perspective on the degree of importance attributed to the factors involved in the digital transformation process of the university.
- Exploratory factor analysis (EFA) using IBM SPSS
- Confirmatory factor analysis (CFA) and structural equation modeling (SEM) to confirm inferred correlations and causal relationships between factors. For this phase, the AMOS extension, v.23 of the SPSS statistical package, was used.

Specifically, the methodological process was carried out, initially, by checking the validity of the constructs through: (1) convergent validation, which allowed evaluating to what extent the selected items were representative to define the latent variables of the model; (2) discriminant validation, which served to verify that the indicators associated with a latent variable were not related to other constructs; and (3) factor analysis, in order to determine how much each factor contributes to defining the construct with which it relates. Subsequently, the structural model was applied, evaluating the goodness of fit from the measures of absolute fit, incremental fit, and parsimony, and then validating the relationships between the constructs that were proposed as preliminary hypotheses in the theoretical model of digital transformation, presented in Table 2.

The data was collected through surveys that were applied to a group of 97 undergraduate students from the Autonomous University of Chile. Prior to data collection, experts were asked to review the questionnaire for validation purposes. The overall content validity of the instrument was 0.714, using the Lawshe model [27].

Survey results were entered into IBM SPSS, and descriptive statistics were used to identify outliers that might result from an error made during data entry.

An exploratory factor analysis was performed to determine the underlying factor structures, that is, to identify the observed variables that were associated with each latent variable.

Using the results of the exploratory factor analysis, a confirmatory factor analysis was performed. It was done in order to demonstrate the validity of the factorial structure that was previously obtained with the EFA and, consequently, confirm the validity of the deductions inferred during the design of the preliminary theoretical model.

The validation of the preliminary digital transformation model of the university was carried out using the SEM technique, which is commonly used in correlational studies in which only the magnitude of the variables is observed that are not manipulated by the researcher. Structural equation models consist of two fundamental parts: (1) the measurement model, which contains the way in which each latent construct is measured by its observable indicators, the errors that affect the measurements, and the relationships that are expected to be found between the constructs when they are related to each other; and (2) the model of structural relationships, which contains the effects and relationships between the constructs [28].

For the study, factor analysis was required, which is considered the technique par excellence for the validation of theoretical constructs [29]. It is a statistical model that represents the relationships between a set of variables or items that can be explained by a series of unobservable (latent) variables called factors, which, in number, are substantially less than those of the observable variables [30]. Conceptually, factor analyzes have two modalities: EFA and CFA, whose fundamental difference lies in the fact that EFA is a data-based technique that tries to discover the underlying structure that these have by searching for patterns of relationships between the indicators, while CFA is mainly driven by substantive theories and by expectations, so the contrasting of the structural hypotheses that derive from the theory will be the one that determines the validity of the construct.

In general, EFA refers to a set of multivariate statistical methods of interdependence that have the purpose of identifying a structure of factors underlying a large set of data [31]. Each of these factors groups interrelated items that, at the same time, are relatively independent from the other sets of items. This interrelation between items is because such variables have something in common and something that differentiates them, so their total variance is due to factors that they share with the other variables (community), but also to factors that are specific to that variable (specificity).

The CFA, its part, seeks to estimate the correlation between the latent variables and their association with the items [32]. Its purpose is to assess whether the latent variables can be accounted for by a reduced number of underlying factors. In this way, the preliminary structure of the model is confirmed or rejected by comparing the results obtained from the observed data. In brief, the findings of the EFA play a role in defining constructs and, consequently, in formulating theoretical models. On the other hand, the significance of the CFA lies in its ability to validate the construct that has emerged from these deductions.

The statistical tests applied as a step prior to factor analysis were: (1) the Kaiser-Meyer-Olkin (KMO) test, and (2) the Bartlett sphericity test. The KMO test measures the suitability of data for factor analysis in terms of the adequacy of sampling for each variable in the model. The resulting value pertains to the portion of variance in the variables that can be attributed to underlying factors. A value less than 0.5 indicates that the results of the factor analysis may not be very useful [33].

For its part, Bartlett's sphericity test allows us to test the hypothesis that the correlation matrix is an identity matrix, which would reflect that the variables are not related and, therefore, are not suitable for the detection of structures. Small values (less than 0.05) of the significance level indicate that factor analysis may be useful with the available data [34].

Sedimentation graphs (Scree Plot) were used to determine the number of factors that were to be extracted to achieve the most parsimonious factorial structure, i.e., in which the factors that explain most of the total variability of the data are reflected.

4 RESULTS

4.1 Exploratory factor analysis

The objective of the EFA was to identify the theoretical structure of the data, identifying the dimensions or latent variables that underlie it. As the dimensions of the model were already defined a priori, this analysis had as its purpose the statistical validation of each dimension, that is, verifying the internal consistency of each construct.

Each indicator was measured through a five-level Likert scale, where it is desired to know the importance assigned to each indicator in the digital transformation process of the university. The scale goes from least important to most important; the levels are: 1 = unimportant, 2 = scarcely important, 3 = neutral, 4 = important, and 5 = very important.

Due to the measurement of variables or indicators through a Likert scale, the factorial method selected was "Principal Component Analysis," with the rotation method "Varimax" employed. The Varimax rotation method adjusts the factor axes orthogonally, ensuring that the factors maintain a 90º angle between them. This approach minimizes the number of variables with high loadings on each factor, thereby simplifying the interpretation of the factors [34].

Having outlined the chosen analysis method, the subsequent sections present and interpret the results attained for each of the phases and dimensions of the model.

Phase 1. Availability of digital resources. This phase is composed of three dimensions:

1. Strategy and culture. This dimension was measured through the following indicators:
   - Organizational structure adaptable to digital
   - IT-focused strategic objectives
   - Mission and vision focused on digital

Prior to the analysis, it was verified that the data were apt to apply the factorial analysis. For this, the Kaiser-Meyer-Olhin (KMO) tests and the Bartlett's Sphericity Test were used, the results of which are shown in Table 3.

Table 3. KMO and Bartlett's Test – Strategy and culture

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.681
Bartlett's Test of Sphericity	Approx. Chi-Square	86.412
	df	3
	Sig.	0.000

As can be seen in the previous table, the KMO value is close to 0.7 (the required value), and the Bartlett's sphericity test is significant (chi-square = 86.412 and $p < 0.01$). This indicates that the theoretical assumptions for applying the factor analysis are met.

Subsequently, the principal component analysis (PCA) was applied to extract the most important factors, that is, those that had an eigenvalue greater than or equal to 1, to verify how many factors were required to explain the dimension satisfactorily (Table 4).

Table 4. Total variance explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.109	70.296	70.296	2.109	70.296	70.296
2	0.541	18.034	88.330			
3	0.350	11.670	100.000			

In the previous table, it could be seen that a single factor is relevant in this dimension, explaining 70.3% of the total variability. In this way, it is confirmed that the use of a single factor to measure the strategy and culture dimensions is adequate. The load of each indicator on this factor is presented in the following table (Table 5), and it can be observed that all the indicators that make up this dimension have a similar importance, above or close to 0.8.

Table 5. Component matrix

No	Indicator	Component
		1
1.1.2	IT-focused strategic objectives	0.879
1.1.3	Mission and vision, focused on digital	0.838
1.1.1	Organizational structure adaptable to digital	0.796

2. Financial resources. EFA was not applied to this dimension because it is made up of only two indicators (investment in learning platforms and investment in administrative technology platforms), falling below the minimum of three indicators that is considered adequate for this type of analysis.

3. Technological Base. This dimension is made up of the following indicators:
   - Digital platform for student affairs
   - IT support to foster work groups
   - Digital support for the student-director-secretary relationship
   - Digitized library
   - Quality technical support in digital processes
   - Digital technologies present in organizational processes

The results of the KMO and Bartlett's Test for this dimension are shown in Table 6.

Table 6. KMO and Bartlett's Test – Technological base

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.797
Bartlett's Test of Sphericity	Approx. Chi-Square	298.641
	df	15
	Sig.	0.000

The assumptions verification tests to apply the factorial analysis were satisfactory. The KMO = 0.797 (greater than 0.7) and the Bartlett's Sphericity test was significant (chi-square = 298.641 and $p < 0.01$). Applying the AFE with all the indicators, the following results were obtained. Table 7 shows the total variance explained.

Table 7. Total variance explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.614	60.231	60.231	3.614	60.231	60.231
2	0.893	14.884	75.114			
3	0.618	10.303	85.417			
4	0.425	7.084	92.501			
5	0.278	4.631	97.132			

The first component can be considered relevant to explaining this dimension because it explains 60.2% of the total variability. This validates the composition of this factor, which is adequate to consider all the indicators as a single dimension. Table 8 shows the coordinates of each indicator in the factor.

Table 8. Component matrix

No	Indicator	Component
		1
1.3.1	Digital platform for student affairs	0.892
1.3.2	IT support to foster work groups	0.848
1.3.3	Digital support for the student-director-secretary relationship	0.835
1.3.4	Digitized library	0.831
1.3.6	Digital technologies present in organizational processes	0.642
1.3.5	Quality technical support in digital processes	0.546

In the previous table, most of the indicators or variables have a significant and similar load on this factor, except for two variables that turn out to be the least relevant: digital technologies present in organizational processes (0.642) and quality technical support in digital processes (0.546).

Phase 2. Use of digital resources. This phase is made up of three dimensions: (1) focusing on the student, (2) teaching-learning processes, and (3) economic-administrative processes. By applying the EFA, the underlying structure of each of them can be explored.

1. Focusing on the student. This latent variable, or dimension, was measured through nine indicators:
    - Comprehensive approach to the student experience
    - Accessible services anywhere, anytime
    - Incorporation of IT for continuity of studies
    - Improvement of contact points with students through ICTs
    - IT Incorporation for student satisfaction and retention
    - Solving problems for students, with an IT approach
    - Digitization of the student life cycle
    - Integration student life project-teaching strategy
    - IT focus on student loyalty and university brand

Table 9 show the results of KMO and Bartlett's Test.

Table 9. KMO and Bartlett's Test – Focusing on the student

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.803
Bartlett's Test of Sphericity	Approx. Chi-Square	86.412
	df	3
	Sig.	0.000

The KMO test is equal to 0.803 and the Bartlett's sphericity test is significant (chi-square = 86.412; $p < 0.01$), indicating that factor analysis can be applied to explore the data. The first output of the analysis returns are as shown in Table 10.

Table 10. Total variance explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.807	53.408	53.408	4.807	53.408	53.408
2	1.449	16.096	69.504	1.449	16.096	69.504
3	0.917	10.187	79.692			
4	0.588	6.532	86.224			
5	0.461	5.125	91.348			
6	0.291	3.230	94.578			
7	0.250	2.781	97.359			
8	0.139	1.542	98.901			
9	0.099	1.099	100.000			

According to the results shown in the previous table, the AFE suggests the existence of two factors to explain this dimension, since between them they explain 69.5% of the variability of the dimension. The composition of each factor is shown in Table 11.

Table 11. Component matrix

No	Indicator	Component	
		1	2
2.1.6	Solving problems for students, with an IT approach	0.903	
2.1.9	IT focus on student loyalty and university brand	0.843	
2.1.2	Accessible services anywhere, anytime	0.829	
2.1.8	Integration student life project - teaching strategy	0.634	
2.1.1	Comprehensive approach to the student experience	0.570	0.416
2.1.3	Incorporation of IT for continuity of studies		0.903
2.1.7	Digitization of the student life cycle		0.898
2.1.5	IT Incorporation for Student Satisfaction and Retention		0.847
2.1.4	Improvement of contact points with students through ICTs		0.617

On the first factor, five indicators are important: 2.1.6, 2.1.9, 2.1.2, 2.1.8, and 2.1.1, while the others do it on the second factor. At this point, there are two options: the first is to use two dimensions with new conceptualizations of each construct, and the second is to eliminate some indicators to force the final solution to be reflected in a single factor.

Without underestimating the first option, work began on option two, managing the variables aimed at obtaining a single factor; for this, some variables of the second factor were discarded, starting with the one with the highest factorial coordinate and so on.

After eliminating the indicators of incorporation of IT for the continuity of studies (2.1.3) and digitization of the student's life cycle (2.1.7), the results shown in Table 12 were obtained.

Table 12. Total variance explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.875	55.355	55.355	3.875	55.355	55.355
2	0.994	14.197	69.551			
3	0.720	10.285	79.836			
4	0.575	8.207	88.043			
5	0.419	5.987	94.030			
6	0.268	3.831	97.862			
7	0.150	2.138	100.000			

When obtaining the solution in a single factor, it is observed that some explained variability is lost, achieving 55.3% of the total variability; however, this proportion is considered "acceptable" since it is greater than 50%. Table 13 shows the final composition of this dimension.

Table 13. Component matrix

No	Indicator	Component
		1
2.1.6	Solving problems for students, with an IT approach	0.880
2.1.2	Accessible services anywhere, anytime	0.817
2.1.9	IT focus on student loyalty and university brand	0.808
2.1.1	Comprehensive approach to the student experience	0.713
2.1.8	Integration student life project-teaching strategy	0.681
2.1.5	IT Incorporation for student satisfaction and retention	0.673
2.1.4	Improvement of contact points with students through ICTs	0.596

In short, there are seven indicators that make up and bear on this factor, with three being the most important: Solving problems for students with an IT approach (0.88); accessible services anywhere, anytime (0.817); and IT focus on student loyalty and university brand (0.808).

2. Teaching-learning processes. This dimension is made up of nine indicators:
   - Academic and pedagogical support with a focus on IT
   - Labor practices and job search with a digital approach
   - Application of ICTs in the teaching-learning process
   - Individualized counseling system
   - Teaching model appropriate to the physical location of the student
   - Use of predictive data to anticipate student needs
   - Incorporation of IT into the student's study rhythm
   - Incorporation of digital teaching strategies in pursuit of family integration
   - Adaptation of the teaching model to the profile of each student

Table 14 show the results of KMO and Bartlett's Test for dimension, teaching-learning processes.

Table 14. KMO and Bartlett's Test – Teaching-learning processes

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.846
Bartlett's Test of Sphericity	Approx. Chi-Square	553.845
	df	36
	Sig.	0.000

The result of the KMO test is 0.846 and the Bartlett's sphericity test is significant (chi-square = 553.845; $p < 0.01$), indicating that the assumptions for applying the factorial analysis are met. The results obtained by component analysis are shown in Table 15.

Table 15. Total variance explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.109	56.768	56.768	5.109	56.768	56.768
2	1.312	14.577	71.345	1.312	14.577	71.345
3	0.816	9.069	80.415			
4	0.456	5.066	85.481			
5	0.372	4.138	89.619			
6	0.324	3.596	93.215			
7	0.244	2.716	95.931			
8	0.194	2.153	98.084			
9	0.172	1.916	100.000			

The solution yields two factors that explain 71.35% of the total variability. This suggests that such indicators are better represented by two dimensions or latent variables.

In a similar way to what happened in the previous dimension, a new dimension can be included in the analysis, but several indicators can also be excluded until obtaining a single dimension. Table 16 shows the structure of each factor.

Table 16. Component matrix

No	Indicator	Component	
		1	2
2.2.6	Use of predictive data to anticipate student needs	0.847	
2.2.7	Incorporation of IT into the student's study rhythm	0.840	
2.2.4	Individualized counseling system	0.821	
2.2.9	Adaptation of the teaching model to the profile of each student	0.820	
2.2.5	Teaching model appropriate to the physical location of the student	0.796	
2.2.3	Application of ICTs in the teaching-learning process	0.641	0.367
2.2.8	Incorporation of digital teaching strategies in pursuit of family integration	0.555	0.506
2.2.1	Academic and pedagogical support with a focus on IT		0.933
2.2.2	Labor practices and job search with a digital approach		0.877

In this case, it is imperative to find the solution with a single factor because in the second factor, only two indicators are significantly loaded, requiring at least three indicators for it to be accepted. Following the previously explained methodology, indicator 2.2.1 was excluded, and the solution was obtained with a single factor, which was what was intended. The results obtained by component analysis are shown in Table 17.

Table 17. Total variance explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.816	60.205	60.205	4.816	60.205	60.205
2	0.864	10.796	71.001			
3	0.759	9.484	80.485			
4	0.451	5.633	86.118			
5	0.365	4.560	90.679			
6	0.319	3.984	94.662			
7	0.233	2.916	97.578			
8	0.194	2.422	100.000			

This factor explains 60.2% of the total variability, which is considered good, although some explained variability is lost with respect to the initial solution; however, all the indicators load on a single factor.

Table 18 shows the composition of the factor, that is, the way in which the variables shape or load it.

Table 18. Component matrix

No	Indicator	Component
		1
2.2.9	Adaptation of the teaching model to the profile of each student	0.861
2.2.6	Use of predictive data to anticipate student needs	0.852
2.2.5	Teaching model appropriate to the physical location of the student	0.819
2.2.4	Individualized counseling system	0.811
2.2.7	Incorporation of IT into the student's study rhythm	0.806
2.1.5	Application of ICTs in the teaching-learning process	0.742
2.2.8	Incorporation of digital teaching strategies in pursuit of family integration	0.717
2.2.2	Labor practices and job search with a digital approach	0.555

Except for the indicator labor practices and job search with a digital approach (2.2.2), all the variables load significantly and are quite similar. The four main indicators that are associated with aspects related to aspects that individualize the teaching process to improve learning, such as the use of data that allows anticipating the needs of the student (2.2.6) or the adaptation of the teaching model to the profile of each student (2.2.9).

3. Economic-administrative processes. This dimension is made up of four indicators:
   - Digitized administrative processes
   - Integration of the student's socioeconomic level with digital teaching strategies
   - Student loyalty strategies with a digital focus
   - Recruitment of potential students through social networks

Table 19 show the results of KMO and Bartlett's Test for this dimension.

Table 19. KMO and Bartlett's Test – Economic-administrative processes

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.729
Bartlett's Test of Sphericity	Approx. Chi-Square	66.001
	df	6
	Sig.	0.000

As can be seen in the table above, both the KMO test (0.729) and the Bartlett's Sphericity test (chi-square = 66.0; p < 0.01) indicate that the data meet the assumptions to apply the factorial analysis, whose results are shown in Table 20.

Table 20. Total variance explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.117	52.929	52.929	2.117	52.929	52.929
2	0.805	20.122	73.051			
3	0.547	13.682	86.734			
4	0.531	13.266	100.000			

The solution provided by the model is one factor, corroborating that the variables are part of the same construct; the factor explains 52.9% of the total variability. To understand the composition of this factor, Table 21 shows how it loads each variable and its magnitude.

Table 21. Component matrix

No	Indicator	Component
		1
2.3.4	Recruitment of potential students through social networks	0.789
2.3.3	Student loyalty strategies with a digital focus	0.780
2.3.2	Integration of the student's socioeconomic level with digital teaching strategies	0.735
2.3.1	Digitized administrative processes	0.587

All the variables load positively and with similar magnitudes, except the indicator, digitized administrative processes (2.3.1), which is less important in the conformation of the factor (0.587).

Phase 3. Integration of technological platforms. This last phase integrates the following dimensions: (1) IT Governance; (2) Competences and capacities, and (3) Management of internal processes. Next, the results for each dimension can be visualized, using the PCA as a means of exploring the underlying relationships in each one of them.

1. IT Governance. This dimension was measured by 12 indicators:
   - Promotion of projects on digital issues
   - Relations with international universities
   - Relations with companies and corporations
   - Automation of teaching services aimed at students
   - Links with the educational community and professors from other universities

- Digital initiatives aligned with corporate strategy
- Relations with communities and social groups
- Positioning through digital platforms
- Identification of points of improvement in digital services
- Analysis of positioning indicators
- Relationships with foundations/NGOs
- Analysis of student perceptions in RRSS

Firstly, it was verified if the assumptions were met to carry out the factorial analysis on the data (Table 22).

Table 22. KMO and Bartlett's Test – IT Governance

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.848
Bartlett's Test of Sphericity	Approx. Chi-Square	944.855
	df	66
	Sig.	0.000

As could be observed in the previous table, the statistical tests indicate that the data meet the conditions to apply the factorial analysis, obtaining a KMO = 0.848 and the Bartlett's Sphericity test being significant (chi-square = 944.855; $p < 0.01$). Table 23 shows the results of applying the component analysis.

Table 23. Total variance explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.339	52.824	52.824	6.339	52.824	52.824
2	1.828	15.237	68.062	1.828	15.237	68.062
3	1.137	9.473	77.535	1.137	9.473	77.535
4	0.673	5.609	83.144			
5	0.568	4.736	87.881			
6	0.412	3.430	91.310			
7	0.319	2.657	93.968			
8	0.197	1.639	95.607			
9	0.175	1.457	97.063			
10	0.163	1.357	98.420			
11	0.116	0.969	99.390			
12	0.073	0.610	100.000			

The solution presents three factors, which collect 77.5% of the total variability (Table 24). As the first factor stands out as being the most relevant because it explains the dimension to a greater degree (52.82%), variables began to be excluded until only one factor was obtained, this being the methodology used for the previous dimensions.

Table 24. Component matrix

No	Indicator	Component		
		1	2	3
3.1.2	Relations with international universities	0.914		
3.1.3	Relations with companies and corporations	0.892		
3.1.5	Links with the educational community and professors from other universities	0.872		
3.1.7	Relations with communities and social groups	0.846	0.325	
3.1.11	Relationships with foundations/NGOs	0.782	0.354	
3.1.4	Automation of teaching services aimed at students	0.513		0.406
3.1.12	Analysis of student perceptions in RRSS		0.871	
3.1.9	Identification of points of improvement in digital services		0.859	
3.1.10	Analysis of positioning indicators		0.823	
3.1.8	Positioning through digital platforms			0.801
3.1.6	Digital initiatives aligned with corporate strategy			0.786
3.1.1	Promotion of projects on digital issues			0.785

On the first factor, six variables are relevantly loaded, mostly associated with relationships and links with other organizations, such as, international universities (3.1.2–0.914), companies and corporations (3.1.3–0.892), educational communities and professors from other universities (3.1.5–0.872), communities and social groups (3.1.7–0.846), and to a lesser extent with foundations/NGOs (3.1.11–0.782).

For the conformation of the second factor, three indicators are important, all related in some way, to analytical functions: analysis of perceptions of students in RRSS (3.1.12–0.871), identification of opportunities for improvement in digital services (3.1.9–0.859), and analysis of positioning indicators (3.1.10–0.823). In the third factor, they also load three variables with a similar magnitude: 3.1.8, 3.1.6, and 3.1.1.

To reduce the number of factors that satisfactorily explain this dimension, variables were excluded from the model. To do this, in principle, dimensions 3.1.8 and 3.1.1 are eliminated, obtaining a two-factor solution explaining 73.9% of the total variability. The underlying structure of these two constructs is shown in Table 25.

Table 25. Component matrix

No	Indicator	Component	
		1	2
3.1.2	Relations with international universities	0.918	
3.1.3	Relations with companies and corporations	0.907	
3.1.5	Links with the educational community and professors from other universities	0.881	
3.1.7	Relations with communities and social groups	0.856	0.314
3.1.11	Relations with foundations/NGOs	0.789	0.362
3.1.4	Automation of teaching services aimed at students	0.516	0.300

(Continued)

Table 25. Component matrix *(Continued)*

No	Indicator	Component	
		1	2
3.1.12	Analysis of student perceptions in RRSS		0.874
3.1.9	Identification of points of improvement in digital services	0.304	0.856
3.1.10	Analysis of positioning indicators	0.306	0.842
3.1.6	Digital initiatives aligned with corporate strategy		0.640

Regarding the first factor, the indicators associated with relationships and links with other organizations are maintained, while variables with connotations in the analysis are loaded in the second factor. Given these circumstances, it would be possible to use two factors or seek that all the variables load in the second factor, requiring this to exclude variables until the desired result is obtained.

Opting for the second form of action, variables 3.1.12, 3.1.9, and 3.1.6 were excluded, obtaining the results shown in Table 26.

Table 26. Total variance explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.789	68.421	68.421	4.789	68.421	68.421
2	0.739	10.551	78.972			
3	0.682	9.736	88.708			
4	0.334	4.776	93.484			
5	0.197	2.810	96.294			
6	0.140	2.001	98.295			
7	0.119	1.705	100.000			

The axis that was obtained as the final solution explains 68.4% of the total variability, which is considered a good proportion. Table 27 shows the structure of the factor.

Table 27. Component matrix

No	Indicator	Component
		1
3.1.5	Links with the educational community and professors from other universities	0.920
3.1.7	Relations with communities and social groups	0.914
3.1.2	Relations with international universities	0.896
3.1.3	Relations with companies and corporations	0.895
3.1.11	Relationships with foundations/NGOs	0.868
3.1.10	Analysis of positioning indicators	0.625
3.1.4	Automation of teaching services aimed at students	0.601

2. Competencies and abilities. This dimension is made up of five indicators:
   - Continuous learning ability
   - Change tolerance
   - Training focused on digital technologies
   - Training in digital pedagogical strategies
   - Promotion of collaborative learning in RRSS

Table 28. KMO and Bartlett's Test – Competencies and abilities

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.806
Bartlett's Test of Sphericity	Approx. Chi-Square	188.013
	df	10
	Sig.	0.000

The results of the statistical tests shown in Table 28 indicate that factorial analysis can be applied to the data, obtaining a value of 0.806 in the KMO test and a significant result in the Bartlett's Sphericity test (chi-squared = 188.013, $p < 0.01$).

After performing the PCA on the data, the results shown in Table 29 were obtained.

Table 29. Total variance explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.961	59.225	59.225	2.961	59.225	59.225
2	0.898	17.959	77.184			
3	0.488	9.762	86.946			
4	0.384	7.684	94.631			
5	0.268	5.369	100.000			

The solution produces a single factor, explaining 59.2% of the total variability. This result validates that all the indicators considered can be considered in a single dimension as a latent variable. This composition, that is, the way in which the indicators load on the factor, can be seen in Table 30.

Table 30. Component matrix

No	Indicator	Component
		1
3.2.3	Training focused on digital technologies	0.920
3.2.1	Continuous learning ability	0.914
3.2.2	Change tolerance	0.896
3.2.4	Training in digital pedagogical strategies	0.895
3.2.5	Promotion of collaborative learning in RRSS	0.601

Except for the indicator, promotion of collaborative learning in social networks, (3.2.5), all the variables have a high contribution to the formation of the factor, above 0.8. The most important indicators were associated with training and learning, specifically, training focused on digital technologies (3.2.3–0.920) and continuous learning ability (3.2.1–0.914).

3. Internal process management. This dimension is the last one to be considered in this model of digital transformation in the university, being made up of four indicators:
   - Decision making incorporating IT
   - Digital technologies in workflows
   - Technologies in back-office optimization of the organization
   - Data-driven decision making

Compliance with the assumptions to perform the factorial analysis is shown in Table 31.

Table 31. KMO and Bartlett's Test – Internal process management

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.715
Bartlett's Test of Sphericity	Approx. Chi-Square	221.136
	df	6
	Sig.	0.000

The PCA yielded the results shown in Table 32.

Table 32. Total variance explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.860	71.502	71.502	2.860	71.502	71.502
2	0.705	17.622	89.124			
3	0.236	5.889	95.013			
4	0.199	4.987	100.000			

As in the previous dimension, all the indicators load on a single factor, explaining a significant proportion of the total variability (71.5%). This result indicates that all the indicators that make up this dimension can be considered as a single construct, validating its theoretical conformation. To delve deeper into the conformation of this factor, Table 33 explores its structure.

Table 33. Component matrix

No	Indicator	Component
		1
3.3.3	Technologies in back-office optimization of the organization	0.878
3.3.1	Decision making incorporating IT	0.850
3.3.2	Digital technologies in workflows	0.831
3.3.4	Data-driven decision making	0.823

In the component matrix, it can be observed that all the variables that make up the internal processes management dimension have a relevant and similar load on the factor; this indicates that in the conceptualization of this construct, all the indicators have the same weight or importance.

4.2 Confirmatory factor analysis

Preliminary considerations. To validate the theoretical model of the digital transformation process of the Autonomous University of Chile, the CFA was used, which aimed to find out if said theoretical model satisfactorily fits the data, thus achieving empirical validation.

Although there is no agreement on the matter, for the CFA it is recommended that the sample size be 10 to 20 cases for each item or variable (Thompson, 2004). Other authors, such as Lloret-Segura et al. [35] point out that the sample size should not be less than 200 cases. In this case, the sample size is 97 cases, a small size. In addition, a dimension was found that only contained two indicators (Financial Resources), when the recommended minimum is three variables or indicators.

To solve this situation, the unweighted least squares (ULS) method was used. This method is recommended when the sample size is small as well as when the dimensions have few variables.

It should be noted that with this method it is not possible to calculate all the indicators associated with the quality of the fit or the t statistics on the significance of the estimated parameters. In principle, it was decided to use the same structure as the proposed model, although the EFA indicates that there are some indicators that are not very relevant in the formation of the factor (latent variable).

To know the goodness of fit, the different indicators calculated using AMOS were examined, which are shown in Table 34.

Table 34. Goodness-of-fit indicators

Indicator	Value
NFI	0.927
GFI	0.933
AGFI	0.927
RMR	0.070

The normed fit index (NFI) measures the proportion of total variability explained by the proposed factorial model but considers the degrees of freedom of the proposed model and the null. This indicator is not sensitive to sample size. It is considered acceptable when the value is greater than 0.90. In the adjustment of the model, the NFI = 0.927, which is higher than 0.90, indicating that the variability explained by the model is acceptable (92.7%).

The goodness-of-fit index (GFI) guides whether the model should be adjusted. The closer it is to zero, the worse the fit, while values greater than 0.90 are good. In the case of the model under analysis, the GFI = 0.933 (GFI > 0.90), which indicates that there is a good fit.

Related to the previous index, the adjusted goodness-of-fit index (AGFI) corrects the tendency of the GFI to increase as the sample is larger, adjusting the value by degrees of freedom. The acceptance criterion is the same as that of the Goodness of Fit Index; that to be acceptable, the values must be greater than 0.90. Table 34 shows that the AGFI = 0.927; maintaining the criterion that the fit to the model is good.

Finally, the root mean squared residual (RMR) is an index based on residuals, which measures the differences between the matrix of variances and covariances of the sample with that of the model estimates. This value must be close to zero to be acceptable. In this case, the RMR = 0.070 is quite close to zero, so the model would be acceptable under the previous criteria.

In short, considering all the indices of the goodness of fit to the model and the proportion of variance explained, it can be stated that there is a good fit of the model, reaching the conclusion that the proposed model fits the data and is empirically validated.

Estimated parameters of the digital transformation model. According to Ruiz (2000), the equations that define the model will be, for the exogenous variables:

$$
\begin{aligned}
x1 &= \lambda 11 \xi 1 + \delta 1 \\
x2 &= \lambda 21 \xi 1 + \delta 2 \\
x3 &= \lambda 31 \xi 1 + \delta 3 \\
x4 &= \lambda 41 \xi 1 + \delta 4 \\
&\cdot \\
xk &= \lambda ks\, \xi s + \delta 4
\end{aligned}
$$

Where:

X_i the observed variables (i = 1, 2, 3, …),

λ_{is} are the weights or structural coefficients of the i-th variable over the latent variable *s*.

ξ_s corresponds to the latent variables (s = 1, 2, 3, …).

δ_i the measurement errors for each observed variable.

For the endogenous variables of the model, the equations are:

$$
\begin{aligned}
y1 &= \lambda 11\ \eta\ 1 + \varepsilon 1 \\
y2 &= \lambda 21\ \eta\ 1 + \varepsilon 2 \\
y3 &= \lambda 31\ \eta\ 1 + \varepsilon 3 \\
y4 &= \lambda 41\ \eta\ 1 + \varepsilon 4. \\
&\cdot \\
&\cdot \\
yk &= \lambda ks\ \eta\ 2 + \varepsilon\ k
\end{aligned}
$$

Where:

y_i the observed variables (i = 1, 2, 3, …),

λ_{is} are the weights or structural coefficients of the i-th variable over the latent variable *s*.

η_s corresponds to the latent variables (s = 1, 2, 3, …)

ε_i are the measurement errors for each observed variable.

Table 35 shows the estimated parameters for each indicator.

Table 35. Estimated parameters (indicators)

Variable	Dimension	Estimated Parameter	Estimated Error
P1.1.1	Strategy and culture	0.781	0.610
P1.1.2		0.775	0.601
P1.1.3		0.663	0.439
P1.2.1	Financial resources	0.872	0.760
P1.2.2		0.955	0.913

(Continued)

Table 35. Estimated parameters (indicators) *(Continued)*

Variable	Dimension	Estimated Parameter	Estimated Error
P1.3.1	Technological base	0.726	0.527
P1.3.2		0.728	0.530
P1.3.3		0.652	0.425
P1.3.4		0.582	0.339
P1.3.5		0.688	0.473
P1.3.6		0.795	0.633
P2.1.1	Focus on the student	0.650	0.422
P2.1.2		0.691	0.478
P2.1.3		0.704	0.495
P2.1.4		0.652	0.425
P2.1.5		0.730	0.533
P2.1.6		0.740	0.548
P2.1.7		0.716	0.513
P2.1.8		0.633	0.401
P2.1.9		0.685	0.470
P2.2.1	Teaching-learning processes	0.708	0.501
P2.2.2		0.705	0.498
P2.2.3		0.744	0.554
P2.2.4		0.723	0.522
P2.2.5		0.697	0.485
P2.2.6		0.693	0.480
P2.2.7		0.700	0.490
P2.2.8		0.731	0.534
P2.2.9		0.685	0.470
P2.3.1	Economic-administrative processes	0.735	0.540
P2.3.2		0.650	0.422
P2.3.3		0.623	0.389
P2.3.4		0.726	0.526
P3.1.1	IT governance	0.735	0.432
P3.1.2		0.650	0.379
P3.1.3		0.623	0.546
P3.1.4		0.726	0.357
P3.1.5		0.657	0.543
P3.1.6		0.616	0.465
P3.1.7		0.739	0.508
P3.1.8		0.597	0.461
P3.1.9		0.737	0.559
P3.1.10		0.682	0.599
P3.1.11		0.713	0.520
P3.1.12		0.679	0.578

(Continued)

Table 35. Estimated parameters (indicators) *(Continued)*

Variable	Dimension	Estimated Parameter	Estimated Error
P3.2.1	Competences and abilities	0.584	0.340
P3.2.2		0.493	0.243
P3.2.3		0.675	0.455
P3.2.4		0.805	0.649
P3.2.5		0.760	0.578
P3.3.1	Internal process management	0.812	0.659
P3.3.2		0.819	0.670
P3.3.3		0.818	0.669
P3.3.4		0.692	0.479

The previous table contains the parameters to estimate the indicators. When analyzing the estimated parameters for each coefficient, it was observed that all of them are of significant magnitude ($\lambda > 0.5$). This observation indicates their substantial contribution to elucidating the corresponding latent variable.

The most relevant coefficients are found in the dimensions of financial resources and management of internal processes. For the first dimension (financial resources), its only two indicators stand out, while in the second dimension (management of internal processes), the three indicators with coefficients greater than 0.80 stand out.

Table 36 shows the parameters used to estimate the values of the nine dimensions, or latent variables, of the model.

Table 36. Estimated parameters (dimensions)

Variable	Estimated Parameter	Estimated Error
Strategy and culture (1.1)	0.887	0.787
Financial resources (1.2)	0.681	0.464
Technological base (1.3)	0.941	0.886
Focus on the student (2.1)	0.998	0.995
Teaching-learning processes (2.2)	0.970	0.941
Economic-administrative processes (2.3)	0.970	0.942
IT governance (3.1)	0.860	0.740
Competences and abilities (3.2)	0.979	0.958
Internal process management (3.3)	0.856	0.733

In the previous table almost all the coefficients of the dimensions are greater than 0.80, the exception being the estimated coefficient associated with the dimension of 'Financial Resources' (0.681), although its magnitude is relevant; In addition, it has the largest estimated error, indicating that its estimate is less precise than the rest of the dimensions ($\varepsilon k = 0.464$).

Figure 1 show the diagram of causal relations of the Digital Transformation Model of the Autonomous University of Chile.

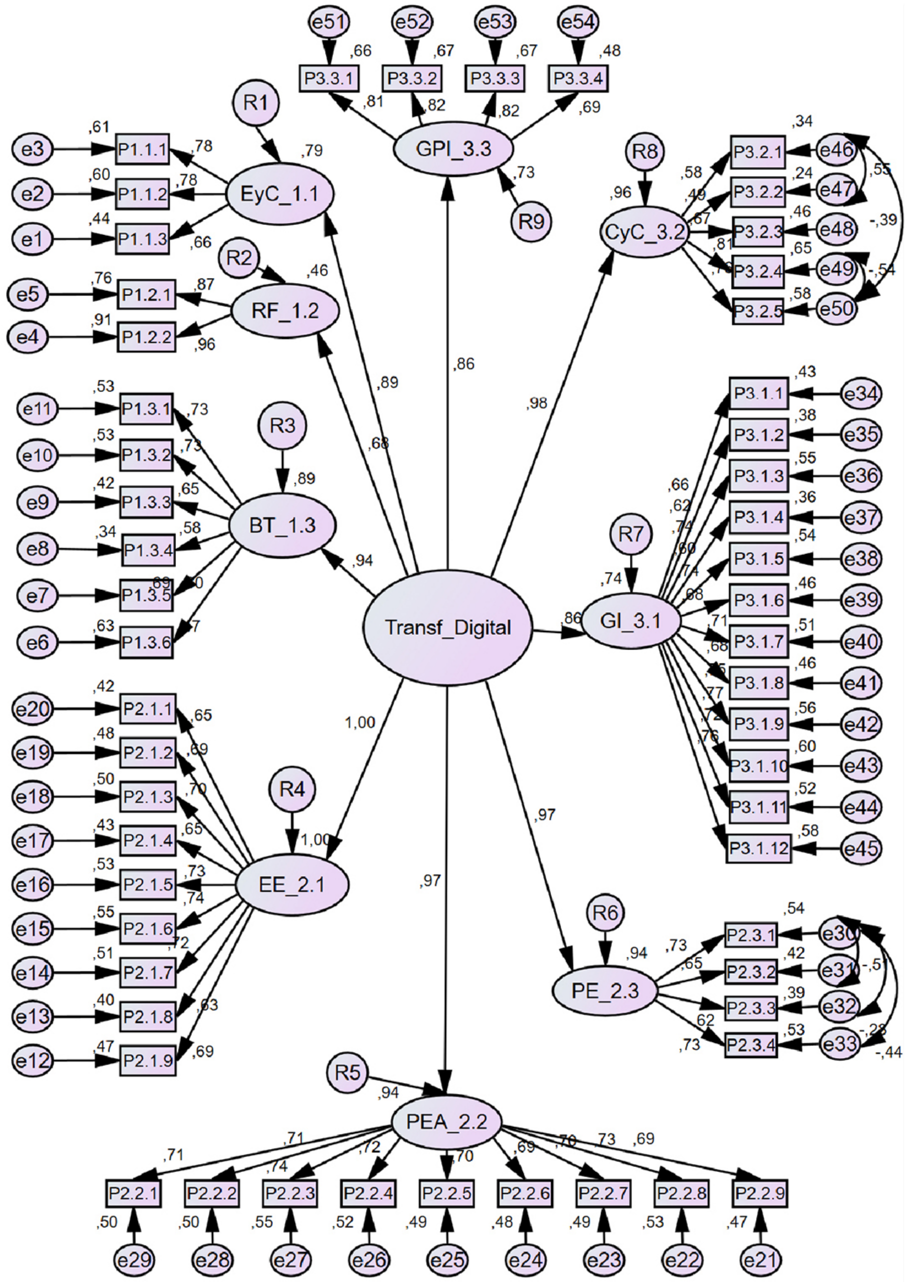

Fig. 1. Diagram of causal relations (with parameters) of the digital transformation model of the Autonomous University of Chile

Notes: EyC: Strategy and Culture; RF: Financial Resources; BT: Technological Base; EE: Student Focus; PEA: Teaching-Learning Processes; PE: Economic-administrative processes; IG: IT Governance; CyC: Competences and Abilities; GPI: Internal Process Management.

5 CONCLUSIONS

The EFA confirms that most of the indicators can be included in a single construct or dimension. In cases where this does not occur, restructuring the composition of the dimension makes it possible for all the indicators to load on a single factor.

The findings found in the EFA were the starting points that served as orientation when respecifying the model through the CFA. In this sense, after carrying out said analysis, it is concluded that all the variables and their corresponding dimensions, nine in total, form a robust construct that explains the phenomenon studied, so the proposed model on the digital transformation process of the Autonomous University of Chile is adequate and intrinsically validated by the data.

The results of the CFA allow us to conclude that "focus on the student" and "skills and abilities" are the two most relevant dimensions in the process of digital transformation at the Autonomous University of Chile. On the other hand, surprisingly, the "financial resources" dimension is the one that contributes the least to this process, although it is necessary to consider that this dimension is the one with the largest estimated error, therefore it is the least precise.

However, in view of the limitations regarding the size of the sample, the model analyzed is not susceptible to generalization since it only constitutes the representation of a reality that is circumscribed to the context in which the data was collected. In this sense, it is recommended to replicate this study using the same theoretical model but increasing the volume of the data to a minimum of 200 cases, while considering that the ideal sample size should contain 10 to 20 cases for each one of the variables or indicators that are analyzed (Thompson, 2004). As the model has 54 indicators, the number of cases should not be less than 540.

On the other hand, to carry out the CFA, it is advisable to increase the number of indicators in the 'Financial Resources' dimension to a minimum of three variables. If the previous recommendations are met, it will be possible to apply other methods in the CFA, such as the maximum likelihood method or the generalized least squares method, which are considered more robust than the unweighted least squares method that was used to carry out this study.

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