Intellectual capital measurement in higher education institutions context from the professors perspective
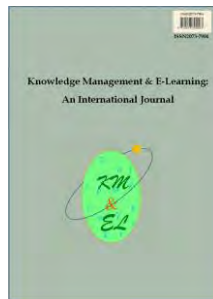
Yuranis Vargas-Atencio
Fundacion Universitaria Tecnologico Comfenalco, Cartagena, Colombia
Julio César Acosta-Prado
Pontificia Universidad Catolica del Peru (PUCP), Lima, Peru
Arnold Alejandro Tafur-Mendoza
Universidad Peruana de Ciencias Aplicadas, Lima, Peru

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Yuranis Vargas-Atencio ⓘ

Faculty of Administrative and Accounting Economic Sciences
Fundacion Universitaria Tecnologico Comfenalco, Cartagena, Colombia
E-mail: yvargas@tecnocomfenalco.edu.co

Julio César Acosta-Prado* ⓘ

Engineering Department
Pontificia Universidad Catolica del Peru (PUCP), Lima, Peru
E-mail: jcacosta@pucp.edu.pe

Arnold Alejandro Tafur-Mendoza ⓘ

Faculty of Psychology
Universidad Peruana de Ciencias Aplicadas, Lima, Peru
E-mail: pcpsataf@upc.edu.pe

*Corresponding author

Abstract: Intellectual capital has aroused growing interest in higher education; however, one area for improvement in its study is how to measure it adequately. Therefore, it is necessary to have instruments based on current models of intellectual capital. This study aims to design and validate an intellectual capital measurement scale in accredited higher education institutions (HEIs) from the perspective of professors. The study was instrumental because a measurement scale was developed. The sample consisted of 341 professors from six accredited HEIs on the Colombian Caribbean Coast. The statistical analysis consisted of three stages: item analysis, collection of validity evidence based on the internal structure and the relationship with other variables, and reliability analysis using the internal consistency method. The scale's internal structure corroborated intellectual capital composition based on human, structural, and relational components. Regarding convergent evidence, all variables possess this source of validity evidence. Reliability levels were also good. Previously, an instrument has yet to be developed those measures intellectual capital in HEIs from the perspective of professors. This study provides a scale that focuses on the characteristics of this stakeholder and is based on an innovative model of intellectual capital composed of human, structural, and relational capital. The theoretical contribution of the study lies in developing a test based on two current models of intellectual capital: the Intellectus model and the Balanced Scorecard model. It also contributes to practice by providing a tool for measuring intellectual capital that allows its adequate management, improvement, and decision-making within higher education.

Keywords: Intellectual capital; Human capital; Structural capital; Relational capital; Measurement scale

Biographical notes: Dr. Yuranis Vargas Atencio is a Full Professor at

Fundacion Universitaria Tecnologico Comfenalco. Her research interests include intellectual capital and digital marketing in the retail sector.

Dr. Julio César Acosta-Prado is a Professor at the Engineering Department at Pontificia Universidad Católica del Perú - PUCP, Lima, Peru. His research interest include strategy, knowledge management, intellectual capital, innovation management, and sustainable development.

Arnold Alejandro Tafur-Mendoza is a Professor Assistant at the School of Psychology at Universidad Peruana de Ciencias Aplicadas. He holds a Bachelor of Psychology from the Universidad Nacional Mayor de San Marcos. His research interests include quantitative methods, applied statistics, and psychometrics.

1. Introduction

There is a growing interest in applying an intellectual capital approach to managing higher education institutions (HEIs), considering that their inputs and outputs are intangible and related to knowledge (Veltri et al., 2014). In this sense, HEIs produce knowledge because of their research, transmitting this new knowledge through teaching with the support of their collaborators (Cong & Pandya, 2003; Punniyamoorthy & Asumptha, 2019). Therefore, developing intellectual capital is one of the main objectives of HEIs, as they are created and financed to build the human capital of the future, stimulate organizational and technological innovation, and manage the different relationships between institutions (Leitner & Warden, 2004). In addition, intellectual capital is considered a performance metric, and a report focused on its results, seeking value creation (Secundo et al., 2018).

As part of their mission, HEIs seek to generate, transmit and innovate knowledge in all its dimensions (Bratianu, 2011). For this reason, they need to be at the forefront of the accelerated and continuous changes in knowledge. In this way, they need to identify strategies that allow them to train human beings as strategic actors for society, where they can play an active role and contribute to forming a culture of service, creating habits, commitments, and knowledge (Brunal Ramos & Vargas Atencio, 2015).

Likewise, these institutions require adequate management mechanisms for professors, administrators, students, and graduates, to guarantee the fulfillment of goals with quality, well-being, and capacity for future projection, following the needs of the region and the nation (Veltri & Puntillo, 2020). One way of achieving this is through the application of intellectual capital, which within HEIs is used to refer to all the non-tangible or non-physical assets of the institution, including its processes, innovation capacity, patents, tacit knowledge of its members, capacities, talents, and skills, as well as the recognition of society or its network of collaborators and contacts (Córcoles, 2012).

HEIs in Colombia have made decisions for change in consideration of local, national, and international scenarios, which are particularly complex and interdependent (Cricelli et al., 2018). These institutions are aware of the need to create the necessary conditions for the consolidation of a high-quality education system, in response to the challenges arising from the processes of modernization and globalization, as well as the intense and growing link between knowledge and the production of goods and services, in convergence with the purposes of the economic, cultural, social, and environmental

development of the country (Consejo Nacional de Acreditación, 2013). Therefore, to provide quality services, HEIs initiate a process of accreditation, which allows them to have a quality certification to recognize the high-performance standards in their internal processes (Consejo Nacional de Acreditación, 2013).

In the case of Colombian HEIs located on the Caribbean Coast, which represents approximately 20% of the country's HEIs, the implementation of intellectual capital has been slow (Atencio, 2020). In the accredited HEIs of the Colombian Caribbean Coast, there is little clarity on the concepts, approaches, and intellectual capital models they apply. Equally important, few studies have been carried out on the measurement of intellectual capital, which has not considered all the conceptual categories that explain it, resulting in the absence of a standardized and validated model that serves for comparison between HEIs and presents homogeneous, reliable, and verifiable information that allows progress to be made in its improvement (Atencio, 2020). In the same sense, have not been evidenced measurement instruments with specific characteristics regarding components, variables, elements, and indicators with statistically validated, allowing them to add value to this interest group.

On the contrary, for evaluating intellectual capital, there are currently batteries of indicators for tangible measurement of their processes to fulfill institutional vision and mission (Brunal Ramos & Vargas Atencio, 2015).

Consequently, there is interest in measuring the intellectual capital of teachers as a contribution to educational quality, considering that they are fundamental actors of human capital, for the fulfillment of the substantive teaching function of HEIs, who, in addition, have the competencies needs and knows the policies and legal regulations that contribute to the integral formation of students.

Given the above, this study aims to design and validate an intellectual capital measurement scale on HEIs from the perspective of professors, which will provide a practical vision of how to identify, measure, and manage this variable within educational institutions. In this way, it seeks to contribute to closing the gap between the current way in which intellectual capital is managed and to move towards a more comprehensive one, which reflects a better performance in human capital, contributing to the increase of structural capital and influencing the relationships of accredited HEIs with different stakeholders such as administrative staff, students, and graduates (relational capital).

The Intellectus and Balanced Scorecard models were used as theoretical perspectives to develop the measurement instrument according to the characteristics of the accredited HIES. From the first model, the dimensions of intellectual capital were taken: human, structural, and relational. Meanwhile, from the second model, we took the way of operationalizing the dimensions of intellectual capital in higher education. In this way, the intellectual capital measurement aligns with the models that present strengths in management and innovation within an HEI.

2. Literature review

2.1. Intellectual capital

Intellectual capital can be considered a possession of knowledge, applied experience, organizational technology, customer relationships, and professional skills that give a firm a competitive advantage in the marketplace (Edvinsson & Malone, 1999). Thus,

intellectual capital is the accumulation of knowledge that creates value or cognitive wealth within an organization, composed of a set of intangible assets or knowledge-based resources and capabilities that, when put into action, according to a given strategy in combination with physical or tangible capital, can produce goods, services and generating competitive advantages or core competencies for the organization (Bueno et al., 2008).

Intellectual capital in the academic context has been used to describe, in an integrated way, all the intangible assets of an institution, including processes, innovation capacity, patents, the tacit knowledge of its members, as well as their skills, talents, and abilities, the recognition of society and their network of collaborations (Ramírez & Gordillo, 2014). In higher education, specifically in HEIs, the elements of intellectual capital can be classified into three: human capital, relating to the intangible value that resides in individual people; structural capital, which involves the resources found in the organization itself; and relational capital, which reflects the intangible resources capable of generating value, linked to the HEI internal and external relationships (Leitner et al., 2014).

In this sense, and as a definition for this study, intellectual capital is considered as the integration of the intangibles of the HEI, based on the human talent that strategically manages the substantive functions of teaching, research, and relations with the environment, supported by the resources and capabilities that allow it to fulfill the mission and achieve the vision, providing value to its stakeholders, achieving its positioning and sustainability in the educational field (Atencio, 2020). Therefore, intellectual capital has an intangible value, is closely related to knowledge, and provides better opportunities for the future success of HEIs (Loyarte et al., 2018).

2.2. Intellectual capital dimensions

2.2.1. Human capital

This capital is the incredible intelligence of the organization's members (Bontis, 1998). It represents the combination of knowledge, skills, innovation, and the capacity of employees. In this way, human capital refers to the knowledge (tacit and explicit) possessed by individuals and teams which is helpful to the entity or used by the organization based on existing explicit or implicit contracts (Bueno, 2003; Seleim et al., 2004). In the HEI context, human capital is the knowledge that resides in people's competencies, which includes the knowledge and experiences of researchers, professors, doctoral students, and technical and administrative staff (Leitner et al., 2014; Rahman et al., 2018).

The elements of human capital considered in this research are knowledge, capabilities and attitudes, and skills. Knowledge is derived from a cognitive characteristic of people, associated with the ability to perform intellectual or manual activities in each context (Edvinsson & Malone, 1999; Nevado & López, 2002; Sullivan, 1999). Capacities refer to the conditions, qualities, and intellectual aptitudes that allow human capital to develop a product, fulfill its functions and perform in a position (López Cabrales & Valle Cabrera, 2008). Finally, attitudes are derived from affective objectives and achieve skills resulting from psychomotor objectives, thereby developing their competencies, visible in their work performance when participating in projects or developing tasks (Bueno et al., 2011).

2.2.2. Structural capital

Structural capital refers to the organization's culture that provides a uniform way of looking at things, establishes the pattern of decision-making, and determines the value system (María Viedma Marti, 2001). In other words, structural capital is the backbone that supports intellectual capital within organizations (Alcaniz et al., 2011; Bueno et al., 2014). The knowledge also remains in the organization at the end of a working day, comprising organizational routines and procedures, systems, culture, and databases (Leitner, 2004; Secundo et al., 2016). At the HEI level, structural capital refers to the resources found in the organization itself, comprising governance principles, research and education routines, procedures, systems, HEI culture, databases, research projects, research infrastructure, publications, and intellectual property of an HEI (Leitner et al., 2014).

The elements of structural capital considered in the study are, on the one hand, organizational capital, which allows intellectual capital to maintain the functioning of HEIs, even if their human capital is not present, enabling decision-making and adding value to them (Secundo et al., 2015). On the other hand, there is technological capital, which considers the intangibles directly linked to the development of the activities and functions of the technical system of the activities carried out in the HEIs (Bueno et al., 2008; Hu et al., 2021).

2.2.3. Relational capital

Relational capital is the value generated by the organization's relationships with customers, suppliers, shareholders, and internal and external stakeholders. In other words, the knowledge is embedded in the organization's relationships. From another perspective, it is the perception of value that customers have when they do business with their suppliers of goods or services (Bontis, 1996; Ordóñez de Pablos, 2003; Stewart, 1997). Thus, relational capital is associated with intangible resources capable of generating value linked to various relationships with its stakeholder, including all activities between academic and non-academic partners. These groups refer to companies, non-profit organizations, public authorities, position and image in networks, the brand, HEI participation in training activities, collaborations with international research centers, networking with professors, international student exchange, international recognition of HEIs, local government, and society in general (Leitner et al., 2014).

Relational capital in teaching staff considers the value for HEIs of relationships with their main agents linked to one of their primary functions, teaching, to improve the knowledge base and achieve objectives (Bueno et al., 2011; Delgado-Verde et al., 2011). Finally, it is necessary to point out that these dimensions of intellectual capital in the HEI environment are not static compartments in which each of them is kept isolated from the others, but, on the contrary, they are constantly interrelated to generate an increase in the value of the HEI and their purpose is to allow the advantage of opportunities over its competitors (Kaplan & Norton, 1996; Ordóñez de Pablos, 2000).

2.3. Intellectual capital models

The development of models for measuring intellectual capital arises from companies and academics who consider that financial measures are insufficient to guide the decision-making process in 21st-century companies (Ramírez et al., 2007). In this sense, there is no single model for measuring and valuing intellectual capital, given that most of the

existing models are related to the corporate strategy of the company and, depending on this, each company establishes the most convenient indicators to measure it (Nevado & López, 2002).

Thus, the measurement model proposed for professors at accredited HEIs on the Colombian Caribbean Coast is based on the Intellectus model and the Balanced Scorecard model, considering the guidelines that facilitate the strategic administration of the set of organizational intangibles, of an intellectual nature, identified and subsequently measured, which is considered a fundamental tool when implementing it in management and decision-making. Likewise, when measuring and managing intellectual capital from the perspective of HEI professors, no instrument in the literature reflects the characteristics of this group of interest.

Among the instruments found in the literature, Pedro et al. (2019) study the intellectual capital of HEIs from a prospective-strategic measurement, presenting a proposal to measure operational intellectual capital. De Frutos-Belizón et al. (2019) developed an instrument to measure intellectual capital in the context of academic research. Bedoya and Parra (2016) sought to measure the level of maturity of knowledge processes in research groups. In addition, Acosta-Prado and Axtle-Ortiz (2017) studied intellectual capital as part of the concern of finding the value of knowledge contributed by an organization's collaborators.

On the other hand, Rojas and Espejo (2020) measured intellectual capital in an HEI, based on the evaluation of the efficiency of investment in scientific research, from the economic resources allocated, considering the human, structural, and relational components. Thus, although studies on intellectual capital are being developed through its different components, to date, there is no model for measuring intellectual capital from the perspective of professors in the HEIs of the Colombian Caribbean Coast. Therefore, it is necessary to have a model of intellectual capital that integrates its components, focuses on the essential competencies that HEIs should possess, aligns with all tangible and intangible resources to achieve more excellent value, manages to measure intellectual capital to benefit the control of the management of intangibles in accredited HEIs.

3. Research method

3.1. Design

The study was instrumental in developing an intellectual capital measurement scale on HEIs from the perspective of professors (Ato et al., 2013). While constructing the instrument, educational and psychological testing standards were followed to obtain valid measures for the proposed uses that substantially benefit test takers and examinees (American Educational Research Association et al., 2014). Additionally, recommendations for good practice in developing and evaluating measures in organizational research were considered (Zickar, 2020).

3.2. Participants

Sampling was non-probabilistic, opinionated, or purposive (Kerlinger & Lee, 2000), using as selection criteria professors from accredited Colombian HEIs belonging to the Colombian Caribbean Coast and of both sexes. Thus, the unit of analysis was the professors. An a priori statistical power analysis was conducted to obtain the sample size

to detect the statistical significance of the factor loadings. In this sense, as input parameters, a one-tailed test, a significance level of 0.05, an effect size (linear correlation coefficient) of 0.20, or a minimum recommended effect size representing practical significance in social science data (Ferguson, 2009). An expected statistical power of 0.80, the minimum recommended in behavioral science (Cohen, 1988), was established. From this analysis, the minimum recommended sample size was 152. However, a larger sample was collected to obtain participants with diverse characteristics.

The final sample consisted of 341 professors from six accredited Colombian HEIs. Table 1 presents the main characteristics of the study sample. Most of the sample was male (54.839%) and had a master's degree (54.839%). Regarding the recruitment type, most professors had an indefinite contract (60.411%). Regarding the professor type, 54.545% taught full-time within the HEI. Most of the teaching experience was between 6 and 10 years (38.123%). On the other hand, considering the classification of the Administrative Department of Science, Technology, and Innovation (Colciencias), 47.507% of the professors were in the "Associate" category. Finally, in the field of research, 92.375% of the sample belonged to a research group, and 91.202% had at least one publication in a scientific journal.

Table 1
Characteristics of the sample ($n = 341$)

Variable	Category	n	%
Gender	Male	187	54.839
	Female	154	45.161
Educational attainment	Undergraduate	5	1.466
	Specialist	82	24.047
	Master	187	54.839
	PhD	65	19.062
	Postdoctoral	2	0.587
Recruitment type	Fixed	135	39.589
	Indefinite	206	60.411
Professors type	Chair/per hour	96	28.152
	Part-time	59	17.302
	Full time	186	54.545
Years of experience	1 to 5	58	17.009
	6 to 10	130	38.123
	11 to 16	92	26.979
	More than 17	61	17.889
Colciencias Category	Junior	105	30.792
	Associate	162	47.507
	Senior	40	11.730
	None	34	9.971
Member of a research group	Yes	315	92.375
	No	26	7.625
Publication in scientific journals	Yes	311	91.202
	No	30	8.798

3.3. Instrument

The scale measures intellectual capital in accredited HEIs from the perspective of professors, responding comprehensively and specifically to their needs. To construct the instrument, a rigorous development process was followed, which involved an extensive review of the literature on intellectual capital for the elaboration of the items, based mainly on the internal logic proposed by the updated Intellectus Model and Balanced Scorecard Model, adapted to the functional characteristics of HEIs and particularly of accredited HEIs. This way, the set of intangible assets that make up intellectual capital was highlighted, from the components of human, structural, and relational capital, followed by the subcomponents and measurement indicators that structure it.

The measurement of intellectual capital sought to identify the capacities and skills that enable the achievement of the strategic objectives of accredited HEIs from the perspective of professors. Therefore, the items of the instrument covered the planning and control of teaching activities, the development of teaching support tools, innovation in teaching practices (Hu et al., 2021), the interaction between professors and students, institutional tools available for teaching, encouragement for the acquisition of new knowledge, professor motivation, and job satisfaction.

Constructing the measurement scale followed a systematic sequence that started with the literature review, the model formulation, and the items' drafting. Subsequently, two procedures were followed, the evaluation by a group of experts and a pilot study. About the expert group, to obtain an assessment of the content of the developed instrument, validity evidence based on test content was collected. For this purpose, a group of five experts, specialists in the construction of instruments, and the study of intellectual capital within HEIs, both at a theoretical and methodological level, was formed. The judges were contacted via e-mail, where an evaluation form for the instrument was attached along with a brief contextualization of the study. In this way, qualitative feedback was obtained, which allowed for the modification and improvement of the items of the measurement scale.

On the other hand, for the pilot study, the corrected version was applied to 34 professors to test the clarity of the items, the detection of errors, ambiguities, and deficiencies, and the understanding of the instructions. The application was carried out via e-mail, where the instrument was shared in Google Forms, which also contained the informed consent authorizing the professor's participation in the pilot study. Finally, after incorporating all the necessary modifications based on the evaluation of the group of experts and the pilot study, the final version of the measurement scale was drafted for application in the study sample. The measurement scale consisted of 66 items (Appendix I, Table A1). Regarding its three components, human capital was measured by 22 items, structural capital by 24 items, and relational capital by 20 items. The instrument has a Likert format with five response options (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree).

The instrument was divided into four sections. The first section requested information on the relevant characteristics of the respondents to describe the study sample. The second section measured human capital, focusing on identifying three sub-components, attitudes and skills, knowledge, and abilities, which enable the achievement of HEI objectives with the collaboration of professors. The third section measured structural capital based on two sub-components, organizational capital (HEI principles, structure, organizational learning, and internal processes) and technological capital (intangibles linked to the development of activities and functions of the HEIs technical

system). Finally, the fourth section evaluated the relational capital, where the relationship between the HEI and the professors for generating value in the organization is observed.

3.4. Procedure

The instrument was applied physically and virtually. For the physical application, the six selected accredited HEIs were contacted directly by the professors available to answer the measurement scale. The average duration of the physical application was 25 minutes. After the evaluation, the data were transferred to a Microsoft Excel spreadsheet. As for the virtual application, the scale was applied through Google Forms and sent to the professor's addresses. In this form of evaluation, the database was generated automatically. In both application modalities, before the presentation of the instrument items, the professors had to agree with the informed consent, where the purpose of the study was explained, the characteristics of the evaluation, and the confidentiality and anonymity of their answers were guaranteed. Informed consent was obtained from all individual participants included in this study. All procedures performed in studies involving human participants followed the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

3.5. Statistical analysis

The statistical analysis of the data followed a three-stage workflow. In the first stage, a descriptive analysis of the items was carried out using statistics such as mean, standard deviation, range, skewness, and kurtosis. Regarding the latest statistics, coefficients between -2.00 and 2.00 were considered unproblematic. Likewise, at this stage, the degree of discrimination of the items was estimated through the item-rest Pearson product-moment correlation. These coefficients were considered adequate when the values were above 0.30 (Meyer, 2014).

In the second stage, validity evidence was collected based on two sources: internal structure and the relationship with other variables. Exploratory factor analysis (EFA) was used for validity evidence based on internal structure. The model parameters estimation method was Unweighted Least Squares (ULS) on a matrix of Pearson correlations. Before the EFA, the adequacy of the data was evaluated using the Kaiser-Meyer-Olkin (KMO) test, expecting values above 0.70, and Bartlett's test of sphericity, expecting a statistically significant result ($p < 0.05$). Parallel analysis was used to select the number of factors, and Oblimin oblique rotation was used as the rotation method. As for factor loadings, those greater than 0.40 were considered good (Ferrando et al., 2022; Lloret-Segura et al., 2014). Regarding the validity of evidence based on the relationship with other variables, convergent evidence was collected through the average variance explained (AVE), with values above 0.50 considered adequate (Moral, 2019).

Finally, in the third stage, the reliability of the scores was analyzed through the internal consistency method, using the omega coefficient due to the multidimensionality of the scale (Viladrich et al., 2017). Values above 0.70 were considered adequate (Nunnally & Bernstein, 1994). Additionally, to better understand the reliability of the scores, inter-item polychoric correlations were estimated, reporting the minimum and maximum values (range), mean, and standard deviation (Ventura-León & Peña-Calero, 2020).

Statistical analyses were performed in the free software environment R version 4.1.0 (R Core Team, 2021) via the integrated development environment RStudio version

1.4.1106 (RStudio Team, 2021). The packages used for the data analysis flow were: pacman version 0.5.1 (Rinker & Kurkiewicz, 2018), lavaan version 0.6-8 (Rosseel, 2012), tidyverse version 1.3.1 (Wickham et al., 2019), psych version 2.1.3 (Revelle, 2021), semTools version 0.5-4 (Jorgensen et al., 2021), CTT version 2.3.3 (Willse, 2018) and pwr version 1.3-0 (Champely, 2020).

4. Results

4.1. Item analysis

The item analysis results show that the response alternative "strongly disagree" was not used in several items, including in item REL_28. In addition to the before response option, the alternative "disagree" was not used either, indicating a greater predisposition of the sample towards the higher response options. Accordingly, the average of all items was higher than 4 (between 4.012 and 4.663), and the variability of responses was low (between 0.537 and 1.019). Regarding the shape of the responses' distribution, the items' skewness presented negative values (between -1.844 and -0.450), although greater than -2.00. On the other hand, 42.42% of the items showed high levels of kurtosis (above 2.00), ranging from -0.663 to 5.459. Finally, the item-rest correlation of the items showed values above 0.30, ranging from 0.388 (item HUM_16) to 0.847 (item STR_49). According to the results, no items were eliminated at this stage (Table 2).

Table 2
Descriptive statistics and item-rest correlation of the items

Item	Range	Mean	Standard Deviation	Skew	Kurtosis	Item-rest correlation
HUM_01	1–5	4.460	0.643	-1.175	2.326	0.682
HUM_02	2–5	4.428	0.641	-0.870	0.599	0.616
HUM_03	2–5	4.340	0.756	-1.138	1.182	0.554
HUM_04	2–5	4.431	0.568	-0.450	-0.195	0.685
HUM_05	1–5	4.399	0.659	-1.007	1.742	0.576
HUM_06	2–5	4.437	0.613	-0.827	0.810	0.647
HUM_07	2–5	4.490	0.640	-1.137	1.339	0.736
HUM_08	2–5	4.504	0.631	-1.174	1.523	0.710
HUM_09	1–5	4.370	0.754	-1.132	1.203	0.737
HUM_10	2–5	4.364	0.688	-0.828	0.327	0.830
HUM_11	2–5	4.469	0.625	-0.892	0.442	0.830
HUM_12	2–5	4.478	0.611	-0.956	1.017	0.530
HUM_13	1–5	4.425	0.689	-1.427	3.502	0.514
HUM_14	1–5	4.413	0.683	-1.342	3.268	0.592
HUM_15	1–5	4.411	0.661	-1.285	3.115	0.466
HUM_16	1–5	4.296	1.019	-1.844	3.197	0.388
HUM_17	1–5	4.419	0.795	-1.695	3.401	0.472
HUM_18	1–5	4.393	0.828	-1.577	2.618	0.661
HUM_19	1–5	4.276	0.930	-1.532	2.360	0.615
HUM_20	1–5	4.466	0.802	-1.645	2.632	0.645
HUM_21	1–5	4.455	0.798	-1.583	2.456	0.632
HUM_22	1–5	4.337	0.837	-1.476	2.473	0.681
REL_23	1–5	4.434	0.637	-1.288	3.481	0.676
REL_24	2–5	4.449	0.619	-0.954	1.277	0.646

REL_25	1–5	4.396	0.719	-1.317	2.362	0.745
REL_26	1–5	4.387	0.717	-1.390	2.806	0.818
REL_27	2–5	4.293	0.772	-0.974	0.600	0.813
REL_28	3–5	4.381	0.629	-0.503	-0.663	0.808
REL_29	2–5	4.452	0.656	-0.973	0.605	0.679
REL_30	1–5	4.282	0.795	-1.208	1.746	0.733
REL_31	1–5	4.235	0.890	-1.323	1.791	0.767
REL_32	1–5	4.188	0.812	-0.978	1.042	0.694
REL_33	1–5	4.364	0.828	-1.502	2.585	0.822
REL_34	1–5	4.372	0.743	-1.404	2.819	0.841
REL_35	1–5	4.416	0.721	-1.372	2.442	0.766
REL_36	1–5	4.267	0.872	-1.257	1.652	0.746
REL_37	1–5	4.012	0.955	-0.812	0.123	0.765
REL_38	1–5	4.018	0.927	-0.919	0.617	0.723
REL_39	1–5	4.085	0.813	-0.779	0.643	0.696
REL_40	1–5	4.311	0.780	-1.119	1.225	0.793
REL_41	2–5	4.243	0.741	-0.766	0.293	0.758
REL_42	1–5	4.340	0.809	-1.255	1.375	0.799
REL_43	1–5	4.326	0.657	-0.890	1.809	0.727
REL_44	1–5	4.393	0.667	-1.117	2.231	0.782
REL_45	1–5	4.334	0.719	-1.112	2.047	0.755
REL_46	2–5	4.323	0.716	-0.752	-0.027	0.758
STR_47	1–5	4.419	0.688	-1.194	2.010	0.748
STR_48	1–5	4.446	0.771	-1.525	2.743	0.750
STR_49	1–5	4.449	0.724	-1.512	3.110	0.847
STR_50	1–5	4.370	0.702	-1.059	1.534	0.768
STR_51	1–5	4.364	0.745	-1.292	2.316	0.780
STR_52	1–5	4.331	0.774	-1.214	1.786	0.750
STR_53	1–5	4.378	0.752	-1.281	2.082	0.762
STR_54	1–5	4.284	0.792	-1.079	1.253	0.728
STR_55	1–5	4.443	0.724	-1.402	2.591	0.792
STR_56	1–5	4.158	0.929	-1.151	1.350	0.692
STR_57	1–5	4.155	0.950	-1.113	0.994	0.666
STR_58	2–5	4.387	0.679	-0.879	0.481	0.662
STR_59	2–5	4.419	0.684	-0.864	-0.015	0.743
STR_60	1–5	4.490	0.662	-1.233	1.875	0.726
STR_61	2–5	4.496	0.649	-1.110	0.907	0.785
STR_62	2–5	4.529	0.640	-1.155	0.788	0.752
STR_63	2–5	4.587	0.586	-1.169	0.803	0.815
STR_64	1–5	4.601	0.558	-1.417	3.932	0.733
STR_65	1–5	4.522	0.658	-1.534	3.346	0.704
STR_66	1–5	4.663	0.537	-1.748	5.459	0.749

4.2. Validity evidence based on the internal structure

Five EFAs were carried out, eliminating items based on three criteria: factor loadings lower than 0.40, a difference of factor loadings in two factors greater than 0.10, and items that did not have theoretical coherence with their factor. In the first EFA, items HUM_01, HUM_02, HUM_03, HUM_04, HUM_06, HUM_09, and HUM_11, were eliminated for having factor loadings below 0.40, as well as items HUM_22, REL_38, REL_40, REL_41, and REL_42 for having a difference of factor loadings greater than 0.10 in two different factors. In the second EFA, item HUM_10 was eliminated for having a factor

loading below 0.40. As for the third EFA, item REL_39 was eliminated because it presented a difference greater than 0.10 between the factor loadings in two different factors and items HUM_05, HUM_07, and HUM_08 because they did not show theoretical coherence with their factor. In the fourth EFA, the following items with lower factor loadings were eliminated to have an equal number of items per factor: REL_29, REL_31, REL_33, REL_36, REL_37, REL_37, STR_47, STR_48, STR_49, STR_50, STR_56, STR_57, STR_58, STR_59, STR_61, and STR_63.

Finally, the fifth EFA presented good item sampling adequacy (KMO = 0.91) and a statistically significant Bartlett's test of sphericity (χ^2 = 7010.36, df = 435, $p < 0.001$). The parallel analysis recommended the extraction of three factors that together explained 52% of the total variance of the items. Each factor comprised ten items with factor loadings above 0.40 in all cases (between 0.471 and 0.847). In addition, moderate correlations were observed between the factors: relational and structural capital ($r = 0.37$), structural and human capital ($r = 0.40$), relational and human capital ($r = 0.48$). Table 3 presents the results of the fifth EFA.

Table 3
Factor loadings of the intellectual capital measurement scale

Item	Factor 1 Relational capital	Factor 2 Structural capital	Factor 3 Human capital	Communality
REL_24	0.847	-0.223	0.104	0.645
REL_23	0.795	-0.176	0.115	0.595
REL_26	0.783	0.067	0.028	0.686
REL_27	0.755	0.127	-0.013	0.668
REL_25	0.739	0.105	-0.043	0.606
REL_28	0.647	0.216	-0.023	0.584
REL_34	0.632	0.261	-0.053	0.591
REL_30	0.617	0.093	0.121	0.522
REL_32	0.568	0.299	-0.136	0.502
REL_35	0.561	0.180	0.056	0.478
STR_54	-0.092	0.824	0.097	0.683
STR_53	-0.021	0.794	0.060	0.656
STR_55	-0.022	0.732	0.104	0.592
STR_52	0.065	0.730	0.028	0.601
STR_51	0.058	0.706	0.066	0.586
STR_65	0.177	0.690	-0.177	0.533
STR_66	0.059	0.626	0.046	0.458
STR_60	0.104	0.582	0.057	0.442
STR_64	0.037	0.580	0.129	0.439
STR_62	0.147	0.547	0.051	0.429
HUM_17	-0.125	0.053	0.744	0.528
HUM_15	-0.119	0.080	0.678	0.456
HUM_18	0.061	0.130	0.652	0.552
HUM_14	0.087	0.088	0.612	0.480
HUM_16	-0.034	0.016	0.587	0.339
HUM_13	0.176	-0.068	0.576	0.399
HUM_19	0.085	0.125	0.566	0.446
HUM_20	0.178	0.072	0.533	0.434
HUM_21	0.283	-0.028	0.501	0.418
HUM_12	0.212	-0.059	0.471	0.310

Note. Factor loadings greater than 0.40 are shown in bold

4.3. Validity evidence based on relations to other variables

Regarding convergent evidence, structural and relational capital showed an AVE above 0.50 (Table 4). Likewise, human capital showed an acceptable level (AVE = 0.421), considering the number of items (n = 10), the average factor loadings (0.694), and a reliability coefficient above 0.80 (ω = 0.875). This shows that the variables included in the intellectual capital model possess this source of validity evidence.

Table 4
Inter-item correlation, convergent evidence, and reliability

Variable	n	Inter-item correlation			AVE	ω	95% CI
		Range	M	SD			
Human capital	10	0.233–0.703	0.413	0.100	0.421	0.875	0.845–0.898
Structural capital	10	0.364–0.816	0.531	0.123	0.561	0.922	0.905–0.935
Relational capital	10	0.388–0.840	0.562	0.090	0.564	0.927	0.908–0.943

Note. n = Number of Items; M = Mean; SD = Standard Deviation; AVE = Average Variance Extracted; ω = Omega Coefficient; CI = Confidence Interval

4.4. Reliability

From Table 4, for all the variables in the model, reliability levels were good (ω > 0.80). Likewise, the inter-item correlations were high, in all cases above 0.40, and with low variability of the correlation coefficients. This leads to the conclusion that the scores on the scale measuring intellectual capital in accredited HEIs from the perspective of professors were reliable.

5. Discussion and conclusions

The objective of this study was to design and validate an intellectual capital measurement scale on HEIs from the perspective of professors. One of the main contributions of this research has been to propose an internal structure for the construction of intellectual capital in accredited HEIs. Based on the contributions provided by the studies reviewed, the model for measuring intellectual capital was proposed, with the management of the triad comprised of human, structural, and relational capital. Human capital includes the knowledge that resides in people's competencies. On the other hand, structural capital refers to the resources found in the HEI. Finally, relational capital is associated with intangible resources that generate value linked to various stakeholder relationships. The denotes the theoretical contribution of the study, which provides empirical evidence for a model of intellectual capital based on the Intellectus Model and Balanced Scorecard Model.

In this research, an instrument has been developed in a Likert scale format with five response options, considering the limitation of not having widely validated measurement scales in the literature mainly oriented to the group under study (professors). In this sense, future efforts should be developed within higher education to verify that the proposed measures generally apply to other HEIs contexts at postgraduate, specialization, or diploma levels. Furthermore, measuring intellectual capital should include other perspectives, such as administrative staff, students, or graduates, who perceive knowledge management in HEIs differently.

To develop the measurement scale, it was considered that the instrument meets the criteria of robustness, which allowed the psychometric qualities of the scale to be confirmed, assessing the validity (evidence based on internal structure and relationship with other variables) and reliability (internal consistency) of the scores. The instrument also met the comprehensibility criterion, relating to how the construct was assessed and interpreted, which was confirmed by a qualitative phase where expert opinion was extracted. Finally, the usefulness criterion allowed the conceptualization of the proposed intellectual capital model from the professors' perspective and the tool considered relevant for managing this stakeholder (Claes et al., 2010).

A battery of indicators was used to measure, monitor, compare, and improve the intellectual capital of accredited HEIs from the professors' point of view, providing relevant information for decision-making. In this way, the developed scale can be used by information managers within the HEIs, who are responsible for improving the internal processes of these institutions. Furthermore, this instrument is of practical use for the academic quality departments of the different HEIs that seek to provide a better service to students through their teaching staff. This is reflected in a benefit for society. Therefore, the practical contribution of the study lies in providing a tool with good psychometric properties of current relevance for measuring intellectual capital in the HEI context.

Finally, about the limitations of the research, one of the aspects is its cross-sectional nature, which was limited to an evaluation of the six accredited HEIs in a single period. In this sense, it is necessary to develop studies over more periods, i.e., a longitudinal evaluation that would allow us to assess the stability of the model over time and its efficiency in detecting changes in intellectual capital when HEIs implement improvement policies. Also, because the psychometric properties of any measurement instrument are related to the scores obtained, and these may vary in different groups, it is necessary to analyze them in HEIs with other characteristics located in different areas of Colombia to corroborate more generalized usefulness.

The impact of the research at a theoretical level lies in developing an instrument for measuring intellectual capital based on the Intellectus model and Balanced Scorecard Model, innovative models with a high degree of organizational efficiency that has allowed the study variable to be correctly operationalized. Thus, we have a solid test at a theoretical level. On the other hand, the impact at a practical level is found in the possibility of adequately measuring intellectual capital from the teacher's point of view, who is sought to be much more involved within the educational institution, assuming a more significant role in the decisions taken internally and externally. Therefore, the instrument developed helps to measure intellectual capital and manage and improve it within HEIs.

Author Statement

The authors declare that there is no conflict of interest.

ORCID

Yuranis Vargas Atencio 🔘 https://orcid.org/0000-0003-2843-7899

Julio César Acosta-Prado 🔘 https://orcid.org/0000-0002-7920-9602

Arnold Alejandro Tafur-Mendoza 🔘 https://orcid.org/0000-0001-8331-1098

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Appendix I

Table A1
Intellectual capital measurement scale

Code	Item
HUM_01	The HEI fosters an appropriate working environment that allows for the motivation of the staff involved.
HUM_02	You are satisfied with your activities versus your contribution.
HUM_03	You are satisfied with the activities you perform versus your compensation.
HUM_04	Their contribution to achieving organizational objectives enables them to fulfill their professional expectations.
HUM_05	At the HEI, there is empathy in the working relationship of its teaching staff.
HUM_06	The HEI informs you of your duties during the academic period.
HUM_07	The HEI follows up on academic planning.
HUM_08	The HEI evaluates academic planning.
HUM_09	The HEI provides professional training for professors for further qualification.
HUM_10	The HEI provides professional training for professors to contextualize in the classroom.
HUM_11	The HEI supports the professional training of professors for further qualification.
HUM_12	In your academic activities, you use information and communication technologies as pedagogical tools to develop your classes.
HUM_13	In your teaching practice, you apply different teaching strategies.
HUM_14	You use the results of your research in developing your classes to generate new knowledge.
HUM_15	In your teaching practice, you apply the knowledge acquired in the scientific events you participate in (as a speaker or assistant).
HUM_16	You advise/direct undergraduate or postgraduate research work in your teaching practice.
HUM_17	In your teaching practice, you evaluate undergraduate or postgraduate research work.
HUM_18	As part of your research work, you work interdisciplinary with other researchers at the HEI.
HUM_19	As part of your research work, you work interdisciplinary with other researchers from other HEIs.
HUM_20	Receives incentives for research publications.
HUM_21	The HEI remunerates its teaching staff following its statute (teaching scale).
HUM_22	The HEI supports the academic mobility of its teaching staff.
REL_23	Knows the HEIs mission, vision, and principles that guide the life of the HEI.
REL_24	It shares the HEIs mission, vision, and principles that guide the life of the HEI.
REL_25	It has the physical resources to carry out its teaching activities.
REL_26	For the development of its teaching activity, it has technological resources.

REL_27	It has the financial resources to carry out its teaching activities.
REL_28	There is a psychosocial working environment for effective performance in their teaching practice.
REL_29	Knows the organizational structure of the HEI.
REL_30	Knows the procedures for working together with other internal and external areas.
REL_31	The HEI provides spaces to stimulate creative and innovative ideas within their pedagogical practices.
REL_32	The HEI has a process for administering and managing documentation that facilitates its teaching work.
REL_33	The HEI invests in the acquisition of technology to develop teaching activities.
REL_34	The HEI has digital resources for the development of teaching and research activities.
REL_35	The HEI has an intellectual property policy to protect the development of teaching and research activities.
REL_36	The HEI has a policy that allows professors to develop prototypes.
REL_37	The HEI has a policy that allows professors to design brands.
REL_38	The HEI has a policy that allows professors to develop brands.
REL_39	The HEI has a policy that allows faculty members to obtain a brand registration.
REL_40	The HEI has a collaborative research policy.
REL_41	The HEI has a selective process to capture internal and external information for decision-making.
REL_42	The HEI has databases to select the data you need quickly.
REL_43	The HEI has links with researchers to increase knowledge.
REL_44	The HEI has links with external research groups that allow it to increase knowledge.
REL_45	The HEI has links with external research centers that allow it to increase knowledge.
REL_46	The HEI has links with technological development centers that allow it to increase knowledge.
STR_47	In professor-HEI relations, the sense of belonging is strengthened.
STR_48	The HEI attracts professors who are distinguished by their performance.
STR_49	The HEI retains professors who distinguish themselves by their performance.
STR_50	The HEI develops policies that favor internal communication with its teaching staff.
STR_51	The HEI supports you in interacting with national research networks.
STR_52	The HEI supports you in interacting with international research networks.
STR_53	The HEI supports you in interacting with national academic networks.
STR_54	The HEI supports you in interacting with international academic networks.
STR_55	The HEI promotes the services that institutional welfare offers to professors.
STR_56	The HEI keeps track of the annual rate of teachers' complaints.
STR_57	The HEI keeps track of the annual rate of teachers' claims.
STR_58	The HEI has relations with public institutions.

STR_59	The HEI has relations with trade unions and private institutions.
STR_60	The HEI promotes and carries out social responsibility actions.
STR_61	The HEIs partnerships with other HEIs are strong.
STR_62	The HEIs partnerships with the external sector are strong.
STR_63	The professional quality of professors is recognized in the environment in which they work.
STR_64	The HEI is renowned for its research products (projects, articles, books, technical reports, prototypes, etc.).
STR_65	The HEI has a reputation for its innovative products.
STR_66	The HEI has a reputation for its professors.

Note. Items from the final version of the measurement scale are shown in bold