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Qualities and attributes of Mexican researchers, according to the vitae researcher development framework

Cualidades y atributos de los investigadores mexicanos, de acuerdo con el marco de desarrollo de investigadores vitae

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Abstract

Different models for researcher development have been reported worldwide, but a country like Mexico has not yet adopted a model, possibly due to the lack of quantitative evaluation of Mexican researchers determining their current situation. The purpose of this study is to ascertain if there is a correlation between the domains defined by the Vitae model and the level of researchers in the Mexican National System of Researchers (SNI) and to determine if the Vitae model is applicable in Mexico for cultivating world-class researchers. The results of an online survey conducted among 276 researchers affiliated with the National System of Researchers and working at Mexican universities and research centers were analyzed using a robust multivariable analysis methodology. The proposed multivariable model confirms the low correlation between the 63 skills proposed by Vitae for a world-class researcher and the SNI level of researchers in Mexico."

JEL Code: I21, I23, I28
Keywords: researcher qualities; development framework; researchers

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Resumen

Se han reportado diferentes modelos para el desarrollo de investigadores en todo el mundo, pero un país como México no ha adoptado un modelo, quizás por la falta de una evaluación cuantitativa de los investigadores mexicanos que determinan su situación actual. El propósito de este estudio es determinar si existe una correlación entre los dominios definidos por el modelo Vitae y el nivel de los investigadores mexicanos en el Sistema Nacional de Investigadores y determinar si el modelo Vitae es aplicable en México para desarrollar investigadores de clase mundial. Los resultados de una encuesta realizada en línea a 276 investigadores pertenecientes al Sistema Nacional de Investigadores y que trabajan para universidades y centros de investigación mexicanos, se analizaron mediante una robusta metodología de análisis multivariable; el modelo propuesto multivariable confirma la baja correlación entre las 63 habilidades propuestas para un investigador de clase mundial propuestas por Vitae el modelo Vitae y el nivel SNI de los investigadores en México.

Código JEL: I21, I23, I28
Palabras clave: cualidades de investigadores; marco de desarrollo; investigadores

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Introduction

The ongoing societal transformation over recent decades defines the historical and social context, presenting challenges and opportunities for public universities as knowledge-producing institutions and developers of human resources for research (Henríquez, 2018). The changes evident in contemporary society are numerous and varied, each carrying significant implications. Among the most prominent are the globalization of economies and the scientific-technological revolution, which are impacting all aspects and spheres of society (Echeverría and Martínez, 2018).

The globalization of national economies is contributing to the consolidation of a new economic development model that demands systematic technical progress and innovation in production systems to achieve the levels of competitiveness required by the modern world (Ramos and Hynes, 2019). Consequently, knowledge has become the catalyst for change, productivity, innovation, and development, evolving into the most valuable product of the modern era. Knowledge has brought forth new social relationships and power structures rooted in its production, distribution, and utilization.

The current context is defined as the transition towards a knowledge society, where science and technology, along with the generation, distribution, appropriation, and utilization of knowledge, play a strategic role in the future development of individuals and contemporary society (Gómez and Pesántez, 2016).

In this context, researchers play a pivotal role in driving productive and technological development, harnessing the benefits of science, technology, and innovation for societal progress and improvement. In Mexico, to date, the development of highly qualified science and technology resources generally involves obtaining a master's degree in science and then a doctorate either domestically or abroad (Grediaga, 2017). These graduate studies primarily take place in federal public universities such as the National Autonomous University of Mexico (UNAM), the National Polytechnic Institute (IPN), the University of Guadalajara (UDG), and the Metropolitan Autonomous University (UAM), as well as in other public and private universities and technological institutes. Doctoral programs constitute the focal point of these researcher development processes, with few attempts to develop them in the private sector within production and business sectors. In countries like Mexico, it is understandable that researchers and their work are largely conditioned by the capacities of the institutions where they studied and where they provide their professional services. Hence, the development of researchers is based on institutional normative conditions and national scientific policies for financing their development, which are associated with the national economic model (Perez-Reveles, Topete-Salazar, and Rodríguez-Salazar, 2014). Nevertheless, this model needs to be replaced with a more conceptually clear and coherent analytical framework (Perez-Reveles et al., 2014).

Current Mexican policies regarding researcher development appear to focus on a single control variable, namely the provision and monitoring of scholarships. The policy discourse seems disconnected from the researcher development process. In the country, current policies on researcher development and doctoral education place greater emphasis on the product and less on the process (Dash, 2015). Consequently, obtaining the degree is considered the completion of the thesis (research), largely ignoring the process through which this thesis is produced and the development of researchers (Saadi, Collins, and Dash, 2018). In the Mexican context, where there is little discussion about researcher development issues, such a transformation of learning becomes not only desirable but also necessary. To create transformative learning opportunities, we must encourage critical evaluation by researchers and those involved in the training process; to understand what it means to develop as a researcher and the processes involved in it. Doctoral education is one of the many paths to researcher development, which in turn is part of the broader theme of research development.

The Researcher Development Framework (RDF) was developed from empirical data generated by an analysis of semi-structured interviews with researchers from Manchester University and Glasgow Caledonian University. The interview data from the two institutional projects were combined to ensure a sufficiently representative sample with comprehensive coverage of researchers' diverse activities. In total, 81 interviews were conducted with researchers encompassing a wide range of experiences, institutions, disciplines, and demographics (Vitae, 2011a).

Most interviews were conducted with experienced researchers at various stages of their careers. They were asked to identify the characteristics of excellent researchers and underperformers at different career stages, as well as to envision the attributes that researchers will require in the future. Through transcription and analysis of the interviews using a phenomenographic study, over 1,000 characteristics of excellent researchers and their variants were identified. The characteristics identified through interviews were reviewed and grouped where commonalities were found, resulting in a set of descriptors. These descriptors were structured into four domains and twelve subdomains.

Initial research into the literature on the subject identified relevant skills, attributes, and competencies of a researcher based on research definitions and the role of researchers. A second review focused on the analysis of existing competency frameworks in academic literature, as well as relevant examples of frameworks for researchers and related occupations. All of this research was used in conjunction with surveys to structure and shape the RDF (Vitae, 2011a).

The RDF was designed as a tool for researchers and other individuals involved in researchers' personal and professional development (Research Center Directors, Research Group Coordinators, public research policy developers, university rectors, etc.). The RDF is designed to be used in various ways, with its use determined by the researchers themselves and their managers, trainers, and advisors. However, the RDF was primarily designed with the specific intention of being useful for researchers planning their own personal or professional development within the research career.

In the context of a knowledge-based learning economy, researchers in universities and research centers are among the world's most specialized professionals. This specialization makes professional development indispensable for researchers and complex for the supporting institution (Irvine and Billot, 2016). To effectively carry out their work, researchers need to continuously acquire and update a set of general and discipline-specific skills required to conduct, disseminate, and manage research in highly specialized areas. Simultaneously, governments worldwide are increasingly focused on assessing researcher quality and linking government funding allocations to research quality and outcomes (Browning, Thompson, and Dawson, 2014; Dash, 2015; Saadi et al., 2018). Different countries have implemented initiatives to promote research excellence (Excellence Initiatives in France, the Excellenz Initiative in Germany, and the U.S. government's Star Metrics initiative), designed to measure the impact of research on innovation, competitiveness, and science (Browning et al., 2014; Dash, 2015). Consequently, universities are increasingly focusing their efforts on building research capacity, quality, and competencies.

Universities in middle-income countries face challenges in developing individuals' research competencies within the context of a nascent or emerging research culture (Perez-Reveles et al., 2014). Particularly, researchers in such universities may need more than just technical research skills (Vitae, 2011c). To be competitive, universities need to build their research capacity to attract, promote, and retain the best and brightest researchers (Bhakta and Boeren, 2016). In this environment, assessing the knowledge, behavior, skills, and attributes of national researchers is crucial to implement training and support programs for both new and experienced researchers (Irvine and Billot, 2016). This information is also relevant to national research policy makers.

Over the past decade, a series of landmark initiatives have demonstrated the need for comprehensive changes in policy and practice regarding researcher development opportunities and support (Briggs, 2015). However, most research and publications on researcher development have originated in a small number of countries, including the United Kingdom, the United States, Japan, China, Canada, South Africa, and Australia (Browning et al., 2014). Publications on researcher development show two main strands in current knowledge: a) empirical studies (mostly) and b) those addressing theoretical and conceptual issues in the field (Gutiérrez, 2014). The empirical research base heavily relies on doctoral education studies and their focus on doctoral research experiences. However, a conceptual framework and coherent analytical framework remain absent. Studies have not established key researcher development concepts, and methodological approaches have tended to vary due to a lack of a conceptual framework. In comparison to empirical research, theoretical and conceptual research is much less established (Evans, 2014).

Many social and environmental factors shape non-cognitive and non-behavioral researcher development, such as institutional climate, resources, peer and mentor networks, and field of study, among others (Browning et al., 2014). However, self-assessment of researchers using a common questionnaire is relevant to determine current qualities and attributes of researchers worldwide and differences with researchers in other countries.

In a knowledge-based learning economy, researchers must plan and manage their careers, including regular participation in continuous education (Bhakta and Boeren, 2016). The challenges researchers face are demanding, requiring them to thrive in a highly competitive global environment, where working under pressure towards high standards is the norm (Saidin and Yaacob, 2016). Therefore, policy makers need quantitative insights into where researchers stand to implement improvement policies and create a critical mass of world-class researchers.

The study presented in this document aligns with the discourse of the competitive knowledge-based economy, where continuous assessment, support, and training are necessary to maintain the professionalism of Mexican researchers. The document is presented in the following sections: introduction and literature review or theoretical framework, objectives, methodological aspects, results and discussion, conclusions, and study limitations.

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Objective of the study

The objective of this study is twofold: to investigate the correlation between the domains defined by the Vitae model and the proficiency level of Mexican researchers within the National System of Researchers (Sistema Nacional de Investigadores, SNI), and to assess the applicability of the Vitae model in Mexico for the development of researchers capable of achieving world-class standards.

This research seeks to contribute to the understanding of the proficiency level of Mexican researchers within the SNI when compared to researchers recognized as world-class, utilizing the RDF domains established in the United Kingdom. The subsequent sections discuss the research methodology employed, present the survey results in comparison to researchers in the United Kingdom, and conclude with the study's findings and limitations.

Methodological aspects

This research follows a deductive approach and utilizes the Vitae RDF as the foundation for constructing the questionnaire. While the RDF was initially developed using a graphical approach through focus groups and semi-structured interviews with researchers—an inductive form of reasoning—this study adopts a deductive approach often aligned with positivism and employed through quantitative methodologies.

Given that the RDF is an existing framework, the research aims to identify development gaps between Mexican researchers within the SNI and world-class researchers. The specific research question guiding this study is: "According to Mexican researchers, what are the disparities in terms of knowledge, skills, behaviors, and attributes when compared to the descriptors identified in the Vitae Researcher Development Framework?"

The research design is quantitative in nature, and data collection adheres to the methodology proposed by Cadena-Iñiguez et al. (2017). The survey consists of two main sections: a) personal information and b) Vitae descriptors. The Vitae descriptors section comprises 63 questions based on the 12 subdomains and 4 major domains delineated by Vitae. Each question stems from a descriptor; descriptors are listed for each domain, and participants are prompted to indicate the degree of disparity for each descriptor based on their ongoing professional development.

The Researcher Development Framework (RDF) is a leading approach to fostering world-class researchers (Vitae, 2011b). It provides a professional development framework for planning, promoting, and supporting researchers' personal and professional growth within Higher Education Institutions and Research Centers in the United Kingdom. By amalgamating successful researchers' knowledge, behaviors, and attributes, the framework empowers researchers to assess and plan their professional advancement. It delineates essential qualities and attributes for succeeding as a researcher in academia, encompassing expert researchers' knowledge, behaviors, skills, and attributes (Kneale, Edwards-Jones, Walkington, & Hill, 2016). The framework comprises four major domains, 12 subdomains, and 63 descriptors (Bhakta & Boeren, 2016). The four major domains are as follows:

Domain A: "Knowledge and intellectual skills," subdivided into subdomains: A1 Knowledge base, A2 Cognitive skills, and A3 Creativity. Seventeen descriptors evaluate this domain.

Domain B: "Personal effectiveness," further divided into subdomains: B1 Professional and career development, B2 Self-management, and B3 Personal qualities. Sixteen descriptors assess this domain.

Domain C: "Research governance and organization," split into three subdomains: C1 Professional behavior, C2 Research management, and C3 Funding and resources. Thirteen descriptors gauge this domain.

Domain D: "Engagement, influence, and impact," comprising three subdomains: D1 Working with others, D2 Communication and dissemination, and D3 Engagement and impact. Seventeen descriptors measure this domain.

The RDF, in terms of structure and design, remains neutral, giving precedence only to the researcher's perspective. In the UK, the RDF planner has successfully contributed to improving researchers' career development in Higher Education Institutions (Bray & Boon, 2011).

The research instrument's questions were formulated based on previous studies (Bhakta & Boeren, 2016; Cadena-Iñiguez et al., 2017). Researchers received and returned the questionnaire via email. The internal reliability of each Vitae RDF domain (measured through Cronbach's Alpha, a metric indicating internal consistency) was calculated to assess whether the gaps in constituent descriptors are consistently measured within a domain (Maese-Núñez, Alvarad-Iniesta, Valles-Rosales, & Báez-López, 2016). Cronbach's Alphas for domains A, B, C, and D were 0.915, 0.906, 0.876, and 0.906, respectively. Given that all Cronbach's Alphas exceed 0.8, the descriptors within each domain are reliable measures for evaluating the significance of gaps in that domain.

The target population for this study consisted of the 28,633 researchers in the SNI during 2019. The sample size was determined considering a 5% margin of error, a 95% confidence level, and a heterogeneity of 20%, resulting in a theoretical sample size of 244 researchers (Otzen & Manterola, 2017).

Statistical techniques employed in this research encompassed: a) Reliability tests of the measurement instrument using Cronbach's Alpha for internal consistency, b) Pearson's correlation coefficient and coefficient of determination, c) Multiple linear regression analysis, and d) Tukey's test, executed using SPSS version 24.0.

Cronbach's Alpha is derived from the covariance between scale items, the total variance of the scale, and the number of scale items. The formula for calculating Cronbach's Alpha utilizing variances is as follows

$$\alpha = \frac{K}{K-1}\left(\frac{\sum_{i=1}^{K}\sigma^2\ Y_i}{\sigma^2\ X}\right)$$

(1)

Where:

K = Number of items in the scale

$\sigma^2 Y$i = Variance of item i

$\sigma^2 X$ = Variance of the observed scores of the individuals

The following expression defines Pearson's correlation coefficient:

$$r_{xy} = \frac{\sum Z_x\, Z_y}{N}$$

(2)

Pearson's correlation coefficient refers to the mean of the cross-products of the standardized scores of X and Y. This formula has some properties that make it preferable to others. As it operates with standardized scores, it is a scale-free measurement index. On the other hand, its value oscillates between 0 and 1 in absolute terms.

Model approach and estimation

The multiple regression model is as follows:

$$Y_i = \beta_0 + \sum_{k=1}^{N}\beta_k\, x_{ki} + u_i$$

(3)

$$y_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \cdots + \beta_K x_{Ki} + u_i$$

(4)

Where $x_1, x_2, \ldots x_k$ are the independent or explanatory variables. The response variable depends on the explanatory variables and an error component that is normally distributed:

$$u_i = N(0, \sigma^2)$$

(5)

The maximum likelihood or least squares methods perform the model fit. In the case of normal distribution of errors, both methods coincide.

The value that the estimated model predicts for the i-th observation is:

$$y_i = \widehat{\beta_0} + \widehat{\beta_1} x_{1i} + \widehat{\beta_2} x_{2i} + \cdots + \widehat{\beta_K} x_{Ki}$$

(6)

and the error made in that prediction is:

$$e_i = y_i - \hat{y_i} = y_i - (\widehat{\beta_0} + \widehat{\beta_1} x_{1i} + \widehat{\beta_2} x_{2i} + \cdots + \widehat{\beta_K} x_{Ki})$$

(7)

Where $\widehat{\beta_0}$, $\widehat{\beta_1}$, $\widehat{\beta_2}$,…, $\widehat{\beta_K}$ are the estimated values of the model. The least squares criterion assigns to these estimated parameters k the value that minimizes the sum of squared errors of all observations.

Tukey's test determines that individual means significantly differ from a set of means. Tukey's test is a multiple comparison test applicable when comparing more than two means. It is generally used after an analysis of variance has shown that a significant difference exists and determines where the difference exists. A pairwise comparison of all means calculates Tukey's test. The significant difference is shown when the pairwise difference between two means exceeds the value calculated as:

$$HSD = q\sqrt{\frac{MS}{n}}$$

(8)

Where MS is the mean square value calculated in the ANOVA, n is the number of samples in each group, and q is determined from the range distribution table under study.

The questionnaire constructed for the study was designed to represent the RDF (Researcher Development Framework) domains. A linear scale model was used, as it is traditionally considered the best for assessing attitudes (Matas, 2018). Among the various linear scaling models, the Likert scale was used because it meets the condition of homogeneity or unidirectionality. The dependent variable was the SNI Level, disaggregated into four levels (candidate, I, II, and III). The independent variables considered are as follows: Domain A, "Knowledge and Intellectual Skills," measured using 17 items and a 5-point Likert scale ranging from 1 (very low) to 5 (maximum), which was adopted from Kerlinger and Lee (2008); Domain B: "Personal Effectiveness," measured using 16 items with the same 5-point Likert scale as Domain A; Domain C: "Research Governance and Organization," measured using 13 items with the same scale, and Domain D: "Commitment, Influence, and Impact," measured using 17 items and the same 5-point Likert scale.

The questionnaire was sent via email between May and July 2019 to 1,600 SNI researchers in the country's main universities and research centers. Each researcher was asked to select the options that best described their opinions regarding the presented questions. A total of 279 completed questionnaires were received via email; of these, three were discarded due to incompleteness. Therefore, they considered 276 completed questionnaires, representing a response rate of 17.4% for complete responses to the questionnaires sent (Liu and Nick, 2016).

Results and discussion

In the sample of respondents who met the inclusion criteria for this study, the distribution of age groups showed that the largest group (32.6 percent) fell within the 56 to 65 years old range, followed by 24 percent between 66 and 75 years old, 21 percent between 46 and 55 years old, 13.1 percent between 36 and 45 years old, 7.9 percent over 76 years old, and only 1.4 percent between 25 and 35 years old. In terms of gender representation, women researchers accounted for 28 percent of the sample, while men constituted 72 percent.

Regarding areas of specialization, the breakdown was as follows: 22.2 percent in "Biotechnology and Agricultural Sciences," 16.6 percent in Biology and Chemistry, 16 percent in Engineering, 15.2 percent in Physics, Mathematics, and Earth Sciences, 10.8 percent in Social Sciences, 9.8 percent in Humanities and Behavioral Sciences, and the remaining group (9.4 percent) in Medicine and Health Sciences.

The questionnaire comprised 63 questions, each corresponding to individual descriptors within the 12 RDF subdomains, and these questions were used to evaluate the four separate domains.

Through statistical analysis using the SPSS program, a coefficient of r=0.967 was obtained, indicating a high level of reliability for the instrument. This suggests that the questionnaire consistently measures what it is intended to measure, demonstrating its internal consistency (Table 1).

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Table 1
Calculation of Cronbach's alpha coefficient
Reliability statistics

Cronbach's alpha	Cronbach's alpha based on typified items	No. of elements	No. of valid cases	% of valid cases	No. of excluded cases (a)
.967	.970	63	276	100	0

(a) Elimination by list based on all the variables in the procedure
Source: created by the authors

To justify the number of items included in the questionnaire, the internal consistency method of Cronbach's Alpha was applied. When considering the removal of items, it was found that eliminating any item did not have a significant impact on the reliability of the instrument. Therefore, no items were removed.

A correlation analysis was conducted, which included the calculation of the coefficient of determination for the variables Domain A, Domain B, Domain C, Domain D, and SNI Level. The following results were obtained, as shown in Tables 2 and 3.

Table 2
Pearson's correlation coefficients (r) of the following variables

		Domain A	Domain B	Domain C	Domain D	VAR00065
Domain A	Pearson correlation	1	.783(**)	.659(**)	.700(**)	.286(**)
	Sig. (bilateral)		.000	.000	.000	.000
	N	276	275	276	276	276
Domain B	Pearson correlation	.783(**)	1	.752(**)	.812(**)	.344(**)
	Sig. (bilateral)	.000		.000	.000	.000
	N	275	275	275	275	275
Domain C	Pearson correlation	.659(**)	.752(**)	1	.724(**)	.190(**)
	Sig. (bilateral)	.000	.000		.000	.002
	N	276	275	276	276	276
Domain D	Pearson correlation	.700(**)	.812(**)	.724(**)	1	.320(**)
	Sig. (bilateral)	.000	.000	.000		.000
	N	276	275	276	276	276
VAR00065	Pearson correlation	.286(**)	.344(**)	.190(**)	.320(**)	1
	Sig. (bilateral)	.000	.000	.000	.000	
	N	276	275	276	276	276

** Correlation is significant at the 0.01 level (bilateral)
Source: created by the authors

Table 3
Coefficients of determination (r^2)

	Domain A	Domain B	Domain C	Domain D	SNI level
Domain A	1	0.613	0.434	0.490	0.081
Domain B	0.613	1	0.565	0.659	0.118
Domain C	0.434	0.565	1	0.524	0.036
Domain D	0.490	0.659	0.524	1	0.102
SNI level	0.081	0.118	0.036	0.102	1

Source: created by the authors

Based on the aforementioned data, the correlation scheme of the variables was formulated, resulting in the model depicted in Figure 1.

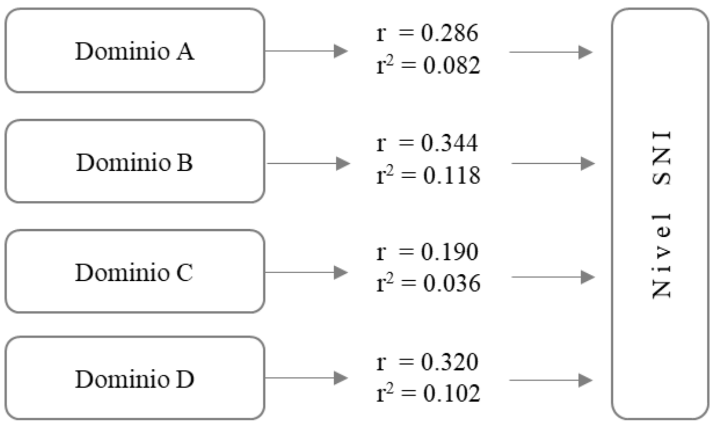

Figure 1. Model depicting the correlation between variables.
Source: Author's own work.

Considering the aforementioned, the results reveal the following: Domains A, B, C, and D exhibited correlation coefficients of 0.286, 0.344, 0.190, and 0.320, respectively, indicating a low yet statistically significant correlation with researchers' SNI levels. According to the determination coefficients, 8.2% of the variation in SNI Level is explained by variability in Domain A, 11.8% by variability in Domain B, 3.6% by variability in Domain C, and 10.2% by variability in Domain D. It is noteworthy that the correlation and determination coefficients were consistently high across all four domains, demonstrating the congruence of the Vitae RDF model.

Subsequently, a linear regression analysis was conducted to investigate whether these factors collectively impact the SNI level. Multiple linear regression analysis was employed to estimate the effect of various independent variables on the dependent variable. In the theoretical model, the dependent variable is the SNI level, and the explanatory variables introduced are Domains A, B, C, and D."

$$SNI\ LEVEL = \beta_0 + \beta_1\ Domain\ A\ + \beta_2\ Domain\ B + \beta_3\ Domain\ C + \beta_4\ Domain\ D +\ € \quad (9)$$

β_0 = constant of regression line

$\beta_1 ... \beta_4$ = parameters of the partial coefficients of variation for each of the independent variables

€= random error or residual of the regression line

Table 4
Individual test of regression coefficients competitiveness

		Unstandardized coefficients		Standardized coefficients		
Model		B	Standard error.	Beta	t	Sig.
1	(Constant)	-.867	.476		-1.820	.070
	Domain A	.006	.010	0.56	.650	.546
	Domain B	.035	.013	.310	2.611	.010
	Domain C	-.029	.012	-.212	-2.3521	.019
	Domain D	.018	.010	.184	1.806	.072

Source: created by the authors

"The SNI level, without considering the influence of the remaining explanatory variables (assuming they are all zero), is approximately -0.867 units. An increase of one unit in Domain A results in a SNI level increase of approximately 0.006 units. An increase of one unit in Domain B leads to a SNI level increase of 0.035 units, an increase of one unit in Domain C results in a decrease of 0.029 units in the SNI level, and an increase of one unit in Domain D leads to a SNI level increase of 0.018 units.

The critical t-statistic value reported in the literature for α=0.05 with 63 degrees of freedom is 1.6694. Given that the calculated t-statistics for Domain A, C, and D are less than 1.6694, it is concluded that they are not statistically significant. Meanwhile, the calculated t-statistic for Domain B is 2.611, which is greater than 1.6694, indicating that the result is statistically significant.

Table 5
Joint test SNI level regression coefficients

Model		Sum of squares	gl	Root mean square	F	Sig.
1	Regression	33.503	4	8.376	11.109	.000(a)
	Residual	203.574	270	.754		
	Total	237.076	274			

a Predictor Variable: (Constant), Domain D, Domain A, Domain C, Domain B
b Dependent variable: VAR00065
Source: created by the authors

Through Analysis of Variance (ANOVA), the Fisher's F-statistic is calculated. The obtained F-statistic value indicates that the model is globally significant. The value of 11.109 needs to be compared with the tabulated value for an F-distribution with 4 degrees of freedom in the numerator (K – 1) and 63 degrees of freedom in the denominator (N - K) at $\alpha=0.05$, which is 2.525. As evident, the obtained value is significantly greater than the tabulated value, leading us to accept the alternative hypothesis of global significance of the proposed model. This result can also be confirmed through the interpretation of the p-value, which is $0.000 < 0.05$, further supporting the global significance of the model. In other words, as a whole, all independent variables have an effect on the SNI level.

Table 6
Quality test SNI level adjustment

Model	R	R square	R square corrected	Standard error of estimation
1	.376(a)	.141	.129	.86832

a Predictor Variable: (Constant), Domain D, Domain A, Domain C, Domain B
Source: created by the authors

The R-squared (R2) indicates that the variables included in the model collectively explain 14.1% of the variability in the SNI level. However, the explanatory power of the adjusted R-squared (R2 adjusted) for the model is only 12.9%, which can be considered somewhat limited. The linear regression analysis reveals that Domain A, 'Knowledge and Intellectual Skills,' Domain C, 'Research Governance and Organization,' and Domain D, 'Commitment, Influence, and Impact,' exhibit weak correlations with researchers' SNI levels in Mexico. Only Domain B, 'Personal Effectiveness,' demonstrates a weak correlation with the SNI level.

Table 7 displays the means for each RDF domain in the researcher's assessment.

Table 7
Means per RDF domain of the evaluation of the researcher, according to their SNI level (mean ± SD of all the elements per domain)

	Number of researchers (276)	DOMAIN			
		A	B	C	D
SNI C	19	3.86 ± 0.75^{a}	3.76 ± 0.89^{a}	3.89 ± 1.04^{a}	3.65 ± 0.93^{a}
SNI I	128	4.01 ± 0.49^{a}	4.22 ± 0.48^{b}	4.26 ± 0.44^{b}	4.13 ± 0.52^{b}
SNI II	61	4.18 ± 0.46^{ab}	4.41 ± 0.37^{bc}	4.33 ± 0.44^{b}	4.25 ± 0.45^{bc}
SNI III	68	4.33 ± 0.46^{b}	4.51 ± 0.42^{c}	4.39 ± 0.48^{b}	4.43 ± 0.41^{c}

^{abc} Different letters in the same column show a significant difference between values according to Tukey's test ($p < 0.05$)
Source: created by the authors

Significant differences were observed in the means of the four RDF domains between SNI level

C researchers (candidate researchers) and SNI I, II, and III researchers (Table 7). The mean response values for the four domains among the 19 SNI C investigators ranged from 3.65 ± 0.93 to 3.89 ± 1.04. Considering that the highest possible RDF value is 5, these values for SNI C researchers would place them at a level between 73% and 78% of a world-class researcher. The mean responses for the 128 SNI I researchers ranged from 4.01 ± 0.49 to 4.26 ± 0.44, which would represent between 80% and 85% of world-class researchers. Similarly, the 62 SNI II researchers considered themselves to be between 84% and 88% of world-class researchers, and the 68 SNI III researchers considered themselves to be between 87% and 90%.

Comparing the self-evaluations of Mexican SNI C researchers presented in Table 7 with the evaluations of young researchers on the RDF website (Vitae, 2011b), significant differences are evident. For example, a young researcher at the Centre for Cancer and Cell Biology Research at Queen's University Belfast had an average self-assessment score of 2.0 for Domain A and 1.8 for Domain D, while Mexican SNI C researchers had average scores of 3.86 for Domain A and 3.65 for Domain D. Similarly, a researcher with one year of experience at the Sustainable Consumption Institute for Climate Change Modeling at the University of Manchester (Vitae, 2011b) had an average self-assessment score of 2.2 for Domain B and 1.5 for Domain D, which are considerably lower compared to the averages of Mexican SNI C researchers (3.76 and 3.65, respectively). These differences in self-evaluations may suggest that Mexican researchers are better prepared than their British counterparts or that they have a tendency to overestimate their abilities. Given that the RDF serves as a strategic framework defining the knowledge, behaviors, and attributes of effective and highly qualified researchers, relevant for various career paths, and represents a novel approach to cultivating world-class researchers by motivating them to strive for excellence through higher-level development, the finding that Mexican researchers self-assess themselves significantly higher than British researchers is noteworthy.

These findings have substantial implications in different countries, as evidenced in India (Dash, 2015). In India, the quality of doctoral research has become a subject of debate, with some educators and academics pointing out the emergence of low-quality doctorates in certain universities. There are no standardized regulations across universities regarding Ph.D. admission requirements, and the current academic system allows even inadequately prepared candidates to enroll in doctoral programs at many institutions. Due to significant variations in rules and regulations among universities, it is challenging to monitor research quality and researchers across institutions. Therefore, an organized system like the RDF could prove valuable in creating a globally comparable measurement scale and assessing the actual level of researchers.

Table 8 displays the mean responses of the 276 Mexican researchers categorized by age range.

Table 8
Means per RDF domain of the researcher's evaluation, according to age range (mean ± SD of all items per domain)

Age range (years)	Number of researchers (276)	DOMAIN			
		A	B	C	D
25-35	4	3.48 ± 0.94[a]	3.46 ± 1.34[a]	3.50 ± 1.00[a]	3.34 ± 1.14[a]
36-45	36	4.04 ± 0.46[b]	4.23 ± 0.49[b]	4.21 ± 0.45[b]	4.09 ± 0.53[b]
46-55	58	4.06 ± 0.55[b]	4.19 ± 0.55[b]	4.24 ± 0.51[b]	4.10 ± 0.59[b]
56-65	90	4.16 ± 0.49[b]	4.38 ± 0.47[c]	4.34 ± 0.54[b]	4.27 ± 0.53[b]
66-75	66	4.18 ± 0.52[b]	4.39 ± 0.46[c]	4.32 ± 0.50[b]	4.28 ± 0.51[b]
75 and over	22	4.14 ± 0.50[b]	4.32 ± 0.42[bc]	4.33 ± 0.49[b]	4.24 ± 0.39[b]

[abc] Different letters in the same column show a significant difference between values according to Tukey's test ($p < 0.05$)
Source: created by the authors

Table 8 shows significant differences between domains A, C, and D between the 25-35 age range and the other age ranges. No significant differences were found in researchers' responses in domains A, C, and D between the age ranges 36-45, 46-55, 56-65, 66-75, and over 75. These results coincide with those reported by Gonzalez-Brambila and Veloso (2007) for Mexican researchers, who found a quadratic relation between the age of researchers and publications per year; researchers are productive in terms of publication between 30 and 79 years old, reaching a maximum at 53 years old. SNI researchers at age 65 are as productive as those aged 43 and more than when they finished their Ph.D. This result is consistent not only for publication counts but also for citations.

The mean number of responses of the 276 Mexican researchers according to area of work is shown in Table 9.

Table 9
Means per RDF domain of the evaluation of the researcher, according to his/her area in the SNI (mean ± SD of all the elements per domain)

SNI area	Number of researchers (276)	DOMAIN			
		A	B	C	D
Physics, Mathematics and Earth Sciences	42	4.06 ± 0.44[acdfg]	4.20 ± 0.51[acef]	4.06 ± 0.62[agh]	4.02 ± 0.59[ad]
Biology and Chemistry	46	4.09 ± 0.47[acdfg]	4.31 ± 0.52[acdef]	4.37 ± 0.43[bcdefgh]	4.25 ± 0.46[acd]
Medicine and Health Sciences	26	4.17 ± 0.40[acdfg]	4.41 ± 0.42[acdef]	4.45 ± 0.37[bcdefg]	4.34 ± 0.41[acd]
Humanities and Behavioral Sciences	27	4.29 ± 0.52[acdeg]	4.42 ± 0.44[acdef]	4.39 ± 0.46[bcdefgh]	4.30 ± 0.47[acd]

Social Sciences	30	4.38 ± 4.40[bcde]	4.50 ± 0.38[bcd]	4.42 ± 0.46[bcdefg]	4.29 ± 0.48[acd]
Biotechnology and Agricultural Sciences	61	4.00 ± 0.65[acf]	4.22 ± 0.62[acef]	4.26 ± 0.59[acdefgh]	4.18 ± 0.67[bcd]
Engineering	44	4.03 ± 0.51[acfg]	4.22 ± 0.48[acef]	4.18 ± 0.50[acegh]	4.11 ± 0.55[bcd]

[abcdefgh] Different letters in the same column show a significant difference between values according to Tukey's test ($p < 0.05$)
Source: created by the authors

There were significant differences between the responses according to the SNI areas. The most important differences were found in the four RDF domains, between the areas of Humanities and Behavior, Social and Economics (social sciences), and the other areas (exact sciences). The average responses of social science researchers were significantly higher than exact science researchers. These results agree with those found by Gonzalez-Brambila and Veloso (2007), who reported significant differences between areas of knowledge, not only in publications and citations but also in the life cycle of productive work. They suggest that the nature of knowledge and the scientific process are different in all areas. In areas such as the exact sciences, Physics, Mathematics and Earth Sciences, Biology and Chemistry, Medicine and Health, Biotechnology and Agriculture, and Engineering and Industrial Sciences, knowledge can be universal, causing research results to be published more frequently and disseminated more widely than in other areas such as the social sciences and humanities.

The means by RDF domain of the researcher evaluation by gender are presented in Table 10.

Table 10
Means per RDF domain of researcher evaluation by gender (mean ± SD of all items per domain)

	Number of researchers (276)	DOMAIN			
		A	B	C	D
Female	77	4.04 ± 0.52[a]	4.25 ± 0.46[a]	4.33 ± 0.55[a]	4.11 ± 0.52[a]
Male	199	4.14 ± 0.52[a]	4.32 ± 0.53[a]	4.27 ± 0.51 [a]	4.23 ± 0.56[a]

[abc] Different letters in the same column show a significant difference between values according to Tukey's test ($p < 0.05$)
Source: created by the authors

It is noteworthy that no significant gender differences were found in the responses of Mexican researchers across the four RDF domains. These results align with those reported by Gonzalez-Brambila and Veloso (2007), who found that there was not a significant gender difference in scientific production in their sample. However, our findings contrast with those of Reynolds et al. (2018), who concluded that reviewed support processes, such as gender-neutral young investigator programs, are also an essential first step in correcting persistent gender inequalities and supporting both men and women in successful research careers. These differences could be explained by the sample; our study included both young and experienced researchers, while Reynolds' study focused solely on young researchers.

The results of this research are of great significance because they quantitatively establish the descriptors in which Mexican researchers perceive their strengths and weaknesses. Additionally, the findings highlight that there is a significant difference in self-assessment between SNI level C researchers compared to SNI I, II, and III researchers. It is notable that there is an overestimation in self-assessment across all SNI levels compared to researchers in the United Kingdom. Furthermore, significant differences were found within the age group of 25-35 years compared to other age ranges, and there were significant differences between SNI areas, while no differences were found based on gender.

Conclusions

This study has revealed the low correlation that exists between the SNI level of researchers in Mexico and the 63 skills proposed for a world-class researcher by Vitae. This underscores the need for internationally recognized indicators to assess the level that researchers in Mexico should attain. The Vitae Model can be considered a viable alternative for our country as it provides more objective parameters.

Significant differences were found in the self-assessment between SNI level C researchers and those at other levels, as well as between the areas of Humanities and Behavioral and Social and Economic Sciences compared to the other five areas. No significant differences were found between men and women. The average self-assessment of Mexican researchers was higher compared to that reported by Vitae for young researchers in the United Kingdom. The findings demonstrate a common trend among Mexican researchers, emphasizing the aspiration to become leaders in research in their chosen fields.

This study also revealed that the Vitae RDF, in addition to serving as a comprehensive development framework and a holistic view of professional growth, could also be used as a quantitative measurement tool to assess how close or far researchers are from achieving world-class status. The RDF proved to be an effective measurement tool for identifying the strengths and weaknesses of Mexican researchers and for developing highly qualified researchers. The RDF evaluation model could be adopted in the country to determine the current status of researchers in Mexico and identify gaps in comparison to a world-class researcher. This outcome could facilitate the design of specific training programs for individual researchers.

Future research should focus on analyzing different methodologies for evaluating researchers worldwide to determine the most suitable approach for the country.

The first limitation pertains to the sample size. The online survey was distributed among researchers, and valid respondents were filtered based on their SNI membership, resulting in 276 researchers who responded. However, the sample can be considered small, given that the total population of SNI researchers in 2018 was around 30,000. The sample size will lead to a smaller margin of error (Watala, 2007). Furthermore, Mexican researchers are not a homogeneous group, considering their age range and the university they come from. Nevertheless, the findings of our study are valuable as they contribute empirical data on the situation of Mexican researchers, adding to the existing body of research on researchers' professional development with a quantitative self-assessment component.

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