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Perception on the integration of research activities in Medicine: Development and validation of an instrument.

Percepción sobre la integración de actividades de investigación en Medicina: Desarrollo y validación de un instrumento.

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Abstract: Scientific training is essential in medicine to address advances in knowledge and make evidence-based clinical decisions. To promote this competency, the 2008 Curriculum (Faculty of Medicine, University of the Republic) incorporated curricular spaces to strengthen it, such as the Scientific Methodology I (MCI) and II (MCII) courses, and the Scientific Conference Workshop (TCC). The objective of this work was to evaluate these courses by designing and validating the "Questionnaire on Perceptions of the Integration of Research Activities" (CPIAI). In a first stage, 271 students (cohort 2022) completed a 40-item questionnaire on the courses Cellular and Molecular Biology (BCM), MCI, MCII, and TCC. An exploratory factor analysis (EFA) was performed to identify their internal structure. In a second stage, 639 students (cohort 2023) completed the same questionnaire, applying confirmatory factor analysis (CFA) and exploratory bifactor analysis (EBA) to assess structural consistency and interpretation of the total score. The EFA identified a four-factor structure, confirmed by the CFA (SRMR = 0.063; RMSEA = 0.079). Factor loadings were high and significant, and the internal consistency of the factors was excellent (Cronbach's $\alpha \geq 0.84$). The EBA showed a hierarchical omega (ωh) of 0.78 and an explained common variance (ECV) of 0.54, supporting the existence of a general factor interpretable as "Integration of scientific knowledge." The scores obtained in the evaluated courses reflected levels of perceived integration consistent with the objectives, teaching methodologies, and activities carried out in the courses. The highest scores were those specifically designed for the incorporation of research activities (TCC and MCII). A progressive increase in the perception of integration was also observed throughout the program. The results support the validity and reliability of the CPIAI as an instrument for assessing the perception of integration of research activities in medical students. They also show a positive impact of the 2008 Plan courses on the scientific training of medical students, highlighting the importance of their incorporation into their programs.

Keywords: scientific training, medical education, validation, questionnaire, Uruguay

Resumen: La formación científica es esencial en Medicina para enfrentar los avances del conocimiento y tomar decisiones clínicas basadas en evidencia. Para promover esta competencia, el Plan de Estudios 2008 (Facultad de Medicina, Universidad de la República) incorporó espacios curriculares para fortalecerla, como los cursos de Metodología Científica I (MCI) y II (MCII), y el Taller de Conferencias Científicas (TCC). El objetivo de este trabajo fue evaluar estos cursos mediante el diseño y validación del "Cuestionario de Percepción sobre la Integración de Actividades de Investigación" (CPIAI). En una primera etapa, 271 estudiantes (cohorte 2022) completaron un cuestionario de 40 ítems sobre los cursos Biología Celular y Molecular (BCM), MCI, MCII y TCC. Se realizó un análisis factorial exploratorio (EFA) para identificar su estructura interna. En una segunda etapa, 639 estudiantes (cohorte 2023) completaron el mismo cuestionario, aplicándose análisis factorial confirmatorio (CFA) y análisis bifactorial exploratorio (EBA) para evaluar la consistencia estructural y la interpretación del puntaje total. El EFA identificó una estructura de cuatro factores, confirmada por el CFA (SRMR = 0,063; RMSEA = 0,079). Las cargas factoriales fueron elevadas y significativas, y la consistencia interna de los factores fue excelente (α de Cronbach ≥ 0,84). El EBA mostró un omega jerárquico (ωh) de 0,78 y una varianza común explicada (ECV) de 0,54, respaldando la existencia de un factor general interpretable como "Integración de conocimiento científico". Los puntajes obtenidos en los cursos evaluados reflejaron niveles de percepción de integración acordes con los objetivos, metodologías de enseñanza y actividades realizadas en los mismos, siendo los cursos específicamente diseñados para la incorporación de actividades de investigación los que tuvieron puntajes más altos (TCC y MCII). Se observó además un aumento progresivo en la percepción de integración a lo largo del avance de la carrera. Los resultados respaldan la validez y confiabilidad del CPIAI como instrumento para evaluar la percepción de integración de actividades de investigación en estudiantes de Medicina. Asimismo, muestran un impacto positivo de los cursos del Plan 2008 en la formación científica de los estudiantes de Medicina, destacando la relevancia de su incorporación en la carrera.

Palabras clave: formación científica, educación médica, validación, cuestionario, Uruguay

1. Introduction

Scientific training in medicine has been a subject of debate since the beginning of the 20th century, especially after the Flexner Report (1910) (1), which promoted a profound reform in medical education. This report highlighted the need to integrate basic sciences and promote evidence-based teaching, marking the beginning of an academic model centered on the scientific method. Over time, this perspective evolved towards the explicit incorporation of research experiences in the curricula of many medical schools. At the beginning of the 21st century, a debate took place in renowned medical schools about the inclusion of specific scientific training in their curricula (2-5), promoting the formal incorporation of scientific methodology experiences in the preclinical and clinical stages of medical careers (6-10).

The incorporation of specific courses for scientific training in undergraduate students at the Faculty of Medicine of the University of the Republic was a slow and debated process over several decades (11-12) that ended up being consolidated in the 2008 Curriculum. The self-assessment report published in 2012 (13) recommends the integration of activities to improve scientific training and it is to this end that the 2008 Plan incorporates the curricular courses Scientific Methodology I (MCI) and II (MCII), and optional activities related to scientific methodology tools (Scientific Conference Workshop, TCC) and dissemination of research lines of the entire Faculty (Scientific Conference Cycle) (11-12). The 2008 Plan of the Faculty of Medicine began to be implemented in 2009, and consists of a 7-year program organized into two three-year periods: basic-clinical-community cycle; general clinical understanding cycle and pre-professional practice cycle: rotating internship (12).

The MCI and MCII courses are introduced at the end of the third and sixth years to promote a solid scientific foundation by integrating basic clinical aspects in addressing health and disease problems and prioritizing training and practice in the scientific method. The MCI course addresses ethical, methodological, and research design aspects for the first time, with an emphasis on the principles of biostatistics. The MCII course was created to consolidate the scientific foundation begun in the first years of the program. It integrates the ethical and methodological aspects covered in the first year and incorporates training in bibliographic searches in specific biomedical literature databases and critical analysis of the literature. The most notable aspect of the course is that, in addition to the theoretical content offered in the MCI and MCII cycles, a practical research exercise is carried out in groups led by professors acting as advisors. This exercise consists of completing a research project, culminating in the presentation of the results in the form of a scientific monograph and poster during the course's Scientific Conference. All monographs produced within the course are incorporated into the Colibrí repository of the University of the Republic.

Alemán A. et al. analyzed human research registered with the Ministry of Public Health (MSP) of Uruguay during the period 2019-2022, demonstrating that the majority of the registered works are carried out within the framework of academic training during undergraduate and postgraduate studies linked to health careers (92.4%) (14). Research carried out within the framework of the MCII course represents 77% of the works registered at the Faculty of Medicine, which corresponds to 17.3% of the total works analyzed. We recently conducted a study characterizing the monographs published in the Colibrí repository in the first 10 years of the course, including the type of design, the topics addressed and their connection with the national health objectives 2020 and 2030. The work allowed the characterization of almost 1000 monographs carried out during the last 10 years on a wide variety of topics and with the participation of most medical disciplines, which demonstrates an important contribution of the course to the research carried out in Uruguay by undergraduate students (15).

The scientific methodology activities incorporated into the 2008 Plan have significantly transformed the scientific training of medical students at the University of the Republic. Fifteen years after the 2008 Plan was implemented, we believe it is essential to rigorously evaluate the impact of these changes. The importance of measuring student perceptions of the integration of research activities lies in its early and sensitive indicator of curricular impact. While objective indicators (number of projects, publications, or presentations) reflect concrete achievements, student perceptions reveal how students interpret and value these experiences in their training, allowing us to identify motivations, barriers, and facilitators that often remain invisible in other metrics. The practical consequences of having this information are multiple: it provides feedback on curriculum design and teaching methodology, directs resources toward areas with the greatest educational impact, and strengthens the research culture from the early stages of the program. Furthermore, the use of instruments for this purpose allows for longitudinal and interinstitutional comparisons, generating useful evidence for educational and university policy decision-making. Thus, measuring perception is not only relevant but also necessary for advancing toward critical, reflective, and evidence-based medical education (9-10, 16-17).

To evaluate how these courses influence medical students' scientific training, we studied their perceptions of research integration throughout their studies. To this end, we developed and validated an instrument (the Research Activities Integration Questionnaire, CPIAI) that was administered to students at different stages and in different years of the PhD program in Medicine at the University of the Republic, Uruguay.

2. Methods

2.1 Participants

An instrumental validation study was conducted by administering a survey to students of the PhD in Medicine program at the Faculty of Medicine (Universidad de la República, Uruguay). The survey was addressed to those who had recently completed the courses Scientific Methodology I (MCI) in their third year and Scientific Methodology II (MCII) in their sixth year. In addition, first-year students who took Cellular and Molecular Biology (BCM) and students from different levels who took the elective course Scientific Conference Workshop (TCC) were included. The study covered the editions of these four courses corresponding to the years 2022 (n = 271) and 2023 (n = 639); therefore, these groups will be referred to hereafter as cohort 2022 or cohort 2023, respectively. The sample size, based on the 40-item questionnaire, met criteria commonly accepted in the literature for conducting exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) (18).

2.2 Instruments

2.2.1 Translation and cultural adaptation

The questionnaire was based on the "Student Perception of Research Integration Questionnaire" (SPRIQ) developed in English by Gerda Visser-Wijnveen et al. from the University of Leydig, the Netherlands (19). For its application, the translation and cultural adaptation to Spanish was carried out following current methodological recommendations (20-21). The process included direct translation independently by two professional translators, the synthesis of both translations, the back translation to the original language, the revision and consolidation by a committee of experts, and the administration of a pretest of the adapted questionnaire (11-12).

2.2.2 Data collection

The self-administered questionnaire was administered online using the Google Forms platform (Google®) and distributed through an e-learning platform and social media. In addition to the 40 items to be completed using a 5-point Likert scale, the questionnaire collected sociodemographic information.

2.3 Data analysis

Data analysis was performed using R software (v4.1.2; R Core Team). The packages used included: tidyverse (v1.3.1), psych (v2.2.5), GPArotation (v2024.3-1), lavaan (v0.6-19), and patchwork (v1.1.1). Initially, a CFA was performed to confirm the internal structure of the adapted SPRIQ. However, the results obtained showed an inadequate fit to the data (see Results section), which led to the performance of an EFA with the aim of identifying an empirical underlying structure more appropriate to the study population (22). The EFA was performed using responses from the 2022 cohort. Since these mostly presented non-normal distributions, methodological approaches that considered the ordinal nature of the Likert scale were used. Incomplete responses and those where all Likert scale items were answered with the same value were excluded from the analysis in order to minimize the introduction of bias. To avoid multicollinearity, items with high correlations (Spearman $r > 0.8$) were eliminated. Subsequently, to evaluate the suitability of the data for factor analysis, the Kaiser-Meyer-Olkin (KMO) adequacy index and Bartlett's test of sphericity were used. KMO values greater than 0.70 and significant results in Bartlett's test were considered as indicators of suitability for factor analysis (23). The EFA was performed using the maximum likelihood factor extraction method with promax oblique rotation (assuming correlated factors) (24). The analysis was performed from the polychoric matrix (25), using the fa() function of the psych package (26).

The retained factors were determined based on eigenvalues greater than 1 (Kaiser's rule), Scree plot analysis, and conceptual interpretation of the factor loadings (27). Factor loadings greater than 0.60 were considered significant, adjusting this criterion to the nature of the variables and objectives of the study.

Based on the structure resulting from the EFA, four theoretical models were formulated and subjected to CFA (28) using the responses of the 2023 cohort. The weighted least squares adjusted for mean and variance (WLSMV) method was used (29-30). Model 1 involved a second-order structure with a single general factor ("Scientific Knowledge Integration") explaining the covariation among four first-order factors: Perception (PER), Engagement (COM), Participation (PAR), and Valuation (VAL). Model 2 introduced two second-order factors ("Cognitive" and "Behavioral"), grouping the PER and COM factors under a cognitive domain, and PAR and VAL under a behavioral domain. Model 3 corresponded to a hierarchical bifactor model, in which all items load simultaneously on a general factor (G) and on their respective specific factors (PER, COM, PAR, VAL), assuming orthogonality between factors. This allows analyzing how much of the variance of each item is due to the general construct and how much to the particular dimensions. Finally, Model 4 postulated four first-order factors correlated with each other, without a superior hierarchical level. All models were compared based on goodness-of-fit indices and their cutoff points reported in the literature: RMR ("root mean square residual"), SRMR ("standardized root mean square residual"), RMSEA ("root mean squared error of approximation"), TLI ("Tucker-Lewis index"), CFI ("comparative fit index") (31). In addition, the factor loadings of the items were examined, considering those greater than 0.50 as significant (32). The internal consistency of the questionnaire was evaluated by calculating Cronbach's α coefficient (33).

The comparability of the questionnaire structure between cohorts (2022 and 2023) was assessed using configural, metric, and scalar invariance tests, following standard procedures in structural equation modeling (28). Models were estimated using WLSMV for ordinal items and compared using scaled χ^2 difference tests and variations in fit indices (CFI, RMSEA, SRMR). Differential item functioning (DIF) was also assessed using the R package mirt (v1.44.0), fitting a multigroup graded response model (34, 35). DIF analysis was performed using a sequential anchoring scheme. Candidate anchor items were initially identified based on the absence of significant DIF (FDR-adjusted p-value < 0.05). Subsequently, those with the greatest discriminatory capacity were selected from among these stable items, also ensuring minimum representation of all questionnaire dimensions. In this way, a set of 5 reference items was identified, on which the presence of DIF was confirmed in the rest of the instrument.

To evaluate the justification for calculating a "total score" representative of "Integration of Scientific Knowledge," an exploratory bifactor analysis (EBA) was used using the omega() procedure of the psych package, reporting the hierarchical omega coefficient (ωh) together with the explained common variance (ECV) index (36). Despite considering the ordinal nature of the items in the factor analysis using polychoric correlations and robust methods such as the WLSMV, the scores for the questionnaire factors were calculated by summing the responses of the corresponding items and transforming them to a percentage scale (from 0 to 100%). This approach, although based on quasi-interval assumptions, has proven to be valid and useful for comparative purposes and group interpretation in studies of Likert scales of five points or more (37-38). The following formula was used to calculate the scores:

$$Points = \frac{\left(\sum of\ answers - Number\ of\ items\right)}{\left(Number\ of\ items \times 5 - Number\ of\ items\right)} \times 100\,\%.$$

Scores were then compared between courses using the nonparametric Kruskall-Wallis test and, in the case of significant differences, Dunn's post hoc test with p-value corrections using the Holm method (39-40). P-values less than 0.05 were considered statistically significant.

2.4 Ethical considerations

The first section of the questionnaire contained the informed consent for participation in the study. Respondents were assured that their participation was voluntary and that they could withdraw from the study at any time. If they did not wish to participate, the questionnaire could be sent with the remaining questions blank so that the response could be filtered during the analysis phase. The information was collected and handled confidentially to maintain the anonymity of the participants and in accordance with the criteria of Law No. 18,331 of 2008 on the Protection of Personal Data in force in Uruguay and Decree 158/19, which regulates research involving human subjects. The study did not involve any clinical data from the participants. The research protocol was approved by the Research Ethics Committee of the Faculty of Medicine, University of the Republic, Uruguay (File No. 070153-000371-20).

3. Results

3.1 Data collection and description of participants

A total of 931 responses were received, of which 9 were excluded for not meeting the inclusion criteria and 12 for presenting uniform responses on the Likert scale, resulting in a total of 910 valid responses (Figure 1). The sample was distributed into two cohorts: 271 participants corresponded to cohort 2022 and 639 to cohort 2023. Within each cohort, students were grouped according to the course in which they participated: Cellular and Molecular Biology (BCM), Scientific Methodology I (MCI), Scientific Methodology II (MCII), and Scientific Conference Workshop (TCC).

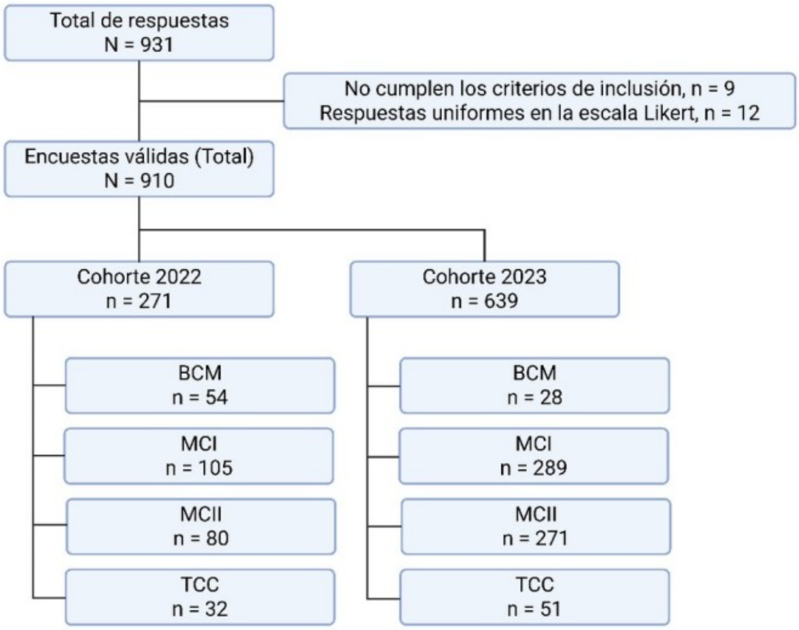

Figura 1. Diagrama de flujo de la muestra.

The demographics of the participants are presented in Table 1. The median age of the students was 22 years, and the majority were enrolled in third- and sixth-year courses (MCI and MCII). A total of 14.4% had previously taken elective courses related to scientific research, and 12.2% had participated in research projects. Approximately 3% of the participants had published scientific papers or presented at scientific events.

Table 1. Demographic data.

Variable	Total (n = 910)	Cohort 2022 (n = 271)	Cohort 2023 (n = 639)
Age (years)	22 (21 - 24.8)	22 (21 - 24)	23 (21 - 25)
Female sex	680 (74.7%)	199 (73.4%)	481 (75.3%)
He took elective courses related to research	131 (14.4%)	31 (11.4%)	100 (15.6%)
Current teaching activity	24 (2.6%)	8 (3.0%)	16 (2.5%)
Participation in research projects	111 (12.2%)	63 (23.2%)	48 (7.5%)
He has scientific publications	26 (2.9%)	16 (5.9%)	10 (1.6%)
Communications at scientific events	29 (3.2%)	9 (3.3%)	20 (3.1%)

The results are presented as n (%), except for age, which is represented as median and interquartile range (Q1 - Q3).

3.2 Development and construct validity of the instrument through factor analysis

In a first stage, the 40 items adapted from the Visser-Wijnveen study (Table 2) (19) were applied to the 2022 cohort, and a CFA was performed to verify the structure of the SPRIQ questionnaire (24 items). However, the fit indices presented values above acceptable thresholds (SRMR = 0.154; RMSEA = 0.157). Based on this, it was decided to perform an EFA to evaluate the underlying structure of the 40 items.

Table 2. Items considered for the development of the instrument.

Ask	Item
P1	I assimilated knowledge about scientific research findings.
P2	I learned to pay attention to the way scientific research is conducted.
P3	I developed an academic attitude.
P4	There was an opportunity to talk with researchers about scientific research.
P5	Attention was paid to recent developments in the field.
P6	The process of scientific research was a fundamental part of the curriculum.
P7	I felt inspired to learn more about this discipline.
P8	My understanding of the most important concepts in this field has increased.
P9	Attention was paid to research methodology.
P10	I felt part of the Faculty's academic community.
P11	I became familiar with the research conducted by my teachers.
P12	My teachers encouraged me not to settle for an immediate explanation.
P13	We seek answers to unresolved research questions together with teachers.
P14	I felt excited about my scientific field.
P15	My contribution to the research was appreciated.
P16	I came into contact with my teachers' research.
P17	My participation in the research was important.
P18	I had the opportunity to learn about current scientific research.
P19	I became familiar with the results of scientific research.
P20	I was encouraged to critically evaluate literature.
P21	I felt involved with the Faculty's research culture.
P22	It increased my knowledge about the research topics that researchers are currently contributing to.
P23	I learned about the types of studies that have been conducted in my field.
P24	My interest in researching this area increased.
P25	I contributed to the development of my field.
P26	I learned the ways in which research can be carried out in this field.
P27	The teachers encouraged us to ask critical questions about our work.
P28	As a student I felt involved with the research.
P29	I had the opportunity to interact socially with the Faculty's researchers.
P30	Links were established with current research practices.
P31	I got involved with my teachers' research.
P32	My teachers encouraged my enthusiasm and personal interest in research .
P33	The teachers had enough time to support me in my learning process.
P34	The teachers carried out their teaching in an appropriate manner.
P35	My teachers were able to explain the topic at hand efficiently.
P36	I developed an accurate picture of what was expected of me.
P37	My learning is stimulated when education is based on research.
P38	It is important to me that my teachers conduct scientific research.
P39	Education focused on scientific research stimulates my learning.
P40	The research culture at the Faculty stimulated my learning process.

The Kaiser-Meyer-Olkin (KMO) sampling adequacy index was 0.95, and Bartlett's test of sphericity was significant (χ^2 (630) = 7889.4; $p < 0.0001$), confirming the relevance of the factor analysis. The maximum likelihood method and promax oblique rotation were used to extract factors, since the factors showed moderate correlations with each other ($_{Spearman}$ r = 0.17–0.66). Based on Kaiser's criterion (eigenvalues > 1), the Scree plot, parallel analysis, and the requirement of having at least three items per factor, four factors were identified that explained 72% of the variance. The factor loadings, presented in Table 3, indicated that 22 items were consistently grouped into the identified factors. All items showed communalities equal to or greater than 0.5, which confirms that they are well represented by the latent factors and supports the validity of the instrument (32).

The identified factors were defined and named according to the characteristics of the items included: Perception, Commitment, Participation, and Appreciation, respectively (Figure 2). Factor 1, called "Perception," included 9 items related to the understanding of scientific concepts and methods and interest in research methodology. Factor 2, "Commitment," comprised 7 items reflecting social interaction with researchers, connection to research practices, and involvement with teachers in scientific activities. Factor 3, "Participation," included 3 items related to enthusiasm and active contribution to the development of the field through research. Finally, Factor 4, "Appreciation," consisted of 3 items highlighting the importance attributed to research-based education and its impact on learning. The summary statistics of the factors for the 2022 cohort are represented in Table 4. The internal consistencies (α) for the four factors were 0.93, 0.93, 0.86 and 0.84 respectively, which are considered good or excellent (33).

Table 3. Rotated factor loadings (promax method) and communalities of the questionnaire items according to EFA.

Item	Communality	Factor 1	Factor 2	Factor 3	Factor 4
P1	0.65	0.80	0.01	-0.05	0.02
P2	0.77	0.85	0.07	0.02	-0.05
P3	0.51	0.69	-0.07	0.00	0.11
P8	0.69	0.79	-0.12	0.09	0.13
P9	0.79	0.96	-0.09	0.09	-0.08
P19	0.67	0.63	0.26	0.02	-0.03
P20	0.59	0.66	0.21	-0.14	-0.01
P23	0.64	0.76	0.03	0.05	0.00
P26	0.69	0.86	0.05	-0.07	-0.06
P4	0.63	0.07	0.76	0.00	-0.02
P11	0.67	0.18	0.64	0.11	-0.06
P16	0.82	-0.05	0.93	0.08	-0.08
P29	0.81	-0.02	0.90	-0.03	0.05
P30	0.75	0.05	0.83	-0.04	0.03
P31	0.87	-0.07	0.90	0.09	0.06
P32	0.69	0.18	0.62	-0.05	0.16
P13	0.87	-0.09	0.17	0.86	0.01
P14	0.78	0.10	-0.15	0.91	0.08
P25	0.81	-0.03	0.17	0.83	-0.09
P37	0.69	0.20	-0.07	0.04	0.73
P38	0.55	-0.04	0.14	-0.01	0.69
P39	0.92	-0.04	-0.02	-0.01	1.00
Cumulative variance		0.27	0.51	0.62	0.72

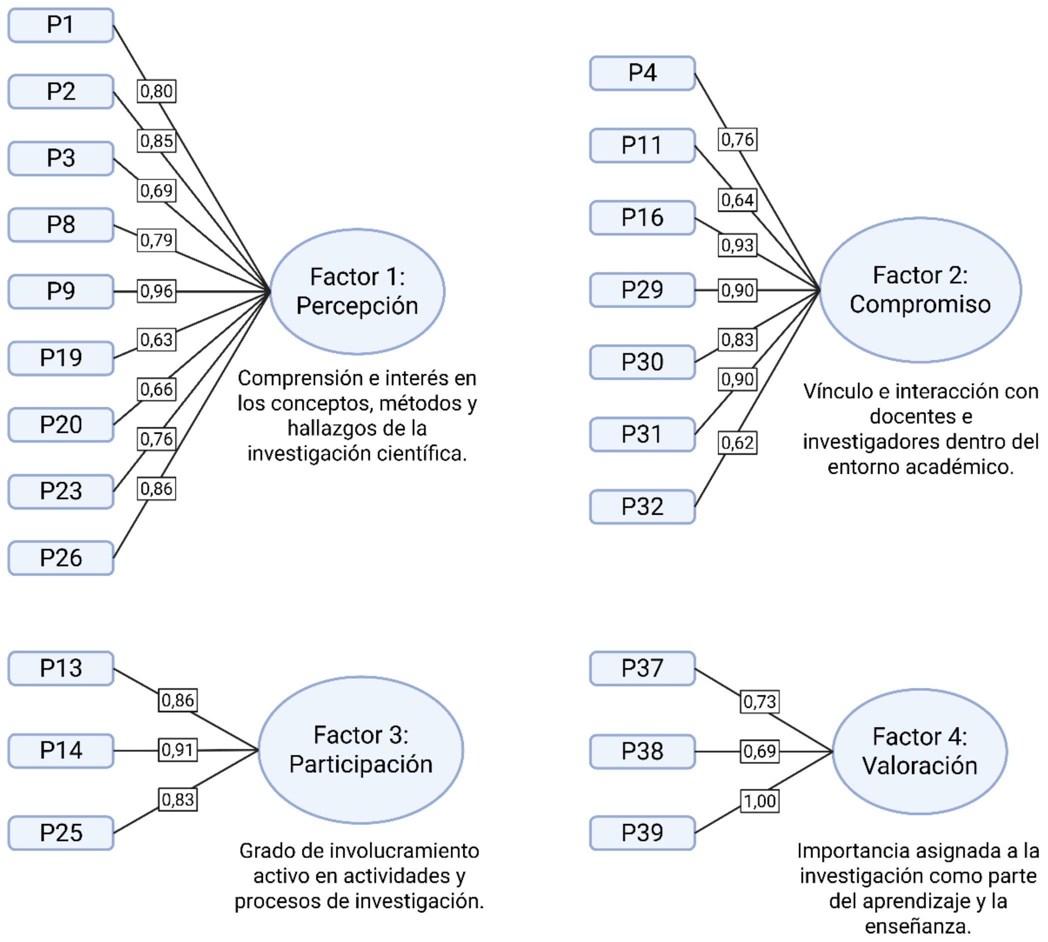

Figure 2. Factor loading diagram of the developed instrument (CPIAI).

Table 4. Summary of the psychometric factors of the developed instrument.

Factor	Median (Q1 - Q3)	Cronbach's α	95% confidence interval
Perception	69.4 (52.8 - 83.3)	0.93	0.92 to 0.94
Commitment	32.1 (10.7 - 57.1)	0.93	0.92 to 0.94
Stake	0 (0 - 41.7)	0.86	0.83 to 0.89
Assessment	66.7 (50.0 - 75.0)	0.84	0.80 to 0.87
Total	**48.9 (35.8 - 64.2)**	**0.94**	**0.93 to 0.95**

Q1: first quartile, Q3: third quartile.

In a second stage, a CFA was conducted using responses from the 2023 cohort (n = 639) to assess the fit of the construct identified through EFA. Different model specifications were compared (see Methods) (Table 5). The results of the CFA applied to the SPRIQ construct (19) using data from the 2022 cohort are presented in the same table. The fit indices far exceed acceptable values, which indicates an inadequate representation of the construct and justifies the development of the new questionnaire.

The results of the CFA of the new instrument indicated that the model with the best fit was the one that considered four correlated factors, without a second-order factor (Model 4), which suggests that the dimensions of Perception, Commitment, Participation and Assessment constitute differentiable aspects within the process of integrating scientific knowledge.

Item factor loadings ranged from 0.70 to 0.93, all statistically significant ($p < 0.0001$), indicating that the items adequately contribute to the latent factors. Furthermore, moderate correlations were observed between factors ($_{\text{Spearman r}}$ = 0.18 to 0.59), supporting the use of oblique rotation in the EFA. In summary, the results support the factor structure identified in the EFA and confirm that the model is adequate to represent the dimensions of the questionnaire. The developed instrument was called the "Perceptions of the Integration of Research Activities Questionnaire" (CPIAI) (Supplementary Materials 1 and 2).

Table 5. Goodness-of-fit indices of the SPRIQ and the developed questionnaire (CPIAI), using CFA, with recommended cut-off points.

Cut-off points based on (31)	**χ2 ***	**df**	**RMR**	**SRMR**	**RMSEA (90% CI) ***	**TLI ***	**CFI ***
	p < 0.05	**-**	**< 0.080**	**< 0.080**	**< 0.080**	**> 0.900**	**> 0.900**
SPRIQ adapted	1912.0 (p < 0.001)	245	0.134	0.154	0.157 (0.150 - 0.164)	0.887	0.900
CPIAI - Model 1 (Single General Factor)	1286.8 (p < 0.001)	205	0.070	0.081	0.091 (0.086 - 0.096)	0.935	0.943
CPIAI - Model 2 (Two second-order factors)	1222.6 (p < 0.001)	204	0.067	0.078	0.088 (0.084 - 0.093)	0.939	0.946
CPIAI - Model 3 (General factor + specific factors)	1196.7 (p < 0.001)	203	0.061	0.071	0.092 (0.087 - 0.097)	0.934	0.946
CPIAI - Model 4 (Without second order factor)	1007.3 (p < 0.001)	203	0.054	0.063	0.079 (0.074 - 0.084)	0.952	0.957

df = degrees of freedom. * Scaled indices using the WLSMV estimator.

3.3 Content validity of the instrument

The CPIAI was administered to students in four courses of the Doctor of Medicine program. Scores were calculated for the assessed dimensions (0 to 100%) (see Methods). The total questionnaire score was obtained as a weighted average of the scores for the four dimensions according to the number of items in each. The results for the 2022 cohort are presented in Figure 3 and Table 6. The results for the 2023 cohort were similar (not shown).

Table 6. Comparison of median scores between courses (2022 cohort).

Dimension	**(a) BCM**	**(b) MCI**	**(c) MCII**	**(d) TCC**
Perception	$44.4^{b, c, d}$	$69.4^{a,d}$	$75.0^{a,d}$	$90.3^{a, b, c}$
Commitment	$14.3^{c,d}$	$17.9^{c,d}$	$50.0^{a,b,d}$	$71.4^{a, b, c}$
Stake	0^{c}	0^{c}	$50.0^{a,b,d}$	0^{c}
Assessment	50.0^{d}	66.7^{d}	58.3^{d}	$83.3^{a, b, c}$
Total	$29.5^{b, c, d}$	$44.3^{a, c, d}$	$60.2^{a, b, d}$	$71.6^{a, b, c}$

Medians were compared using the Kruskal-Wallis test and Dunn's post hoc test, with the p-value corrected using the Holm method. The superscript letter following the mean indicates the group with statistically significant differences ($p_{Holm} < 0.05$).

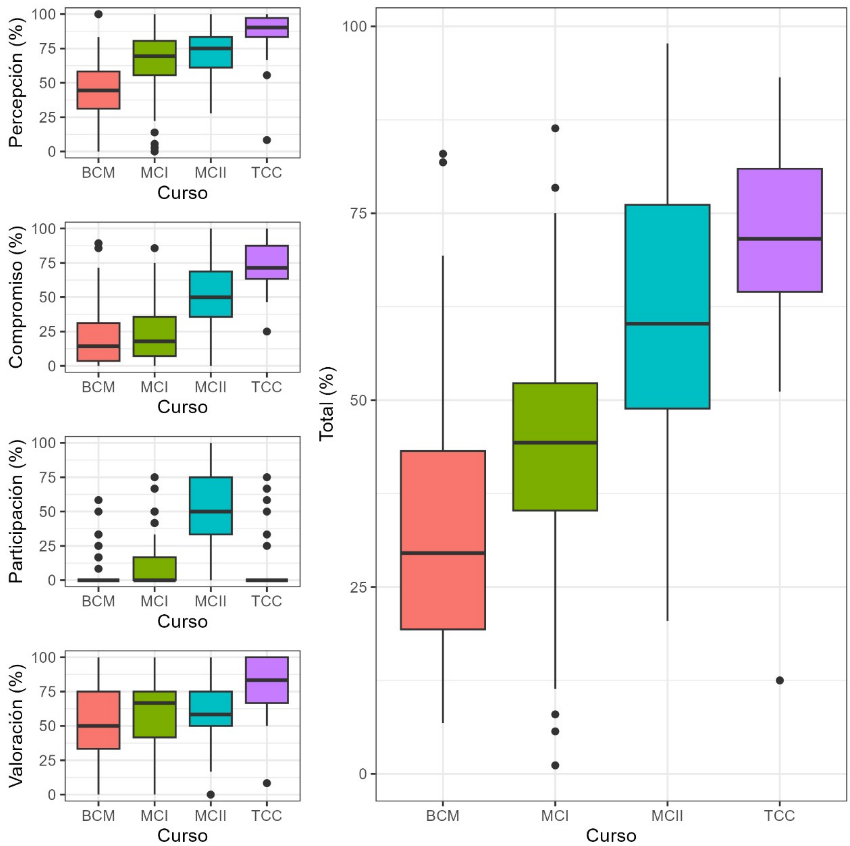

Figure 3. Distribution of CPIAI scores by course (2022 cohort).

In the Perception dimension, the BCM course obtained the lowest score, consistent with its introductory nature and focus on laboratory practices and seminars (Table 6). In contrast, the three courses focused on integrating research and scientific methodology obtained high scores.

In Engagement, BCM again had the lowest score (14.3), while TCC (71.4) and MCII (50.0) achieved the highest. MCI's low score in this dimension is attributed to its theoretical focus on statistics. In contrast, MCII promotes engagement by engaging students with their advisors throughout the year.

The Participation dimension assesses active involvement in research. MCII achieved the highest score (50.0), given that students contribute directly to the progress of a project. BCM, MCI, and TCC do not include active participation, reflected in median scores of 0 in this dimension.

Regarding Assessment, all courses showed good results, with TCC standing out (83.3). TCC obtained the highest scores in most dimensions, except for Participation, which was dominated by MCII. This is consistent with the objectives of both courses: TCC, which is optional and focuses on methodological discussion in small groups, favors positive assessment and perception; MCII, designed for practical participation, excels in engagement and active participation.

BCM presented the lowest scores in all dimensions, in line with its introductory and theoretical nature. MCI showed intermediate performance, with similarities to MCII in some areas, although its focus is primarily theoretical. The differences between courses reflect their content and methodologies and support the content validity of the instrument.

The total scores were: BCM 29.5; MCI 44.3; MCII 60.2; and TCC 71.6, the latter being the most focused on the practice of research activities. This order corresponds to the academic year of the program in which they are enrolled (the TCC course is taken by students of various ages, with a mean of 21.0 ± 1.9, which corresponds approximately to the third year) (Figure 4). This suggests that, as students progress and incorporate scientific methodology courses in their third and sixth years, their perception of integration increases considerably. This also supports the initial strategy proposed in the 2008 Plan of gradual and cumulative incorporation of scientific methodology courses as they progress through the program.

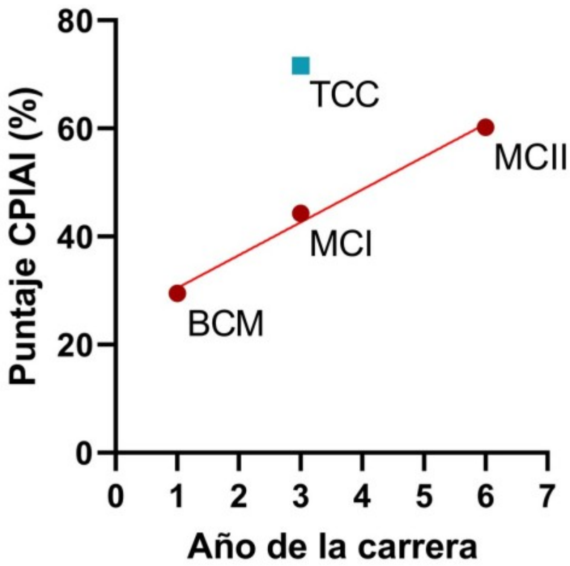

Figura 4. Comparación entre el puntaje CPIAI total según el año de la carrera (cohorte 2022).

3.4 Analysis of factorial invariance and differential item functioning

The four-factor model showed a good fit in terms of configural invariance (CFI = 0.993; RMSEA = 0.061; SRMR = 0.059). When the restriction of equal factor loadings (metric invariance) was imposed, the fit indices remained practically unchanged (CFI = 0.993; RMSEA = 0.062; SRMR = 0.061), and the difference in scaled χ^2 was not significant ($\Delta\chi^2 = 25.0$; df = 18; p = 0.124). Likewise, the model with restricted intercepts (scalar invariance) presented equivalent fit indices (CFI = 0.993; RMSEA = 0.056; SRMR = 0.060) and did not differ significantly from the metric model ($\Delta\chi^2 = 43.8$; df = 62; p = 0.962). These results support the existence of configural, metric, and scalar invariance between the 2022 and 2023 cohorts, ensuring the comparability of the factor structure and latent scores over time.

Additionally, differential item functioning (DIF) analysis using a graded response model identified a set of five stable items (2, 8, 14, 30, and 37) characterized by the absence of DIF and adequate discrimination parameters, which were used as anchors in the sequential procedure. With this anchoring, it was observed that only item 29 of the Commitment dimension ("I had the opportunity to interact socially with researchers within the Faculty") showed evidence of differential functioning, indicating that the probability of responding to this item varies between cohorts even when controlling for the latent level of the construct.

3.5 Characterization of research activities

The research activities of the surveyed students were characterized, taking as indicators presentations at scientific events, publications, and participation in research projects, and comparing these indicators between first-, third-, and sixth-year students (Table 7). When analyzing the research activities reported by course, greater participation was observed among MCII students. Beyond the natural progression in the program, substantive differences were noted between the experiences of third-year students (MCI) and sixth-year students (MCII). In the latter group, a higher proportion of participation in research projects (21.4%) and scientific production was recorded, including conference abstracts (6.6%) and publications in scientific journals (6.6%). These results could be linked to the inclusion, in MCII, of a practical research experience, which acts as a stimulating factor for active participation in scientific activities. The MCII course specifically promotes the publication of results in peer-reviewed journals, and this difference is noticeable when compared to the publications reported in the first year (0%) and third year (0.8%).

Table 7. Characteristics of participants by course (cohort 2022 + cohort 2023).

Variable	Total n = 910	BCM n = 82	MCI n = 394	MCII n = 351	TCC n = 83
Year of the race	-	1	3	6	≈ 3
Age (years)	22 (21 - 24.8)	19 (18 - 20)	21 (21 - 22)	24 (24 - 26)	20 (19.5 - 21)
Female sex	680 (74.7%)	64 (78.0%)	301 (76.4%)	249 (70.9%)	66 (79.5%)
He took elective courses related to research	131 (14.4%)	2 (2.4%)	50 (12.7%)	63 (18.0%)	16 (19.3%)
Current teaching activity	24 (2.6%)	0	7 (1.8%)	17 (4.8%)	0
Participation in research projects	111 (12.2%)	8 (9.8%)	23 (5.8%)	75 (21.4%)	5 (6.0%)
He has scientific publications	26 (2.9%)	0	3 (0.8%)	23 (6.6%)	0
Communications at scientific events	29 (3.2%)	0	6 (1.5%)	22 (6.3%)	1 (1.2%)

4. Discussion

The translation and cultural adaptation of the original instrument was carried out according to previous reports (11, 20, 21). The CFA of the adapted SPRIQ instrument, composed of 24 items (19), did not yield satisfactory results in our sample. For this reason, an EFA was performed using the original 40-item battery by the same author, leading to the creation of a new instrument: the Questionnaire of Perceptions on the Integration of Research Activities (CPIAI), composed of 22 items. The EFA allowed the identification of four underlying factors, called Perception, Commitment, Participation and Appraisal, which group the items in a manner consistent with the theoretical constructs involved (Figure 2). Each identified factor included at least three items, meeting minimum criteria for psychometric interpretation (22).

The reliability of the instrument was analyzed using Cronbach's α coefficient, obtaining values equal to or greater than 0.84 in all factors, indicating a high level of internal consistency. These results far exceed the commonly accepted cut-off point ($\alpha \geq 0.70$) for considering an instrument as "reliable" (11, 22), which supports the construct validity of the questionnaire. The CFA performed on the 2023 cohort (n = 639) showed that the best-fitting model was the four-factor correlated model without a second-order general factor (Model 4) (RMSEA = 0.079, SRMR = 0.063, CFI = 0.957, and TLI = 0.952) (Table 5).

Although the CFA did not reveal a clear hierarchical structure, the EBA indicated a dominant general factor (ωh = 0.78; ECV = 0.54), justifying the use of a total score. This finding is consistent with that proposed by Reise (2013) (41).

Furthermore, the factorial invariance analysis showed that the questionnaire structure is stable across consecutive cohorts, supporting its robustness to longitudinal or cross-sectional comparisons across different student cohorts. The DIF assessment complements the evidence of metric/scalar invariance observed in the multi-group CFA, indicating that, in practical terms, the items function comparably across consecutive cohorts.

Regarding content validity, the scores obtained in the different courses were consistent with the teaching objectives and strategies implemented. In particular, the courses specifically oriented toward research training (MCII and TCC) obtained the highest scores, reinforcing the instrument's logical and content validity (Table 6).

The analysis of the results shows that the scores for the perception of integration of research activities showed a gradual and considerable increase as the student progressed through the program, suggesting that the strategy adopted in the 2008 Plan, which distributes scientific methodology courses throughout the program, was effective in fostering the gradual integration of research activities into the training of medical professionals.

When analyzing research activities broken down by course (Table 7), it is observed that they increase as the degree progresses and that in the case of the MCII course, a higher percentage of participation in research projects, communications at scientific events, as well as scientific publications is observed, compared to the other courses analyzed in the degree. This would be related to the objectives of the course that involves participation in a research project and the publication of the results in a scientific monograph, incentivizing the publication process and learning the editorial process. In fact, the 10 best papers of each year are published in the journal of the Faculty of Medicine (Annals of the Faculty of Medicine) (42), which constitutes an important stimulus for publication.

Several instruments have been previously developed to assess student perceptions of the integration of research into university teaching. Among them, the SPRIQ is one of the most widely used. This questionnaire, applied in European contexts, is composed of four factors and 24 items that assess the integration of research into teaching, the research environment, the role of the instructor, and the student's self-perception as a research learner. Our instrument shares the SPRIQ's purpose of exploring student perceptions, but differs in its focus, specifically geared toward medical students and the integration of research activities into their curriculum. Furthermore, while the SPRIQ reports evidence of construct validity and internal reliability, our study incorporates complementary analyses (configural, metric, and scalar invariance across cohorts, as well as DIF analysis) that strengthen the instrument's longitudinal comparability. Similarly, other questionnaires such as the URSSA (43) or the SURE (44) have investigated the relationship between teaching and research at university levels, although in most cases without including invariance or DIF analysis. In this sense, our work represents a novel methodological contribution by providing a psychometrically robust instrument for the evaluation of the integration of research activities in medical programs (Supplementary Table 1).

A recent study evaluated the scientific activity of medical students and its impact on postgraduate research. The results showed that students who published during their studies were more scientifically productive, continued to publish, and had a higher impact factor (45). Other studies published by Al-Busaidi et al. analyzed the relationship between academic success and early publication in medical journals, showing that publishing in a medical student journal is associated with future academic success and contributes to the development of a clinical academic workforce (46-48). Similar studies published by Dyrbye et al. studied the scientific productivity of graduates from three research training programs at the Mayo Clinic. The authors analyzed the number of funded projects obtained, academic standing, number of publications, and the H-index. The results showed that all indicators were better in programs that began their scientific training earlier (49-50). Although a causal relationship cannot be attributed, evidence suggests that early participation in research is important and that substantial scientific training can influence physicians' future scientific activities and development of academic careers.

5. Conclusions

- In this study, a new instrument, the Research Activities Integration Perceptions Questionnaire (CPIAI), was designed, validated, and applied to assess medical students' perceptions of their scientific training throughout their studies. Factor analyses supported the construct validity of the CPIAI, demonstrating its organization into four distinct but related dimensions. While a unidimensional structure was observed in the EBA, the best fit in the CFA corresponded to the four-factor correlated model, justifying both the use of the dimensions and the calculation of a total score to represent the overall construct of "Integration of Scientific Knowledge."
- The results obtained support the instrument's content validity and demonstrate a growing perception of research integration as students advance in their programs. In particular, courses with explicit objectives in scientific methodology (MCII and TCC) showed the highest scores, suggesting that the phased design of scientific training implemented in the 2008 Plan has had a positive impact.
- The CPIAI represents a useful and reliable tool for evaluating the impact of curricular strategies aimed at strengthening scientific training in medical students. Its application could contribute to the monitoring and continuous improvement of research teaching programs at the university level.

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Authors' contributions: Conceptualization of the idea and general design (SM, MG, CZ, RR, AC and SB), design of the methodology (SM, MG, CZ, RR, AC and SB), analytical tools (SM and MG), validation, re-analysis and verification of the results (SM, MG, CZ, RR, AC and SB), statistical analysis of the data (SM, MG and SB), data collection (SM, MG, CZ, SB), data extraction, access to equipment or resources (SM, MG, CZ, RR, AC and SB), writing of the manuscript (SM, MG, CZ, RR, AC and SB), critical review of the manuscript (SM, MG, CZ, RR, AC and SB), elaboration of graphs and diagrams (SM and SB), academic supervision and advice (RR, AC and SB), management and coordination of the study (SM, AC and SB).

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Data availability : The database with the responses to the 40 Likert scale questions corresponding to the 2022 and 2023 cohorts is included as supplementary material, along with the identification of the course to which each response belongs and the script of the analysis performed in R (Supplementary Material 3, available at https://zenodo.org/records/17065001, DOI: https://doi.org/10.5281/zenodo.17065001).

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