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Abstract

This study explores the role of neuroscience in shaping the perceptions and teaching strategies of university teachers. Using a quantitative, non-experimental approach, a survey was conducted among 132 teachers to assess the links between neuroscientific knowledge (brain plasticity, individual differences, and emotional learning) and pedagogical dimensions (educational technology, active teaching, and socio-emotional learning). The reliability, validity, and structure of the relationships between the constructs were analyzed using partial least squares structural equation modelling (PLS-SEM). The results indicate that neuroscience influences on teachers' perceptions of innovation and the development of teaching strategies, which explains a considerable proportion of the variability in didactic of the variability in the didactics of learning and its associated dimensions. The study concludes that improving the neuroscientific knowledge of teachers and adopting active methodologies contribute to more effective and inclusive higher education.

Keywords: educational neuroscience; active learning; brain plasticity; brain plasticity; social-emotional learning; PLS-SEM; teachers; active teaching.

Resumen

Este estudio explora el papel de la neurociencia en la configuración de las percepciones docentes y las estrategias didácticas en universidades. A partir de un enfoque cuantitativo no experimental, se encuestó a 132 docentes con el fin de evaluar los vínculos entre el conocimiento neurocientífico (plasticidad cerebral, diferencias individuales y aprendizaje emocional) y las dimensiones pedagógicas (tecnología educativa, enseñanza activa y aprendizaje socioemocional). Se utilizó un modelo de ecuaciones estructurales con mínimos cuadrados parciales (PLS-SEM) para analizar la fiabilidad, la validez y la estructura de relaciones entre los constructos. Los resultados evidencian que la neurociencia tiene un impacto significativo en la percepción docente sobre la innovación y el desarrollo de estrategias de enseñanza, explicando gran parte de la varianza de la didáctica de aprendizaje y de sus dimensiones asociadas. El estudio concluye que fortalecer la alfabetización neurocientífica del profesorado y adoptar metodologías activas contribuye a una educación superior más eficaz e inclusiva.

Palabras clave: neurociencia educativa; enseñanza activa; plasticidad cerebral; aprendizaje socioemocional; PLS-SEM; docentes.

INTRODUCTION

The educational context in cities such as Tacna, near the border with Chile, is characterized by constant exchange due to geographical proximity and binational integration policies. This border has given rise not only to a relationship that goes beyond the commercial sphere, but also to ties that promote development in higher education. Thus, teachers, students, and even professionals engage in circular migration motivated by the search for opportunities that complement the academic offerings of each country. In turn, inter-institutional agreements and even bilateral agreements promote the implementation of research projects, student mobility, mirror classes, among others, which enrich the educational experience by integrating not only the academic world but also the cultural diversity (De Wit, 2005; UNESCO, 2021).

Furthermore, the border population shares a type of cultural identity that requires educational responses adapted to local realities as well as global challenges. Issues such as labor market integration in binational markets, strengthening professional skills, and interculturalism are becoming topics on the agenda even in universities. Several authors have studied how circular mobility directly impacts the educational systems of both countries, understanding how border interactions generate unique dynamics that even affect the educational environment (Alarcón-Muñoz and Rojas-Véliz, 2021; Jiménez et al., 2024; Rojas-Pedraza and Abarca-Guzmán, 2023; Sáez-Carreras and López-García, 2022; Sanhueza-Henríquez and Riquelme-Urbina, 2020).

The scientific literature on neuroscience has shown that exposure to different languages and cultures strengthens neural connections, mainly because it develops memory, creativity, critical thinking, and, above all, problem-solving skills (Huang and Huang, 2022). This fosters more adaptable and resilient brains, which is essential in globalized societies that are constantly changing. In this sense, Tacna is home to an academic exchange where neuroscientific processes are intrinsically linked to learning and cultural adaptation (Floca et al., 2020). Authors such as Sierra-Huedo and Foucart (2022) and Arnaiz-Castro et al. (2022) highlight that students participating in mobility programs between Tacna and students from Chile are exposed to multicultural and bilingual contexts that activate mechanisms of brain plasticity, promoting the development of cognitive and socio-emotional skills.

Therefore, bilingualism and intercultural practice become factors that enhance cognitive flexibility in border students. Neuroscience is therefore a key tool in the teaching-learning process, as it provides knowledge to improve the design of student-centered teaching strategies.

1.1. Neuroscience and Education

In recent years, neuroscience has emerged as a contributor to the improvement of teaching practices. It offers teachers tools based on knowledge of the brain that serve to improve teaching and learning processes. However, as Bernau (2023) points out, not all teachers are aware of the incorporation of neuroscience in the classroom, which constitutes an obstacle to its impact on educational quality. Jolles and Jolles (2021), as well as Nurmakhanova et al. (2021), emphasize that the integration of neuroscientific knowledge into education should be conceived as a two-way process. However, significant challenges remain, as pointed out by Vig et al. (2023), Ferreira and Rodríguez (2022), and Llorens et al. (2022), who show that insufficient teacher training sometimes prevents teachers from distinguishing between validated scientific contributions and approaches that lack rigor in the classroom. Other authors identify additional barriers related to restricted access to up-to-date academic resources and a lack of language skills to understand specialized literature in neuroscience (Simoes et al., 2022).

In the field of higher education, applications of neuroscience have led to the use of active methodologies that enable lasting learning. Various authors agree on the need to move away from a traditional teaching model and toward strategies and mechanisms that promote effective retention in students, where the value of play-based learning, as well as resilience and cognitive flexibility, contribute to the consolidation of learning (Fragkaki et al., 2022; Koernes and Francis, 2020). Other authors have studied the emotional barriers that limit the university experience, such as Spagnola and Yagos (2020), who address the neuroscience of fear and propose strategies for improving student learning. n contrast, Romero et al. (2022) demonstrate improvements in academic performance through instructional guides based on neuroscientific findings. Davidesco (2020) shows that neural synchronization between teachers and students reinforces participation, while Wheatley et al. (2020) highlight the positive effects of physical activity on academic performance. Miranda et al. (2021) propose active methodologies such as experiential learning and open laboratories to reduce gaps in STEM areas. Phillips and Sontheimer (2023) broaden the scope of neuroscience by showing its relevance in various specialties as potential in vocational training.

1.2. Dimensions of Neuroscience

The most widely studied dimensions of neuroscience include:

Brain plasticity

It studies how the brain's capacity can reorganize itself based on experience and the environment (Milbocker et al., 2023). The concept of plasticity has evolved from Cajal's neuronal theory to studies highlighting the factors that influence learning (Rozo et al., 2024; Milbocker et al., 2023), while technological advances have demonstrated the relevance of adult neurogenesis in memory, learning, and recovery in pathologies such as depression or obsessive-compulsive disorder (Kaczmarek, 2020).

Individual differences

It should be noted that cognitive ability influences brain structure and function. Neuroimaging studies have identified significant variations in parietofrontal pathways that explain differences in intelligence (Deary et al., 2010), while others suggest that these particularities are decisive for specific talents, especially in highly gifted individuals (O'Boyle, 2000). These differences cannot be reduced to a single factor; on the contrary, they must be understood as emerging properties of distributed processing networks (McFarland, 2017).

Emotional learning

Emotional learning is demonstrated through neuroscience to be not a complement, but rather a structural component of educational processes (Barrios and Botero, 2020). Incorporating experiences such as positive emotions into teaching practices enhances motivation, promotes empathy, and contributes to meaningful learning (Ramírez, 2021). Emotional education is presented as a key strategy for the comprehensive training of university students (Corrales, 2024; Valenzuela and Miño, 2021).

1.3. Dimensions of Teaching Strategies for EDA Learning

Educational technology and digital learning

Recent studies find that innovative pedagogical approaches are crucial for promoting meaningful and sustainable learning in higher education. Active methods such as service learning, problem-based learning, and project-based learning have proven effective in developing skills related to sustainability (Tejedor et al., 2019; Martín-Requejo and Santiago-Ramajo, 2022). Advances in artificial intelligence also contribute to the enrichment of these strategies and facilitate pedagogical innovation (Vigueras et al., 2024). However, various authors emphasize that its implementation must be adapted to the conditions of the student body, especially in rural or adult education contexts, where the technological divide can accentuate inequalities (Simões and Rocha, 2023). Another important factor is understanding how teachers perceive this interaction between neuroscience and technology, noting that these perceptions are crucial to understanding the adaptation of their practices (Corona et al. 2019).

Active teaching strategies

Matienzo (2020) argues that the role of university teachers should be geared toward promoting meaningful, critical, and self-critical learning, addressing declarative, procedural, and attitudinal content in a balanced manner.

Social and emotional learning

Another important aspect to study is the socio-emotional component, which has taken on an important role with the recognition that skills such as empathy, self-regulation, and ethical decision-making are essential for academic and professional success (Bolaños, 2020). Alzina and Rebolledo (2021) argue that incorporating these skills early on helps mitigate psychosocial problems in the university environment. Meanwhile, Yugcha et al. (2023) highlight the direct relationship between the development of these skills and general intelligence.

Objective and Hypothesis

Considering the academic literature reviewed, this research seeks to analyze how neuroscience and teaching strategies for learning (EDA) influence the perceptions of teachers in higher education. Specifically, the following hypotheses are proposed:

(H1) Brain plasticity positively influences teachers' perceptions of pedagogical innovation.

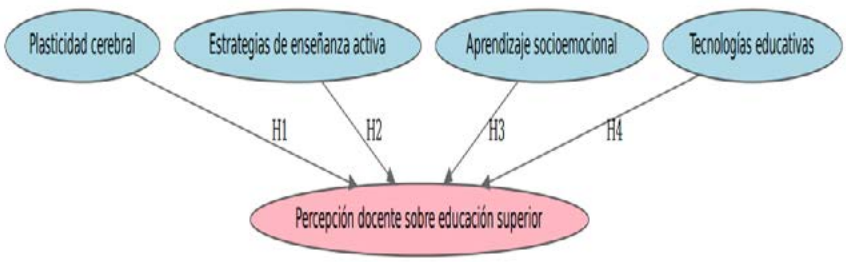
(H2) Active teaching strategies significantly affect teachers' perceptions of teaching effectiveness.

(H3) Social-emotional learning positively affects perceptions of the impact on comprehensive education.

(H4) The use of educational technologies positively influences teachers' perceptions of teaching quality.

Based on the hypotheses, the following theoretical research model was proposed (Figure 1).

Figure 1
Theoretical model.



Note. The figure represents the hypothesized relationships between the dimensions of neuroscience and teaching strategies for learning (EDA) and teacher perceptions in higher education.

METHOD

2.1. Study design

A basic quantitative study was conducted using a non-experimental cross-sectional design, since the objective was to analyze the variables as they occur in their natural context, without any manipulation by the researchers (Hernández and Mendoza, 2018).

2.2. Study Participants

The population consisted of university professors from the cities of Tacna and Arica. A total of 164 questionnaires were administered, of which 132 were valid after data cleaning. The inclusion criteria were being an active teacher at a university in one of these cities and having provided informed consent. Respondents with incomplete questionnaires were not included. The final sample was determined based on the availability of participants in the third quarter of 2023 and was adequate for analysis using partial least squares structural equation modeling (PLS-SEM), taking into account recommendations for small samples.

2.3. Instruments

For the fieldwork, a questionnaire was designed based on a review of specialized literature on educational neuroscience and teaching strategies. The instrument included:

A questionnaire on education-based neuroscience. This was based on studies by Milbocker et al. (2023), Rozo et al. (2024), Baroncelli and Lunghi (2020), and Kaczmarek (2020), among others. The questionnaire consisted of 15 items measured on a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree).

A questionnaire on teaching strategies for learning (EDA). Based on the research work of Corrales (2024), Valenzuela and Miño (2021), and Ramírez (2021). It also includes 15 items in Likert format.

The questionnaire has been validated by three expert jurors in university education and neuroscience. A reliability analysis was also generated using Cronbach's Alpha, obtaining $\alpha = 0.977$ for neuroscience and $\alpha = 0.974$ for EDA.

2.4. Procedure

The questionnaire was administered during the third quarter of 2023 in person at various universities. The unit of study was the teaching staff, who were informed of the objectives of the study and assured of the confidentiality of their responses.

2.5. Statistical analysis

The empirical work was carried out using descriptive and inferential statistical techniques. To evaluate the theoretical model, the partial least squares structural equation modeling (PLS-SEM) method was used (Hair et al., 2022). The reliability of the constructs was evaluated using Cronbach's alpha coefficient and reliability composites, while validity and discriminant validity were estimated using AVE (Average Variance Extracted) and the Fornell-Larcker criterion. Overall fit indices were also verified, and standardized regression coefficients were calculated to test the hypotheses.

RESULTS

3.1. Descriptive analysis of teacher perception

53.0% of the teachers surveyed said they totally agreed with the importance of brain plasticity and an additional 33.3% agreed, while negative responses were less than 7%. 61.4% perceive that teaching based on brain plasticity benefits university learning ability, and 56.1% believe that neuroscience offers practical approaches to leverage it in the classroom. In addition, 44.7% of teachers reported feeling confident in their ability to apply these concepts in their practice.

77.2% of teachers acknowledged the existence of individual differences, and 82.6% were willing to adapt their teaching methods to address them. 83.4% believed that understanding these differences improves their ability to provide academic support, and 86.3% are willing to use flexible approaches that respond to the cognitive needs of each student.

In relation to emotions and learning, 56.1% of teachers recognized that emotional impact is crucial to the educational process, and 50.8% said they were willing to implement strategies that create a positive classroom environment. In addition, 54.5% said that emotional learning improves information retention, while 57.6% said that emotions influence student motivation. 43.9% indicated that they were familiar with neuroscientific advances in this field.

The neuroscience indicator was constructed, showing that most teachers were at intermediate levels for brain plasticity (61.4%), individual differences (50.0%), and emotional learning (64.4%), while the overall level of neuroscience was distributed relatively evenly across the three levels (low=31.8%, medium=31.8%, high=36.4%).

In terms of teaching strategies for learning, in the technological dimension, 39.4% of teachers strongly agreed, and 40.2% agreed that the integration of mobile applications and online platforms enhances students' intellectual development. 40% reported observing improvements in creativity and problem-solving skills thanks to the use of digital tools, and a similar percentage acknowledged that these technologies allow for the personalization of learning. 62.9% considered it essential to train teachers in the use of educational technology to maximize its impact on student intelligence.

More than half of teachers (53.0%) stated that practical activities and problem solving promote a deep understanding of concepts, and 86.4% highlighted the effectiveness of collaborative projects in stimulating critical thinking and creativity. Some 56.8% emphasized that debates and discussions strengthen communication and argumentation skills, while 56.1% pointed out that these strategies increase interest and motivation to learn. 56.8% highlighted the value of project-based activities for transferring knowledge to real-world contexts.

With regard to social-emotional learning, 44.7% of teachers recognized that the development of social-emotional skills such as empathy and self-regulation contributes to overall intelligence development. 50.0% considered that these skills influence the ability to make rational decisions, and more than 40% agreed that teaching social-emotional skills should be an essential part of the university curriculum.

An indicator was also constructed on teaching strategy levels, which showed that perceptions of the use of educational technology were concentrated at the low level (43.9%), while active teaching strategies and social-emotional learning were predominantly high (47.7% and 45.5%, respectively). Thus, the overall indicator for teaching strategies was mostly at the high level (49.2%).

3.2. Validation of the measurement model

The PLS-SEM measurement model allowed us to evaluate the reliability and validity of the constructs. Table 1 shows the internal consistency and convergent validity indices, where the constructs achieved Cronbach's alpha and reliability values of 0.89, and the average variance extracted (AVE) values exceeded the threshold of 0.69, indicating adequate consistency and convergence.

Table 1

Reliability and convergent validity of constructs

Construct	Alfa	CR	AVE
Emotional Learning	0.929	0.943	0.785
Social-Emotional Learning	0.954	0.955	0.879
Learning Didactics	0.903	0.904	0.838
Individual Differences	0.933	0.935	0.790
Active Teaching	0.957	0.957	0.854
Neuroscience and Education	0.906	0.907	0.843
Brain Plasticity	0.945	0.947	0.821
Educational Technology	0.890	0.897	0.694

Note: The table shows the constructs with their respective Alpha, CR, and AVE values.

Discriminant validity was verified using the Fornell–Larcker criteria and the HTMT ratio. In the Fornell–Larcker matrix, the square root of the AVE for each construct exceeded the correlations with the other constructs. Most HTMT ratios were below the threshold of 0.90, although some combinations approached 1, meaning that the overall model showed adequate discrimination among the constructs.

3.3. Structural model

Figure 2 shows the route model estimated using PLS-SEM. The standardized coefficients of the routes (β), the values of determination (R^2), and their statistical significance are presented in Table 2. The data indicate that all direct effects were positive and significant ($p<0.001$).

Figure 2
Structural model

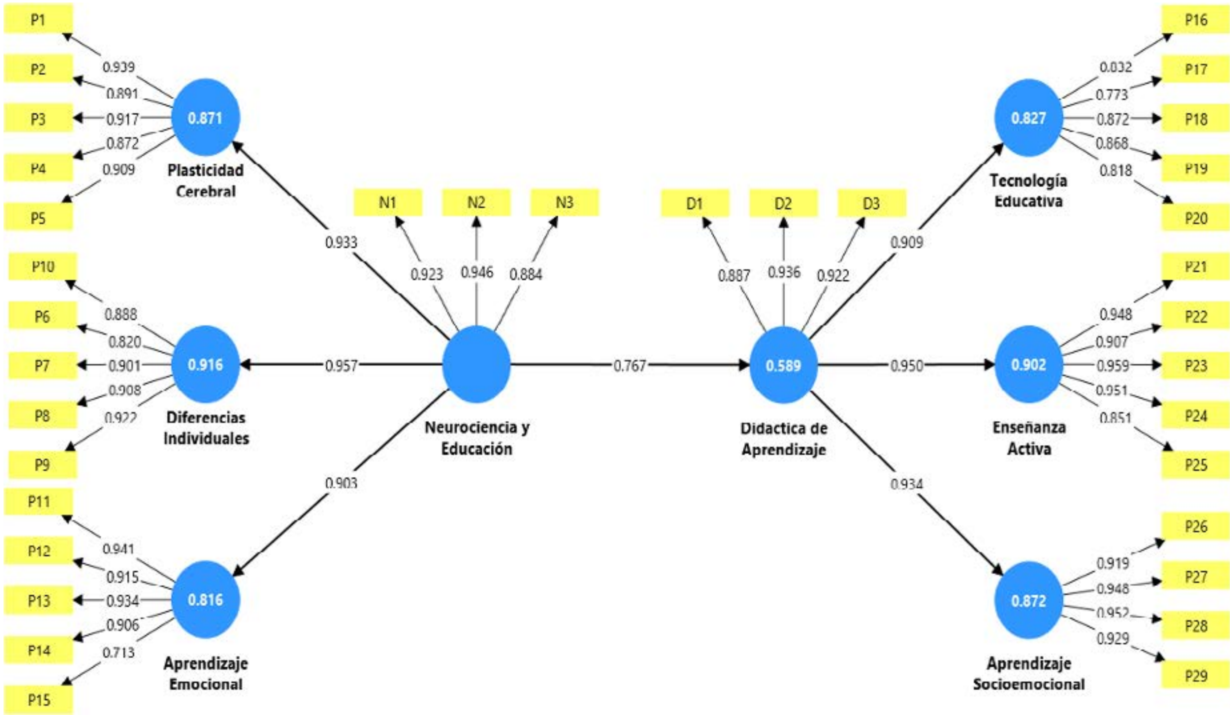


Table 2
Structural model results (total effects)

Route	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T-statistics (|O/STDEV|)	P values
Teaching_Learning -> Social-Emotional Learning	0.934	0.933	0.02	47.456	0.000
Teaching_Learning -> Active Teaching	0.95	0.949	0.012	76.353	0.000
Teaching_Learning -> Educational_Technology	0.909	0.909	0.023	39.625	0.000
Neuroscience and Education -> Emotional Learning	0.903	0.901	0.041	22.173	0.000
Neuroscience and Education -> Social-Emotional Learning	0.717	0.713	0.067	10.724	0.000
Neuroscience and Education -> Teaching_Learning	0.767	0.764	0.065	11.733	0.000
Neuroscience and Education -> Individual_Differences	0.957	0.957	0.01	94.173	0.000
Neuroscience and Education -> Active Teaching	0.729	0.726	0.068	10.731	0.000
Neuroscience and Education -> Brain Plasticity	0.933	0.932	0.018	52.156	0.000
Neuroscience and Education -> Educational_Technology	0.698	0.696	0.072	9.739	0.000

The coefficient of determination (R^2) for the teaching variable was 0.589, indicating that approximately 59% of its variance is explained by the dimension of neuroscience and education. Social-emotional learning, active teaching, and educational technology obtained R^2 values of 0.872, 0.902, and 0.827, respectively, demonstrating the model's high explanatory power in these dimensions. The first-order variables brain plasticity (R^2=0.871), individual differences (R^2=0.916), and emotional learning (R^2=0.816) also showed high explained variances. In addition to the structural effects, the adequacy of the measurement model was evaluated. The factor loadings of each item on its target construct were high (between 0.71 and 0.96), while cross-loadings with other factors were practically nil. This confirms the convergent validity and correct assignment of the items. The variance inflation factors (VIF) associated with each indicator were below 5, which rules out problems of collinearity between the observation variables.

To verify discriminant validity, the Fornell–Larcker criteria and the HTMT ratio were applied. In the Fornell–Larcker matrix, the square root of the mean variance extracted from each construct (diagonal values) exceeded all correlations with other constructs, indicating that each dimension explains more variance from its own indicators than it shares with other latent variables. The HTMT ratios remained, for the most part, below the threshold of 0.90; only a few pairs of constructs (Learning Didactics–Active Teaching) approached 1.

DISCUSSION

The results obtained in this research confirm the decisive role of neuroscience in teachers' perceptions of teaching strategies in higher education. As Bernabeu (2023) and Ferreira and Rodríguez (2022) argue, rigorous knowledge of brain processes is a strength for educational innovation. In our study, the neuroscience and education dimension showed a positive and significant effect on teaching methods ($\beta = 0.767$, $p < 0.001$; $R^2 = 0.589$), confirming that teachers with a greater understanding of neuroscience deploy more flexible, reflective, and emotionally sustained methodologies. This finding coincides with that reported by Vig et al. (2023) and Jolles and Jolles (2021), who show that a solid foundation in neuroscience fosters critical thinking as a more effective classroom strategy.

The empirical results reinforce the relevance of integrating active methodologies with emotional components into training processes. In the structural model, learning didactics had a very high effect on active teaching ($\beta = 0.950$; $R^2 = 0.902$) and social-emotional learning ($\beta = 0.934$; $R^2 = 0.872$). This empirical relationship is related to the contributions of Fragkaki et al. (2022), Romero et al. (2022), and Spagnola and Yagos (2020), who demonstrated that methodologies based on neuroscientific principles enhance motivation, working memory, and sustained attention. Likewise, research by Milbocker et al. (2023) and Rozo et al. (2024) supports the idea that brain plasticity is strengthened through collaborative and emotionally meaningful experiences. In this sense, teachers who apply experiential approaches not only consolidate lasting learning, but also contribute to the comprehensive development of university students, in line with the arguments of Barrios and Botero (2020) and Corrales (2024) on the centrality of emotion in education.

The significant relationship observed in the study between neuroscience, brain plasticity, and individual differences ($\beta = 0.957$; $R^2 = 0.916$) corroborates the need to move toward teacher training that recognizes cognitive diversity and different learning rhythms. Research by Slagter and Bouwer (2021) and McFarland (2017) highlights that understanding neurocognitive variations allows for the design of more inclusive and equitable pedagogical experiences. Valenzuela and Miño (2021) and Yugcha et al. (2023) indicate that neuroscience-based strategies strengthen social-emotional skills such as empathy and self-regulation, which are key elements for social cohesion in multicultural environments. Thus, this study expands the evidence that incorporating neuroeducational principles into university teaching promotes the integration of knowledge with the human dimension of learning, especially in border areas where interculturality is an integral part of the educational process.

Regarding the relationship between educational technology and neuroscience, the data show a robust relationship ($\beta = 0.909$; $R^2 = 0.827$), although descriptive levels reveal that technology adoption is still limited (43.9%). This contrast suggests the existence of a gap between pedagogical potential and practical application, a phenomenon identified in the research of Martín-Requejo and Santiago-Ramajo (2022) and Corona et al. (2019), who warn that educational digitization requires teaching skills based on neuroscientific evidence to avoid the superficial use of technological tools.

Although the model showed high levels of validity and reliability, some HTMT ratios (≥ 0.90) between learning didactics and active teaching show conceptual proximity among the constructs. This result coincides with the observations of Nurmakhanova et al. (2021) and Vigueras et al. (2024), who point out that neuroeducation, active pedagogy, and digital competencies form an interdependent system rather than isolated spheres.

CONCLUSION

This research confirms that neuroscience applied to higher education represents a transformative force for pedagogical innovation, providing scientific foundations that guide more conscious, inclusive, and emotionally meaningful teaching. The results obtained demonstrate that understanding the principles of brain plasticity, individual differences, and emotional learning has a multiplier effect on active strategies and teaching quality, validating the relevance of the proposed model. In line with Corrales (2024) and Valenzuela and Miño (2021), the findings reaffirm that social-emotional learning is a core competency in university education, essential for student well-being and the consolidation of an empathetic and global citizenship. Likewise, the significant relationship between neuroscience and learning pedagogy shows that a solid neuroscientific literacy promotes reflective, critical, and emotionally responsible teaching. Therefore, the institutionalization of training in neuroeducation within teacher development programs is proposed, ensuring the effective transfer of scientific knowledge into everyday teaching practice. The study also shows that teachers' positive perceptions of educational neuroscience are reflected in a greater willingness to embrace methodological innovation and personalized learning. However, the lower level of mastery of emotional learning and limitations in the use of educational technology highlight the need to strengthen teacher training programs in digital skills, emotional self-regulation, and critical interpretation of neuroscientific findings.

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The authors declare that they have no conflict of interest.

Authors Roles:

GCA: conceptualization; **KVP:** methodology; **GPRE:** research; **JDCBC:** research; **ALMBS:** conceptualization; **NCVR:** methodology and data curation; **PNC:** Formal analysis.

All authors reviewed and participated in the writing of the final version of the manuscript, which was approved by the entire group.

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MATERIAL SUPLEMENTARIO

El presente documento complementa el artículo principal y proporciona información detallada sobre el modelo de medición utilizado en el estudio. Contiene las cargas factoriales, los factores de inflación de la varianza (VIF) y las matrices de validez discriminante (HTMT y Fornell–Larcker) para todos los constructos incluidos en el modelo.

Tabla S1.
Cargas factoriales y factores de inflación de la varianza (VIF)

	Aprendizaje Emocional	Aprendizaje Socioemo-cional	Didactica de Aprendizaje	Diferencias Individuales	Enseñanza Activa	Neurocien-cia y Educación	Plasticidad Cerebral	Tecnología Educativa	VIF
D1			0.887						2.343
D2			0.936						3.736
D3			0.922						3.353
N1						0.923			3.608
N2						0.946			4.358
N3						0.884			2.36
P1							0.939		5.494
P2							0.891		3.338
P3							0.917		4.34
P4							0.872		2.985
P5							0.909		3.877

P6			0.82			2.249
P7			0.901			3.729
P8			0.908			3.798
P9			0.922			4.27
P10			0.888			3.124
P11	0.941					5.846
P12	0.915					4.117
P13	0.934					4.997
P14	0.906					3.868
P15	0.713					1.621
P16					0.832	2.717
P17					0.773	2.364
P18					0.872	2.814
P19					0.868	2.993
P20					0.818	2.218
P21				0.948		6.654
P22				0.907		4.8
P23				0.959		9.05
P24				0.951		6.824
P25				0.851		2.829
P26		0.919				4.087

P27	0.948	5.524
P28	0.952	5.989
P29	0.929	4.475

Cada ítem se asocia únicamente con su constructo objetivo; las celdas vacías indican que la carga sobre los constructos restantes es nula. Todos los valores de VIF se mantienen por debajo de 10, lo que descarta problemas de multicolinealidad.

Tabla S2

Matriz HTMT (Heterotrait–Monotrait)

Constructo	Aprendizaje Emocional	Aprendizaje Socioemocional	Didactica de Aprendizaje	Diferencias Individuales	Enseñanza Activa	Neurociencia y Educación	Plasticidad Cerebral	Tecnología Educativa
Aprendizaje Emocional								
Aprendizaje Socioemocional	0.688							
Didactica de Aprendizaje	0.809	1.005						
Diferencias Individuales	0.866	0.66	0.773					
Enseñanza Activa	0.737	0.917	1.02	0.693				
Neurociencia y Educación	0.983	0.734	0.85	1.039	0.775			
Plasticidad Cerebral	0.793	0.709	0.788	0.954	0.724	1.006		
Tecnología Educativa	0.84	0.817	1.005	0.823	0.856	0.881	0.785	

Esta matriz presenta las ratios HTMT entre los pares de constructos. Los valores se interpretan como la relación entre la varianza compartida y la varianza específica de cada par de constructos. Un valor inferior a 0,90 indica una adecuada validez discriminante; valores cercanos o superiores a 1 sugieren solapamiento conceptual.

Tabla S3
Matriz de Fornell–Larcker

Constructo	Aprendizaje Emocional	Aprendizaje Socioemo-cional	Didactica de Aprendizaje	Diferencias Individuales	Enseñanza Activa	Neurocien-cia y Educación	Plasticidad Cerebral	Tecnología Educativa
Aprendizaje Emocional	0.886							
Aprendizaje Socioemocional	0.655	0.937						
Didactica de Aprendizaje	0.748	0.934	0.915					
Diferencias Individuales	0.813	0.624	0.709	0.889				
Enseñanza Activa	0.701	0.877	0.95	0.655	0.924			
Neurociencia y Educación	0.903	0.683	0.767	0.957	0.72	0.918		
Plasticidad Cerebral	0.748	0.673	0.727	0.898	0.688	0.933	0.906	
Tecnología Educativa	0.778	0.765	0.909	0.755	0.808	0.796	0.725	0.833

En la diagonal se muestra la raíz cuadrada de la varianza media extraída (AVE) de cada constructo. Los valores fuera de la diagonal representan las correlaciones entre los constructos. Para que exista validez discriminante, los valores diagonales deben ser superiores a las correlaciones horizontales y verticales correspondientes.

Efectos totales

Constructo	Muestra original (O)	Media de la muestra (M)	Desviación estándar (STDEV)	Estadísticos t (|O/STDEV|)	Valores p
Didactica de_Aprendizaje -> Aprendizaje_Socioemocional	0.934	0.933	0.02	47.456	0.000
Didactica de_Aprendizaje -> Enseñanza_Activa	0.95	0.949	0.012	76.353	0.000
Didactica de_Aprendizaje -> Tecnología_Educativa	0.909	0.909	0.023	39.625	0.000
Neurociencia y_Educación -> Aprendizaje_Emocional	0.903	0.901	0.041	22.173	0.000
Neurociencia y_Educación -> Aprendizaje_Socioemocional	0.717	0.713	0.067	10.724	0.000

Neurociencia y_Educación -> Didactica de_Aprendizaje	0.767	0.764	0.065	11.733	0.000
Neurociencia y_Educación -> Diferencias_Individuales	0.957	0.957	0.01	94.173	0.000
Neurociencia y_Educación -> Enseñanza_Activa	0.729	0.726	0.068	10.731	0.000
Neurociencia y_Educación -> Plasticidad_Cerebral	0.933	0.932	0.018	52.156	0.000
Neurociencia y_Educación -> Tecnología_Educativa	0.698	0.696	0.072	9.739	0.000

Modelo estructural