

Integración de la Escala sMARS Adaptada y Métricas Sintéticas del BCI Emotiv Insight para la Evaluación de la Ansiedad Matemática en Estudiantes de Educación Superior

Nombres y apellidos

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RESUMEN

La presente tesis doctoral se centra en la evaluación integral de la ansiedad matemática en estudiantes universitarios, mediante la integración de la escala sMARSCOL v2, adaptada al contexto colombiano, con métricas sintéticas derivadas del dispositivo BCI Emotiv Insight. El objetivo principal fue diseñar un protocolo de medición, que permitiera una evaluación multidimensional de la Ansiedad Matemática en estudiantes de educación superior.

La investigación se desarrolló en cinco fases. En la primera, se llevó a cabo la validación de contenido por juicio de expertos, quienes evaluaron la claridad, pertinencia y coherencia de los ítems, así como la incorporación de una subescala orientada a la ansiedad social en contextos matemáticos. En la segunda, se aplicó el instrumento a estudiantes de primer y segundo semestre de programas de educación superior, lo que permitió obtener información empírica para la validación de constructo mediante análisis factorial exploratorio (AFE) y confirmatorio (AFC), con resultados que demostraron adecuados índices de ajuste y consistencia interna.

En la tercera fase, se integraron datos sintéticos derivados de métricas EEG simuladas con el dispositivo Emotiv Insight, procesados mediante algoritmos de inteligencia artificial, lo que permitió contrastar los resultados psicométricos con

indicadores neurofisiológicos simulados y evidenciar la convergencia entre ambas fuentes de información. En la cuarta fase, se realizaron análisis bivariados que mostraron asociaciones estadísticamente significativas entre los niveles de ansiedad matemática y variables sociodemográficas como el sexo y la facultad de pertenencia. Finalmente, en la quinta fase, se formuló un protocolo sistemático de evaluación e intervención que combina las dimensiones psicométricas y neurofisiológicas, orientado a fortalecer los procesos institucionales de acompañamiento estudiantil.

Los hallazgos revelan que la ansiedad matemática predomina en niveles moderados dentro de la muestra estudiada, con diferencias significativas por sexo siendo las mujeres más propensas a reportar niveles altos y por facultad con mayor prevalencia en Ciencias Jurídicas y Sociales. Asimismo, la integración de métricas sintéticas y modelado predictivo confirmó la efectividad de la escala sMARSCOL v2 para clasificar a los estudiantes en distintos niveles de ansiedad. En conjunto, la investigación propone un modelo innovador que contribuye tanto al avance de la psicometría como al diseño de políticas educativas basadas en evidencia.

Palabras clave: Validación psicométrica, Interfaz Cerebro-Computador, Datos sintéticos, Aprendizaje automático, Computación afectiva.

ABSTRACT

This doctoral dissertation focuses on the comprehensive assessment of mathematics anxiety in university students through the integration of the sMARSCOL v2 scale, adapted to the Colombian context, with synthetic metrics derived from the Emotiv Insight BCI device. The main objective was to design a measurement protocol that enables a multidimensional evaluation of mathematics anxiety in higher education students.

The research was carried out in five phases. In the first phase, content validation was conducted through expert judgment, where specialists evaluated the clarity, relevance, and coherence of the items, as well as the incorporation of a subscale oriented toward social anxiety in mathematical contexts. In the second phase, the instrument was administered to first- and second-semester higher education students, providing empirical data for construct validation through exploratory (EFA) and confirmatory factor analyses (CFA). The results demonstrated adequate fit indices and internal consistency.

In the third phase, synthetic data derived from simulated EEG metrics obtained with the Emotiv Insight device were integrated and processed using artificial intelligence algorithms. This allowed for a comparison between psychometric results and

simulated neurophysiological indicators, providing evidence of convergence between both sources of information. The fourth phase involved bivariate analyses, which revealed statistically significant associations between mathematics anxiety levels and sociodemographic variables such as gender and academic program. Finally, in the fifth phase, a systematic protocol of evaluation and intervention was developed, combining psychometric and neurophysiological dimensions with the aim of strengthening institutional student support processes.

The findings indicate that mathematics anxiety predominantly manifests at moderate levels within the studied sample, with significant differences by gender women being more likely to report higher levels and by faculty, with greater prevalence in Legal and Social Sciences. Furthermore, the integration of synthetic metrics and predictive modeling confirmed the effectiveness of the sMARSCOL v2 scale in classifying students into different anxiety levels. Overall, the research proposes an innovative model that contributes both to the advancement of psychometrics and to the design of evidence based educational policies.

KeyWords: Psychometric validation, Brain-Computer Interface (BCI), Synthetic data, Machine learning, Affective computing.

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