International Journal of Information Technology & Computer Engineering

ISSN 2347–3657

Volume 13, Issue 4, 2025

Assessing Student Stress With AI And Fuzzy Logic: A Novel Approach

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ABSTRACT
This study investigates the key factors influencing student well-being and performance using the Fuzzy Analytic Hierarchy Process (FAHP). A numerical survey was conducted among college students in Tamil Nadu, India, and the collected responses were reviewed by experts with over 30 years of teaching experience to ensure reliable pairwise comparisons. Four primary criteria were evaluated: Academic Pressure (C1), Personal Issues (C2), Physiological Markers (C3), and Psychological Factors (C4). The FAHP results reveal that Academic Pressure (C1) is the most critical factor impacting student outcomes. The findings provide meaningful insights for students, educators, and college administrators, highlighting the importance of managing academic workloads and offering holistic support. The study further suggests that integrating sports activities, yoga practices, and stress-relief programs can help reduce academic stress and promote improved student well-being and performance.

Keywords:
Fuzzy Analytic Hierarchy Process (FAHP); Student Well-Being; Psychological Factors; Fuzzy MCDM;.

1.INTRODUCTION

In the education sector, stress is a complex and multifaceted issue that significantly affects both students and educators. For students, major sources of stress include academic pressure, time management difficulties, family expectations, and financial constraints. The increasing demand to perform well academically, combined with the challenge of balancing coursework with extracurricular activities and personal responsibilities, often results in heightened anxiety and burnout. Family expectations related to

academic achievement and future career choices can intensify this stress, while financial burdens associated with tuition, materials, and living expenses further contribute to students' overall strain. Limited access to mental health resources, counseling services, and institutional support systems frequently leaves students without adequate coping mechanisms. Educators also experience substantial stress, driven by high performance expectations, heavy workloads, administrative duties, and pressure to meet institutional standards. These stressors can diminish their capacity to support students effectively. Social and peer pressures further influence students' mental health and academic performance, creating an environment where stress becomes pervasive. Despite growing awareness of these issues, significant research gaps remain. More comprehensive studies are needed to examine the role of family dynamics in shaping student stress, as well as longitudinal research to understand the long-term consequences of stress on academic and personal development. The effectiveness of stress-reduction strategies—such as yoga, counseling, and other wellness programs—also requires deeper exploration across diverse cultural and regional contexts. Additionally, the impact of teacher stress on student outcomes and the emerging influence of digital technology as a stressor have not been fully investigated. Addressing these gaps will contribute to a clearer understanding of stress in the educational environment and support the development of more effective intervention strategies.

1.1.Literature review

Research conducted between 1990 and 2025 consistently demonstrates that student well-being and academic performance are shaped by a complex interaction of academic, personal, physiological, and psychological factors. Early investigations highlighted the rising burden of academic pressure on college students, emphasizing how heavy course loads, inadequate time management, and performance expectations contribute to increased stress and anxiety (Misra & McKean, 2000). Over time, substantial evidence has confirmed that academic stress remains one of the strongest predictors of mental health concerns and diminished academic productivity. Physiological determinants, particularly sleep quality, fatigue, and overall physical health, have been shown to critically affect learning capacity, memory, and cognitive functioning, with inadequate sleep linked to impaired academic outcomes (Hershner & Chervin, 2014). Psychological attributes—including emotional resilience, self-motivation, and mental well-being—further influence students' ability to cope effectively with academic demands, often determining their level of engagement and success (Keyes, 2014). Complementing these findings, advancements in multi-criteria decision-making (MCDM) techniques, especially the Fuzzy Analytic Hierarchy Process (FAHP), have enabled researchers to evaluate the multidimensional and uncertain nature of student well-being more accurately. Since the introduction of fuzzy comparison methodologies in the 1990s (Saaty, 1990; Chang, 1996), FAHP has been widely applied to assess student stress, educational quality, and well-being indicators, offering a more nuanced and realistic analysis than traditional linear approaches. Recent literature (2020–2025) further highlights the value of holistic interventions such as sports participation, yoga, and mindfulness practices, which have been shown to reduce stress, enhance physiological balance, and strengthen emotional well-being (Pascoe et al., 2020; Schleinzer, 2024). Collectively, the literature underscores that student well-being is inherently multidimensional and is best understood through analytical frameworks that integrate uncertainty—affirming FAHP's relevance in analyzing the combined influence of academic, personal, physiological, and psychological factors.

1.2.Research Gaps and Limitations

Despite extensive research on student well-being, several gaps remain in the literature. While numerous studies examine academic, physiological, psychological, or personal factors individually, few integrate all four dimensions into a unified decision-making framework. The application of advanced fuzzy multi-criteria decision-making (MCDM) techniques, such as the Fuzzy Analytic Hierarchy Process (FAHP), remains limited, particularly in prioritizing combined stressors affecting overall well-being. Most studies rely on self-reported surveys or cross-sectional data, which fail to capture daily fluctuations in sleep, fatigue, emotional resilience, or academic load. Additionally, existing research often involves small or homogenous student populations, restricting the generalizability of findings. Intervention effectiveness, such as the impact of yoga, sports, or mindfulness, is rarely assessed quantitatively using structured fuzzy decision frameworks. Post-pandemic stressors, including online learning fatigue and digital overload, are also insufficiently explored. Furthermore, the literature suffers from inconsistencies in well-being definitions, limited consideration of cultural and regional differences, and inadequate handling of uncertainty in human judgment. Collectively, these limitations highlight the need for comprehensive, data-driven, and context-sensitive approaches that integrate advanced fuzzy MCDM techniques to evaluate and improve student well-being effectively.

2. FUZZY ANALYTIC HIERARCHY PROCESS (FUZZY AHP)

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ISSN 2347–3657
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The Analytic Hierarchy Process (AHP), introduced by Thomas L. Saaty in 1980, simplifies complex decision-making by structuring it into a hierarchical model and employing pairwise comparisons to establish priority scales. To address the uncertainty in judgments, this method has been enhanced with Triangular Fuzzy Numbers (TFNs), allowing for a more flexible and nuanced evaluation.

1.Developing a fuzzy comparison matrix

First the scale of linguistics is determined.The scale used is the TFN scale from one to nine are shows in Table 1

Table 1. Scale of Interest

Scale of Interest	Linguistic Variable	Membership Function
1	Equally important	(1,1,1)
3	Weakly important	(2,3,4)
5	Strongly more important	(4,5,6)
7	Very strongly important	(6,7,8)
9	Extremely important	(8,9,10)

Then, using the TFN to make pair-wise comparison matrix for the main criteria and sub-criteria. Equation (1) shows the form of fuzzy comparison matrix.

$$\bar{\mathcal{A}} = \begin{bmatrix} 1 & \cdots & \overline{a_{1n}} \\ \vdots & \ddots & \vdots \\ \overline{a_{n1}} & \cdots & 1 \end{bmatrix} \quad (1)$$

2. Define Fuzzy Geometric Mean

The fuzzy geometric mean is then calculated using Equation (2)[13]:

$$\bar{x}_i = \left(\bar{a}_{(i1)} \otimes \bar{a}_{(i2)} \otimes \ldots \otimes \bar{a}_{(in)}\right)^{\frac{1}{n}} \quad (2)$$

Where $\tilde{a}_{in}$ is a value of fuzzy comparison matrix from criteria I to n. Result from the fuzzy geometric mean will be referred to later as local fuzzy number.

3. Calculate the weight of fuzzy of each dimension

The next step is to calculate the global fuzzy number for each evaluation dimension with Equation (3).

$$\tilde{w}_i = \tilde{x}_1 \otimes (\tilde{x}_1 \oplus \tilde{x}_1 \oplus \ldots \oplus \tilde{x}_1)^{-1} \quad (3)$$

4. Define the best non fuzzy performance (BNP)

The global fuzzy number is then converted to crisp weight value using the Centre of Area (COA) method to find the value of best BNP from the fuzzy weight in each dimension, calculated using Equation (4).

$$BNP_{wi} = \frac{[(u_{wi} - l_{wi}) + (m_{wi} - l_{wi})]}{3} + l_{wi} \quad (4)$$

2.1. Case study

In this study, the Fuzzy inference system was utilized to evaluate factors affecting student well-being and performance. The criteria assessed included C1 - Academic pressure, C2 - personal issues,C3 - physiological markers, C4 - psychological factors. These four criteria we consider based on expert openion then only create fuzzy threshold value.The fuzzy AHP. The Fuzzy Analytic Hierarchy Process (FAHP) was used to determine the relative weights of these criteria, with the FAHP values presented in Table 1

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Table 1: Determining the weights of the criteria by FAHP Approach

Criteria	C_1	C_2	C_3	C_4	C_5
Fuzzy Weights	0.2205	0.2145	0.2008	0.1801	0.136
Rank	1	2	3	4	5

3.CONCLUSIONS

The analysis demonstrates that academic pressure is the most influential factor affecting student well-being and performance among the four evaluated criteria. These results underscore the need for colleges to develop strategies that mitigate academic stress and create supportive learning environments. Encouraging students to engage in physical activities, yoga, counseling sessions, and other stress-management programs can effectively enhance their mental and physical health. For college management, the findings offer a valuable framework for designing student-centered policies and interventions. Overall, this study emphasizes the importance of addressing academic stress and implementing holistic well-being initiatives to promote healthier, more productive student communities.

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