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Adverse Experiences and Academic Success in Engineering Education

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Abstract:
Adverse Childhood Experiences (ACEs) have a significant impact on individuals' cognitive, emotional, and social development, with consequences extending into adulthood and affecting academic performance in higher education. This study examines the relationship between ACEs and academic performance of engineering students at the Technological Institute of San Juan del Río, Mexico. Using a mixed-methods approach, a questionnaire (n=313) and a focus group (n=9) were conducted to assess the prevalence of ACEs, their impact on emotional well-being, and academic performance. Results indicate a high prevalence of ACEs among students, with 67.8% reporting at least one adverse experience. A significant negative correlation was found between the number of ACEs and academic average ($r = -0.28$, $p < 0.001$). Qualitative analysis revealed recurrent themes of difficulties in emotional regulation, low self-esteem, and problems in interpersonal relationships. This study underscores the need to implement specific psychological and academic support programs for students with histories of childhood adversity in higher education institutions.

Keywords: Engineering education, mental health, adverse experiences, childhood, academic performance, mixed methods.

I. INTRODUCTION

Adverse childhood experiences (ACEs), including various forms of abuse, neglect, and family dysfunction, have lasting impacts on individual development and well-being (Kothapalli et al., 2023). Research has demonstrated that these experiences can significantly affect academic performance and psychosocial adjustment in higher education (Maloney et al., 2024; Albayrak et al., 2024; Adiba et al., 2023).

In engineering education, where academic demands are particularly high, the impact of ACEs can be especially pronounced. Engineering students must not only master complex technical concepts but also develop problem-solving abilities, teamwork skills, and stress management capabilities (Zoromba et al., 2024). The aftermath of ACEs can interfere with these capacities, affecting both academic performance and emotional well-being.

Despite growing awareness of the importance of addressing ACEs in educational contexts, there remains a significant research gap regarding their impact on engineering students in Mexico. This study aims to bridge this gap by focusing on students at the Instituto Tecnológico de San Juan del Río.

The primary objective of this research is to examine the relationship between ACEs and engineering students' academic performance, as well as their impact on emotional well-being and coping strategies.

Specifically, this study aims to:

- Determine the prevalence of ACEs among engineering students at the Institute
- Analyze the relationship between ACEs and academic performance
- Explore the impact of ACEs on students' emotional well-being and coping strategies
- Identify psychological and academic support needs among students with histories of childhood adversity

This research builds upon the work of Kothapalli et al. (2023), who found a high prevalence of childhood abuse among healthcare profession students, and Sun et al. (2023) regarding the relationship between childhood trauma and insomnia in university students with major depressive disorder. Additionally, it considers the findings of Tanju and Demirbas (2012) on how traumatic experiences affect perceptions of family functioning among university students.

II. METHODOLOGY

A convergent mixed-methods design (Creswell & Plano Clark, 2017) was employed, combining quantitative and qualitative techniques to achieve a comprehensive understanding of the phenomenon. This approach enabled data triangulation and robust interpretation of results. The design choice was based on the need to understand both the statistical correlations of ACEs and students' lived experiences within their academic context.

Participants were engineering students from the Instituto Tecnológico de San Juan del Río, a public higher education institution within Mexico's National Technology System. The quantitative component included 313 students (mean age = 20.3 years, SD = 2.1, 42% female). The sample comprised students from various engineering programs (Industrial, Computer Systems, Electromechanical, and Business Management) across all academic years (first through ninth semester). Sample size was determined through statistical power calculation, using a 95% confidence level and 5% margin of error.

The qualitative component involved a focus group with 9 strategically selected students to ensure diversity in gender (5 female, 4 male), socioeconomic background (varied family income and geographic origin), and academic performance (GPA ranging from 7.0 to 9.5). Focus group participant selection also considered willingness to share personal experiences and ability to articulate reflections on their experiences.

Recruitment began with an open invitation through institutional channels, followed by a selection process based on predefined criteria to ensure sample representativeness. Special attention was paid to including students from different semesters and engineering programs to capture a broad range of experiences and perspectives.

A. Questionnaire

The questionnaire was designed to assess multiple dimensions and validated by educational psychology experts. It comprised ten main sections:

Demographic information: age, gender, and current semester

Adverse childhood experiences: adapted from the ACE Study, including questions about emotional and physical abuse, neglect, and family dysfunction

1. Resilience and coping mechanisms: assessing stress management techniques and recovery capacity
2. Academic performance: overall GPA and specific areas of difficulty
3. Mental health: using PHQ-4 to assess anxiety and depression
4. Social support and current relationships: evaluating support systems and interpersonal relationships

5. Engineering career perception: motivations and expectations
6. University support services: awareness and utilization of institutional resources
7. Pandemic impact: effects on academic performance and emotional well-being
8. Emotional and psychological support needs

The instrument incorporated validated scales such as the PHQ-4 for mental health assessment, alongside questions specifically designed for the engineering student context. A 5-point Likert scale was employed (ranging from "Never" to "Always" or "Strongly Disagree" to "Strongly Agree" as appropriate). Open-ended questions were strategically included to allow detailed expression of personal experiences.

B. Focus Group Guide

The focus group guide followed a semi-structured approach organized into seven sections:

1. Introduction (10 minutes)
- Welcome and moderator introduction
- Study purpose explanation
- Participation guidelines establishment
- Confidentiality assurance

2. Opening Activity (5 minutes)
- Group trust-building exercise

3. Contextualization (15 minutes)
- Factors influencing engineering study choice
- Description of academic trajectory

4. Childhood Experiences Exploration (20 minutes)
- Influence of childhood experiences on career choice
- Emotional challenges faced during university studies

5. Core Questions (40 minutes)
- Perceived influence of childhood family dynamics on current academic performance
- Experiences of rejection, abandonment, humiliation, injustice, or betrayal
- Impact of these feelings on university life
- Stress management strategies
- Effects of childhood emotional wounds on teamwork capabilities

6. Support Services and Well-being (15 minutes)
- Awareness of available psychological support services
- Additional support needs identification

7. Closing and Final Reflections (5 minutes)
- Main themes summary
- Final comments opportunity

C. Procedure

The questionnaire was administered via Google Forms during the August-December 2024 semester. An institutional dissemination campaign was conducted, sending invitations to all engineering students through institutional email. Participation was voluntary, with weekly reminders to maximize response rates.

The focus group was conducted in a private space within the institute, lasting 97 minutes. Participants were selected through stratified sampling ensuring balanced gender distribution (5 female, 4 male), aged 18-25. Inclusion criteria required enrollment in an engineering program at Instituto Tecnológico de San

Juan del Río and willingness to share personal experiences in a group discussion.
The session was moderated by a researcher experienced in qualitative research and audio-recorded with participant consent. Field notes documented non-verbal observations and significant group dynamics.

D. Data Analysis

Quantitative data were analyzed using SPSS v26, including:

- Descriptive statistics for demographic characteristics and ACE prevalence
- Bivariate correlations between ACEs and academic performance
- T-tests comparing groups with and without ACEs
- Multiple regression analysis examining ACE-academic performance relationships, controlling for demographic variables

Qualitative data were transcribed verbatim and analyzed using NVivo 12, following Braun and Clarke's (2006) thematic analysis approach:

- Data familiarization
- Initial code generation
- Theme search and review
- Theme definition and naming
- Final report production

E. Ethical Considerations

The study adhered to strict ethical principles protecting participant welfare. A rigorous informed consent process ensured participants fully understood study objectives, procedures, and their rights as participants. Confidentiality was maintained through a data coding system protecting participant identities, with all information securely stored on password-protected devices accessible only to the research team.
Participation was strictly voluntary, emphasizing participants' right to withdraw at any time without negative consequences. Given the sensitive nature of topics discussed, a referral protocol to psychological support services was established for participants requiring assistance during or after the study.
Additionally, all participants received detailed information about available institutional support resources, including counseling and psychological support services.

III. RESULTS

A. Demographic Characteristics and Career Choice Motivations

The questionnaire sample (N=313) showed a relatively balanced gender distribution (52.2% female, 46.4% male, 1.4% other) (see Figure 1), with predominant ages between 18 and 25 years (89.5%) (see Figure 2). Primary motivations for choosing engineering included career opportunities (59.3%), future income potential (40.7%), and family influence (33.9%) (see Figure 3).

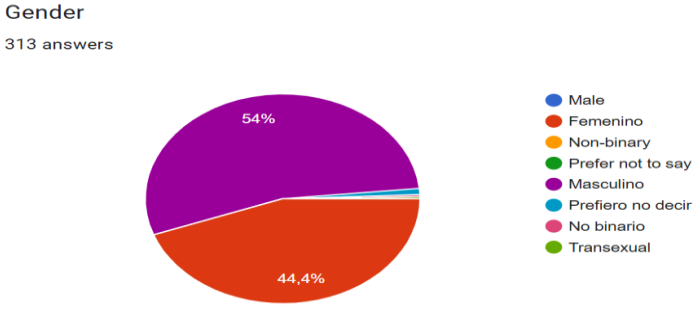

Fig. 1. Gender distribution

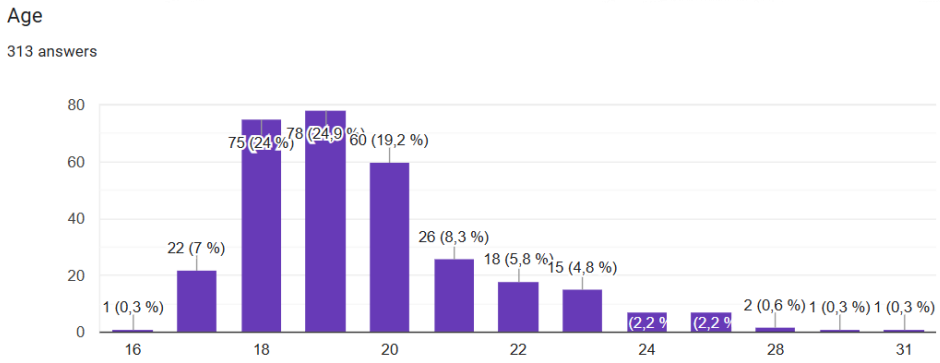

Fig. 2. Participant Ages

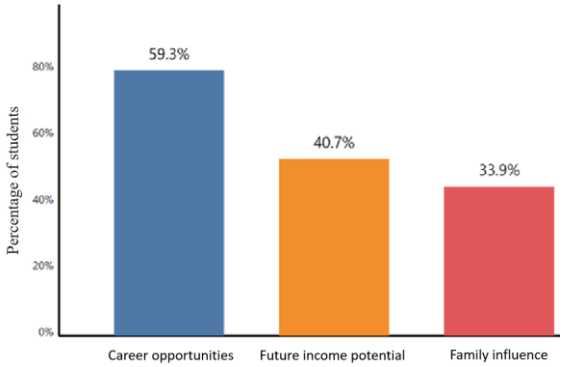

Fig. 3. Career Choice Motivation

These quantitative data were enriched by focus group findings where participants elaborated on their motivations, revealing that adverse childhood experiences (ACEs) also played a role in their career choice. The focus group (n=9) provided additional context, revealing the significant influence of family role models in engineering and early exposure to technology. One participant shared: "I chose engineering to prove I could overcome my circumstances and succeed," while another noted: "Seeing my father's financial struggles motivated me to pursue a career that would provide financial stability." In contrast, another student shared how adversities and comparisons with siblings motivated them to persist in their studies despite feeling significant insecurity and lack of support.

B. Quantitative Analysis

ACE Prevalence: 67.8% of students reported at least one adverse childhood experience. The most common forms of ACEs were (see Figure 4):

1. Parental divorce or separation (32.5%)
2. Emotional abuse (27.8%)
3. Physical abuse (21.7%)
4. Emotional neglect (20.3%)
5. Substance abuse in the household (18.6%)

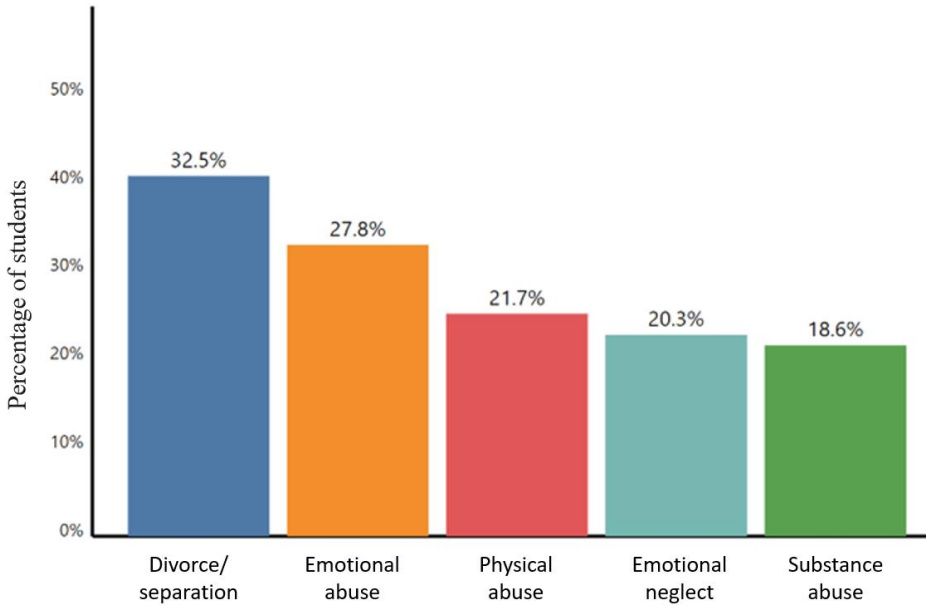

Fig. 4. Distribution of Adverse Childhood Experiences (ACEs) reported by engineering students at the Instituto Tecnológico de San Juan del Río (N=313). Bars represent the percentage of students reporting each type of adverse experience

These results align with Kothapalli et al.'s (2023) findings of high childhood abuse prevalence among university students.

ACE-Academic Performance Relationship: A significant negative correlation was found between number of ACEs and academic average ($r = -0.28$, $p < 0.001$). Students with 4 or more ACEs had significantly lower averages ($M = 7.9$, $SD = 0.8$) compared to those without ACEs ($M = 8.7$, $SD = 0.7$), $t(293) = 5.12$, $p < 0.001$ (see Figure 5).

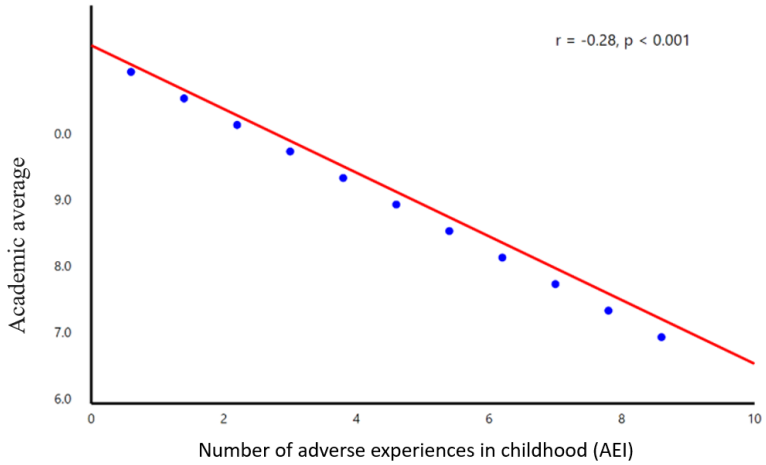

Fig. 5. Correlation between the number of Adverse Childhood Experiences (ACEs) and academic average of engineering students (N=313). The trend line shows a significant negative relationship ($r = -0.28$, $p < 0.001$).

Multiple regression analysis, controlling for age, gender, and year of study, revealed ACEs remained a significant predictor of academic performance ($\beta = -0.25$, $p < 0.001$), explaining 13% of variance in academic averages.

Mental Health and Coping Strategies: 40.3% of students reported anxiety symptoms and 37.6% reported depression symptoms according to PHQ-4. Positive correlations were found between number of ACEs and anxiety ($r = 0.33$, $p < 0.001$) and depression symptoms ($r = 0.37$, $p < 0.001$).

The most common coping strategies reported were (see Figure 6):

1. Seeking social support (66.4%)
2. Engaging in hobbies/recreational activities (61.7%)
3. Breathing/meditation techniques (44.7%)
4. Regular physical exercise (41.4%)
5. Time management and planning (37.3%)

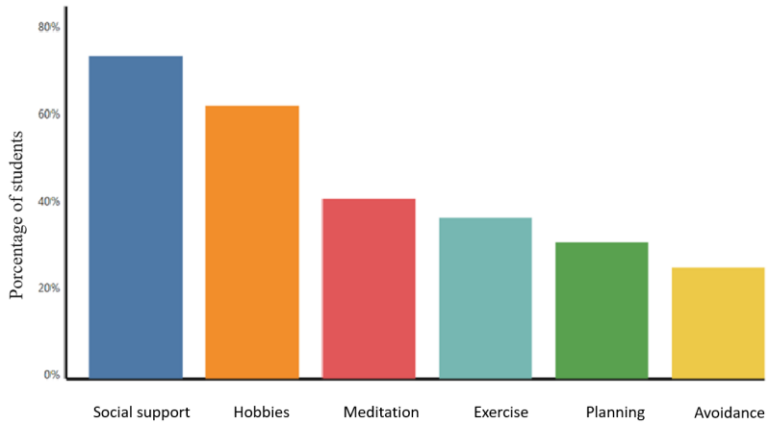

Fig. 6. Most common coping strategies reported by engineering students (N=313). Percentages indicate the proportion of students using each strategy.

Students with higher ACE counts tended to use more avoidance strategies ($r = 0.22$, $p < 0.01$) and fewer social support-seeking strategies ($r = -0.17$, $p < 0.05$).

B. Qualitative Analysis

Thematic analysis of the focus group (n=9) revealed several recurring themes that complement and deepen the quantitative findings:

1. Impact of ACEs on Career Choice: Participants indicated that their adverse experiences influenced their decision to study engineering. One student commented: "Seeing my father struggle financially motivated me to pursue a career that would give me financial stability." Another mentioned: "I chose engineering to prove I could overcome my circumstances and succeed," while another student said: "I was always surrounded by engineers and saw that their economic lives were better than families without a degree." On the other hand, motivations stemmed from negative situations, mockery and humiliation, and primarily pain, receiving comparisons and doubting their ability, which they say led them to prove to others, and to themselves, that they chose to "take the risk" and continue their academic training by pursuing a university degree. Without being certain they can complete it.
2. Difficulties in Emotional Regulation: Students with histories of ACEs reported greater difficulty managing academic stress. One participant expressed: "When I face a difficult exam, I feel like I'm that helpless child again and I freeze." Another added: "Sometimes, academic pressure triggers memories from my childhood and I struggle to concentrate." Most students expressed not knowing how to handle stressful situations, and being exposed to circumstances of addiction, hysteria, and

making poor decisions.

3. Interpersonal Relationship Problems: Difficulties in teamwork and establishing trust relationships were identified. One student shared: "I find it very hard to trust my team members, I always feel they will disappoint me like my parents did." Another mentioned: "I prefer to work alone because I find it difficult to communicate effectively in groups." The remaining students also expressed having little tolerance for teamwork, and stated they are unwilling to adapt to other colleagues' working styles, preferring to work in isolation, which may be due to their family isolation during childhood.
4. Resilience and Motivation: Despite adversities, many students showed strong motivation. One participant mentioned: "My difficult experiences have made me stronger and more determined to succeed in my career." Another student added: "I use my past experiences as motivation to prove I can achieve great things."
5. Need for Institutional Support: Students expressed the need for greater psychological and academic support. A recurring comment was: "We need professors who understand what we've been through and support us, not just academically." Another student suggested: "It would be helpful to have specific support groups for students who have gone through difficult experiences."
6. Impact on Academic Performance: Several participants directly related their past experiences to their current performance. One student commented: "Sometimes I struggle to concentrate in class because memories from my childhood distract me." Another mentioned: "I've developed a strong work ethic as a result of my experiences, which helps me academically."
7. Coping Strategies: Participants described various strategies for managing stress and academic difficulties. One student shared: "I practice meditation daily to manage my anxiety." Another mentioned: "I seek support from close friends when I feel overwhelmed by studies," two other students acknowledge overeating and say they have difficulty seeking psychological support, while in other cases they seek psychological support and professional help to deal with adverse situations

These qualitative findings provide deeper context to the quantitative results, illustrating how ACEs affect various aspects of engineering students' academic and personal lives. The combination of quantitative and qualitative data offers a more complete picture of the impact of ACEs on this student population.

IV. DISCUSION

The results of this study underscore the significant impact of adverse childhood experiences (ACEs) on academic performance and emotional well-being among engineering students at the Instituto Tecnológico de San Juan del Río. The high prevalence of ACEs found (67.8%) aligns with previous studies in university populations (Kothapalli et al., 2023), suggesting this is a widespread issue requiring urgent attention.

The negative correlation between number of ACEs and academic average indicates that early adverse experiences can have lasting effects on educational performance, even at advanced educational levels. This may be attributed to various factors, including difficulties in emotional regulation, attention and concentration problems, and challenges in study skills, as suggested by Maloney et al. (2024) and Zoromba et al. (2024).

The qualitative results provide deeper insight into how ACEs affect engineering students' educational experience. The influence of ACEs on career choice, for example, suggests that these experiences can shape educational aspirations and decisions in complex ways. This aligns with Albayrak et al.'s (2024) findings on how early experiences can influence life trajectories.

Figure 7 presents a conceptual model synthesizing this study's key findings, illustrating how ACEs influence engineering students' academic performance and emotional well-being. This model highlights the crucial role of mediating factors, such as emotional regulation, coping strategies, and interpersonal relationships, in how ACEs affect academic and emotional outcomes.

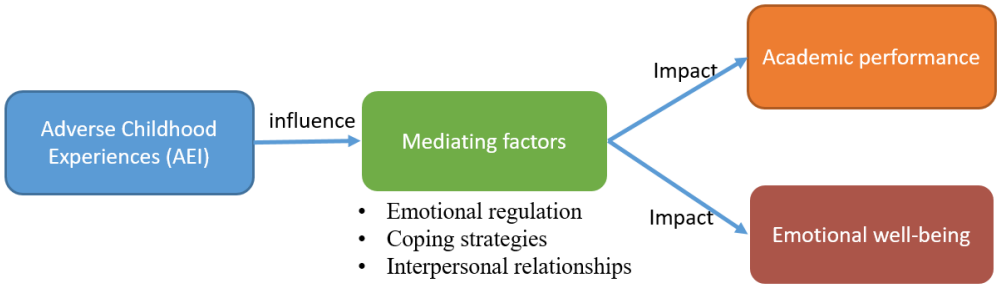

Fig. 7. Conceptual model illustrating the relationships between Adverse Childhood Experiences (ACEs), academic performance, and emotional well-being of engineering students, based on study results.

The reported difficulties in emotional regulation and interpersonal relationships are particularly concerning in engineering education, where teamwork and stress management are crucial. These findings support Tanju and Demirbas's (2012) research on how childhood trauma affects family functioning and, by extension, interpersonal relationships in adult life.

The high prevalence of anxiety and depression symptoms among students with ACEs is consistent with Sun et al.'s (2023) findings and underscores the need for accessible and effective mental health services in higher education institutions. The tendency of students with more ACEs to use less adaptive coping strategies suggests the need for interventions promoting more effective coping skills.

Despite these challenges, the resilience and motivation expressed by many students provide a starting point for interventions that capitalize on these strengths. This aligns with the resilience approach proposed by Somers et al. (2024) for promoting well-being in individuals with histories of adversity.

The expressed need for greater institutional support emphasizes the importance of developing comprehensive programs that address both academic and emotional needs of students. This could include training for professors on trauma-informed practices, as suggested by Gray et al. (2023), as well as implementing mentoring and peer support programs.

Focus group results provided deeper insight into how ACEs influence engineering students' career choices and university experiences. The motivation to overcome past adversities and seek financial stability reflects the complex interaction between traumatic experiences and educational and professional aspirations. These findings underscore the need for a holistic approach to vocational guidance and student support that considers students' life experiences.

The deep understanding of how ACEs, rooted in transgenerational patterns and manifested through complex family dynamics, impact engineering students' academic and personal development, provides an invaluable reference framework for designing effective psycho-pedagogical interventions. Evidence suggests that these interventions, when designed considering the multifaceted nature of ACEs, not only have the potential to improve academic performance but can also significantly strengthen students' socioemotional development. This comprehensive approach contributes to forming more resilient engineering professionals who can integrate their adverse experiences as catalysts for developing

creativity and innovation while maintaining healthy emotional balance. Moreover, implementing these interventions could generate a multiplier effect, as future engineers, having processed and reframed their own adverse experiences, would be better equipped to contribute to technological and engineering solutions addressing complex social problems.

The reported difficulties in emotional regulation and interpersonal relationships are particularly relevant in engineering education, where teamwork and stress management are crucial skills. These findings suggest the need to integrate socioemotional skills development into the engineering curriculum, an approach supported by recent research on the importance of soft skills in engineering education (Koslouski et al., 2023).

V. LIMITATIONS AND FUTURE DIRECTIONS

This study has several limitations. First, being a cross-sectional study, it cannot establish definitive causal relationships. Future longitudinal studies could provide a clearer understanding of how ACEs affect academic development over time. Second, the sample was limited to a single institution, which may limit the generalization of results. Multi-institutional studies could offer a broader perspective.

Future research could explore specific interventions to support engineering students with ACE histories, such as trauma-informed mentoring programs or coping skills development workshops. Additionally, it would be valuable to examine how different types of ACEs may differentially affect academic performance and emotional well-being.

Another promising area for future research is the exploration of protective factors that may mitigate the negative impact of ACEs in academic contexts. This could include studying resilience, social support, and adaptive coping strategies specific to engineering students.

VI. CONCLUSION

This study provides robust evidence of the significant impact of adverse childhood experiences on academic performance and emotional well-being of engineering students at the Instituto Tecnológico de San Juan del Río. Quantitative findings demonstrate a significant negative correlation ($r = -0.28$, $p < 0.001$) between ACEs and academic performance, while qualitative data reveal complex patterns of how these experiences influence motivation, learning, and interpersonal relationships. The results underscore the imperative need for a comprehensive approach in higher education that recognizes and addresses students' previous experiences, especially considering that 67.8% of participants reported at least one significant adverse experience.

Higher education institutions, especially those focused on engineering education, should consider implementing comprehensive support programs including:

1. Accessible mental health services adapted to engineering students' specific needs, including:
- Specialized individual and group counseling
- Stress prevention and management programs
- Crisis intervention services
- Personalized follow-up for at-risk students

2. Faculty training on trauma-informed pedagogical practices, covering:
- Recognition of trauma and stress signals
- Trauma-sensitive communication strategies
- Flexible and adaptive assessment techniques

- Creation of safe learning and support environments

3. Mentoring programs that foster resilience and development of adaptive coping skills, through:

- Strategic pairing with trained mentors
- Structured personal development sessions
- Personalized academic support
- Peer support networks

4. Integration of socioemotional skills in the engineering curriculum, including:

- Emotional intelligence modules
- Effective communication workshops
- Teamwork skills development
- Stress management and self-regulation

5. Creation of safe spaces for students to share their experiences and receive peer support, through:

- Professionally facilitated support groups
- Community-building activities
- Physical and virtual spaces for social connection
- Student wellness programs

By addressing the impact of ACEs in engineering education, institutions can not only improve their students' academic performance but also contribute to their integral development as resilient and emotionally competent future professionals. Results suggest that early interventions and continuous support can help students transform their adverse experiences into sources of motivation and personal growth.

This study represents an important step toward understanding and addressing the unique needs of engineering students with histories of childhood adversity. The research reveals that these experiences, although challenging, can become catalysts for developing resilience and determination when appropriate support is provided. By recognizing and addressing these experiences, higher education institutions can create more inclusive and supportive environments that not only foster academic success but also promote overall student well-being.

The effective implementation of these recommendations requires sustained institutional commitment, dedicated resources, and continuous impact evaluation. Future studies could examine the effectiveness of these interventions and explore how different types of ACEs may require specific support approaches. This research lays the foundation for a paradigmatic shift in engineering education, towards a model that recognizes and addresses not only academic needs but also the psychological and emotional dimensions of learning and professional development.

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