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# Influence of information and communication technologies on academic resilience in vulnerable contexts

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## ABSTRACT

This study investigates how the use of information and communication technologies (ICT) influences the academic resilience of high school students in Soacha, Colombia, an area with significant socioeconomic challenges. The objective of the research is to analyze whether greater access to and proper use of ICT can improve students' ability to face academic and emotional adversities. A mixed methodology was applied, combining quantitative surveys and qualitative interviews with 300 students from three educational institutions, measuring ICT use and academic resilience through validated scales. The findings revealed a significant positive correlation ($r=0.95$) between ICT use and academic resilience, demonstrating that students who used ICT more frequently showed higher levels of self-efficacy, better stress management, and more efficient academic organization. These results highlight the importance of integrating ICT into educational policies in vulnerable contexts, given their impact on both academic performance and students' emotional well-being. It is recommended to prioritize digital competence training in educational institutions to strengthen students' abilities to face academic and emotional challenges.

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## 1. INTRODUCTION

Academic resilience and the use of information and communication technologies (ICT) have gained significant attention due to their potential to improve student performance in challenging educational environments [1], [2]. Academic resilience refers to students' ability to overcome adversity and continue their studies, while ICT provides tools and resources that support this process [3], [4]. In vulnerable contexts, such as Soacha, Colombia, where socioeconomic inequalities limit access to education, ICT can play a crucial role in overcoming both academic and personal barriers [5]. Soacha exemplifies challenges present in many regions of Latin America, making it an ideal case to study how ICT can enhance academic resilience in such contexts.

The main problem addressed in this paper is the limited understanding of how ICT impacts academic resilience in vulnerable areas like Soacha, where students face significant socioeconomic and educational barriers. Although many studies have examined the role of ICT in urban educational settings,

there is a lack of research focusing on regions with limited access to infrastructure and technology, leaving a gap in knowledge about the transformative potential of ICT in improving resilience and academic outcomes in such disadvantaged areas. The central issue is to determine whether ICT can be an effective tool in bridging these educational gaps and enhancing students' ability to persist in their studies despite the challenges they face.

Although many studies have addressed the role of ICT in education, most focus on urban settings, leaving gaps in understanding how ICT impacts vulnerable areas like Soacha [6]. Soacha, with its limited infrastructure and access to ICT, presents unique challenges that have not been thoroughly explored. By focusing on Soacha, this study aims to provide insights applicable to other regions facing similar conditions, such as parts of Peru and Bolivia, where educational inequalities persist.

ICT has demonstrated its transformative capacity in education by facilitating access to information and promoting dynamic, interactive learning methods. In vulnerable contexts, ICT is key to bridging the digital divide and offering equitable opportunities for students [7]–[9]. However, limited access to ICT resources and digital skills can perpetuate existing inequalities, highlighting the need for policies that integrate ICT at all educational levels [10]. Previous research has shown that ICT can improve academic performance, such as in the case of the INSTAL project in Sindh, Pakistan, which increased students' science grades significantly [11], and in Spain, where family, teachers, and peers played a key role in supporting academic resilience [12]. The COVID-19 pandemic further highlighted ICT's importance in maintaining academic resilience during disruptions, especially in vulnerable contexts like Soacha [13].

This study hypothesizes that intensive and appropriate use of ICT is positively correlated with higher levels of academic resilience in students. To test this hypothesis, a mixed-methods approach was employed, combining quantitative surveys to measure ICT usage and resilience levels, with qualitative interviews to explore students' experiences with ICT [14], [15]. The research questions guiding this study are:
i)     What is the level of ICT use among secondary students in Soacha?
ii)    Is there a significant relationship between ICT use and students' academic resilience?
iii)   How does academic resilience vary according to the level of ICT use across different educational institutions?

Previous research shows that digital competencies and self-efficacy in ICT use are linked to greater motivation and more effective study approaches [10]. Moreover, programs designed to enhance digital resilience have been shown to improve academic resilience and foster metacognitive self-regulation [16]. These findings suggest that ICT can be a powerful tool for developing skills necessary for academic success, particularly in areas like Soacha where educational and socioeconomic limitations persist.

Soacha faces unique challenges in access to quality education due to its socioeconomic conditions. ICT interventions can help alleviate these challenges by reducing stress, promoting school engagement, and supporting students' psychological well-being, all of which are critical for academic success [17], [18]. The pandemic reinforced the importance of ICT in ensuring educational continuity, especially in areas with limited traditional educational infrastructure [19]. This study aims to address gaps in research by contributing valuable insights into how ICT can enhance academic resilience in vulnerable regions. Additionally, it underscores the need for future research to evaluate the long-term effects of ICT interventions and explore emerging technologies like artificial intelligence to further improve academic resilience in disadvantaged areas [20]–[23].

## 2.    METHOD

This study adopts a holistic methodological approach, integrating various epistemological and methodological perspectives to address the complexity of the phenomenon being investigated [24], [25]. This approach enables a comprehensive understanding of the relationship between ICT and academic resilience, as it considers both objective and subjective dimensions. The triangulation of quantitative and qualitative data strengthens the validity of the results, providing a deeper understanding of the socioeconomic context and individual perceptions of the students.

### 2.1.  Approach and type of research

A mixed-methods approach was employed, combining qualitative and quantitative techniques to investigate the relationship between ICT use and academic resilience [24], [25]. This approach not only enables the description of measurable characteristics but also offers a deeper exploration of students' subjective experiences. By integrating both data types, the study captures a broader and more nuanced understanding of how ICT impacts academic resilience [26].

## 2.2. Research design

The research design is descriptive-correlational, focusing on both the description of ICT usage levels and the relationship between ICT use and academic resilience. This design aims to generate educational proposals, such as an ICT-based didactic model to strengthen resilience [27]. The inclusion of this projective approach aligns with the study's goal of improving educational strategies in Soacha, Colombia [28]. The integration of quantitative and qualitative techniques—such as structured surveys and thematic interviews—enables a richer understanding of how digital environments influence students' coping capacities. Moreover, this design facilitates the articulation of statistical findings with real-world educational dynamics, informing the creation of relevant pedagogical innovations.

## 2.3. Population and sample

The study targeted high school students from three educational institutions in Soacha. Purposive sampling was employed, selecting students representative of academic and technological vulnerability. The total sample comprised 300 students, equally distributed among Las Villas, Ricaurte, and Eduardo Santos schools, as shown in Figure 1 (for sample distribution). This ensures that the variability in ICT usage and resilience levels is adequately represented, allowing for meaningful comparisons between institutions [29]. Sampling criteria included socioeconomic status, access to ICT, and academic performance, reflecting the broader inequalities present in Soacha.
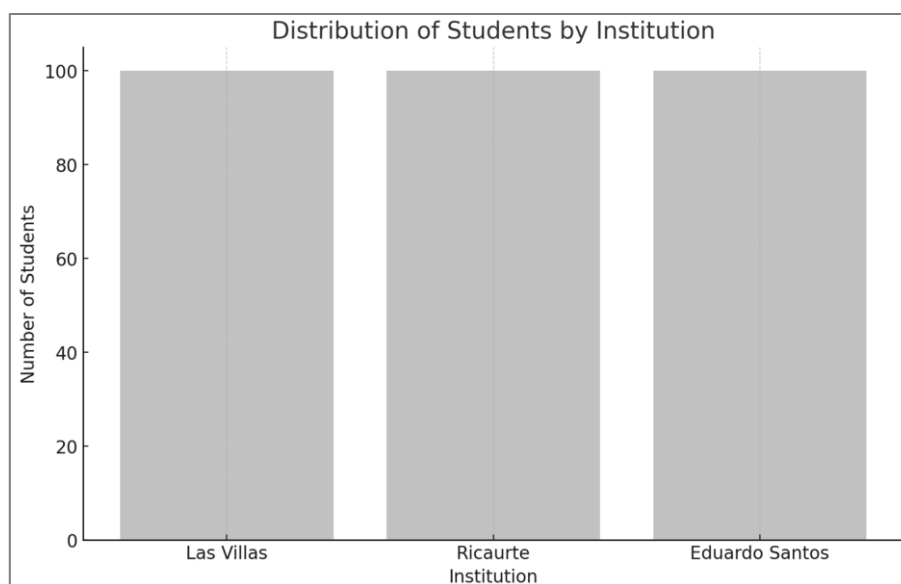


Figure 1. Sample distribution by educational institution

Previous studies have emphasized the importance of having an adequate sample size to obtain statistically significant and generalizable results. In descriptive and correlational research, a sample size of at least 100 individuals per group is typically sufficient to detect significant differences and relationships between variables. This study follows these recommendations, ensuring that the selected sample allows for a thorough and complete analysis. The integration of quantitative and qualitative data facilitates triangulation, increasing the validity and reliability of the results [30].

## 2.4. Data collection techniques and instruments

Data collection combined quantitative and qualitative methods. The quantitative surveys included two validated scales: one for ICT usage and one for academic resilience, both adapted for the Colombian context through cultural and linguistic adjustments. These surveys were administered to all participants. Qualitative data were gathered through semi-structured interviews with 30 randomly selected students, focusing on their experiences with ICT and its impact on resilience. The qualitative data were analyzed using thematic analysis to identify patterns in the students' responses [14]. This integration of quantitative and qualitative data allows for a comprehensive view of the relationship between ICT and resilience.

## 2.5. Validation and reliability

The content validation of the instruments was conducted by a panel of five experts in ICT and academic resilience. These experts, with backgrounds in educational technology and psychology, ensured that the instruments were contextually appropriate for the students of Soacha. The reliability of the instruments was evaluated using Cronbach's alpha, with both scales exceeding a value of 0.85, indicating high internal consistency, as shown in Figure 2 (for internal consistency results). This high reliability confirms that the instruments are robust and suitable for the study's objectives [31], [32].
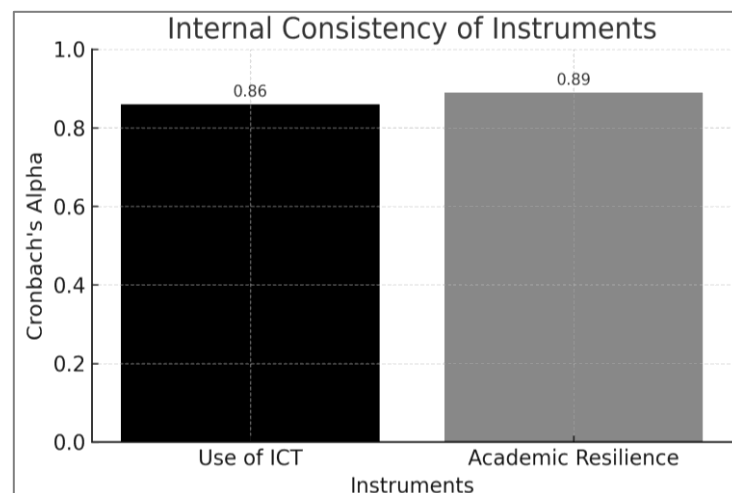


Figure 2. Internal consistency of instruments

## 2.6. Data collection procedure

The data collection process was conducted in three phases: i) Preparation phase: instruments were adapted to the Colombian context, and the research team was trained in administering surveys and conducting interviews. The adaptation process ensured cultural relevance and efficiency in data collection; ii) Collection phase: quantitative surveys were administered online, while interviews were conducted both in person and virtually, depending on the conditions at each institution. This mixed approach provided flexibility and maximized participation; and iii) Analysis phase: quantitative data were analyzed using SPSS for statistical correlations, while qualitative data were analyzed through NVivo for thematic analysis [33]. This combination of tools ensured a thorough analysis, identifying key patterns and relationships between ICT use and academic resilience.

## 2.7. Ethical considerations

Ethical principles were rigorously followed throughout the study. Informed consent was obtained from all participants and their guardians, ensuring they understood the purpose of the research and had the option to withdraw at any time. Confidentiality was strictly maintained, with all data anonymized to protect participants' identities [17]. These measures ensured that the research adhered to ethical standards.

## 2.8. Equations and statistical analysis

The primary statistical analysis involved Pearson's correlation coefficient (r) to measure the relationship between ICT use and academic resilience. Pearson's correlation is calculated using (1).

$$r = \frac{\sum (X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum (X_i - \bar{X})^2 \sum (Y_i - \bar{Y})^2}} \tag{1}$$

Where:
$X_i$ and $Y_i$ are the individual values of the variables $X$ (ICT use) and $Y$ (academic resilience).
$\bar{X}$ y $\bar{Y}$ are the means of the respective variables [33].
This analysis determined the existence and magnitude of the relationship between ICT use and academic resilience among students, providing valuable information for the development of educational interventions.

## 2.9. Holistic research methodology scheme

The overall methodology of the study is summarized in Figure 3, which illustrates the integration of epistemological and methodological perspectives, the sampling process, data collection techniques, and analysis procedures. This visual representation highlights how descriptive-correlational and projective components converge to address both empirical measurement and educational transformation. The scheme also emphasizes the sequential articulation of preparation, execution, and analysis phases. Together, these elements provide a comprehensive framework to support evidence-based pedagogical innovation in vulnerable educational contexts.
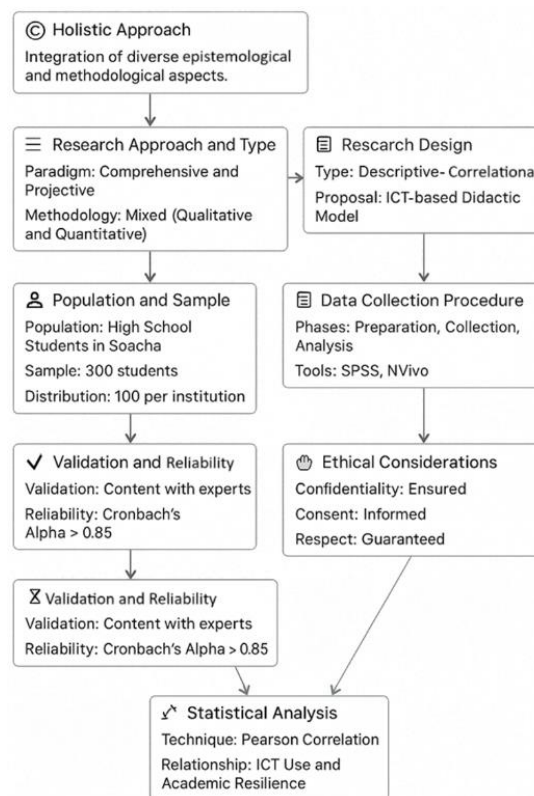


Figure 3. Holistic research methodology scheme

## 3. RESULTS AND DISCUSSION

The study involved 300 students from three educational institutions in Soacha, Colombia. ICT use and academic resilience were measured on a scale from 1 to 5. The results indicate that the Eduardo Santos Educational Institution reported the highest levels of ICT use and academic resilience, while Ricaurte reported the lowest. Las Villas was in an intermediate position. This variation highlights the disparities in access to and utilization of ICT, which appear to correlate with levels of academic resilience. The analysis suggests that greater use of ICT might foster higher levels of resilience, particularly in educational environments where access to technology is more consistent.

The mixed-methods approach used for data collection provided both quantitative and qualitative insights. Quantitative data, gathered via scales adapted for the Colombian context, were analyzed using descriptive and correlational statistics. Tables 1 and 2 summarize the results of ICT use and academic resilience by institution, respectively.

Table 1. Average levels of ICT use by educational institution

| Item | Las Villas | Ricaurte | Eduardo Santos |
|---|---|---|---|
| Use of ICT for research | 4.3 | 3.9 | 4.6 |
| Use of ICT for school assignments | 4.2 | 3.7 | 4.5 |
| Use of ICT for communication | 4.1 | 3.8 | 4.4 |
| Use of ICT for entertainment | 4.2 | 3.9 | 4.5 |
| Overall average | 4.2 | 3.8 | 4.5 |

Table 2. Average levels of academic resilience by educational institution

| Item | Las Villas | Ricaurte | Eduardo Santos |
|---|---|---|---|
| Self-efficacy | 3.8 | 3.4 | 4.2 |
| Stress management | 3.7 | 3.5 | 4.0 |
| Adaptation to academic changes | 3.6 | 3.4 | 3.9 |
| Seeking academic and emotional support | 3.7 | 3.3 | 4.0 |
| Overall average | 3.7 | 3.5 | 4.0 |

As seen in Tables 1 and 2, the differences across institutions highlight the impact of ICT use on students' capacity to cope with academic challenges. Students at Eduardo Santos reported frequent use of ICT tools for academic purposes, which is reflected in their higher levels of self-efficacy and stress management compared to students at Ricaurte, where ICT use was less prevalent. This finding suggests that the appropriate integration of ICT can enhance academic resilience, enabling students to better organize their work and manage academic stress. Additionally, semi-structured interviews were conducted with a randomly selected subsample of 60 students to explore their personal experiences with ICT and its influence on resilience. Table 3 presents the key themes that emerged from these interviews, which were analyzed using thematic analysis.

The qualitative findings complement the quantitative results, revealing that students perceive ICT as essential for organizing academic tasks, accessing educational resources, and interacting with teachers and peers. These perceptions are consistent with previous studies, which highlight the positive role that ICT plays in enhancing academic resilience by providing tools that support students in overcoming challenges [10], [16]. Students who reported higher ICT use also indicated that these tools helped them manage their academic tasks more effectively.

The correlational analysis, using Pearson's coefficient ($r=0.95$), demonstrated a strong positive correlation between ICT use and academic resilience, further reinforcing the idea that increased use of ICT is associated with better academic resilience outcomes. This finding aligns with previous research that links ICT use with improvements in academic performance and resilience [10], [16]. However, the relationship between ICT use and academic resilience is not uniform across all contexts, as several demographic factors also play a significant role.

Table 3. Emerging themes from qualitative interviews on ICT use and academic resilience

| Category | Description | Example response |
|---|---|---|
| Study organization | How ICT helps students organize their tasks and academic activities. | "I use my tablet to make to-do lists and check the school calendar daily." |
| Access to resources | The ease with which students access digital educational materials. | "I can search for information on the internet and watch educational videos that help me understand subjects better." |
| Interaction and support | Interaction with peers and teachers through digital platforms. | "I chat with my classmates and teachers to resolve doubts and work on group projects." |

## 3.1. Influence of demographic factors

It is important to consider that demographic factors, such as socioeconomic status, gender, and access to technology, significantly influence how ICT impacts academic resilience. Various studies have shown that students from higher socioeconomic backgrounds tend to have better access to ICT, which in turn enhances their resilience [17]. In the context of this study, students at Eduardo Santos—likely benefiting from better access to ICT—demonstrated higher resilience levels compared to those at Ricaurte, where access to technology was more limited. This reinforces the idea that equitable access to ICT is crucial for fostering resilience in students from all backgrounds [34].

Furthermore, unequal access to ICT can widen the gap in academic resilience between students from different socioeconomic contexts. In vulnerable environments, where students may not have consistent access to digital devices or reliable internet, the positive impact of ICT on resilience is likely to be diminished. This finding highlights the importance of educational policies that promote equitable access to ICT, ensuring that all students have the opportunity to benefit from these tools [35]. Such policies are essential for reducing disparities in academic outcomes and ensuring that students from all socioeconomic backgrounds can develop the resilience necessary to overcome academic challenges.

## 3.2. Theoretical implications and educational frameworks

These findings are consistent with modern educational theories, such as the principle-based approach to resilience curriculum design, which emphasizes the importance of a student-centered, strengths-based approach to building resilience [34]. Integrating ICT into educational curricula can enhance

both the technical skills and the emotional resilience of students. In particular, programs that focus on developing resilience through the use of ICT have been shown to significantly improve students' capacity to manage academic stress and adapt to challenges [15].

Moreover, incorporating resilience modules into the curriculum, supported by ICT, can help students develop the skills needed to navigate academic challenges more effectively. This approach not only supports academic performance but also contributes to students' emotional well-being by providing them with tools to manage stress and seek support when needed. Figure 4 illustrates the average levels of ICT use and academic resilience across the three institutions.

To gain a more nuanced understanding of the data, the specific components of ICT use and academic resilience were further analyzed. The results show that students who used ICT more frequently were better able to adapt to academic challenges, organize their studies, and access educational resources. This suggests a possible causal relationship between ICT use and resilience, as seen in Figure 5.
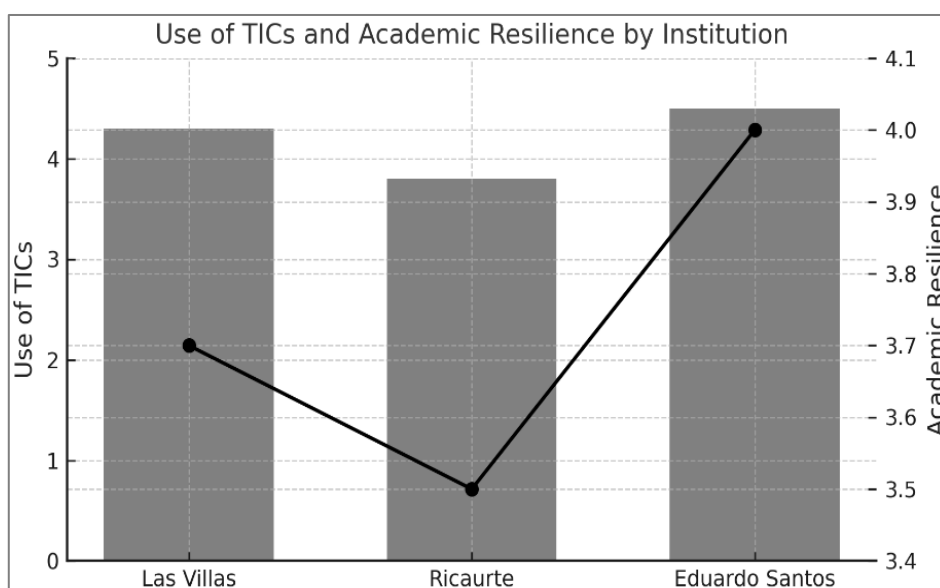


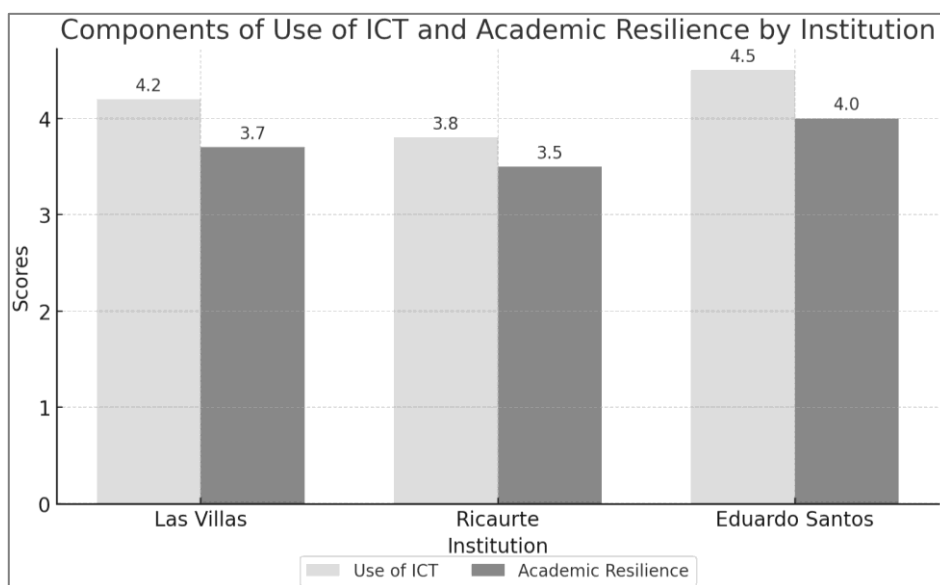Figure 4. ICT use and academic resilience by educational institution



Figure 5. Components of ICT use and academic resilience by educational institution

### 3.3. Broader implications and future research

This study confirms a significant relationship between intensive ICT use and academic resilience in students from vulnerable contexts, with a positive correlation found between both variables ($r$=0.95) [33]. The high internal reliability of the instruments used, as demonstrated by Cronbach's alpha coefficients exceeding 0.85, reinforces the robustness of the previous findings [36], [37]. Additionally, the qualitative interviews revealed that students recognize ICT as a valuable tool for organizing academic tasks, accessing resources, and managing stress [14].

Students at the Eduardo Santos Educational Institution, who reported the highest levels of ICT use, highlighted how these tools helped them overcome both academic and emotional barriers [5]. This underscores the importance of integrating ICT into educational strategies designed to foster resilience in vulnerable contexts. The role of ICT in supporting students' emotional and psychological well-being is especially critical, as it enables them to manage stress and adapt more effectively to academic challenges [31], [37]. Furthermore, during educational disruptions such as the COVID-19 pandemic, ICT played a crucial role in maintaining continuity and supporting resilience [18].

The evidence presented expands existing knowledge about the impact of ICT on education, showing that, beyond academic performance, ICT can positively influence students' emotional well-being. Previous research on digital resilience and self-regulation supports these findings, as ICT can help reduce academic stress and improve metacognitive strategies [5], [17]. This highlights the need for educational policies that prioritize digital competencies for both students and teachers, ensuring that they can fully benefit from the integration of ICT into learning processes.

Moreover, although this study is contextualized in Soacha, Colombia, the findings can be applied to other regions facing similar socio-economic challenges. ICT could play a key role in promoting academic resilience in other vulnerable areas in Colombia and Latin America, where the implementation of strategies that integrate ICT into educational practices could help address gaps in resources and access [12], [22], [38]. Equitable access to ICT is crucial for creating inclusive learning environments that foster resilience among students.

In this sense, the implementation of emerging technologies, such as adaptive learning platforms, could further strengthen academic resilience across a variety of educational settings. These technologies provide personalized learning experiences that can support students' academic and emotional development [12], [22], [38]. Therefore, the transformative potential of ICT extends beyond local contexts and offers opportunities for improving both learning and well-being on a broader, international scale.

Finally, although the current study focused on three institutions with different levels of ICT access, which limits the generalizability of the results, it provides a solid foundation for future research. Expanding the scope to include a greater variety of educational contexts would allow for more comprehensive validation of the findings. Further studies should explore the impact of different technological tools, such as adaptive learning platforms, and how they can be integrated effectively into educational strategies to maximize academic and emotional benefits [39]. Such research could offer valuable insights into the mechanisms by which ICT influences resilience in diverse educational environments, ultimately enhancing both students' academic success and emotional resilience [40], [41].

### 4.    CONCLUSION

The study findings confirm a strong positive relationship between ICT use and academic resilience among high school students in Soacha, Colombia. Evidence from the Eduardo Santos Educational Institution, where students reported the highest levels of both variables, highlights ICT's transformative role in fostering resilience, self-efficacy, and stress management in vulnerable educational contexts. This correlation aligns with sustainable development goal 4 (SDG 4), which advocates for inclusive, equitable, and quality education. Integrating ICT pedagogically not only enhances access to educational resources but also supports students' ability to organize their studies, manage academic challenges, and maintain emotional well-being, making ICT essential for resilient, motivating learning environments that address both academic and personal growth.

Future research should focus on longitudinal studies in varied educational contexts to validate and generalize these findings and explore the impact of emerging technologies like artificial intelligence and adaptive learning platforms in promoting academic resilience and emotional well-being. To support SDG 4, it is essential for educational institutions to implement policies that integrate ICT effectively into curricula and provide digital competency training for both students and teachers. This approach contributes significantly to creating equitable educational opportunities, supporting students' holistic development, and fulfilling international commitments to inclusive and supportive learning in vulnerable areas.

## AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

| Name of Author | C | M | So | Va | Fo | I | R | D | O | E | Vi | Su | P | Fu |
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|---|---|---|
| C : **C**onceptualization | I : **I**nvestigation | Vi : **Vi**sualization |
| M : **M**ethodology | R : **R**esources | Su : **Su**pervision |
| So : **So**ftware | D : **D**ata Curation | P : **P**roject administration |
| Va : **Va**lidation | O : Writing - **O**riginal Draft | Fu : **Fu**nding acquisition |
| Fo : **Fo**rmal analysis | E : Writing - Review & **E**diting | |

## CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

## INFORMED CONSENT

Written informed consent was obtained from all individuals included in this study. For participants under the age of 18, consent was also provided by their parents or legal guardians. All participants were clearly informed about the purpose of the study, the voluntary nature of their participation, their right to withdraw at any time, and the guarantees of confidentiality and anonymity. Data collection was conducted with full respect for participants' privacy and dignity, in accordance with applicable national regulations and internationally accepted ethical standards, including the tenets of the Helsinki Declaration.

## ETHICAL APPROVAL

The research involving human participants was conducted in full compliance with relevant national regulations and institutional policies, and in accordance with the ethical principles outlined in the Helsinki Declaration. All necessary ethical safeguards were implemented to ensure the protection, confidentiality, and well-being of participants throughout all stages of the study.

## DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author [RBN], upon reasonable request. Due to ethical considerations and the inclusion of minors in the research, the datasets are not publicly available to ensure the confidentiality and privacy of the participants. Any access request will be evaluated in accordance with institutional and ethical guidelines.

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