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Building Resilience in Students for STEM Careers

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Abstract. *Today's society is dominated by technology, which is present in people's lives across all fields. Jobs, especially those in the technical domain, rely on the use of new technologies and innovation. To prepare young people for success in a technical career, their training needs to start as early as possible. Additionally, for them to adapt to changes in the field, they must be resilient that will help them achieve success.*

Current specialized literature does not provide a clear picture of the early preparation process for students aiming to excel in a technical career. Furthermore, despite teachers having access to information and technological tools, they are not adequately trained to apply clear methodologies that guide young people in identifying and developing specific skills to achieve successful careers in the technical field.

The research methodology is mixed, employing a survey using a questionnaire as the research instrument, targeting students from a technical university in Bucharest, Romania. The primary objective of this study is to analyze and interpret the data collected from students regarding their acquisition of resilience during their studies to ensure future career success.

The main findings on building resilience among students reveal that most students demonstrate a high level of resilience, perseverance, and emotional balance. They manage to face challenges through planning, collaboration, and the support of family, peers, and teachers. However, there are opportunities for improvement in preparing students for achieving success in STEM careers.

The study's results are valuable for educators, education policymakers, students, and future employers. These results are also particularly valuable for business management professionals aiming to optimize talent development processes in STEM-focused industries.

Keywords: STEM education, STEM careers, resilience, students' motivation, talent development, business management, career preparation.

Introduction

STEM employees become responsible for the nation's competitiveness and innovation through the nature of their work, generating ideas, companies, and new industries. Today, society relies on technology, with many studies conducted in recent years supporting the fact that STEM job growth is three times higher than that of non-STEM jobs. (Briseño, 2015)

Beyond the individual benefits provided by quality STEM education, it is also essential for society as a whole. Today, the world is facing various extreme weather events, climate change, and diverse diseases. (Sarma & Bagiati, 2020) To control or even eliminate these negative effects, skilled STEM workers with expertise specific to their fields are required.

In this context, it is necessary for teachers to create a rich environment when organizing STEM activities from an early age, engaging children in exploratory investigations and focusing their observations. It is well known that 21st-century skills are important, and nowadays, STEM education is considered to play a crucial role in preparing students for an advanced society. (ÇetiN et al., 2020)

This research addresses the question: *To what extent do resilience influence the likelihood of success in STEM careers among students?* The main hypotheses are as follows: (1) students who

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exhibit high levels of resilience are better equipped to face academic and professional challenges in STEM fields; and (2) students who actively develop resilience strategies are more likely to sustain long-term engagement and success in STEM careers. These hypotheses guide the study in exploring how resilience contribute to the preparation of students for careers in STEM fields.

Literature review

Students' resilience

Resilience is defined as the ability to bounce back or recover from stressful circumstances to achieve full adaptation to the environment (Ahern et al., 2006; Smith et al., 2008). Additionally, resilience can contribute to students' mental health and well-being (Dunn et al., 2008; Watson & Field, 2011) and has been positively linked to academic engagement and performance (Martin et al., 2015). Moreover, since resilience is linked to the presence of social risk factors, it is necessary to adopt an ecological interpretation of this construct, one that takes into account the interactions between individuals and their environment (Ungar, 2012). The term "resilience" should be used when referring to the process or phenomenon of demonstrating competence despite adversities. (Luthar et al., 2000).

A person's resilience reflects the ability to adapt successfully in the face of risks and adversities. The study of the phenomenon of resilience starts from the essential hypothesis that understanding how individuals overcome obstacles in the development process and recover from trauma can provide insights into coping mechanisms, useful to guide interventions to support others in similar situations. Assessing an individual as "resilient" involves an assessment of his level of adaptation (internal, external or both) in relation to an established frame of reference (Wang et al., 1994).

Another study examined the relationships between academic resilience, perceived teacher emotional support, and school engagement, as well as the mediating role of emotional support. The results highlighted the importance of fostering personal and contextual resources in schools to promote student well-being. Academic resilience was found to be associated with perceived teacher emotional support, and both were linked to school engagement (Romano et al., 2021).

A recent study shows that feelings of safety and comfort in STEM environments stemmed from shared passion and interest in STEM, building social connections, receiving appropriate support, fostering resilience and inclusion, receiving recognition and respect, individual beliefs in one's capabilities, and STEM literacy. The study also emphasized that individual resilience is crucial for STEM students to cope with challenges and negative outlooks, and it is linked to social connections, perseverance, and environmental factors (Dost, 2024).

Regarding how teachers can help students handle stressful situations, a study conducted in 2011 proposes a model based on three fundamental themes: supporting understanding, building and maintaining relationships, and classroom management. Additionally, employing participatory structures, teacher mobility, and a range of teaching practices can contribute to fulfilling one or more of the aforementioned functions (Anderman et al., 2011).

Beyond the significant influence of teachers, family support also plays a crucial role in helping students succeed. Family support for learning is closely linked to students' choices regarding science education and engagement in this field, which, in turn, impacts their interest and self-efficacy in science. Furthermore, physical resources provided by families, such as dedicated learning spaces and materials, also fall under the umbrella of family support (Sha et al., 2015).

In addition to support from teachers and family, students must also possess coping skills to help them navigate challenges in STEM fields. Coping strategies include cognitive, physiological,

psychological, and behavioral methods for managing stress. Students need effective techniques to handle the stress associated with their studies. A 2018 study suggests stress management courses and involving students in extracurricular physical and mental activities as effective methods. These activities can contribute to maintaining students' well-being and lead to positive outcomes (Kassymova et al., 2018).

Choosing a STEM career

Young people start to have STEM aspirations as early as their teens. This makes the high school years the critical period for identifying the motivational and cognitive factors that contribute to increasing the likelihood of youth finding employment in the STEM field (Wang et al., 2017).

Many studies on choosing a STEM career support the fact that extracurricular activities help motivate students to choose a STEM career. An example of such a study is the one carried out by Miller et al. who support the fact that students who had the opportunity to participate in STEM competitions are more likely to show interest in a career in this field at the end of high school, compared to other students who did not participate in such activities. Also, the same authors claim that the impact of participation in competitions on a STEM career is three times stronger when students participate in more than one competition. Therefore, STEM competitions are an effective method to stimulate young people's interest in careers in the STEM field (Miller et al., 2017).

Another study carried out on the subject of choosing a STEM career by students presents the idea that the role of mathematics is a fundamental one for a career in this field, and the way in which students perceive themselves in the process of learning mathematics has a crucial impact on their aspirations for a STEM career, especially among girls. The authors of the study propose that schools plan instruction in such a way as to improve students' self-perception and their performance in mathematics. Also, several interconnected factors associated with students' aspirations for STEM careers were presented in the study, such as: gender, cultural capital, age, parents' occupation in the STEM field, and previous performance in mathematics and reading (Holmes et al., 2018).

Students' interest in STEM careers is also influenced by family, media, and formal and informal learning experiences. A study that analyzed the role of self-efficacy in this process, on a sample of 1485 students, shows that family influences and informal learning stimulate interest in STEM through self-efficacy, and the media has both direct and indirect effects. Surprisingly, school learning did not have a significant impact. Therefore, the informal experiences of young people had an impact, and within the school there is a need to increase the quality of the educational act (Halim et al., 2021).

The link between choosing a career and resilience

The results of a survey of 666 chinese students show that career resilience and adaptability can reduce young people's difficulties in making career decisions. The results of the study support the fact that it is necessary to pay special attention to the positive factors of students in the career decision-making process (Pang et al., 2021).

A study by Isnaini et al. shows that career motivation influences academic resilience, despite the fact that CBT (Cognitive Behavioral Therapy) and Objective Structured Clinical Examination (OSCE) scores did not have a major impact on academic resilience. However, these scores influenced academic resilience at the same time, in a proportion of 38.7%. Academic resilience is influenced by career choice motivation, scores previously listed, educational environment and students' personality (Isnaini et al., 2021).

Methodology

The research methodology is mixed, employing both qualitative and quantitative methods, with the primary research instrument being a questionnaire designed in Google Forms and administered to students from a technical university in Bucharest, Romania.

This study aims to explore the impact of resilience on the success of students in STEM fields, focusing on the connection between motivation, support, and coping strategies. It seeks to highlight the role of these factors in supporting academic performance, fostering students' personal development, and preparing them for successful careers in technical fields.

The main objectives of this research are:

1. *To analyze the primary factors influencing students' decision to study exact sciences.*
2. *To investigate the types and levels of support students receive from family, peers, friends, and professors.*
3. *To evaluate the role of professors in students' personal and academic development.*
4. *To examine the strategies students employ to manage academic stress.*
5. *To analyze students' behaviors and attitudes toward resilience in the academic environment.*

The sampling methodology used was convenience sampling, involving undergraduate and graduate students enrolled in engineering and technical programs at a technical university in Bucharest. A total of 548 responses were collected through a questionnaire consisting of 20 questions grouped into three sections: demographic information, questions related to resilience, and open-ended questions designed to capture students' perceptions of resilience and its impact on their academic journey.

The data collection period spanned four months, from February 2024 to May 2024. Quantitative data were analyzed descriptively, while qualitative responses to the open-ended questions were examined to identify recurring themes and relevant perspectives. No complex statistical techniques were employed; the study focused on narrative interpretation and contextual exploration of the collected data.

It is worth noting that the research has a significant limitation due to the use of self-reported data, which may introduce a certain degree of subjectivity.

Results

The following section presents the main results obtained from analyzing the students' responses to the questionnaire. In the first part, the questionnaire included questions aimed at collecting demographic data.

The study participants consisted of 548 students in their first, second, or third year at STEM-related faculties. Their ages were divided into three categories: under 20 years old (37.22% of participants), between 20 and 25 years old (62.04%), and over 25 years old (0.73%).

From a gender perspective, the groups are balanced, with 56.02% identifying as female and 43.79% as male, along with one participant identifying as non-binary (0.18%).

The majority of participants come from urban areas (70%), although among the 30% from rural backgrounds, most chose to attend a high school in an urban area, with 96.16% of respondents having graduated from an urban high school.

Students' motivation in learning exact sciences

The students participating in the study provided a variety of reasons that help them in learning exact sciences. The main reasons given by the students were: the fact that the teacher

taught them how to learn the subject (28.3%), individual inclinations (23.4%), the teacher's enthusiasm (21%), the explanation of the practical utility of the knowledge (12.2%), and the desire to have a career based on the subject (10.6%). This is also supported by literature that supports the fact that most students who major in STEM make this choice during high school, and this choice is linked to a growing interest in math and science. (Maltese & Tai, 2011). Also, the specialized literature also talks about the impact of passionate teachers who are able to highlight the practical applicability of knowledge that can influence the academic orientation of students (Aschbacher et al., 2010).

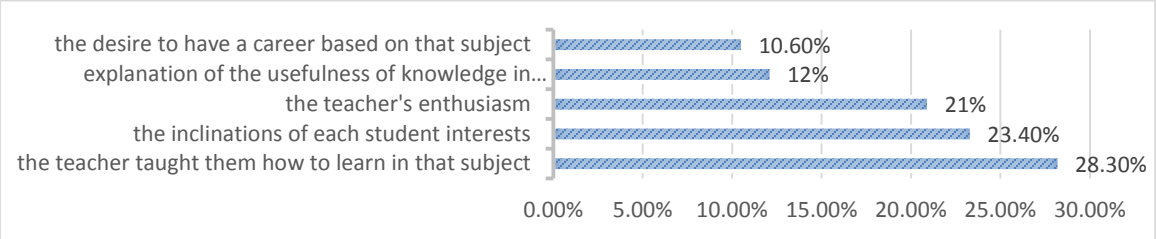

Figure 1. Students' motivation in learning exact sciences

Source: Authors' own research.

The concern of exact science teachers for students' personal development

Regarding this topic, a large portion of students (72.1%) stated that exact science teachers should also be concerned with their personal development. In contrast, 11.3% of respondents said that exact science teachers should not be concerned with this aspect, while 16.6% mentioned that they had not thought about this before. These results support the idea that teachers, regardless of the subject they teach, should pay special attention to students' personal development in order to motivate them and build their resilience, helping them achieve academic success. This is also supported by the specialized literature, by presenting the idea that educators should make connections between the subject taught and current events, the lives and interests of students (Martin, 2002).

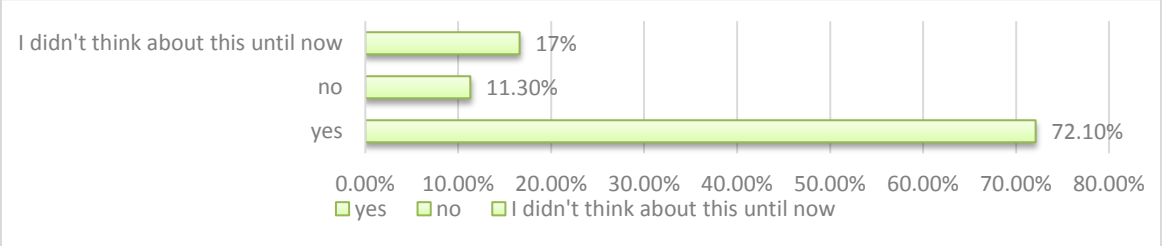

Figure 2. Science teachers should also be concerned with students' personal development

Source: Authors' own research.

Was the choice of a technical university influenced by counseling from an exact science teacher?

More than half of the students (62%) stated that the reason they chose a technical university was not due to counseling from an exact science teacher. However, 23% of students indicated that they were advised by a science teacher regarding their choice of university major, and the remaining 15% provided examples of teachers who motivated them during this process. The main subjects taught by the teachers who provided counseling were mathematics, physics, and computer science.

These results indicate a need among students for guidance from teachers when choosing a technical university, with those teaching these subjects being best positioned to identify students' skills, develop them, and help them navigate the path to university more easily. Science teachers have a significant influence on students' motivation to engage in STEM (Munro & Elsom, 2000).

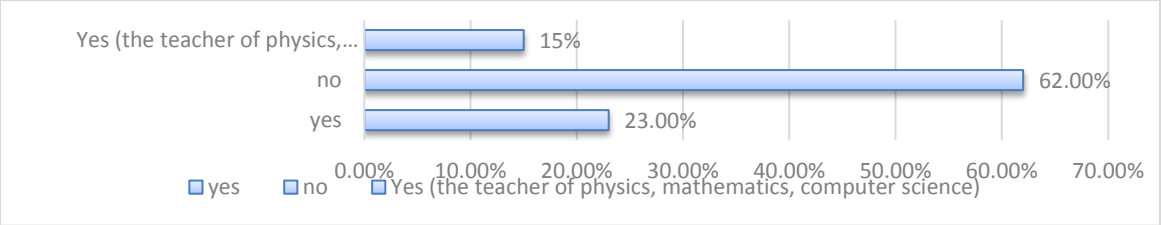

Figure 3. Counseling of students by science teachers regarding the choice of faculty profile

Source: Authors' own research.

Reasons for choosing a technical university

For this question, students had the option to select one or more answers or provide their own response. The majority of students who completed the questionnaire stated that the main reason they chose to attend a technical university was their passion for technology and science (62.6%), career opportunities (66%), the influence of teachers (12%), and the study of preferred subjects (39.1%). In addition to these, students also provided other personalized reasons such as the influence of their parents, a passion for the STEM field, or the influence of others. Therefore, students primarily chose to attend university out of passion, which is encouraging, and the fact that they made this decision independently helps them to be more motivated and engaged in the entire educational process, thereby increasing their resilience.

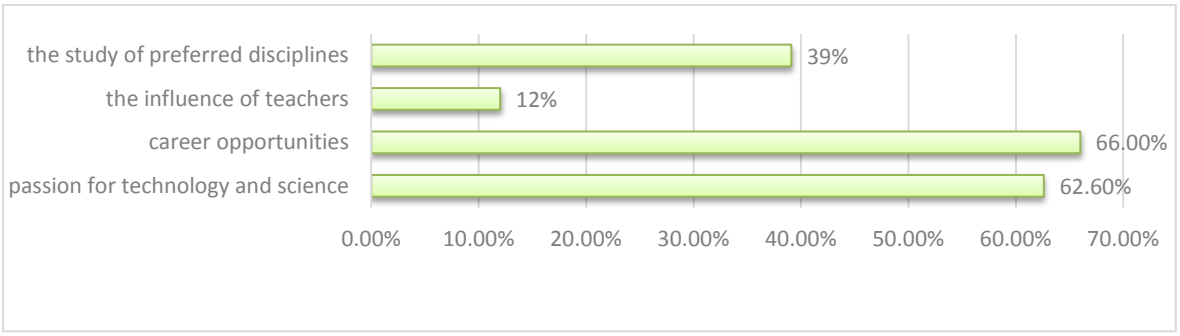

Figure 4. The reasons for choosing a technical faculty by students

Source: Authors' own research.

Why do you think you needed more from your high school teachers to have more success in university?

For this question, students had the freedom to choose multiple responses.

Just over half (50.7%) stated that they felt the need for more practical hours, more learning techniques (48.7%), more focus on preparation for university admission (24.6%), more encouragement (38.7%), and more information (35.6%). Additionally, approximately 4% of students mentioned that they did not feel the need for further actions from their teachers or provided examples of personalized actions.

Therefore, students feel the need for more practice and more learning techniques. These needs should be addressed by teachers to help students cope more easily with the challenges they

will face at university. Moreover, many students also mentioned that they needed more encouragement. Teachers should consider this, regardless of the subject they teach, because students can achieve much better results if they are sufficiently encouraged, being resilient and overcome difficult situations.

However, the students' need for more information and university preparation should not be ignored either. These could be addressed through more effective communication between schools or high schools and universities, by organizing various projects, preparatory courses, or other types of activities that prepare students for university life and provide the information they need, which middle or high school teachers may not be able to offer.

Who has been the person who helped you the most to cope with the challenges during your studies so far?

Regarding the support persons for students, more than half of them (55.1%) stated that the person who helped them the most to cope with challenges was a friend or a family member. Additionally, 24.1% mentioned that they were helped by colleagues, 13.1% by professors, and the rest provided answers such as "myself" or "no one."

Therefore, family and friends are the main support persons for students. According to specialized literature, communication with family and social support from friends are the essential factors for students' well-being (Yubero et al., 2018). The percentage of students who did not mention any category of people who helped them is not very high, but it should not be ignored. These students are in a concerning situation and could end up experiencing burnout or suffer from depressive states due to facing challenges alone and not receiving help from others.

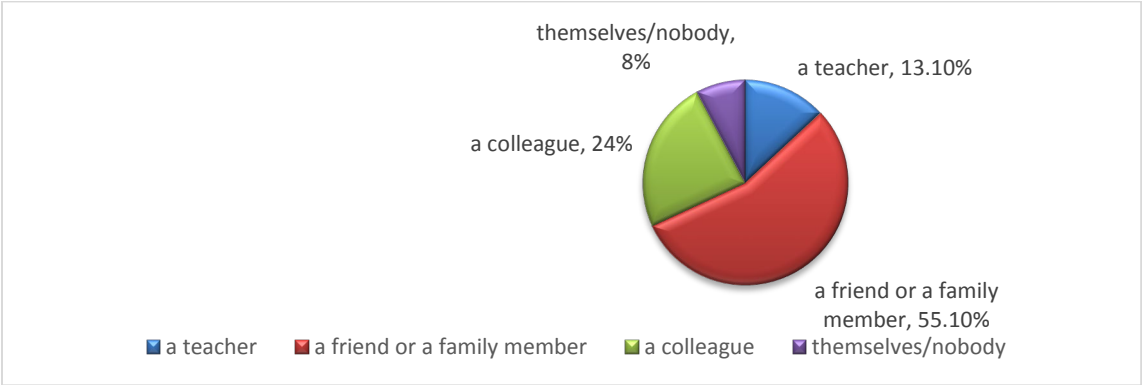

Figure 5. The support persons of the students

Source: Authors' own research.

To what extent do you believe your family has supported you in learning a science subject?

The students' responses to this question indicate that their families have supported them to a great extent in studying science subjects, with 48.9% stating that they were greatly supported. A very small percentage, only 2.9%, stated that the family's influence was minimal. Therefore, family represents the main support for students in learning science subjects (and probably beyond). A study conducted on this topic supports the fact that early adolescents' perceived family support for learning is associated with their choices and involvement in science learning and that these effects are mediated by the effects on the child's interest and self-efficacy in science (Sha et al., 2015).

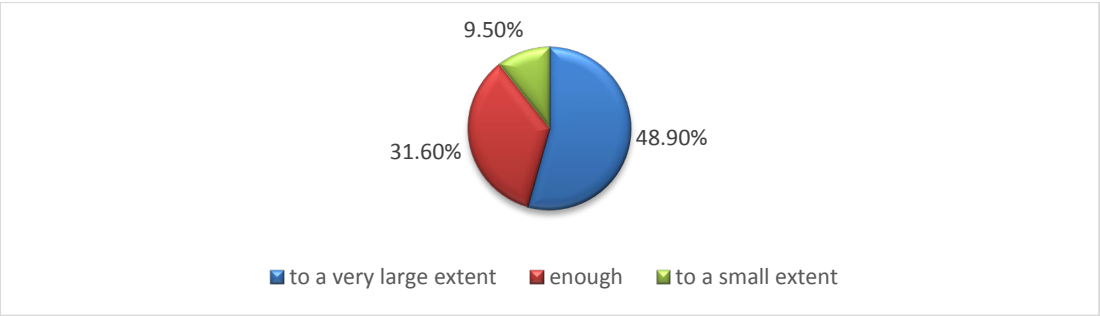

Figure 6. Family support in science learning

Source: Authors' own research.

How do you manage the stress and pressure related to tasks and projects during university?

Most students selected two or more of the provided response options. The highest percentage (68.8%) chose planning and organization as a way to effectively manage stress and challenges. Additionally, 56.2% of students selected collaboration with peers, 48.7% said taking regular breaks helps them, and 37.6% mentioned emotional support from close ones. It is also worth noting that some students (4.1%) stated they struggle to manage stress or resort to other methods to cope with difficult situations, such as hobbies, using technology as a relaxation tool, or consuming coffee.

These results highlight the importance of structured approaches, such as planning and collaboration, in managing academic stress and the need for targeted interventions, such as stress management courses and engaging in extracurricular physical and mental activities. (Kassymova et al., 2018)

Figure 7. Managing stress and pressure related to tasks and projects during university studies

Source: Authors' own research.

Studies show that using self-regulation techniques such as goal setting, time management, learning strategies, self-assessment, self-attributions, help-seeking, or
important self-motivational information and beliefs, such as self-efficacy and intrinsic interest of the task, can improve academic performance and increase student resilience (Zimmerman, 2002)

How do you overcome challenges in STEM subjects?

Students were asked about the ways they manage difficulties in STEM disciplines. The most selected options were: "I know how to overcome them" (61.1%), "I ask my peers for help" (71.9%), "I look for solutions online" (75.3%). In contrast, the least selected solutions were: "I get discouraged" (22.3%), "I give up on finding solutions" (8%), "I don't look for solutions because they don't exist" (1.5%). These results indicate that students handle challenges by actively seeking

solutions and support from others, with very few giving up. This highlights their resilience, perseverance, and balance.

Discussion

The results presented above emphasize the crucial role of resilience in fostering students' academic and professional success. This is supported by Deb and Arora (2012), who argue that individuals reporting higher levels of resilience perform better academically compared to those with lower resilience levels. Moreover, previous research has demonstrated that intrinsic motivation, particularly the enjoyment of learning, is a significant predictor of academic persistence, reinforcing the idea that students with strong intrinsic motivation are more likely to persevere in demanding academic environments (Brubacher, 2019).

Additionally, the positive relationships students maintain with peers, professors, and family play a vital role in enhancing their resilience and overcoming the challenges they face during their studies.

Finally, the use of effective strategies by students to address challenges—such as collaboration, planning, and seeking external support—reinforces existing resilience models by encouraging proactive and adaptive behaviors. However, developing effective strategies to improve students' academic performance requires a deeper understanding of the factors contributing to successful academic adaptation (Cazan et al., 2024).

Limitations and further research

The present study also acknowledges several limitations. First, since the data used were entirely self-reported, various errors could arise, leading students to either underestimate or overestimate their level of resilience. Additionally, they might omit certain coping strategies or fail to mention specific categories of supportive individuals.

Another significant limitation is the lack of longitudinal data. This shortcoming affects the analysis of how resilience develops over time and its long-term impact on students' academic outcomes. A similar study conducted longitudinally could track the progression of resilience and its influence across different stages of students' academic and professional careers.

Furthermore, the representativeness of the sample also falls within the limitations of this research, as it is restricted to students from a single university. This limitation may not fully capture the diversity of experiences and challenges faced by students in other educational institutions or geographical regions.

Lastly, the relationship between resilience and the academic or professional outcomes of students—or even employees in STEM fields—could be explored in greater depth. This topic could serve as a valuable avenue for future research, incorporating qualitative methods and adopting a longitudinal study design to gain more nuanced insights.

Conclusion

Therefore, enhancing resilience among students aspiring to pursue STEM careers is crucial for their smooth adaptation to future career challenges and achieving success.

Based on the findings presented earlier, it is evident that students predominantly choose STEM field due to their passion for technology and science, indicating strong intrinsic motivation. Also, students are motivated of the career opportunities offered by the STEM field.

Family, friends or the teachers play a crucial role in helping student's resilience and helps them to overcome STEM challenges. Educators influence both personal an professional growth of students, providing academic knowledge and their mentoring and emotional support are essential in preparing students for successful careers.

Most students demonstrates resilience by adopting strategies like planning, collaborating or seeking external support to overcome challenges. Also, almost all of the students acknowledged the fact that resilience is further connected to academic success. Enhancing educational practices by incorporating resilience-building activities, emotional intelligence training, and mentorship can better prepare students for technical careers. Also, early preparation through practical sessions helps students identify and develop skills essential for STEM careers.

This findings, underline the importance of holistic approach to education, emphasizing resilience, emotional intelligence, and support networks to equip students for success in both academic and professional context.

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