Cognitive and Behavioral Science Digest

WISDOM ACADEMIC ISSN: 3104-6436 | E-ISSN: 3104-6444 *Volume 1 , Issue 2*

Article

A Review of the Mechanism of Mental Resilience in Career Development of STEM Undergraduate Students

Zeqing Guo*, Amalia bt Madihie

Faculty of Cognitive Science and Human Development, Universiti Malaysia Sarawak, Kota Samarahan 94300, Malaysia.

***Corresponding author:** Zeqing Guo, 21020119@siswa.unimas.my.

CITATION

Guo ZQ and Madihie AB. A Review of the Mechanism of Mental Resilience in Career Development of STEM Undergraduate Students. Cognitive and Behavioral Science Digest. 2025; 1(2): 231.

https://doi.org/10.63808/cbsd.v1i2.231

ARTICLE INFO

Received: 30 September 2025
Accepted: 13 October 2025
Available online: 15 October 2025

Abstract: This article highlights protective factors that will sustain persistence in demanding, academically demanding, and professionally oriented fields by offering a thorough review of mental resiliency as a foundational process in influencing academic and career development among undergraduate STEM students. By demonstrating how hardiness acts as a strong defense against the negative effects of academic stressors, life traumas, career ambiguity, and numerous failed trials that are inherent to the STEM educational environment, this investigation incorporates recent empirical evidence into an explanation of complex issues at the intersection between psychological resilience and success outcomes in STEM-related fields of study. Within a multileveled ecological system of environmental influences (laboratory culture, mentorship relationships, and institutional support systems) and individual characteristics (sex, cultural background, and past educational experiences), these developmental processes operate. According to the theoretical model, resilience has multifaceted effects because it can be attributed to both direct stress-buffering effects and indirect mediating pathways in a situational dependent manner. This means that underrepresented populations require multifaceted intervention strategies that address both the immediate need for stress-protection coping and the underlying psychological processes that translate resilience into career-related outcomes.

Cognitive and Behavioral Science Digest
WISDOM ACADEMIC ISSN: 3104-6436 | E-ISSN: 3104-6444 Volume 1 , Issue 2

Keywords: mental resilience; career development; STEM undergraduate students; mediating mechanisms; higher education

1. Introduction

The important psychological factors contribute to the student's persistence in adapting, responding favorably to education requirements, and interest in undertaking a particular career in STEM (science, technology, engineering, and mathematics) domains. Researchers claim that college students who are resilient employ different coping strategies in pursuing their learning goals and maintaining self-efficacy (Freire et al., 2020).

Compared to their peers in other academic fields, undergraduate STEM students face a number of challenges related to career development. Because STEM education is so demanding, students are subjected to unique stressors that necessitate specialized teaching strategies and institutional support to help them manage their anxiety and maintain their wellbeing (Hsu and Goldmith, 2021). Strong links between academic stress and mental health outcomes across different student populations show that the COVID-19 pandemic has exacerbated these problems. This highlights the importance of comprehending protective factors, such as resilience (Barbayannis et al., 2022). Because STEM fields require students to deal with highly technical material, rigorous quantitative reasoning standards, and repeated experimental failures, resilience is particularly crucial.

Many stakeholders in STEM education need to understand how psychosocial resilience affects career paths. Students' career goals and paths are influenced by the interaction between their self-concept and how they view STEM professionals (Chen et al., 2024). Recent data indicates that students have lower levels of motivation, certainty, and satisfaction with their career trajectory and frequently change their career plans, even in STEM fields (Rosenzweig et al., 2024). This emphasizes the value of interventions that promote career commitment and resilience. One key aspect on which qualitative knowledge of the self-perceptions and goals in life of students attending STEM fields is essential involves the development of professional identity (Tripp and Liu, 2024). Key to supporting students' transitions into engineering (and other STEM) is an understanding of how factors like academic career self-efficacy are

developed across educational sectors, and what mediates or moderates influences on it in universities/colleges (Mahajan, 2024).

Through an examination of immediate stress-buffering effects and underlying meditative mechanisms, such as academic self-efficacy, professional identity formation, and problem-focused coping strategies, this review investigates the implications of mental resiliency for career development among STEM undergraduates. The environmental and personal factors that shape these relationships are then examined, and the conversation includes implications for the creation of interventions as well as future research avenues that will enhance theoretical knowledge and real-world applications for assisting STEM students in achieving their professional goals.

2. Mechanisms of Mental Resilience in Career Development

2.1. Direct Mechanisms: Stress-Buffering Effects

One protective factor that directly lessens the negative effects of stress on the careers of students in STEM fields is mental resilience. Given that some studies have shown that students with greater mental resilience are likely to be better able to handle extreme academic pressure by maintaining motivation and career focus, there may be a protective effect that directly addresses the detrimental effects of stress on career development processes (Sang et al., 2020).

The mental resilience buffer is arguably most noticeable when it comes to how STEM students deal with the stress of anxiety and career indecision. There is a lot of concern about career prospects because of the high stakes and fierce competition in STEM fields, the quickly changing technological requirements, and the ambiguous job pathways. Capermint students are being held back by the mental toughness exercise. Not precisely, but one thing is certain: the mentally tough students we describe are better able to cope with this uncertainty without succumbing to crippling anxiety (and thus giving up a career path or additional opportunities for work-related growth). Even in the face of unfavorable or unclear career-related events, this direct protection makes it easier for students to participate in professional social learning and carry out their career consequences.

Poorly designed experiments and problem sets, as well as competitive research environments, are frequently to blame in STEM education. Mental toughness prevents issues before they become serious and undermines dedication and confidence in previous work. It also makes it easier to respond quickly to setbacks and recover from them. Even though the difficulties are a natural part of their work, mentally tough students will continue to work hard and view setbacks as opportunities to grow rather than as a reflection of their character. By preventing short-term losses to the field from turning into long-term departures from STEM careers, this adaptive coping also directly maintains the pipeline.

2.2. Indirect Mechanisms: Mediating Pathways

In addition to its direct effects, mental resilience influences career success through a number of interrelated mediating mechanisms. Through behavioral and psychological processes, these vicarious effects show how resilience is transformed into quantifiable signs of professional advancement.

(1) Academic Self-Efficacy as a Mediator

Academic self-efficacy serves as a major mediating mechanism to account for why mental resilience contributes to desired work-related growth. The fact that more resilient students believe they can achieve in challenging STEM courses drives better career opportunities and aspirations. Resilience develops academic grit and the capacity to do well on difficult learning tasks by enhancing self-efficacy beliefs through a reciprocal relationship. In turn, these elements motivate students to actively participate in career development practices.

Given the particular context (i.e., STEM education), the mediating effect of academic self-efficacy is even more noticeable. High-difficulty first- and second-year university/college courses in mathematics, physics, and engineering often serve as gatekeepers for influencing career pathways. When faced with initially intimidating course material, resilience of mind enables students to maintain their self-efficacy, preventing confidence declines that would have led them in a different direction (Liu et al., 2024). Furthermore, resilient students exhibit a remarkable capacity for self-efficacy even when faced with setbacks in research projects or experimental work, viewing these as opportunities for skill development rather than indicators of

incapacity. This persistence of self-efficacy in the face of challenges is encouraging for women continued professional growth in STEM fields.

(2) Professional Identity Formation as a Mediator

Students increasingly internalize the values, conventions, and practices related to their chosen STEM field as they develop their professional identities, which can be viewed as a very complex process. By enabling students to handle the difficulties, unknowns, and ambiguities of socialization into their future profession, psychological toughness aids in the formation of such an identity. Students who possess greater resilience are better equipped to absorb the criticism from their mentors, reconcile conflicts between their personal and professional values, and stick with their developing identity in the face of setbacks or difficulties.

Mental toughness is the best way to support the significant psychological acclimatization needed for this transition from the student to the engineer/scientist identity. Students must navigate a variety of identity transitions, from shifting how they view themselves and their professional language to becoming part of professional communities. The ability to handle these changes without losing one's sense of self or career path is known as mental toughness. Research shows that, in comparison to professional practice, students who are more resilient are better able to deal with the identity issues of navigating culture or breaking into male-dominated STEM fields (Singer et al., 2020).

(3) Problem-Focused Coping as a Mediator

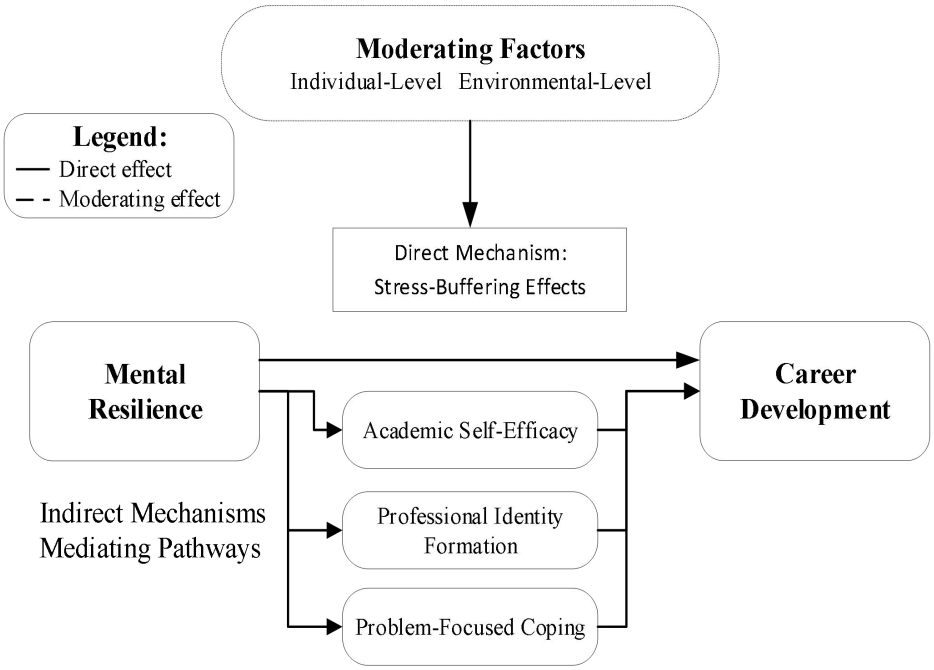
Since analytical thinking is a defining characteristic of people who study STEM-based subjects, problem-focused coping strategies are proactive and solution-oriented in handling stress. University students' propensity to approach career decision-making challenges with problem-focused coping strategies rather than emotion-focused or avoidant ones is positively correlated with mental toughness. The way this mediating process operates is by converting the adaptive energy of resilience into problem-solving exercises that are specifically designed to get past obstacles to career advancement.

The method of solving problems through Problem-Focused Coping and the acquired skill contribute to STEM careers in a long-term way. Antifragile students approach career issues methodically, deconstruct complex problems into smaller components, and test various solutions in a methodical manner. Mental resilience has a direct impact on career outcomes through a strong proximal mediating path created

by the intersection of problem-oriented coping strategies and the cognitive demands of STEM work.

Figure 1

Conceptual Framework of Mental Resilience Mechanisms in STEM Students' Career Development



The theoretical model incorporates both direct and indirect pathways through which mental resilience may impact STEM students' career development, as illustrated in **Figure 1**. Based on the model, mental resilience acts as a direct stress buffer in protecting career development from academic and career-related stressful experiences. Nevertheless, Problem-Focused Coping, Professional Identity Development, and Academic Self-Efficacy are the three mainstream mediating mechanisms through which mental resilience exerts its indirect effects. The protectivity of resilience is mediated by these intervening variables into specific abilities and characteristics that foster STEM success. Given that these mechanisms are not exclusive and may be moderated by both individual and situational factors, there is a complex interplay of effects on career development routes. The model highlights the complex and nuanced nature of the relationship between CD and resilience and offers that direct and indirect paths should be considered when designing interventions aimed at supporting STEM students toward successful careers.

3. Moderating Factors of the Mechanisms

3.1. Individual-Level Moderators

Given this, and individual characteristics that shape how resilient individuals are able to translate resilience into career success, we would expect differences in the way in which mental toughness relates to STEM students' career development. As stereotype threat and underrepresentation in STEM fields commonly present added difficulties for female students, gender is an important moderator. Females would need to be more resilient than males, on average, in order for them to achieve similar work success (although perhaps they would just turn into a more stubborn form of the already-stubborn phenomenon). This "buffer" may exist in fields where men predominate, such as computer science and engineering, where gendered barriers may make learning more challenging.

Cultural values also influence how students interpret failures or setbacks. For example, while people in more individualistic cultures may have resilience based more on personal self-efficacy, resulting in different mediating pathways, other cultures believe that a failure will actually decrease the chances of landing a good job.

Experience and readiness are the cornerstones upon which everything rests. While less prepared students might require some basic resilience to attend in the first place, high school students with a STEM background can readily acquire this academic grit for the careers they aspire to. Exposure to STEM fields, such as early research, internships, scientific competition participation, or preparation, is an investment that boosts resilience and builds self-confidence in advancing a career.

3.2. Environmental Moderators

The academic context generates more or less favorable conditions for the operation of resilience as an asset in vocation. The lab culture and style of research have a profound impact on how to translate students' resilience into scientific maturity. In classrooms that foster collaboration, psychological safety, and support, students can take intellectual risks for errors from which to learn. But challenging or dog-eat-dog environments can drain resilience resources by getting students to focus their mental

energies on threats over building their careers. The association between professional outcomes and resilience is largely dependent on mentoring and advising strategies.

In environments designed by developmental mentors who challenge and support them, resilient students can thrive and realize their full professional potential. These connections translate resilience into tangible career activities through conferences, publications, and professional networking. Mentor-student matches also lessen these effects because good mentors assist students in building the resilience required for a successful career development.

The nature of the relationship between resilience and career is greatly influenced by the structure and level of difficulty of the STEM curriculum. The idea that programs with high workloads might experience diminishing returns from increased resilience raises the possibility of a ceiling effect. Project-based learning and action-focused courses allow resilient students to apply their professional and academic knowledge. When career integration is integrated into the curriculum through internships and industry connections, resilience can support both academic success and career readiness. Career counseling and tutoring are examples of institutional resources that can enhance the positive effects of resilience on career outcomes.

4. Implications for Practice and Research

4.1. Intervention Strategies

The mechanisms found in this review point to specific strategies for using resilience interventions to improve STEM students' career development. STEM curricula should include resilience training programs as structured modules that combine discipline-specific challenges with cognitive-behavioral techniques. These courses might include stress inoculation training, in which students practice coping mechanisms unique to STEM fields and are exposed to controlled academic stressors. Given the frequency of experimental setbacks, workshops that focus on redefining failure as a teaching opportunity would be especially beneficial. Culturally sensitive methods should also be used in training to address the difficulties encountered by underrepresented groups.

Advisors may want to use developmental models to help students understand that resilience is a part of being career-ready. Lessons could concentrate on helping students develop coherence in narratives about challenges faced and accomplishments, helping them to develop professional identities that utilize resilience as a core competency. Group counseling could also encourage peer-to-peer education about problem-focused coping and normalize the challenges of STEM careers.

The fact that resilience operates through a variety of channels should be acknowledged in curriculum design. These programs might provide graduated challenge sequences, allowing for ongoing career development engagement and the gradual development of resilience. In order to successfully meet professional standards, students can acquire and practice resilience skills through real-world STEM project-based learning. Course designs must be challenging while maintaining equilibrium so as not to overwhelm students' resilience.

4.2. Future Research Directions

A number of methodological considerations are necessary to advance our understanding of resilience mechanisms. Richer insights would be obtained through mixed-methods approaches that combine qualitative investigation of lived experiences with quantitative resilience assessment. It may be possible to determine which elements of resilience training best improve career outcomes by using experimental designs that test particular intervention components. To capture the intricate relationships between moderators, mediators, and resilience, research should use advanced analyses such as moderated mediation.

For thorough theoretical models, unstudied mediating variables should be investigated. Not enough research has been done on social capital, growth mindset, and emotional control as possible mediators between career development and resilience. As STEM fields develop, it becomes more crucial than ever to comprehend how technological adaptability and digital competencies mediate the resilience-career relationship.

Research that follows students from undergraduate school through their early careers would shed light on how resilience mechanisms change over time. These kinds of studies could pinpoint crucial times for interventions and monitor the ways in which early resilience affects long-term outcomes. In order to inform inclusive

intervention strategies, cross-cultural comparative studies would improve knowledge of resilience mechanisms across cultural contexts and educational systems. Research should also look at how the relationship between career development and resilience is impacted by new technologies and shifting demands on the STEM workforce.

Conflict of interest: The authors declare no conflict of interest.

Funding: This research received no external funding.

References

[1] Barbayannis, G., Bandari, M., Zheng, X., Baquerizo, H., Pecor, K. W., & Ming, X. (2022). Academic stress and mental well-being in college students: Correlations, affected groups, and COVID-19. *Frontiers in Psychology, 13*, 886344. https://doi.org/10.3389/fpsyg.2022.886344

[2] Chen, Y., So, W. W. M., Zhu, J., & Chiu, S. W. K. (2024). STEM learning opportunities and career aspirations: The interactive effect of students' self-concept and perceptions of STEM professionals. *International Journal of STEM Education, 11*(1), 1. https://doi.org/10.1186/s40594-024-00466-7

[3] Freire, C., Ferradás, M. D. M., Regueiro, B., Rodríguez, S., Valle, A., & Núñez, J. C. (2020). Coping strategies and self-efficacy in university students: A person-centered approach. *Frontiers in Psychology, 11*, 841. https://doi.org/10.3389/fpsyg.2020.00841

[4] Hsu, J. L., & Goldsmith, G. R. (2021). Instructor strategies to alleviate stress and anxiety among college and university STEM students. *CBE—Life Sciences Education, 20*(1), es1. https://doi.org/10.1187/cbe.20-08-0189

[5] Liu, A., Shapiro, C., Gregg, J., Levis-Fitzgerald, M., Sanders O'Leary, E., & Kennison, R. L. (2024). Scaling up a life sciences college career exploration course to foster STEM confidence and career self-efficacy. *Research in Science & Technological Education, 42*(2), 378–394. https://doi.org/10.1080/02635143.2022.2083599

[6] Mahajan, P. (2024, August). Co-creating academic career self-efficacy: Exploring academic career segments, mediating and moderating influences in engineering education trajectory. *Frontiers in Education, 9*, 1359848. https://doi.org/10.3389/feduc.2024.1359848

[7] Rosenzweig, E. Q., Chen, X. Y., Song, Y., Baldwin, A., Barger, M. M., Cotterell, M. E., ... & Lemons, P. P. (2024). Beyond STEM attrition: Changing career plans within STEM fields in college is associated with lower motivation, certainty, and satisfaction about one's career. *International Journal of STEM Education, 11*(1), 15. https://doi.org/10.1186/s40594-024-00475-6

[8] Singer, A., Montgomery, G., & Schmoll, S. (2020). How to foster the formation of STEM identity: Studying diversity in an authentic learning environment. *International Journal of STEM Education, 7*(1), 57. https://doi.org/10.1186/s40594-020-00254-z

[9] Tripp, J. N., & Liu, X. (2024). Towards defining STEM professional identity: A qualitative survey study. *Journal for STEM Education Research, 7*(2), 1–39. https://doi.org/10.1007/s41979-024-00131-2

[10] Wu, Y., Sang, Z. Q., Zhang, X. C., & Margraf, J. (2020). The relationship between resilience and mental health in Chinese college students: A longitudinal cross-lagged analysis. *Frontiers in Psychology, 11*, 108. https://doi.org/10.3389/fpsyg.2020.00108