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Research article

Exploring self-leadership strategies and the successful transition of STEM students to higher education in Malaysia: Academic anxiety as a bridge

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Abstract: The transition from secondary school to higher education is pivotal in shaping students' academic and career trajectories. In Malaysia, declining interest in higher education, particularly in Science, Technology, Engineering, and Mathematics (STEM) fields, poses a challenge to developing a skilled workforce for the Fourth Industrial Revolution (IR4.0). Factors such as low confidence, lack of motivation, and limited awareness contribute to this trend. Despite increasing concern, few researchers have explored how psychological and self-leadership strategies can support the transition to higher education, particularly within Malaysia's under-researched matriculation system, which plays a critical role in preparing STEM students for university-level studies. In this study, we investigated the role of self-leadership strategies, including behavior-focused strategies (BFS), natural reward strategies (NRS), and constructive thought pattern strategies (CTS), in facilitating STEM students' transition to higher education. Grounded in Self-regulation Theory, Intrinsic Motivation Theory, Cognitive Behavioral Theory, Cognitive Appraisal Theory, and Schlossberg's Transition Theory, we examined their impact on academic performance, with academic anxiety as a mediating factor. A survey of 436 Malaysian STEM students from the 2023/2024 matriculation program was analyzed using SPSS and SmartPLS 4. Our findings indicated that BFS, NRS, and CTS positively influence academic performance, with BFS having the strongest effect. Academic anxiety mediates these relationships, underscoring BFS's role in reducing anxiety. The study emphasizes the importance of fostering self-leadership strategies and mitigating anxiety to support STEM students' transitions,

offering actionable insights for educators, policymakers, and institutions to strengthen Malaysia's STEM talent pipeline.

Keywords: self-leadership strategies, behavior-focused strategies, natural reward strategies, constructive thought pattern strategies, academic anxiety, successful transition, academic achievement, STEM

1. Introduction

The transition from secondary school to higher education represents a pivotal phase in a student's life, marked by increased responsibilities, academic challenges, and personal growth opportunities. This period is widely recognized as a critical determinant of success or failure in higher education, shaping students' future trajectories and career paths [1]. Successful transition of a student is often measured by academic achievement in the first year, a period critical for determining long-term success in higher education [2–12]. Academic achievement, typically assessed through grade point average (GPA), is a primary indicator of transition success [5,13,14].

In Malaysia, this transition is particularly significant for STEM (science, technology, engineering, and mathematics) students, as the nation strives to build a robust STEM workforce to meet the demands of a knowledge-based economy and the Fourth Industrial Revolution (IR4.0) [15,16]. Students completing the Sijil Pelajaran Malaysia (SPM), a national examination taken by Form 5 secondary school students, have various pathways to higher education, especially in STEM. The Matriculation program, administered by the Ministry of Education Malaysia (MoE), is a key gateway to STEM disciplines, preparing students for STEM-related degrees at public universities. In 2020, 77.21% of Matriculation graduates progressed to STEM fields [17], demonstrating the program's effectiveness and alignment with Malaysia's workforce development goals.

However, despite the growing importance of STEM education, Malaysia faces a concerning decline in student interest and enrolment in STEM fields. Data reveals that only 74.5% of students enrolled in matriculation programs opted for STEM streams in 2023, a significant drop from 87.5% in 2019 [18]. This decline is exacerbated by factors such as low confidence, lack of interest, and limited awareness of STEM career opportunities among students [19–23]. Compounding the issue, a 2022 report by the Department of Statistics Malaysia (DOSM) highlighted that 72.1% of Sijil Pelajaran Malaysia (SPM) school graduates expressed no interest in pursuing higher education, citing job opportunities in the gig economy, aspirations to become social media influencers, and skepticism about the benefits of further studies as key reasons [15,23–25].

This shift in student priorities presents a major challenge for national development. According to the National Council for Scientific and Research Development, Malaysia requires at least 500,000 scientists and engineers to meet the demands of the Fourth Industrial Revolution (IR 4.0) [26]. However, as of 2019, there were only 70,000 certified engineers in the country, fulfilling merely 17% of the projected need [27,28]. This alarming shortfall threatens to undermine Malaysia's technological advancement and industrial growth. Without urgent and effective interventions to increase the number of STEM graduates, the nation risks falling behind in global innovation and competitiveness. As Malaysia aspires to become a high-technology, high-income nation by 2030, closing the STEM talent gap is more critical than ever [29,30].

The gravity of this situation is further magnified when situated within global educational and workforce trends. The Future of Jobs Report 2020 by the World Economic Forum (WEF) highlights that nine of the top ten emerging job roles by 2025 will be in STEM-related fields [23,31]. This projection underscores a pressing need for all nations, not least Malaysia, to not only sustain but significantly expand investment in STEM education. Doing so will ensure the development of a workforce equipped to thrive in an increasingly digital, automated, and sustainability-oriented global economy [32]. Moreover, strengthening STEM capacity is essential to advancing the United Nations' Sustainable Development Goals (SDGs), as STEM competencies are foundational to addressing complex global challenges such as climate change, healthcare innovation, food security, and equitable access to technology.

Amid these challenges, self-leadership strategies and academic anxiety emerge as critical factors influencing students' successful transition to higher education. Self-leadership, defined as the process of self-influence that enables individuals to achieve self-direction and self-motivation [33,34], positively impacts academic achievement [35–43]. However, there is a paucity of research exploring how self-leadership strategies specifically facilitate the transition of STEM students to higher education, particularly in the Malaysian context. Concurrently, academic anxiety, characterized by feelings of worry, tension, or apprehension related to academic tasks [44], plays a dual role in this transition. While excessive anxiety can hinder academic performance by impairing focus and memory [45], moderate levels of anxiety may enhance motivation and morale, contributing to better outcomes [45–48]. Given that 88.4% of university students experience anxiety during their transition to higher education [49], understanding its mediating role between self-leadership strategies and academic success is crucial.

We seek to address these knowledge gaps by exploring the interplay between self-leadership strategies, academic anxiety, and the successful transition of STEM students to HE in Malaysia. By examining the relationships among behavior-focused, natural reward, and constructive thought pattern strategies and academic achievement, and considering the potential mediating role of academic anxiety, the study aims to provide actionable insights for educators, policymakers, and students. This research contributes to the broader goal of fostering a resilient STEM workforce, ensuring Malaysia's competitiveness in the global knowledge economy, and supporting students in navigating the challenges of higher education.

2. Research purpose and objectives

We aim to explore how three aspects of self-leadership strategies impact the successful transition of Malaysian STEM students from secondary school to higher education, with academic anxiety acting as a mediator. To achieve this, we have set the following objectives:

1) To examine the significant relationship between behavior-focused strategies, natural reward strategies and constructive thought pattern strategies on successful transition

2) To examine the significant between behavior-focused strategies, natural reward strategies and constructive thought pattern strategies on academic anxiety

3) To examine the significant relationship academic anxiety and successful transition

4) To examine the mediating effect of academic anxiety on the relationship between behavior-focused strategies, natural reward strategies, constructive thought pattern strategies and successful transition

3. Literature review

3.1. Theoretical outline

We integrate five key theories to provide a comprehensive understanding of academic performance and students' successful transition. Self-regulation theory [50,51] explains how behavior-focused strategies such as goal-setting, self-talk, and self-reward enhance students' self-regulatory abilities, which in turn improve academic outcomes. Intrinsic motivation theory [52] emphasizes the inherent satisfaction derived from academic tasks, which plays a crucial role in helping students navigate higher education challenges. When students find joy and meaning in their studies, they engage deeply, perform better, and achieve their educational goals. This theory aligns with natural reward strategies, empowering students to take control of their learning and succeed in their transition to higher education. Constructive thought pattern strategies in self-leadership are closely aligned with Cognitive Behavioral Theory (CBT) [53], which asserts that individual thoughts shape emotions and behaviors [54]. By identifying and modifying negative thought patterns, students can improve their responses to academic challenges and achieve better outcomes.

However, academic challenges often trigger anxiety, interfering with self-regulatory processes as outlined in self-regulation theory, diminishing the intrinsic motivation that drives students to engage deeply in their studies, and exacerbating negative thought patterns as described in cognitive behavioral theory. Cognitive Appraisal Theory [55] explains how students' interpretations of academic tasks as overwhelming or threatening lead to anxiety. Addressing these cognitive appraisals and providing targeted support can reduce anxiety, enabling students to better apply self-regulation strategies and perform more effectively.

Schlossberg's Transition Theory [56] identifies key factors: Situation, self, support, and strategies, that shape students' ability to navigate transitions, such as the shift from secondary to higher education. Successful transitions require not only effective self-regulation and emotional management but also supportive environments and adaptive strategies. When these factors are effectively addressed, students are better equipped to manage anxiety, apply self-leadership strategies, and succeed in their academic transitions. Together, these theories provide a holistic framework that enhances understanding of academic success and successful transitions.

3.2. Self-leadership strategies and successful transition

Generally, most prior studies have shown positive significant contribution of self-leadership strategies towards successful transition of the students in terms of academic achievement. These include studies by Alam Afridi et al. [35], Boonyarit [36], Gannouni and Ramboarison-Lalao [37], Garger and Jacques [57], Jooyun [58], Kim [38], Napiersky and Woods [39], Sampl et al. [40], Sampurna [41], Situmorang [59], Vaeazi et al. [60], Woods et al. [42], and Zakir et al. [43].

Behavior-focused strategies are essential for promoting positive actions and preventing academic setbacks, playing a key role in achieving academic excellence [36,61]. Studies consistently show a strong positive link between these strategies and academic success [36,38–40,43,60]. For example, Boonyarit [36] studied 350 students at Chiang Mai University and found that behavior-focused strategies, such as self-goal setting, self-observation, self-reward, and self-cueing, had a significant positive impact on academic performance, based on Structural Equation Modeling (SEM) analysis. Similarly, Kim [37] surveyed 199 South Korean university students and identified a strong positive

correlation between these strategies and academic achievement using Pearson correlation analysis. In another study, Sampl et al. [40] conducted an intervention with 109 undergraduate students at the University of Innsbruck. Students trained in behavior-focused strategies achieved significantly higher cumulative GPAs than those in the control group, confirming the positive effect of these strategies on academic performance.

Thus, we propose the following hypothesis:

H1: Behavior-focused strategies are positively associated with successful transition.

In the context of natural reward strategies, they focus on creating situations where individuals are motivated or rewarded by the inherently enjoyable aspects of a task or activity [62,63]. Supporting this, Woods et al. [42] studied 157 postgraduate business students in the UK and found that natural reward strategies were positively linked to successful transitions, particularly in academic achievement. Using survey questionnaires and linear regression, the study highlights the crucial role of these strategies in fostering academic success during postgraduate transitions and emphasizes the importance of self-leadership in enhancing educational outcomes. Similarly, Napiersky and Woods [39] conducted a longitudinal study with 150 UK business students. At the beginning of the academic year, students reported their use of self-leadership strategies, including natural reward strategies. The results revealed a positive association between these strategies and students' end-of-year GPA, further demonstrating their impact on academic success. Building on this body of evidence, the following hypothesis is proposed:

H2: Natural reward strategies are positively associated with successful transition.

Constructive thought pattern strategies, which promote positive and optimistic thinking [24,64,65], significantly impact academic performance. Zakir et al. [43] identified a strong positive correlation between these strategies (evaluating beliefs, visualizing success, and self-talk) and CGPA among 326 students at the Women University of AJK Bagh, using Pearson correlation analysis. Similarly, Vaeazi et al. [60] found a significant positive relationship between self-talk and academic performance among 954 students at Birjand University, highlighting self-talk as a critical self-leadership strategy. These studies underscore the importance of cognitive strategies in enhancing academic success. Thus, we propose the following hypothesis:

H3: Constructive thought pattern strategies is positively associated with successful transition.

3.3. Self-leadership strategies and academic anxiety

Self-leadership strategies effectively reduce academic anxiety. Sampl et al. [40] found that behavior-focused strategies (self-goal setting, self-reward, self-observation, and self-cueing) and constructive thought pattern strategies (visualizing successful performance, self-talk, and evaluating beliefs and assumptions) significantly alleviated test anxiety among 109 Austrian undergraduates. Similarly, Wang et al. [66] demonstrated that behavior-focused, natural reward, and constructive thought pattern strategies significantly predicted reduced academic anxiety. These findings underscore the value of self-leadership approaches in mitigating academic stress. Thus, we postulate the following hypotheses:

H4: Behavior-focused strategies are negatively associated with academic anxiety

H5: Natural reward strategies are negatively associated with academic anxiety

H6: Constructive thought pattern strategies are negatively associated with academic anxiety

3.4. Academic anxiety and successful transition

Academic anxiety is a common phenomenon, particularly during transitions to new academic environments, where unfamiliarity can impact students' performance [67]. Research consistently highlights a significant negative correlation between academic anxiety and achievement [48,67–77]. For instance, Nasir and Zaman [67] found that among 150 first-semester teacher training students, those with lower anxiety outperformed their higher-anxiety peers. Similarly, Rana and Mahmood [73], studying 414 postgraduate science students at a public university in Lahore, reported an inverse relationship between academic anxiety and academic achievement, reinforcing the detrimental effects of academic anxiety on performance. Therefore, we formulate the following hypothesis:

H7: Academic anxiety is negatively associated with successful transition

3.5. The mediating role of academic anxiety

Research highlights significant links between self-leadership strategies and academic anxiety [40,45,66,78] and between academic anxiety and successful transition [48,67,68]. While effective management of academic anxiety is critical for navigating challenging educational transitions, no studies have yet explored its mediating role between self-leadership strategies and successful transition. This gap presents an opportunity to uncover how self-leadership strategies influence students' ability to navigate transitions.

While academic anxiety has been identified as a key factor influencing student transitions, its role as a mediator between self-leadership strategies and academic success has not been well-explored. From a theoretical perspective, academic anxiety can either hinder or facilitate the application of self-leadership strategies, depending on its intensity. Theoretically, excessive anxiety interferes with self-regulation, while moderate anxiety can serve as a motivator, driving students to perform better. Practically, addressing academic anxiety through targeted interventions can enable students to better apply self-leadership strategies, which is critical for improving academic performance and easing the transition to higher education.

Addressing this, we propose the following hypotheses:

H8: The relationship between the behavior-focused strategies and successful transition is mediated by academic anxiety.

H9: The relationship between natural reward strategies and successful transition is mediated by academic anxiety.

H10: The relationship between constructive thought pattern strategies and successful transition is mediated by academic anxiety.

3.6. The development of conceptual framework

We expand on the literature to address research gaps by examining the relationships among the variables and addressing the following key research questions:

Q1. What is the impact of behavior-focused strategies, natural reward strategies, and constructive thought pattern strategies on the successful transition of students from secondary school to higher education?

Q2. Does academic anxiety play a mediating role in the relationship between behavior-focused strategies, natural reward strategies, and constructive thought pattern strategies and the successful transition of students from secondary school to higher education?

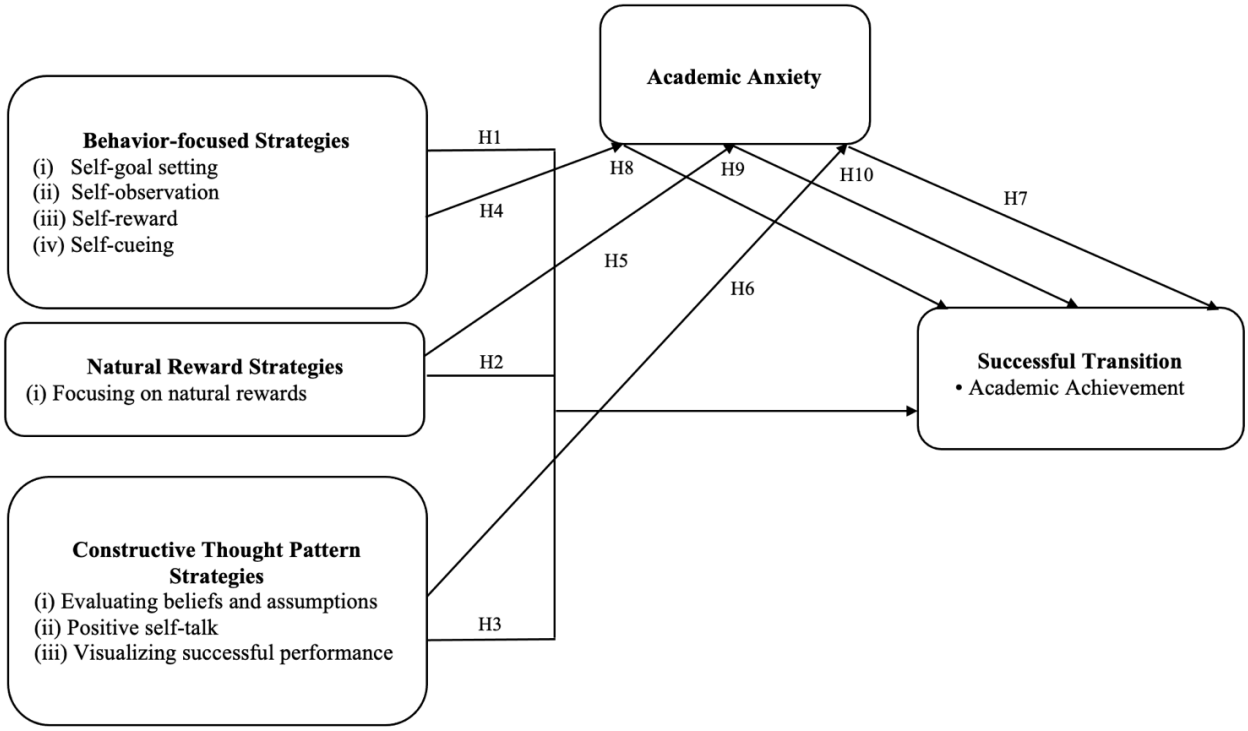

Figure 1. Conceptual framework.

3.7. Research gaps

Researchers have extensively explored the relationship between self-leadership strategies and various organizational outcomes, such as job performance, job satisfaction, and organizational commitment [79–87]. However, most of these studies are concentrated within the business and management domains, with limited focus on the education sector. This imbalance leaves a critical gap in understanding how these strategies function in educational contexts, particularly in relation to successful transition (academic performance).

Within the education sector, a substantial body of research has consistently demonstrated significant relationships between self-leadership strategies and academic anxiety [40,43,45,66,78,88,89], as well as between academic anxiety and successful transition [48,67–72,74,76].

Academic anxiety, when effectively managed, is key to ensuring a smooth transition, especially during challenging educational phases or shifts between academic levels. Despite established links, however, to date, no studies have explored how academic anxiety mediates the relationship between self-leadership strategies and successful transition to higher education, particularly among STEM students in Malaysia. This omission is significant, as academic anxiety could could be the key explanatory mechanism through which self-leadership enables students to navigate transitional challenges and maintain academic performance.

This study is novel in its integration of self-leadership strategies with academic anxiety to understand their combined influence on students' transition success, filling a crucial gap in the literature and contributing new theoretical and practical insights for educational stakeholders.

4. Methodology

4.1. Research design

We examined the influence of self-leadership strategies, comprising behavior-focused strategies, natural reward strategies, and constructive thought pattern strategies on successful transition. A quantitative research approach is employed, with data gathered through survey questionnaires.

4.2. Study setting and population

We targeted students enrolled in Malaysia's Ministry of Education (MoE) matriculation program for the 2023/2024 academic year, focusing on those pursuing Science or Technical streams. The sample encompasses five major regions in Malaysia: Northern, Central, East Coast, Southern, and Borneo. Matriculation colleges were selected due to their pivotal role in equipping students with the foundational skills and knowledge required for STEM degree programs at public universities. These institutions serve as a critical pipeline for STEM education, with 77.21% of matriculation graduates advancing to STEM-related degree programs in 2020 [19]. To establish the study population, the 2023 Malaysia Educational Statistics report from the Educational Planning and Research Division (EPRD) was utilized. As of August 2023, a total of 19,263 students were enrolled in STEM majors across matriculation colleges, spanning both the Two-Semester and Four-Semester Systems for the 2023/2024 academic session [20].

4.3. Sampling technique

In this study, we employed a multi-stage sampling technique to select a representative sample of STEM students from matriculation colleges distributed across Malaysia. The approach involves segmenting the broader population into progressively smaller clusters to ensure inclusivity. Two levels of sub-clusters are utilized: Regions and matriculation colleges. Data is initially categorized into five regions: The Northern region (Perlis, Kedah, Penang, Perak), Central region (Selangor, Negeri Sembilan), East Coast region (Kelantan, Pahang), Southern region (Johor, Malacca), and Borneo region (Sabah, Sarawak). Across these regions, there are 16 matriculation colleges offering STEM-focused programs in Science or Technical streams, as illustrated in Figure 2. Based on the population of 19,263 students, and referencing the sample size determination table by Krejcie and Morgan [90], a minimum sample size of 377 students is required for the study.

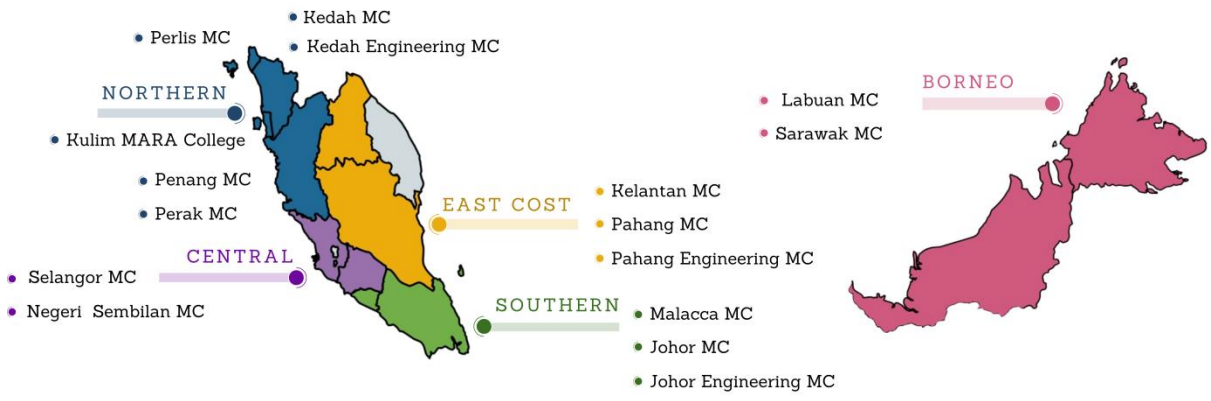

Figure 2. Matriculation colleges.

4.4. Validity of the instrument

Validity refers to the extent to which an instrument accurately measures what it is intended to measure [91]. In this study, face and content validities were systematically established to ensure the quality of the survey instrument.

Face validity was assessed through feedback from three alumni of STEM matriculation colleges, who reviewed the questionnaire items for clarity, relevance, and appropriateness. Their insights helped confirm that the items were understandable and aligned with the intended constructs.

Content validity was evaluated by a panel of ten academic experts from relevant disciplines. Experts in educational leadership reviewed the self-leadership strategies section, while professionals in medical education and educational psychology assessed the academic anxiety component. These experts used a structured content validation form to evaluate each item.

The completed forms were analyzed using the Content Validity Index (CVI), a widely accepted quantitative method for assessing content validity [92]. According to Yusoff [92], the CVI requires evaluations from a panel of at least two and up to ten subject matter experts. Table 1 presents the acceptable CVI thresholds based on the number of experts involved in the review process.

Table 1. Acceptable CVI values.

No. of Experts	Acceptable CVI Values	Source of Recommendations
2	At least 0.80	David (1992)
3-5	1	Polit and Beck (2006) and Polit et al. (2007)
At least 6	At least 0.83	Polit and Beck (2006) and Polit et al. (2007)
6-8	At least 0.83	Lynn (1986)
At least 9	At least 0.78	Lynn (1986)

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The calculation of the Content Validity Index (CVI) involves the use of three specific formulas: The Item-Level CVI (I-CVI), the Scale-Level CVI based on the average method (S-CVI/Ave), and the Scale-Level CVI based on universal agreement (S-CVI/UA), as illustrated in Table 2.

Table 2. Definitions and formulas of I-CVI, S-CVI/Ave and S-CVI/UA.

The CVI Indices	Definition	Formula
I-CV (item-level CVI)	• The proportion of content experts giving item a relevance rating of 3 or 4.	I-CVI = (agreed item)/(no. of expert)
S-CVI/Ave (scale-level CVI based on the average method)	• The average of the I-CVI scores for all items on the scale or the average of proportion relevance judged by all experts. • The proportion relevant is the average of relevance rating by individual expert.	S-CVI/Ave (scale-level CVI based on the average method)

S-CVI/UA (scale-level CVI based on the universal agreement method)	• The proportion of items on the scale that achieve a relevance scale of 3 or 4 by all experts. • Universal agreement (UA) score is given as 1 when the item achieved 100% experts in agreement, otherwise the UA score is given as 0.	S-CVI/UA (scale-level CVI based on the universal agreement method)

If the I-CVI, S-CVI/Ave, and S-CVI/UA values meet the acceptable thresholds outlined in Table 1, it can be concluded that the questionnaire demonstrates an adequate level of content validity. Based on the computed values, all items across the instruments satisfy the minimum required CVI standards: RSLQ (I-CVI = 1.00, S-CVI/Ave = 1.00, S-CVI/UA = 1.00), AAS (I-CVI = 0.83, S-CVI/Ave = 0.97, S-CVI/UA = 0.91), and the successful transition scale (CVI = 0.83). Therefore, all items are deemed valid and suitable for inclusion in the pilot study. The adapted RSLQ and AAS instruments, along with the complete survey questionnaire, were subsequently revised and refined by the researcher in response to the constructive feedback provided by the content validity experts.

4.5. Pilot test

A pilot study was conducted prior to the main research to assess the effectiveness and clarity of the survey instrument. This initial phase involved 35 students from the 2023/2024 Science stream cohort, selected from one of the nine participating matriculation colleges. The purpose of the pilot was to evaluate the clarity, relevance, and contextual appropriateness of the questionnaire items. Feedback gathered during this stage was instrumental in guiding final revisions before proceeding with full-scale data collection.

4.6. Reliability of the instrument

Reliability refers to the consistency of an instrument in measuring a construct [91,93]. In this study, Cronbach's alpha was used to assess the internal consistency of each construct. All constructs achieved acceptable reliability scores, with alpha values ranging from 0.621 to 0.842. These results confirmed that the instruments are reliable and suitable for measuring the intended variables.

4.7. Questionnaire

We employed a structured, adapted questionnaire to collect data from survey participants. The instrument incorporates established, validated scales that have undergone rigorous statistical testing in prior research, ensuring reliability and alignment with best practices in the literature.

The original questionnaire was developed in English and administered in the same language, as English serves as the primary medium of instruction in Malaysian matriculation colleges. Minor linguistic adjustments were made to enhance clarity and ensure better comprehension among local students, without compromising the original constructs or intended meanings of the items.

The questionnaire is organized into four sections: Part A addresses self-leadership strategies, Part B focuses on academic anxiety, Part C examines successful transition, and Part D gathers respondent background information.

To measure self-leadership strategies, 31 items were adapted from the Revised Self-Leadership Questionnaire [94] (see Appendix 1). These items are grouped into three constructs: behavior-focused strategies (14 items), natural reward strategies (5 items), and constructive thought pattern strategies (12 items). Responses are rated on a 5-point Likert scale, ranging from 1 ("strongly disagree") to 5 ("strongly agree"). Part B assesses academic anxiety using the Academic Anxiety Scale (AAS) adapted from Cassady et al. [95] (refer to Appendix 2), comprising 11 items rated on a 4-point scale: 1 ("Not at all typical of me"), 2 ("Somewhat typical of me"), 3 ("Quite typical of me"), and 4 ("Very typical of me"). Part C evaluates successful transition with a single-item measure: the CGPA of STEM students in their first semester of matriculation. Part D collects respondent demographic data, including gender, age, program type, and major of study, through four items.

4.8. Data collection and analysis

Data collection was conducted via an online questionnaire, enabling extensive reach across the five regions. The structured questionnaire was adapted to align with the study's objectives and underwent a rigorous review by academic experts to ensure validity. Minor revisions were implemented to improve clarity and respondent comprehension. The collected data were analyzed using two software tools: SmartPLS for Structural Equation Modeling (SEM) and the Statistical Package for the Social Sciences (SPSS) for descriptive analysis. SPSS was utilized to examine respondents' demographic profiles, offering a comprehensive understanding of the sample. In contrast, SmartPLS 4 was employed to explore the relationships between variables through Partial Least Squares Structural Equation Modeling (PLS-SEM). These analytical methods provided robust insights into the interplay between self-leadership strategies and successful transitions, with academic anxiety serving as a mediator. The combined use of these tools ensured methodological rigor and reliability in the study’s findings.

5. Analysis and findings

5.1. Descriptive analysis

Of the 900 distributed online survey questionnaires, 436 were completed, yielding a response rate of 48.44%. This aligns closely with the findings of Wu et al. [96], who reported an average online survey response rate of 44.4%. Moreover, the achieved sample size exceeds the minimum requirement of 377 respondents, as recommended by Krejcie and Morgan [90] for a population of 19,263, providing a solid foundation for robust data analysis. The demographic profiles of the respondents, detailed in Table 3, offer valuable insights into the study's context, covering variables such as gender, age, academic programs, and majors. Female participants form the majority, accounting for 59.2% (n = 258), while males comprise 40.8% (n = 178). The majority of respondents are 19 years old (91.3%, n = 398), followed by 18 years old (5.7%, n = 25), 20 years old (2.5%, n = 11), and 17 years old (0.5%, n = 2).

In terms of academic programs, 87.8% (n = 383) of respondents are enrolled in the Two-Semester System, while 12.2% (n = 53) are part of the Four-Semester System. Respondents represent a wide array of STEM majors, with the largest proportions in Basic Engineering (26.1%, n = 114) and Life Sciences (25.0%, n = 109). Other disciplines include Civil Engineering (11.7%, n = 51), Mechanical Engineering (10.1%, n = 44), Physical Sciences (9.4%, n = 41), Electrical & Electronics Engineering (9.2%, n = 40), and Computer Science (8.5%, n = 37). These descriptive statistics provide essential

context for interpreting the study's findings and underscore the diversity of the sample across key demographic and academic variables.

Table 3. Descriptive statistics of respondents.

No.	Demographic Variables	Frequency *(f)*	Percentage *(%)*
1.	**Gender**		
	Female	258	59.2
	Male	178	40.8
2.	**Age**		
	17 years old	2	0.5
	18 years old	25	5.7
	19 years old	398	91.3
	20 years old	11	2.5
3.	**Program of Study**		
	Two Semester System	383	87.8
	Four Semester System	53	12.2
4.	**Major of Study**		
	Life Sciences Stream	109	25.0
	Physical Sciences Stream	41	9.4
	Computer Science Stream	37	8.5
	Basic Engineering Stream	114	26.1
	Civil Engineering Stream	51	11.7
	Electrical & Electronics Engineering Stream	40	9.2
	Mechanical Engineering Stream	44	10.1

Note. $n = 436$

Next, the proposed hypotheses are evaluated and validated using the Structural Equation Modeling (SEM) approach, facilitated by Smart PLS 4.

5.2. Measurement and model assessment

5.2.1. Reflective measurement model

The evaluation of reflective measurement models involved assessing reliability at both the indicator level (indicator reliability) and construct level (internal consistency reliability). Validity was examined through convergent validity, measured via average variance extracted (AVE), and discriminant validity, assessed using the heterotrait-monotrait (HTMT) ratio of correlations [97].

Developed in SmartPLS 4, the reflective measurement model for this study comprised nine lower-order constructs (see Figure 3). These included self-goal setting (SG, 5 items), self-observation (SO, 4 items), self-reward (SR, 3 items), self-cueing (SC, 2 items), focusing on natural rewards (FN, 5 items), evaluating beliefs and assumptions (EB, 4 items), self-talk (ST, 3 items), visualizing successful performance (VS, 5 items), and academic anxiety (AA, 11 items).

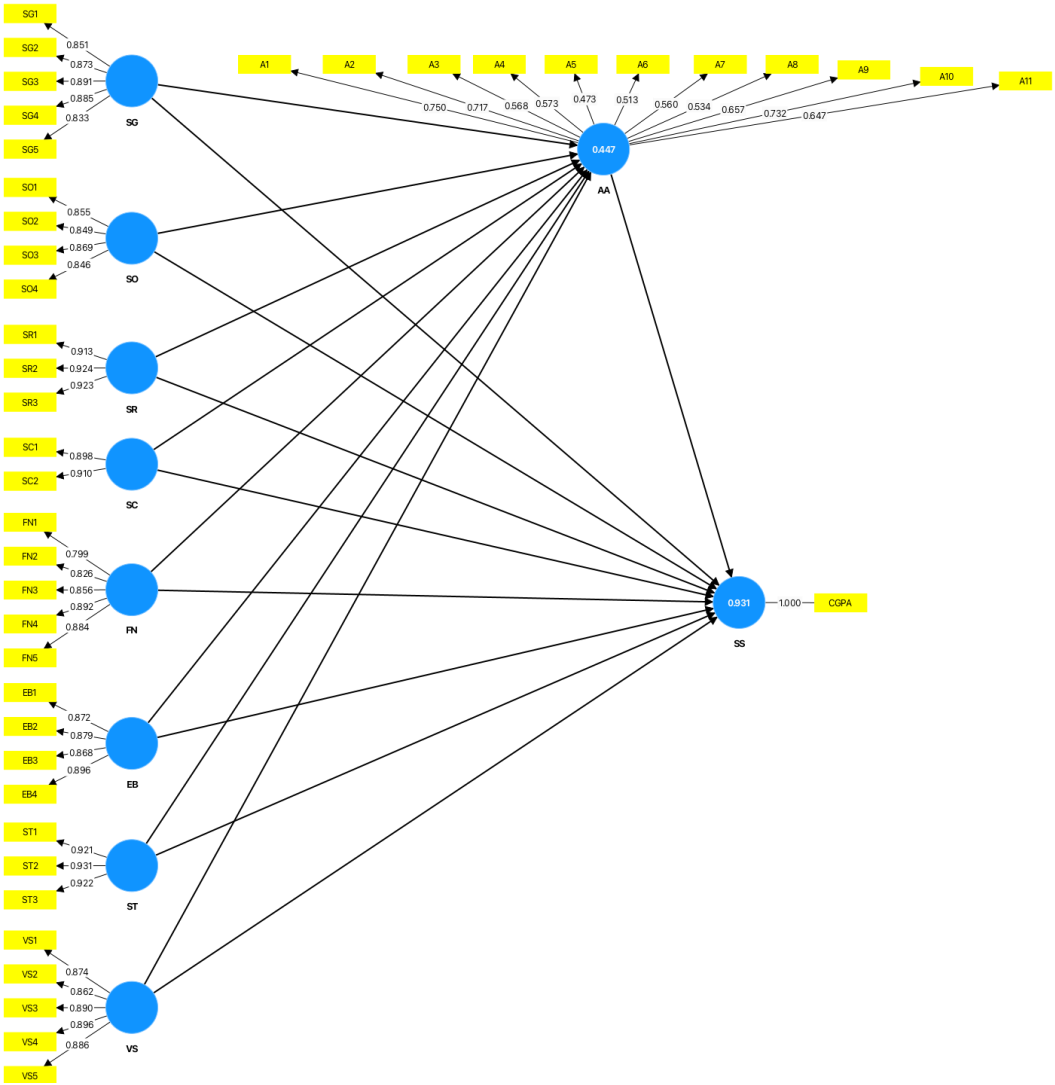

Figure 3. Reflective measurement model.

5.2.1.1. Step 1: Indicator reliability

The initial step in assessing a reflective measurement model is to evaluate the outer loadings of its indicators. In practice, outer loadings around 0.70 are often deemed sufficiently close to 0.708 to be acceptable [97]. In social science research, it is common to encounter weaker outer loadings (i.e., < 0.70) [98]. Typically, indicators with outer loadings between 0.40 and 0.70 should only be considered for elimination if their removal results in a marked improvement in internal consistency reliability or convergent validity, surpassing the established threshold values [97].

At the initial stage of analysis, no indicators were removed as all outer loadings exceed 0.40 (see Figure 3). However, 8 of 11 academic anxiety indicators have outer loadings between 0.40 and 0.70: A3 (0.568), A4 (0.573), A5 (0.473), A6 (0.513), A7 (0.560), A8 (0.535), A9 (0.657), and A11 (0.647). Subsequent evaluation of the construct's internal consistency reliability and convergent validity was conducted to determine whether these indicators should be retained or removed.

5.2.1.2. Step 2: Internal consistency reliability

The internal consistency reliability was confirmed using reliability coefficient (rho_a) and Cronbach's alpha. Scores between 0.70 and 0.95 are considered "adequate to good," while scores between 0.60 and 0.70 are deemed "suitable for exploratory research" [97,99]. As shown in Table 4, all rho_a coefficients and Cronbach's alpha values fall within the acceptable range, above 0.70 and below the critical threshold of 0.95. This indicates that the constructs exhibit sufficient internal consistency reliability without redundancy. Consequently, the measurement model meets the required reliability standards, allowing for confident progression to further analysis. This ensures that the indicators capture a diverse range of aspects of the underlying constructs, enhancing the overall validity and robustness of the measurement model.

Table 4. Internal consistency reliability.

	Cronbach's alpha	Reliability coefficient (rho_a)
AA	0.834	0.842
EB	0.902	0.903
FN	0.905	0.908
SC	0.777	0.779
SG	0.917	0.919
SO	0.877	0.878
SR	0.910	0.915
ST	0.915	0.916
VS	0.929	0.934

5.2.1.3. Step 3. Convergent validity

As shown in Table 5, all constructs, except for academic anxiety, exhibit an Average Variance Extracted (AVE) above the accepted threshold of 0.5 [97,99]. This threshold indicates that at least 50% of the variance in the indicators is explained by the latent construct, ensuring sufficient validity. Initially, the academic anxiety (AA) construct had an AVE of 0.382, below the 0.5 threshold. To address this, five AA indicators (A5, A6, A8, A7, and A4) were systematically removed. The AVE increases to 0.403 after removing A5, and further rises to 0.425, 0.452, 0.485, and finally 0.535 with the removal of A6, A8, A7, and A4, respectively (see Table 5). This process ensured that the academic anxiety construct achieves adequate convergent validity, maintaining its validity within the model.

Table 5. Average Variance Extracted (AVE).

	Average Variance Extracted (AVE)					
	Original	**A5 removal**	**A6 removal**	**A8 removal**	**A7 removal**	**A4 removal**
AA	0.382	0.403	0.425	0.452	0.485	0.535
SG	0.751	0.751	0.751	0.751	0.751	0.751
SO	0.731	0.731	0.731	0.731	0.731	0.731
SR	0.847	0.847	0.847	0.847	0.847	0.847
SC	0.818	0.818	0.818	0.818	0.817	0.817

FN	0.726	0.726	0.726	0.726	0.726	0.772
EB	0.772	0.772	0.772	0.772	0.772	0.855
ST	0.855	0.855	0.855	0.855	0.855	0.777
VS	0.777	0.777	0.777	0.777	0.777	0.726

The final outer loadings, Cronbach's alpha, reliability coefficient (rho_a), and average variance extracted (AVE) are summarized in Table 6.

Table 6. Outcomes of (validity and reliability) reflective measurement model.

Construct	Indicator	Outer loadings	Cronbach's alpha	rho_a	AVE
AA	A1	0.788	0.822	0.825	0.535
	A2	0.768			
	A3	0.570			
	A9	0.742			
	A10	0.801			
	A11	0.692			
SG	SG1	0.851	0.917	0.919	0.751
	SG2	0.873			
	SG3	0.892			
	SG4	0.884			
	SG5	0.832			
SO	SO1	0.854	0.877	0.878	0.731
	SO2	0.85			
	SO3	0.871			
	SO4	0.844			
SR	SR1	0.913	0.910	0.915	0.847
	SR2	0.924			
	SR3	0.924			
SC	SC1	0.895	0.777	0.781	0.817
	SC1	0.913			
FN	FN1	0.796	0.905	0.908	0.772
	FN2	0.827			
	FN3	0.857			
	FN4	0.892			
	FN5	0.885			
EB	EB1	0.872	0.902	0.902	0.855
	EB2	0.881			
	EB3	0.867			
	EB4	0.896			
ST	ST1	0.92	0.915	0.915	0.777
	ST2	0.931			
	ST3	0.923			

VS	VS1	0.875	0.929	0.934	0.726
	VS2	0.861			
	VS3	0.891			
	VS4	0.895			
	VS5	0.886			

5.2.1.4. Step 4: Discriminant validity

Discriminant validity assesses the degree to which a construct is empirically distinct from other constructs in a structural model [99,100]. As shown in Table 7, each construct exhibits stronger associations with its own indicators than with other constructs, confirming discriminant validity. We employed the heterotrait-monotrait ratio of correlations (HTMT), a robust and contemporary method for evaluating discriminant validity [101–103]. Henseler et al. [102] recommend an HTMT threshold of 0.90 for conceptually similar constructs, with values above this threshold indicating insufficient discriminant validity. For conceptually distinct constructs, a stricter threshold of 0.85 is advised [104]. In this study, all HTMT values are below 0.859, as presented in Table 7, confirming the distinctiveness of the constructs within the model and indicating no discriminant validity issues.

Table 7. Heterotrait–monotrait ratio of correlation (HTMT).

	AA	**EB**	**FN**	**SC**	**SG**	**SO**	**SR**	**ST**	**VS**
AA									
EB	0.553								
FN	0.492	0.614							
SC	0.620	0.600	0.486						
SG	0.597	0.600	0.488	0.859					
SO	0.614	0.623	0.482	0.802	0.798				
SR	0.585	0.537	0.380	0.805	0.817	0.779			
ST	0.511	0.852	0.574	0.549	0.589	0.608	0.559		
VS	0.490	0.854	0.562	0.526	0.585	0.626	0.504	0.786	

Note. Successful transition (SS) is excluded from the table since it is a single-item construct and thus not relevant for discriminant validity assessment.

5.2.2. Formative measurement model

The evaluation of formative measurement models involves two critical steps. First, researchers must assess potential collinearity issues to ensure that multicollinearity among formative indicators does not compromise the model's validity. Once collinearity is addressed, the significance and relevance of the formative indicators are evaluated to confirm their meaningful contribution to the construct. This process ensures that only the most relevant indicators are retained, resulting in a robust and reliable formative measurement model [97,100,103].

In this study, the higher-order formative measurement model, illustrated in Figure 4, was developed using SmartPLS 4. It consists of two higher-order formative constructs. The first, behavior-focused strategies (BFS), is formed by four latent constructs: Self-goal setting (SG), self-cueing (SC), self-observation (SO), and self-reward (SR). The second, constructive thought pattern strategies (CTS), comprises three latent constructs: Evaluating beliefs and assumptions (EB),

self-talk (ST), and visualizing successful performance (VS). The formative approach highlights the contribution of each latent construct to the higher-order dimensions, emphasizing that changes in one construct may significantly affect the overall model, thereby enhancing the study's depth and analytical rigor.

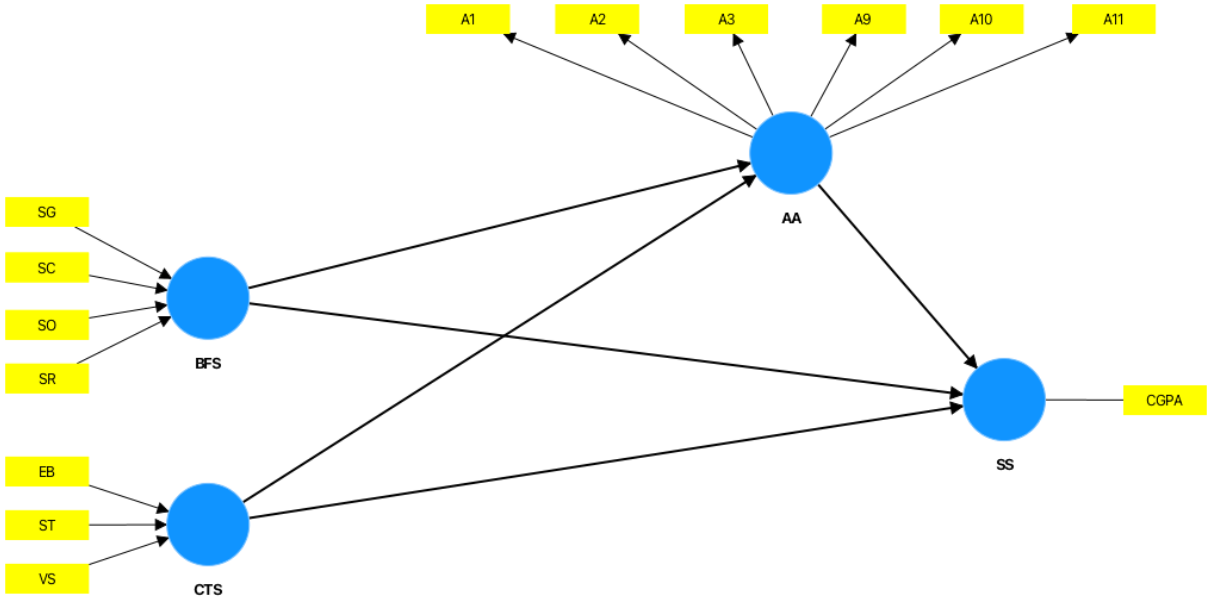

Figure 4. Formative measurement model.

5.2.2.1. Step 1: Assess formative measurement models for collinearity issues

To assess whether multicollinearity poses a problem in formative measurement models, we used the Variance Inflation Factor (VIF), with a threshold of 5 [97,100,103]. Since all indicators show VIF values lower than 5 (refer Table 8), it can be concluded that there are no multicollinearity issues among the indicators. Consequently, all indicators are retained for further analysis.

Table 8. VIF values.

	VIF
SG	3.098
SO	2.448
SR	2.703
SC	2.434
EB	3.350
ST	2.733
VS	2.836

5.2.2.2. Step 2: Assess the significance and relevance of the formative indicators

Following the confirmation of no multicollinearity issues, the next critical step involved evaluating the significance of outer weights to assess the absolute and relative contributions of formative indicators to their respective constructs. This assessment helps identify the extent to which each

indicator contributes to the construct, guiding informed model refinement decisions [97]. Indicators with significant outer weights are interpreted for their contributions, while those with non-significant weights are evaluated based on their outer loadings. Indicators with loadings ≥ 0.5 are retained, regardless of significance, whereas those with loadings < 0.5 undergo significance testing. Non-significant indicators with low loadings are removed, while significant ones with low loadings may be considered for exclusion, ensuring the model retains only statistically robust and relevant indicators.

As illustrated in Figure 5, the formative measurement model results present outer weights and p-values, with Table 9 providing a detailed summary of significance testing for formative constructs and their indicators. Two formative constructs, behavior-focused strategies (BFS) and Cognitive thought pattern strategies (CTS) are examined, each comprising multiple formative indicators. Positive outer weights indicate that increases in the indicators correspond to increases in the constructs. Significance is assessed using t-values, p-values, and confidence intervals bias corrected (CI BC). All indicators meet the significance criterion, with p values less than 0.05, and the 95% confidence intervals, excluding zero, further validate their significance. This rigorous evaluation ensures the reliability and validity of the formative measurement model.

A bootstrapping procedure with 10,000 samples and a two-tailed test at a 0.05 significance level was performed using the most-important (faster) method. As shown in Table 9, the indicators for the BFS construct, SG, SO, SR, and SC, demonstrate significant contributions, with outer weights of 0.323 (p = 0.002), 0.281 (p = 0.003), 0.277 (p = 0.009), and 0.251 (p = 0.006), respectively, highlighting their importance within the construct. For the CTS construct, the indicators EB and ST also show significant contributions, with outer weights of 0.534 (p < .001) and 0.338 (p = 0.004). However, the outer weight of VS (0.210) is not significant (p > 0.05), prompting further analysis of its outer loading to assess its relevance.

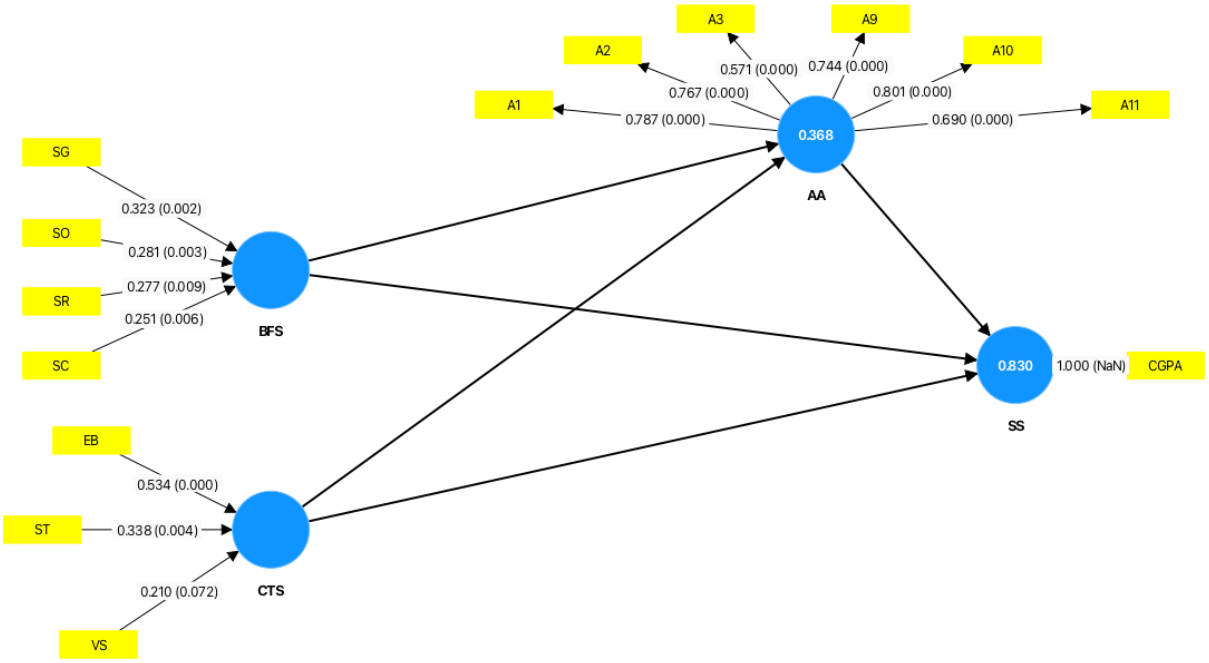

Figure 5. Formative measurement model results in SmartPLS 4 (outer weight/p-value).

As shown in Table 9, the outer loading of VS (0.872) exceeds the threshold of 0.5, confirming its relevance and justifying its retention for further analysis.

Table 9. Significance testing results of formative constructs' outer weights using bootstrapping.

Formative constructs	Formative indicators	Outer weights (Outer loadings)	*t* value	*p* value	95% CI BC	Significance[a] (p < 0.05)?
BFS	**SG**	0.323 (0.913)	3.050	0.002	[0.118, 0.537]	Yes
	SO	0.281 (0.871)	3.014	0.003	[0.099, 0.463]	Yes
	SR	0.277 (0.884)	2.625	0.009	[0.070, 0.482]	Yes
	SC	0.251 (0.859)	2.751	0.006	[0.070, 0.425]	Yes
CTS	**EB**	0.534 (0.959)	4.312	0.000	[0.289, 0.775]	Yes
	ST	0.338 (0.903)	2.899	0.004	[0.116, 0.570]	Yes
	VS	0.210 (0.872)	1.801	0.072	[-0.024, 0.433]	No

5.3. Structural model

Following the establishment of construct reliability and validity, as outlined in the preceding section, the subsequent critical step involved assessing the structural model results. This evaluation adheres to a systematic four-step procedure, guided by established methodologies from Hair et al. [97], Hair, Black, et al. [100], and Hair, Risher, et al. [99].

5.3.1. Step 1: Assess the structural model for collinearity issue

The analysis began with evaluating collinearity issues through the variance inflation factor (VIF) to ensure the accuracy of path coefficient estimates. The results confirm no multicollinearity concerns, as all VIF values fall below the recommended threshold of 5.0. As shown in Table 10, none of the indicators exhibit multicollinearity, consistent with the thresholds established by Hair, Black, et al. [100], and Hair et al. [101].

Table 10. Variance Inflation Factor (VIF) values.

	AA	BFS	CTS	NRS	SS
AA					1.616
BFS	1.690				1.984
CTS	1.996				2.026
NRS	1.539				1.577
SS					

5.3.2. Assess the significance and relevance of the structural model relationships

Bootstrapping, a robust resampling technique, was utilized to evaluate the significance and relevance of the hypothesized relationships. Referring to Figure 6 and Table 11, the evaluation of behavior-focused strategies (BFS), natural reward strategies (NRS), and constructive thought pattern strategies (CTS) on successful transition (SS) reveals that BFS exerts the strongest effect on SS (β = 0.182), followed by CTS (β = 0.099). In contrast, NRS shows the weakest effect on successful

transition (β = 0.079) compared to the other strategies. The comprehensive results of hypothesis testing for the direct relationships within the structural model are detailed below.

Hypothesis 1: Behavior-focused strategies are positively associated with successful transition.

The result shows a positive and significant association between behavior-focused strategies and successful transition (β = 0.182, p < 0.05, t = 6.695). The t-value exceeds the threshold of 1.645 at the 5% level of significance. Consequently, hypothesis 1 is supported based on the output of algorithm and bootstrapping in PLS-SEM.

Hypothesis 2: Natural reward strategies are positively associated with successful transition.

Our findings indicate a positive and significant relationship between natural reward strategies and a successful transition (β = 0.079, p < 0.05, t = 3.514). The relationship is significant with a t-value ≥ 1.645 at a 5% significance level. Therefore, hypothesis 2 is supported based on the PLS-SEM algorithm and bootstrapping results.

Hypothesis 3: Constructive thought pattern strategies are positively associated with a successful transition.

The results reveal a positive and significant association between the constructive thought pattern and successful transition (β = 0.099, p < 0.05, t = 3.493). The relationship has a t-value ≥ 1.645 at 5% level of significance. Hence, based on the output of algorithm and bootstrapping in PLS-SEM, hypothesis 3 is supported.

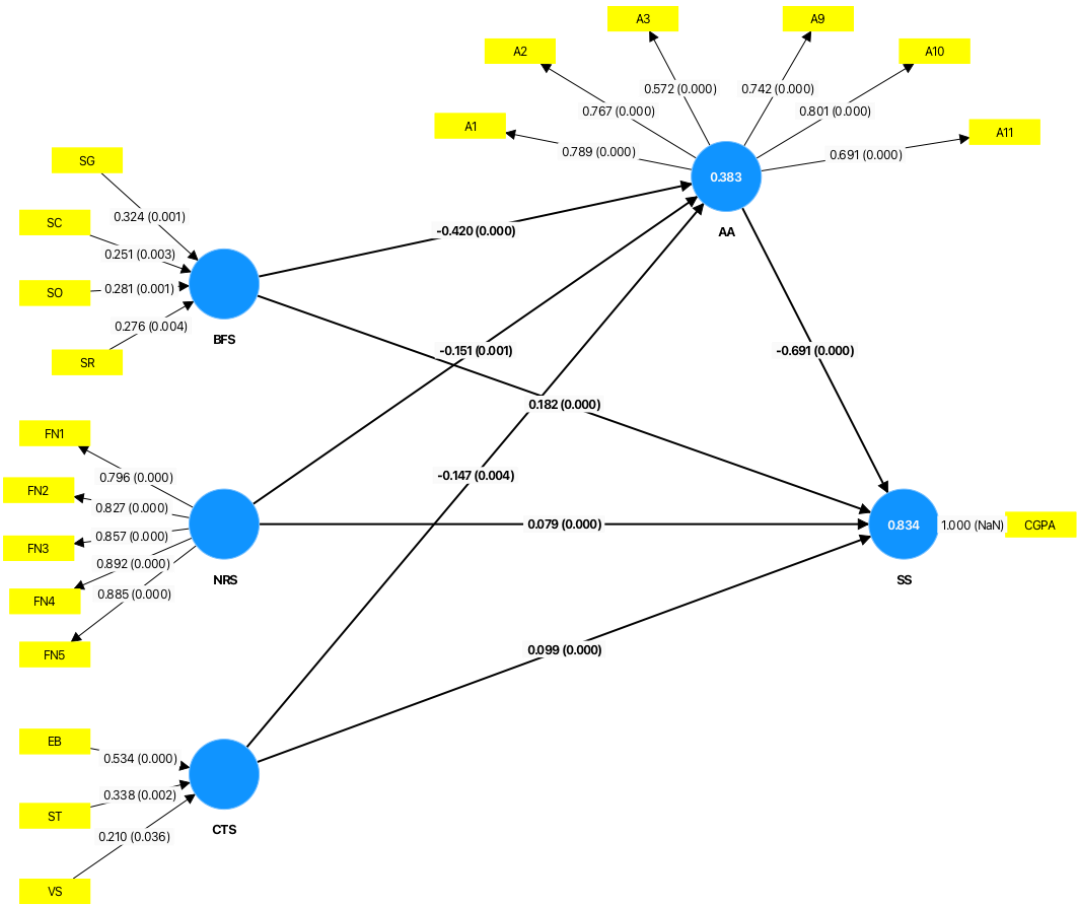

Figure 6. PLS-SEM analysis for the structural model.

Table 11. Significance testing results of the structural model path coefficients.

Hypothesis	Relationship	Path coefficient (β)	Standard deviation (STDEV)	*t* value	*p* value	95% CI BC	
						LB 5.00%	UB 95.00%
H1	**BFS -> SS**	0.182	0.027	6.695	0.000	0.138	0.228
H2	**NRS -> SS**	0.079	0.022	3.514	0.000	0.042	0.114
H3	**CTS -> SS**	0.099	0.028	3.493	0.000	0.050	0.144
H4	**BFS -> AA**	-0.420	0.045	9.354	0.000	-0.490	-0.343
H5	**NRS -> AA**	-0.151	0.050	3.030	0.001	-0.234	-0.071
H6	**CTS -> AA**	-0.147	0.055	2.643	0.004	-0.234	-0.052
H7	**AA -> SS**	-0.691	0.018	38.53	0.000	-0.72	-0.661

Note. CI BC = Confidence interval bias corrected; LB = Lower bound; UB = Upper bound

When evaluating the impact of behavior-focused strategies (BFS), natural reward strategies (NRS), and constructive thought pattern strategies (CTS) on academic anxiety (AA), by referring to Figure 6 and Table 11, the results reveal that BFS has the strongest effect on AA ($\beta = -0.420$), followed by NRS, with a β value of -0.151. In contrast, CTS exhibits the weakest effect on successful transition ($\beta = -0.147$) as compared to the other strategies. The comprehensive results of hypothesis testing for the direct relationships within the structural model are outlined below.

Hypothesis 4: Behavior-focused strategies are negatively associated with academic anxiety.

The path coefficient results show that behavior-focused strategies significantly and negatively influence academic anxiety ($\beta = -0.420$, $p < 0.05$, $t = 9.354$). The relationship has a t-value ≥ 1.645 at a 5% significance level. Therefore, hypothesis 4 is supported.

Hypothesis 5: Natural reward strategies are negatively associated with academic anxiety.

A significant and negative relationship exists between natural reward strategies and academic anxiety ($\beta = -0.151$, $p < 0.05$, $t = 3.030$). The relationship has a t-value ≥ 1.645 at a 5% significance level. Therefore, hypothesis 5 is supported.

Hypothesis 6: Constructive thought pattern strategies are negatively associated with academic anxiety.

The results confirm a significant and negative relationship between constructive thought pattern strategies and academic anxiety ($\beta = -0.147$, $p < 0.05$, $t = 2.643$). The relationship has a t-value ≥ 1.645 at a 5% significance level. Therefore, hypothesis 6 is supported.

Last, when examining the impact of academic anxiety on successful transition, this study posits a negative association between academic anxiety (AA) and successful transition (SS), as shown in Figure 6 and Table 11.

Hypothesis 7: Academic anxiety is negatively associated with successful transition.

The results show that academic anxiety is significantly and negatively related to a successful transition ($\beta = -0.691$, $p < 0.05$, $t = 38.530$). The relationship has a t-value ≥ 1.645 at a 5% significance level. Therefore, hypothesis 7 is supported.

5.3.3. Assess the model explanatory power

In the third step, we evaluated the model's explanatory power by analyzing the coefficient of determination (R^2) values and f^2 effect sizes, which measure the proportion of variance in the dependent variables explained by the independent variables. As outlined in Table 12, the R^2 value for successful transition is 0.834, indicating that academic anxiety, behavior-focused strategies, natural reward strategies, and constructive thought pattern strategies collectively account for 83.4% of the variance in STEM students' successful transition.

For academic anxiety, the R^2 value is 0.383, suggesting that the three self-leadership strategies explain 38.3% of its variance. Following Hair et al. [104], R^2 values of 0.75, 0.50, and 0.25 represent substantial, moderate, and weak explanatory power, respectively. Thus, the R^2 value for successful transition demonstrates substantial explanatory power, while that for academic anxiety is relatively weak.

Table 12. Coefficients of determinants, R^2.

	R^2	$R^2_{adjusted}$
Academic Anxiety	0.383	0.378
Successful Transition	0.834	0.833

Table 13 displays the f^2 values for all combinations of endogenous constructs (columns) and their corresponding exogenous (predictor) constructs (rows), illustrating the effect sizes of predictor constructs on the variance explained in endogenous constructs. According to Cohen [105], f^2 values are categorized as small ($0.02 < f^2 \leq 0.15$), medium ($0.15 < f^2 \leq 0.35$), or large ($f^2 > 0.35$), with values below 0.02 indicating no measurable impact [97,101,105].

Academic anxiety demonstrates a large effect ($f^2 = 1.781$) on successful transition, underscoring its critical role in explaining variance in CGPA. Additionally, behavior-focused strategies exhibit a medium effect ($f^2 = 0.166$) on academic anxiety. Moreover, BFS ($f^2 = 0.100$), NRS ($f^2 = 0.024$), and CTS ($f^2 = 0.029$) each show small effects on successful transition, while NRS ($f^2 = 0.024$) similarly has a small effect on academic anxiety. In contrast, CTS ($f^2 = 0.017$) has no significant effect on the variance in academic anxiety.

Table 13. f^2 effect sizes of predictor variables in each direct relationship.

	AA	**BFS**	**CTS**	**NRS**	**SS**
AA					1.781
BFS	0.166				0.100
CTS	0.017				0.029
NRS	0.024				0.024
SS					

5.3.4. Step 4: Assess the model's predictive power ($PLS_{predict}$)

Finally, the model's predictive power was assessed using $Q^2_{predict}$, which must be greater than zero to confirm predictive validity, as suggested by Hair, Risher, et al. [99]. In this study, the $Q^2_{predict}$

values for academic anxiety and successful transition are 0.365 and 0.526, respectively, both surpassing zero and thereby affirming the model's predictive power.

5.4. The mediating effect of academic anxiety

To analyze the mediating effects of academic anxiety on the relationship between behavior-focused strategies, natural reward strategies, and constructive thought pattern strategies and successful transition, we conducted a bootstrapping procedure with 10,000 samples and a two-tailed test with a 0.05 significance level, employing the most-important (faster) method. Figure 7 demonstrates the results of PLS-SEM analysis using SmartPLS 4.

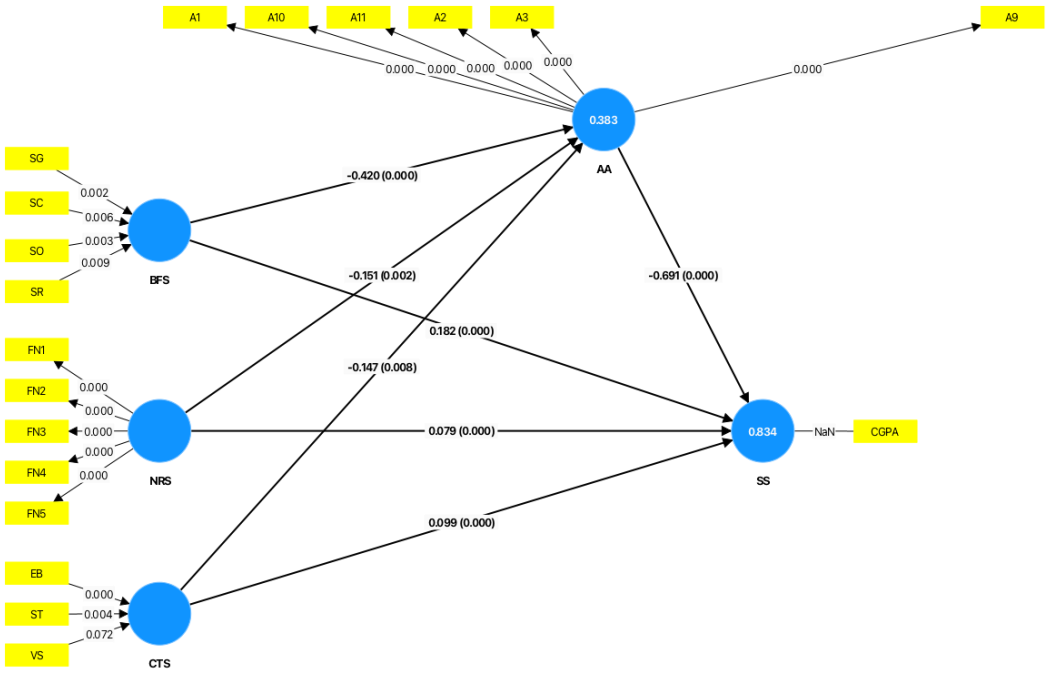

Figure 7. Simple mediation with direct relationships (two-tailed).

Table 14 presents the results of bootstrapping for mediation analysis. In general, a mediating effect exists for the three relationships since p-values are less than 0.05.

Table 14. Results of bootstrapping for mediation analysis.

Hypothesis	Relationship	Path coefficient (β)	Standard deviation (STDEV)	*t* value	*p* value	95% CI BC	
						LB 2.50%	UB 97.50%
H8	**BFS -> AA -> SS**	0.290	0.031	9.494	0.000	0.228	0.347
H9	**NRS -> AA -> SS**	0.104	0.034	3.042	0.002	0.039	0.173
H10	**CTS -> AA -> SS**	0.101	0.038	2.632	0.008	0.024	0.174

Note. CI BC = Confidence interval bias corrected; LB = Lower bound; UB = Upper bound

The mediation analysis results indicate that behavior-focused strategies (BFS) exert the strongest indirect effect on successful transition (SS) through academic anxiety (AA), with a path coefficient of 0.290, the highest among the three strategies. Following BFS, natural reward strategies (NRS) show a moderate mediating effect on successful transition through academic anxiety, with a path coefficient of 0.104. Furthermore, constructive thought pattern strategies (CTS), with a path coefficient of 0.101, also demonstrate a statistically significant but comparatively weaker impact on successful transition via academic anxiety. The following section provides a thorough explanation of the mediation analysis for each hypothesis.

Hypothesis 8: The relationship between behavior-focused strategies and successful transition is mediated by academic anxiety.

The bootstrapping analysis as presented in Figure 7, and Table 14 indicates that the specific indirect effect in H8 ($\beta = 0.290$) is statistically significant, with a p-value of 0.000 ($p < 0.05$) and a t-value of 9.494, exceeding the critical threshold of 1.96. Moreover, the 95% CI BC for this indirect effect [LB = 0.228, UB = 0.347] does not contain zero, confirming the presence of mediation. Hence, it is considered that behavior-focused strategies (BFS) and successful transition (SS) is mediated by academic anxiety.

Subsequently, the mediation results are carefully analyzed using Variance Accounted For (VAF) (refer to Figure 8). For H8 (SIDE = 0.290, TE = 0.472), the VAF is 61.4%, representing that academic anxiety partially mediates the association between behavior-focused strategies and successful transition. As depicted in the figure below (Figure 8), the analysis reveals that both the indirect effect (a×b) and the direct effect (c) of behavior-focused strategies on successful transition are statistically significant. Additionally, the product of these effects (a×b×c) yields a positive result, indicating the presence of complementary partial mediation through academic anxiety. This suggests that academic anxiety plays a crucial role in mediating the relationship between behavior-focused strategies and achieving a successful transition.

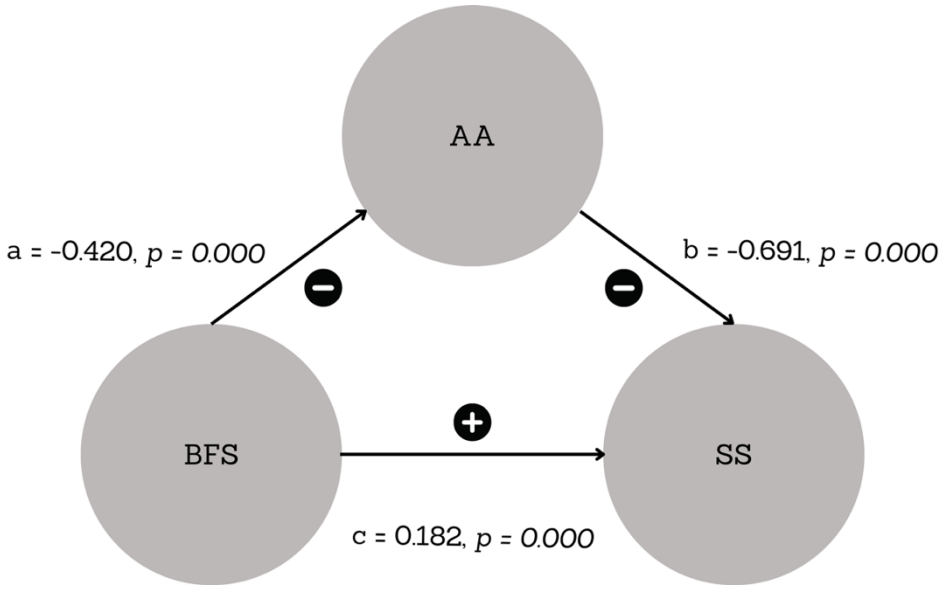

Figure 8. Analysis outcome of H8.

Hypothesis 9: The relationship between natural reward strategies and successful transition is mediated by academic anxiety.

According to the findings presented in Figure 7 and Table 14, the bootstrapping analysis indicates that the specific indirect effect described in hypothesis H9 (β = 0.104) is statistically significant (p-value = 0.002, which is less than 0.05), with t-values of 3.042, exceeding the threshold of 1.96. Furthermore, the 95% confidence interval bias corrected (CI BC) for this specific indirect effect ranges from [LB = 0.039, UB = 0.173] and does not include zero, confirming the presence of mediation. These results demonstrate that academic anxiety (AA) significantly mediates the relationship between natural reward strategies (NRS) and successful transition (SS).

Next, the mediation results are carefully analyzed using VAF (refer to Figure 9). For H9 (SIDE = 0.104, TE = 0.183), the VAF is 56.8%, representing that academic anxiety partially mediates the association between natural reward strategies and successful transition. As demonstrated in the figure below (Figure 9), the analysis reveals that both the indirect effect (a×b) and the direct effect (c) of natural reward strategies on successful transition are statistically significant. Additionally, the product of these effects a×b×c yields a positive result, indicating the presence of complementary partial mediation through academic anxiety. This suggests that academic anxiety plays a crucial role in mediating the relationship between natural reward strategies and achieving a successful transition.

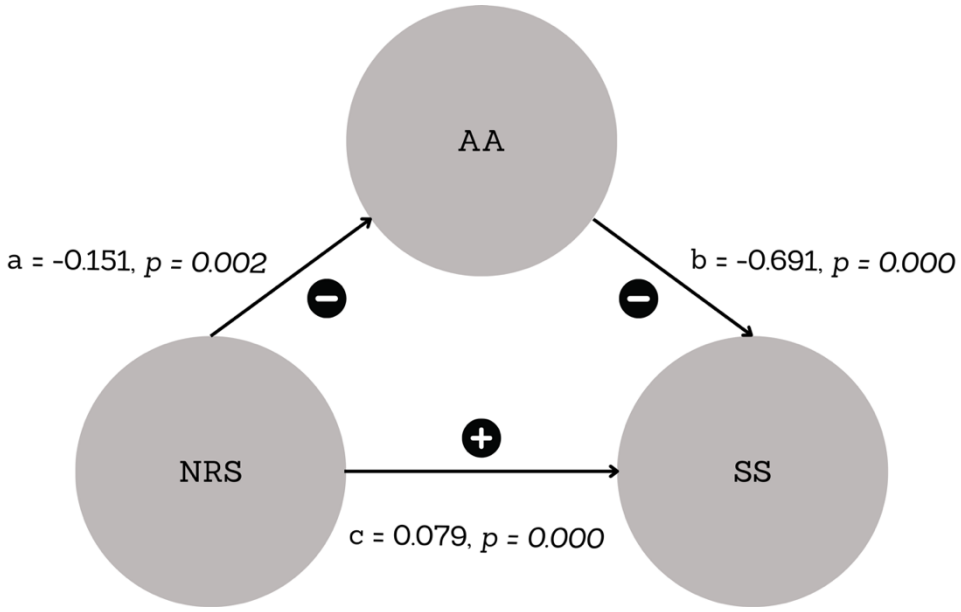

Figure 9. Analysis outcome of H9.

Hypothesis 10: The relationship between constructive thought pattern strategies and successful transition is mediated by academic anxiety.

Based on the bootstrapping analysis results presented in Figure 7 and Table 14, it is shown that the specific indirect effect in H10 (β = 0.101) is statistically significant, with a p-value of 0.000 (p < 0.05) and a t-value of 2.632, exceeding the critical threshold of 1.96. Moreover, the 95% CI BC for this indirect effect [LB = 0.024, UB = 0.174] does not contain zero, confirming the presence of mediation. Hence, it is considered that constructive thought pattern strategies (NRS) and successful transition (SS) are mediated by academic anxiety.

Following this, the mediation results were carefully examined by employing VAF (refer to Figure 10). For H10 (SIDE = 0.101, TE = 0.201), the VAF is 50.3%, representing that academic anxiety

partially mediates the association between constructive thought pattern strategies and successful transition.

As depicted in Figure 10, the analysis reveals that both the indirect effect (a ×b) and the direct effect (c) of constructive thought pattern strategies on successful transition are statistically significant. Additionally, the product of these effects a ×b ×c yields a positive result, indicating the presence of complementary partial mediation through academic anxiety. This suggests that academic anxiety plays a crucial role in mediating the relationship between constructive thought pattern strategies and achieving a successful transition. Table 15 summarizes the mediation analysis outcome conducted in this study.

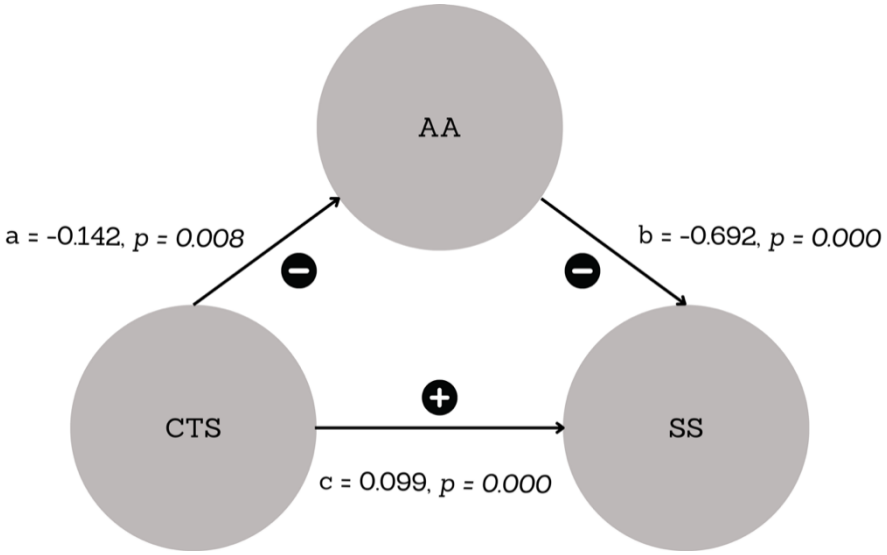

Figure 10. Analysis outcome of H10.

Table 15. *Summary of mediation analysis.*

Hypothesis	Relationship	Path coefficient (*β*)	Standard deviation (STDEV)	*t* value	*p* value	95% CI BC		Mediation Existence	Type of Mediation	VAF (SIDE/TE)
						LB 2.50%	UB 97.50%			
H8	**BFS -> AA -> SS**	0.290	0.031	9.494	0.000	0.228	0.347	Yes	Complementary Partial Mediation	0.614
H9	**NRS -> AA -> SS**	0.104	0.034	3.042	0.002	0.039	0.173	Yes	Complementary Partial Mediation	0.568
H10	**CTS -> AA -> SS**	0.101	0.038	2.632	0.008	0.024	0.174	Yes	Complementary Partial Mediation	0.502

Note. CI BC = Confidence interval bias corrected; LB = Lower bound; UB = Upper bound

6. Discussions

6.1. Relationship between behavior-focused strategies, natural reward strategies, constructive thought pattern strategies, and successful transitions

In this study, we evaluate the impact of behavior-focused strategies (BFS), natural reward strategies (NRS), and constructive thought pattern strategies (CTS) on successful transitions (SS) among matriculation college students. The findings reveal that BFS has the strongest positive effect on SS, followed by CTS, while NRS exhibits the weakest influence. These results provide critical insights into how various self-leadership strategies facilitate academic transitions, offering both theoretical and practical implications.

BFS, encompassing self-goal setting, self-observation, self-reward, and self-cueing, demonstrates the most substantial positive association with successful transitions. This aligns with prior research [36,38–40,42,43,58,60], which highlights the role of BFS in helping students adapt to new academic environments. Self-goal setting provides direction, self-observation enables progress monitoring, self-reward sustains motivation, and self-cueing reinforces productive behaviors. Grounded in self-regulation theory [50,106,107], BFS empowers students to manage academic challenges effectively, aligning with Schlossberg's Transition Theory, which emphasizes the importance of coping mechanisms in navigating transitions.

NRS, which fosters intrinsic motivation by encouraging students to find enjoyment in academic tasks, also shows a positive but weaker relationship with SS. This aligns with intrinsic motivation theory [52,62], and prior studies by [36,39,40,42,60], suggesting that NRS reduces the perceived burden of academic tasks, enhancing persistence and performance during transitional periods. However, the weaker impact of NRS compared to BFS may reflect its focus on emotional engagement rather than structured behavioral regulation.

CTS, including positive self-talk, belief evaluation, and visualization, significantly supports successful transitions, measured by academic performance in the first semester, by reshaping students' cognitive responses to academic demands. This aligns with previous studies by Boonyarit [36], Kim [38], Sampl et al. [40], Vaeazi et al. [60], and Zakir et al. [43]. Rooted in Cognitive Behavioral Theory (CBT), CTS helps students manage stress and build resilience, fostering a constructive mindset during transitions [54]. Positive self-talk, in particular, enhances academic resilience, while belief evaluation and visualization reduce anxiety and improve confidence. These findings align with Schlossberg's Transition Theory, which underscores the role of cognitive resources in adapting to new environments [56].

However, the study contrasts with Napiersky and Woods [39], who found that excessive reliance on CTS may hinder academic engagement if not balanced with active learning practices. This highlights the need for a balanced approach, integrating cognitive strategies with practical academic planning to optimize transition outcomes.

In conclusion, this study underscores the pivotal role of self-leadership strategies in facilitating successful academic transitions. BFS emerges as the most effective strategy, followed by CTS and NRS, with each contributing uniquely to students' adaptation. By integrating these strategies, educators can design targeted interventions to support students in navigating the challenges of new academic environments, promoting academic success and well-being.

6.2. Relationship between behavior-focused strategies, natural reward strategies, and constructive thought patterns on academic anxiety

This study provides significant insights into the relationship between self-leadership strategies, behavior-focused strategies (BFS), natural reward strategies (NRS), constructive thought pattern strategies (CTS), and academic anxiety. Each strategy demonstrates a significant negative influence on academic anxiety, with BFS having the strongest effect, followed by NRS and CTS. These findings, though underexplored in prior research, align with key studies on self-leadership and anxiety, offering a deeper understanding of how these strategies mitigate academic stress.

The negative relationship between BFS and academic anxiety is consistent with the literature, such as Sampl et al. [40], who found that self-goal setting, self-reward, self-observation, and self-cueing reduce test anxiety. BFS empowers students to create structured frameworks for managing academic tasks, enhancing their sense of control and reducing stress. Additionally, studies like de Melo and Mendonça [108] highlight that BFS reduces academic procrastination, a behavior linked to anxiety, by fostering self-regulation and preventing the accumulation of academic pressures.

NRS also shows a significant negative relationship with academic anxiety, suggesting that students who derive intrinsic enjoyment from academic tasks experience lower anxiety levels. This aligns with Wang et al. [66], who found that NRS reduces maladaptive behaviors like procrastination. By focusing on the inherent satisfaction of learning, students perceive tasks as less burdensome, thereby reducing stress [109]. NRS shifts attention from external pressures to the intrinsic rewards of learning, fostering a positive academic experience and aligning with self-leadership theory's emphasis on intrinsic motivation for psychological well-being.

Similarly, CTS, including positive self-talk, visualizing successful performance, and reframing negative beliefs, significantly reduces academic anxiety. Research by Houghton et al. [78] supports this, demonstrating that positive self-talk decreases test anxiety and improves academic performance. Hooda and Saini [45] and Rincon [88] further affirm that CTS helps students reinterpret anxiety-inducing situations, fostering resilience and confidence. By promoting optimistic mindsets, CTS equips students to manage academic challenges effectively, reducing cognitive and emotional stress.

Overall, the findings underscore the critical role of various self-leadership strategies in managing academic anxiety. By addressing a gap in the literature, this study highlights the practical value of BFS, NRS, and CTS in helping students regulate emotional responses to academic demands. These strategies not only mitigate anxiety but also support successful transitions into challenging educational environments, offering actionable insights for educators and students alike.

6.3. Relationship between academic anxiety and successful transitions

The results indicate a significant negative relationship between academic anxiety and successful transitions, consistent with previous research [47,48,67,69–72,74–77,95]. Academic anxiety, characterized by worry and nervousness about academic performance, poses a significant barrier to students' successful transitions. Elevated anxiety disrupts emotional regulation, information processing, and task execution, hindering students' ability to meet academic and social demands in new educational environments.

The findings can be understood through Cognitive Appraisal Theory (CAT) by Lazarus [55], which suggests that emotions stem from individuals' evaluations of events relative to their goals. For students, academic performance is closely tied to critical goals like high grades and academic advancement. When academic tasks are perceived as threats, anxiety increases, impairing focus and performance, thus undermining successful transitions. Conversely, viewing academic challenges as growth opportunities supports better emotional regulation and resilience, key to successful transitions.

Schlossberg's Transition Theory [56] further explains that successful transitions depend on how challenges are perceived and managed. Viewing academic tasks as threats impedes coping strategies and resource utilization, disrupting emotional regulation and academic performance. Reframing these challenges as opportunities for growth reduces anxiety and enhances adaptation, leading to more successful outcomes.

Practically, these findings suggest that helping students reframe their perceptions of academic tasks from threats to challenges can reduce anxiety and facilitate smoother transitions. Educational support programs focusing on cognitive restructuring and stress management can empower students to appraise academic demands more positively, enhancing emotional resilience and resource utilization, contributing to smoother transitions and improved academic success.

6.4. Mediating effect of academic anxiety on the relationship between behavior-focused strategies, natural reward strategies, constructive thought pattern strategies, and successful transition

In this study, we demonstrate that academic anxiety significantly mediates the relationship between self-leadership strategies, including behavior-focused strategies (BFS), natural reward strategies (NRS), and constructive thought pattern strategies (CTS), and students' successful transitions (SS) in academic settings. BFS exhibits the strongest indirect effect on successful transitions through reduced academic anxiety, followed by NRS and CTS. These findings offer critical insights into how various self-leadership strategies facilitate academic transitions by mitigating anxiety, thereby enhancing students' adaptability in educational contexts.

Behavior-focused strategies, encompassing self-goal setting, self-observation, self-reward, and self-cueing, positively influence successful transitions by reducing academic anxiety. These strategies enhance self-regulation and foster constructive cognitive appraisals of challenges, enabling students to better navigate the uncertainties of academic transitions. Similarly, natural reward strategies, which emphasize intrinsic enjoyment of academic tasks [52,62], alleviate anxiety by reducing the cognitive and emotional burden of academic demands. This intrinsic focus bolsters resilience and sustains motivation, promoting smoother transitions. Constructive thought pattern strategies, such as positive self-talk, belief evaluation, and visualizing success, further support transitions by reframing academic challenges as manageable rather than overwhelming. This positive cognitive restructuring helps students maintain goal focus and a constructive mindset during transitions.

While researchers have explored various self-leadership strategies and academic anxiety separately, we are the first to identify academic anxiety as a mediating variable linking self-leadership to successful transitions. The findings align with Cognitive Appraisal Theory [55], suggesting that various self-leadership strategies shape students' appraisals of academic demands, influencing their emotional responses and transition outcomes.

Theoretical implications highlight academic anxiety as a key mediator in the self-leadership-transition relationship, advancing the understanding of self-leadership's role in academic success. Practically, the findings advocate for educational interventions that reduce academic anxiety through self-leadership training. Programs focusing on self-goal setting, intrinsic motivation, and cognitive restructuring can equip students with tools to manage anxiety, build resilience, and navigate academic transitions effectively.

In conclusion, this study underscores the critical mediating role of academic anxiety in the relationship between various self-leadership strategies and successful academic transitions. By addressing this mediation, it provides a nuanced understanding of how self-leadership supports students in adapting to new academic environments. The findings bridge a significant research gap and offer actionable strategies for fostering academic success through anxiety management and self-leadership development.

7. Study implications

7.1. Theoretical implications

We extend self-leadership theory beyond workplace settings, demonstrating its relevance in higher education by fostering autonomy, self-regulation, intrinsic motivation, and resilience among STEM students in Malaysian matriculation colleges. It highlights self-leadership strategies like behavior-focused, natural reward, and constructive thought patterns as essential for student success. Additionally, the study reinforces academic anxiety's role as a mediator between self-leadership and student performance, offering insights into its impact beyond well-being. It also broadens transition theory by emphasizing self-leadership as a critical internal factor in academic transitions, complementing traditional focuses on social and institutional support. These findings provide a foundation for further research on self-leadership's role in education.

7.2. Policy implications

To enhance student transitions and performance, the Ministry of Education (MoE) Malaysia should integrate self-leadership training into transition programs, curriculum design, and mentorship initiatives. Policies should promote mental health support services, including counselling and stress management workshops, while standardizing self-leadership modules across all matriculation colleges. Additionally, expanding resources for academic and psychological support and implementing monitoring systems would ensure continuous evaluation of these initiatives. Aligning self-leadership training with national workforce needs can further equip students with essential competencies for professional success. These policy measures would strengthen the STEM pipeline and support Malaysia's economic development.

7.3. Practical implications for higher education (Matriculation College)

Matriculation colleges should embed self-leadership development into curricula through workshops and training sessions to help students manage academic challenges. A cross-disciplinary approach can reinforce the application of various self-leadership strategies across subjects, improving overall student performance. Establishing mentorship programs with faculty, professionals, or senior

students can provide personalized guidance in developing self-leadership skills. Additionally, fostering a supportive campus environment that encourages collaboration and open communication can help reduce academic anxiety, promoting a smoother transition into higher education.

7.4. Practical implications for academicians

Academicians may support students' transition by integrating self-leadership into coursework, promoting self-directed learning, and mentoring students on academic anxiety. Encouraging goal-setting, self-reflection, and resilience-building fosters independence, while project-based learning and reflective activities enhance engagement. Regular check-ins and stress-management guidance help students cope with academic pressure. A supportive classroom environment with open communication reduces anxiety, and raising awareness of mental health resources ensures access to necessary support. These strategies enhance academic performance and well-being.

7.5. Practical implications for students

Students may improve their transition by developing self-leadership skills, practicing self-motivation, and managing academic anxiety effectively. Setting goals, using positive self-talk, and seeking support from mentors or counselors fosters resilience. Engaging in self-directed learning, utilizing campus resources, and adopting stress-management techniques like time management and exercise can enhance academic performance and emotional well-being. Applying these strategies empowers students for a smoother transition and long-term success.

8. Conclusions

The transition from secondary school to higher education represents a pivotal milestone in a student's academic and personal development. It is a transformative phase marked by new challenges, responsibilities, and opportunities for growth, shaping future achievements and career trajectories. Higher education plays a critical role in advancing Lifelong Learning (LLL) by fostering skills, knowledge, and inclusive opportunities, while also preparing individuals to contribute actively to their communities and societies.

This study contributes to understanding the influence of various self-leadership strategies on successful academic transitions, with academic anxiety as a mediator. Findings reveal that behavior-focused strategies, natural reward strategies, and constructive thought pattern strategies are each positively impact the academic performance of STEM students in matriculation colleges, with behavior-focused strategies exerting the strongest influence. Additionally, the mediation analysis highlights academic anxiety as a significant pathway, with behavior-focused strategies showing the most substantial indirect effect on successful transitions.

Our findings align with theoretical frameworks and provide empirical evidence for application in educational contexts. They offer actionable insights for policymakers, educators, and higher education institutions to design interventions aimed at strengthening self-leadership skills while addressing academic anxiety. Specifically, integrating self-leadership training into curricula, promoting mental health support services, and ensuring ongoing academic and psychological support are critical for enhancing student success and easing the transition to higher education.

From a policy perspective, this study underscores the importance of creating an educational environment that fosters self-regulation and resilience, both of which are essential for students to thrive in higher education and beyond. These findings also have significant implications for aligning educational practices with the goals of Sustainable Development Goal 4 (SDG4), which seeks to provide inclusive and equitable quality education and promote lifelong learning opportunities for everyone. By tackling academic anxiety and enhancing self-leadership, educational institutions can help achieve SDG4, ensuring students are well-equipped for their future roles in society.

While these findings are promising, we acknowledge its limitations and recommend further longitudinal research to build on and validate the outcomes. This will provide deeper insights into the long-term impact of self-leadership strategies on academic transitions and performance.

9. Limitations and future scope

This study has several limitations that suggest opportunities for future research. First, the exclusive focus on STEM students limits the generalizability of the findings to other academic disciplines. Future research should include both STEM and Arts students to compare factors influencing academic choices and performance. This approach could uncover unique and shared challenges, enabling the development of inclusive strategies to support students in both streams. Second, we included only matriculation students, excluding those from other pre-university pathways such as Diplomas, Foundations, A-levels, ADP, and SAM. Future research should expand the sample to include students from these diverse academic backgrounds, as different pathways may influence student readiness and transitions in varying ways. By doing so, researchers could identify tailored interventions to support students from all pre-university programs.

Third, the reliance on online surveys as the sole method of data collection limits the depth of data gathered and may exclude the perspectives of students who are less responsive to this format. Future studies should adopt a mixed-methods approach, incorporating interviews or focus groups alongside surveys. This combination would provide richer qualitative data and improve the overall reliability of findings. Fourth, we explored academic anxiety as the sole mediator, which, while significant, may not fully capture the complexities of factors influencing student transitions and academic success. Future research should entail additional mediators, such as motivation, self-efficacy, and social support, to provide a more comprehensive understanding of the factors affecting students' adaptation to higher education.

Last, while this study offers theoretically grounded insights into the relationships among self-leadership strategies, academic anxiety, and academic performance, it is important to acknowledge the inherent limitations of a cross-sectional design. Such a design does not permit the establishment of temporal precedence, which is typically required to draw definitive causal conclusions. Nevertheless, the hypothesized relationships were guided by well-established theoretical frameworks and supported by empirical evidence. Future research may benefit from adopting longitudinal designs to further validate the proposed mediating role of academic anxiety over time and to examine how these relationships evolve throughout students' academic transitions. Additionally, emerging evidence (e.g., Ti et al., 2025) suggests that academic achievement may also shape students' emotional responses. Thus, future studies could explore potential bidirectional or reciprocal relationships, such as the influence of academic performance on academic anxiety, to deepen our understanding of student development during transitional phases. Addressing these limitations will

help researchers develop a broader and more nuanced understanding of the challenges and supports necessary for successful academic transitions, particularly among STEM students in Malaysia.

An additional area for future research lies in examining the role of teachers in shaping student outcomes. For instance, the following questions can be addressed: How do teachers contribute to reversing low self-confidence or a lack of motivation among students? What strategies or pedagogical approaches do they employ to foster a more supportive learning environment? Moreover, do teachers possess the necessary cognitive competence and training to effectively address these challenges? Investigating these aspects would provide important insights into the external factors influencing student success and could significantly enrich the discussion of student development.

Furthermore, although not directly examined in this study, researchers should consider the moderating effects of socioeconomic and cultural factors unique to the Malaysian context. Malaysia's multiethnic composition, disparities in rural versus urban education access, and varying levels of family income and educational support may influence how students engage with self-leadership strategies and experience academic anxiety. These contextual variables could play a critical role in shaping the effectiveness of interventions and should be examined to develop more equitable and culturally responsive policies and programs.

Author contributions

Fadhilah Jamaluddin: Conceptualization, Formal analysis, Resources, Writing – original draft, Writing – review and editing; Ahmad Zabidi Abdul Razak: Conceptualization, Supervision, Writing – review and editing; Suzieleez Syrene Abdul Rahim: Conceptualization, Supervision, Writing – review and editing. All authors have read and approved the final version of the manuscript for publication.

Use of Generative-AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

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Conflict of interest

The authors declare there is no conflict of interest in any part of this article.

Ethics declaration

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Appendices

Appendix 1. Revised self-leadership questionnaires (RSLQ).

Dimensions/ Scales	Constructs/ Sub-scales	Measurement items
Behavior- focused strategies	Self-goal setting	SG1- I establish specific goals for my own performance. SG2- I consciously have goals in mind for my work efforts. SG3- I work toward specific goals I have set for myself. SG4- I think about the goals that I intend to achieve in the future. SG5- I write specific goals for my own performance.
	Self-observation	SO1- I try to keep track of how well I'm doing while at college. SO2- I usually am aware of how I am performing on an activity. SO3- I pay attention to how well I am doing in my work. SO4- I keep track of my progress on projects I'm working on.
	Self-reward	SR1- When I do an assignment especially well, I like to treat myself to some thing or activity I especially enjoy. SR2- When I do something well, I reward myself with a special event such as a good dinner, movie, shopping trip, etc. SR3- When I have successfully completed a task, I often reward myself with something I like.
	Self-cueing	SC1- I use written notes to remind myself of what I need to accomplish. SC2- I use concrete reminders (e.g., notes and lists) to help me focus on the things I need to accomplish.
Natural Reward Strategies	Focusing thoughts on natural rewards	FN1- I focus my thinking on the pleasant rather than the unpleasant aspects of my college activities. FN2- I try to surround myself with the objects and people that bring out my desirable behaviors. FN3- When I have a choice, I try to do my work in ways that I enjoy rather than just trying to get it over with. FN4- I seek out activities in my work that I enjoy doing FN5- I find my own favorite way to get things done.
Constructive Thought Pattern	Evaluating beliefs and	EB1- I think about my own beliefs and assumptions whenever I encounter a difficult situation.

Strategies	assumptions	EB2- I try to mentally evaluate the accuracy of my own beliefs about situations I am having problems with.
		EB3- I clearly express and evaluate my own assumptions when I disagree with someone.
		EB4- I think about and evaluate the beliefs and assumptions I hold.
	Positive self-talk	ST1- Sometimes I find I'm talking to myself (out loud or in my head) to help me deal with difficult problems I face.
		ST2- Sometimes I talk to myself (out loud or in my head) to work through difficult situations.
		ST3- When I'm in difficult situations I will sometimes talk to myself (out loud or in my head) to help me get through it.
	Visualizing successful performance	VS1- I use my imagination to picture myself performing well on important tasks.
		VS2- I visualize myself successfully performing a task before I do it.
		VS3- Sometimes I picture in my mind a successful performance before I actually do a task.
		VS4- I purposefully visualize myself overcoming the challenges I face.
		VS5- I often mentally rehearse the way I plan to deal with a challenge before I actually face the challenge.

Appendix 2. Academic anxiety scale (AAS).

No.	Measurement items
1.	I often worry that my best is not as good as expected in college.
2.	I tend to delay doing college work because it stresses me.
3.	I often worry that I am not doing assignments properly.
4.	I am less confident about college than my classmates.
5.	I feel a sense of unease when I am in my classrooms.
6.	I tend to find my lecturers intimidating.
7.	I spend much of my time at college worrying about what is next.
8.	There is something about college that scares me.
9.	I am concerned about what my classmates think about my abilities.
10.	I often feel sick when I need to work on a major class assignment.
11.	I have a hard time handling college responsibilities.