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Research article

Academic resilience in science: An examination of high achievers from low socioeconomic backgrounds

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Abstract: Research on academic resilience has gained attention for its potential to promote equitable opportunities, especially for socioeconomically disadvantaged students who face significant barriers. Yet, research on factors supporting academic resilience in science specifically across different cultural contexts remains limited. This study investigates academic resilience in science among secondary school students in two socio-culturally distinct countries, Sweden and Vietnam. It examines how students' motivation to learn science and perceptions of school science differ between academically resilient and non-resilient students in each country. The analysis utilises data from the 2015 Programme for International Student Assessment (PISA) science cycle, involving 5,458 students from 202 Swedish schools and 5,826 students from 188 Vietnamese schools. The findings show a lower proportion of academically resilient students in Sweden (36.19%) compared to Vietnam (59.89%). Despite socio-cultural differences, both countries share common factors contributing to resilience in science, including enjoyment of science, science self-efficacy, teacher support, and a sense of belonging. However, several factors distinguishing resilient from non-resilient students vary between these countries, which are pertinent not only to students but also to teachers and their teaching approaches. This study underscores the importance of discipline-specific and contextually relevant approaches for fostering academic resilience in science education, particularly among disadvantaged youth. Adapting interventions to align with cultural and contextual needs can enhance equitable science learning outcomes.

Keywords: educational equity, low-socioeconomic status, science achievement, sociocultural context

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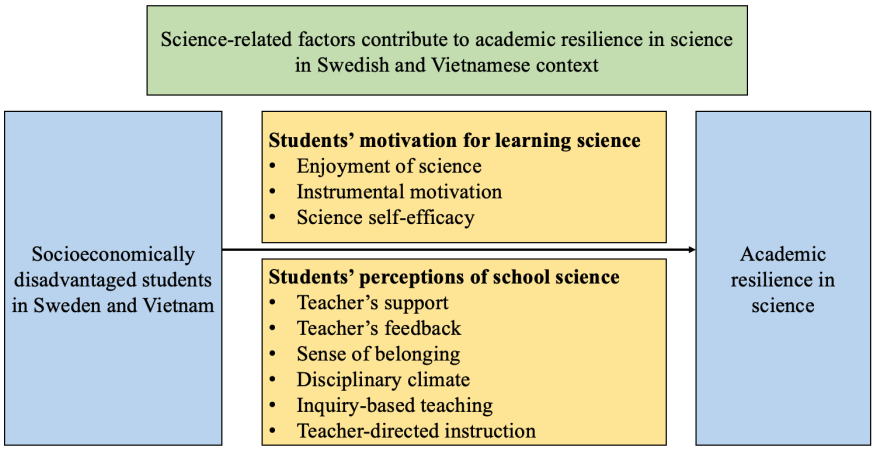

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1 Introduction

Socioeconomic status (SES) has long been identified as a powerful predictor of student achievement (Korous et al., 2022; Liu et al., 2022; Sirin, 2005). As such, students from low-SES backgrounds often face significant challenges, including increased dropout rates and limited access to higher education (Sirin, 2005; Wang & Chi, 2023). Despite these challenges, some socioeconomically disadvantaged students manage to succeed against the odds. Emerging research terms this phenomenon as academic resilience—where students from socioeconomically disadvantaged backgrounds do well academically despite experiencing adverse circumstances (e.g., Rudd et al., 2021; Ye et al., 2021; Truong & Triventi, 2021). Rather than being a static characteristic, resilience is seen as a dynamic process that evolves across different contexts and throughout one's life (Gartland et al., 2011; Rutter, 2012). This phenomenon of overcoming educational adversity can be important for understanding how to support and replicate these successes on a broader scale. Thus, identifying factors related to academic resilience is crucial for developing policies and practices that promote educational equity and effectively mitigate disparities in student achievement.

Despite the breadth of research on academic resilience, much of existing literatures focuses on overall academic performance (Agasisti et al., 2018), or particular domains like mathematics (Cheung, 2017; Sandoval-Hernández & Białowolski, 2016), or reading (Agasisti & Longobardi, 2017; Cheung et al., 2014), with comparatively limited attention to science. Given the distinct cognitive demands, instructional approaches, and assessment formats, resilience may manifest differently across disciplines. For example, Clavel et al. (2022) found a positive link between intrinsic motivation and resilience in science, while Alivernini et al. (2016) observed no such association in mathematics. Examining academic resilience in science is thus vital—not only to better support these students but also promote the broader social and individual benefits of scientifically literature population (Camasso & Jagannathan, 2017). This study seeks to address that gap by offering insights into academic resilience in science specifically.

Moreover, the existing few studies on academic resilience in science education mainly conducted in the context of USA (e.g., Ferguson & Martin-Dunlop, 2021; Stevenson et al., 2019) and East Asia (e.g., Jiang et al., 2024; She et al., 2019; Wang et al., 2023; Wang & Chi, 2023), other educational contexts remain unexplored, especially in Nordic and Southeast Asian countries. To fill this gap, we examine PISA data from Sweden and Vietnam—two contrasting contexts rarely examined in academic resilience research. Sweden has demonstrated modest performance in PISA science assessments, whereas Vietnam has consistently achieved strong performance (OECD, 2016, p. 68). Additionally, Sweden is often known for its individualistic values and an education system celebrated for its equality and accessibility, while Vietnam is a developing country marked by significant educational disparities and collectivist principles (Hofstede Insights, 2022). Exploring these two contexts contributes to a broader understanding of academic resilience in science across diverse cultural and educational settings.

In this study, we investigate the following research questions (RQs):

1. How prevalent are academically resilient students in science in Sweden and Vietnam?
2. To what extent do factors related to students' motivation to learn science and their perception of school science vary between resilient and non-resilient students in Sweden and Vietnam?

2 Literature Review

2.1 Academic Resilience and Its Relevance in Science Education

Research on resilience originated in the 1970s, initiated by researchers in psychopathology and child development who were exploring the positive adaptation observed in children facing developmental adversities due to trauma, distress, and poverty (Luthar et al., 2000). Since then, resilience research has evolved through four waves: (1) identifying resilient qualities, (2) uncovering the resilience process, (3) promoting resilience through prevention and intervention, and (4) focusing on the dynamics of adaptation and change (Masten et al., 2023).

There is an ongoing scholarly debate about whether resilience should be viewed as a trait or a process or if it represents an outcome (Kuldas & Foody, 2022). Initially perceived as a fixed personal trait innate to individuals, resilience was thought to distinguish 'invulnerable' individuals, with heritable characteristics and distinct aspects of personality, who could cope and excel, from those who could not (Luthans et al., 2007). However, this view later evolved, recognising resilience as a state or a process that encompasses human cognitive and motivational potentials such as hope, optimism, and self-regulation—qualities that are flexible and can be developed within supportive socio-ecological settings (Luthans et al., 2007). As an outcome, resilience is demonstrated when individuals have successfully overcome exposure to risk and attained positive results, such as academic success (Kuldas & Foody, 2022). These diverse interpretations highlight the complexity of resilience, which is recognised across multiple disciplines as a concept with no universal definition (Rudd et al., 2021; Ye et al., 2021).

In educational research, academic resilience is often referred to as "the heightened likelihood of success in school and life, despite environmental adversities shaped by early traits, conditions, and experiences" (Wang et al., 1994, p. 46). Science education research has a long tradition of equity-oriented work, predominantly focused on exclusionary mechanisms impacting minoritised students' performance and sense of belonging. Some qualitative studies explore the experiences of minoritised students in science—women, people of colour, and Indigenous individuals— navigating societal challenges related to perceptions of who typically belongs in the field. They detail how these students ultimately achieve academic success and pursue careers in science or STEM-related fields (Science, Technology, Engineering, and Mathematics). For example, Ferguson & Martin-Dunlop

(2021) explored the experiences of eight African women in STEM fields who, through resilience and identity-building, overcame racism and sexism to earn terminal degrees. Their findings suggest that cultural brokers and resources outside the traditional classroom, such as religious beliefs and extracurricular activities, were crucial to their success. Similarly, Stevenson et al. (2019) suggested that preserving heritage languages is vital for constructing cultural identities and building support networks that helped three Georgia Latina participants develop resilience and achieve academic success. These studies highlight the importance of understanding supportive mechanisms of disadvantaged students in science, moving beyond just detailing the factors that contribute to their exclusion.

While qualitative research on academic resilience in science education remains scarce, recent studies using data from international large-scale assessments offer valuable insights. Wang and Chi (2023) analysed the PISA 2015 dataset to identify key factors contributing to the success of low-SES Chinese students, including parental emotional support, effective science teaching practices, and positive attitudes towards science. In a similar vein, Wang et al. (2023) examined data from the Trends in International Mathematics and Science Study (TIMSS) 2019 data from Hong Kong and found that resilient students exhibited higher levels of confidence in science, greater enjoyment of science learning, and a stronger perception of the value of science. Further research in East Asia highlights how different instructional approaches—such as inquiry-based versus teacher-directed methods—impact resilient students. For instance, Jiang et al. (2024) point out that inquiry-based teaching in Japan and teacher-directed instruction in Macao each offer distinct advantages to resilient students, as observed in their respective PISA 2015 datasets. These findings emphasise the importance of students' motivation to learn science and their experience of school science, highlighting how educational strategies can foster resilience in various ways across different countries. It underscores the value of investigating underexplored cultural contexts like Sweden and Vietnam.

2.2 Operationalising Academic Resilience: Adversity and Success in Science

Resilience, commonly viewed as achieving success despite adversity, is usually defined by two primary components: adversity and academic success (Rudd et al., 2021; Ye et al., 2021). Adversity refers to a wide range of challenges students face in their home environments, schools, communities, or broader society (Masten et al., 2023). In terms of academic resilience research, SES emerges as a significant form of adversity that influences educational outcomes across many countries (Rudd et al., 2021; Ye et al., 2021). SES encompasses an individual or family's social, economic, educational, and occupational resources (OECD, 2017; Rudd et al., 2021).

SES inequalities are linked to persistent disparities in science achievement (Camasso & Jagannathan, 2017; Nilsen & Teig, 2024). Low-SES students typically face numerous challenges, including limited access to high-quality educational materials, increased

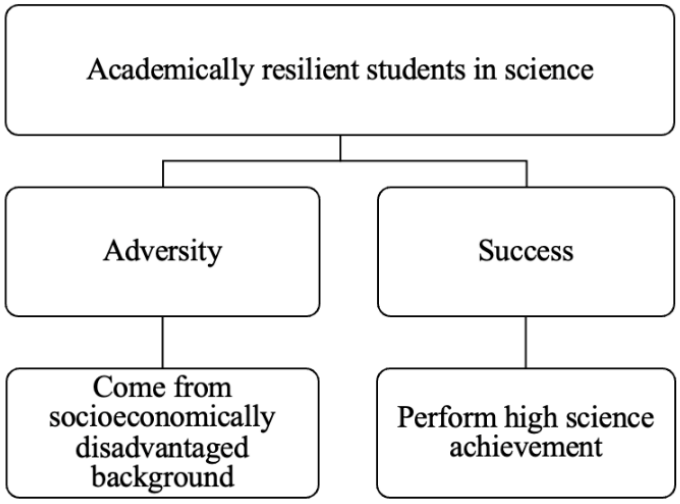
exposure to stressors, lower academic achievement, and issues with reduced school attendance (Jensen, 2009). They also have fewer opportunities to engage in informal science activities outside of school (Coley et al., 2020). This SES-achievement gap is a global issue, evident in many countries including Sweden and Vietnam. In Sweden, disparities in academic achievement among students from various SES groups are more pronounced compared to other Nordic countries (Kjeldsen et al., 2024). Conversely, in Vietnam, the disparities are distinctly evident not only between SES groups but also between rural and urban areas, reflecting significant educational inequalities linked to both economic resources and geographic location (Nguyen, 2019).

In this study, we use SES as a key indicator of adversity that aligns with prior studies demonstrating its influence on student outcomes (Kjeldsen et al., 2024; Korous et al., 2022; Liu et al., 2022). This is especially relevant in Sweden and Vietnam, where SES disparities significantly affect students' educational outcomes (Nilsen & Teig, 2024). By focusing on SES, which includes factors such as access to educational resources, this study explores how these elements shape the challenges of disadvantaged students in these diverse contexts.

The second component of resilience is academic success, which encompasses a broad spectrum of cognitive and non-cognitive outcomes, varying widely across different educational contexts. In research on academic resilience, cognitive outcomes often refer to students' performance in standardised tests within a specific discipline and are measured through assessments such as TIMSS and PISA (Jiang et al., 2024; Wang et al., 2023). These outcomes may also encompass overall performance across multiple domains, including mathematics, science, and reading (Agasisti et al., 2018). Meanwhile, non-cognitive outcomes might include indicators such as overall well-being (Siebecke, 2023), a sense of belonging and life satisfaction (Cerna et al., 2021), as well as engagement, confidence, and interest in academic subjects (Johansson et al., 2023).

In this study, we drew on previous research using PISA data (e.g., Jiang et al., 2024) by defining successful science students based on their performance on scientific literacy assessments. This allows us to quantitatively measure success and examine the factors contributing to academic resilience in Sweden and Vietnam. Figure 1 summarises our conceptualisation of academic resilience, which focuses on students' adversity and success in science.

Figure 1. The conceptualisation of academic resilience in science in the present study.



2.3 Science-Related Factors Contribute to Academic Resilience in Science

Bronfenbrenner's ecological framework (1979) offers a valuable lens for understanding how individual development, including academic resilience, is shaped by interactions across multiple environmental systems. At its core, the model situates the individual within four nested levels: the microsystem (e.g., family, school, and peers), mesosystem (e.g., interactions among microsystems); exosystem (indirect influences such as school policies); macrosystem (broader cultural and societal norms).

This study focuses specifically on two science-related factors—students' motivation to learn science and their perceptions of school science—both situated within the microsystem, where are also influenced by more distal contexts; for instances, cultural attitudes toward science (macrosystem) or school resources and policies (exosystem) may indirectly shape classroom experiences. By situating motivation and perceptions within this ecological model, the study highlights how these key factors function as pathways through which environmental influences impact students' capacity to succeed in science despite adversity.

2.3.1 Students' motivation to learn science

Motivation is a key to understanding academic achievement and profoundly influences resilience (Jiang et al., 2024). It can be classified into intrinsic motivation, which arises from personal enjoyment and interest in science, and instrumental motivation, which is driven by the perceived utility of science for future endeavours (Ryan & Deci, 2000). Low-SES students often exhibit strong instrumental motivation as a means to achieve their goals, contributing to their academic resilience (Özden & Atasoy, 2020). However, a focus solely on instrumental outcomes can sometimes undermine resilience if not complemented by intrinsic interests and adequate support (Clavel et al., 2022; Wang & Chi, 2023).

Further research highlights that students who enjoy science and believe in their capabilities are more likely to persist through challenges and achieve better academic outcomes (She et al., 2019; Wang et al., 2022). In regions like East and Southeast Asia, where students often underestimate their abilities in science, enhancing enjoyment and self-efficacy in science can be particularly transformative (Clavel et al., 2022). Similarly, in developed countries like Sweden, evidence suggests that resilient students are significantly driven by their interest in school subjects, which substantially contribute to their educational success (Thorsen et al., 2021).

2.3.2 Students' perceptions of school science

Students' perceptions of school science encompass various facets associated with teaching and learning environments. Among these, teacher support and feedback emerge as crucial elements that shape these perceptions, especially for low-SES students who often lack educational resources at home (Teig & Nilsen, 2022). Students who perceive their teachers as supportive are more likely to experience a greater sense of belonging, demonstrate higher levels of engagement and motivation in school, and achieve better academic results (Ma, 2003). Studies have shown that when feedback is specific, constructive, and timely, it significantly enhances learning outcomes (e.g., Ruiz-Primo & Li, 2013), enabling disadvantaged students to overcome their academic challenges. Nevertheless, these findings might vary across countries. For example, Jiang et al. (2024) revealed a favourable correlation between teacher support and the emergence of resilient students in science, but teacher feedback was not a key predictor of academic resilience.

Additionally, a strong sense of belonging has been linked to improved student performance and can act as a protective factor, particularly in diverse cultural settings (Chen et al., 2021). Feeling accepted in science classrooms can reduce feelings of isolation among disadvantaged students, with research identifying this sense of belonging as a key driver of academic resilience in places like Hong Kong (Wang et al., 2022). These insights underscore the importance of fostering a supportive classroom environment to promote resilience and potentially reduce educational inequalities.

Different instructional approaches also play significant roles in shaping student outcomes, particularly for socioeconomically disadvantaged students (Nilsen & Teig, 2024; Teig & Nilsen, 2022). A positive disciplinary climate, characterised by well-managed classrooms with clear expectations and minimal disruptions, provides a structured learning environment that these students may lack at home (Scherer, 2020). This is essential for maintaining focus and providing stability. Teacher-directed instruction, involving clear explanations and structured activities, offers explicit guidance to bridge knowledge gaps (Chuang, 2012). This approach is especially beneficial for disadvantaged students, as it provides the necessary scaffolding to develop a strong foundation in scientific language and practices, which they often lack exposure to outside of school (Wang & Chi, 2023). Inquiry-based teaching, which encourages students to construct their own understanding and engage in scientific practices, leads to significant

gains in achievement for all students, with even greater benefits for those from low-SES backgrounds (Blanchard et al., 2010).

2.4 Academic resilience across different socio-cultural contexts

Recent research has highlighted the role of socio-cultural and national contexts in shaping academic resilience (Li et al., 2017). This study focuses on Sweden and Vietnam contexts, two countries that actively benchmark their education systems, yet differ significantly in socio-cultural values and educational traditions, which in turn influence students' academic outcomes.

Cultural orientations—particularly the distinction between individualism and collectivism—play a key role in shaping classroom practices and student-teacher dynamics. Individualist cultures, such as Sweden, emphasise autonomy, self-actualisation, and promoting student-centred and inquiry-based learning approaches (Wang & Lin, 2019). In contrast, collectivist cultures, such as Vietnam, prioritise social harmony, respect for authority, and family obligations, often favouring teacher-directed instruction (Jiang et al., 2024; Triandis, 2018).

These broader socio-cultural orientations and pedagogical traditions are likely shape students' motivations and perceptions of school science (Li et al., 2017). In a culture like Sweden with a robust welfare system and high trust in institutions, students may be more inclined to frame science learning in terms of personal interest and self-development, with less reliance on family and social networks (Hofstede Insights, 2022). Conversely, in Vietnam, students may view education as a way to secure a better future, meet family expectations, and contribute to society (Mate et al., 2017).

3 Methods

3.1 Data source and sampling

The study draws on data from the 2015 cycle PISA, which assesses the competencies of 15-year-old students in mathematics, reading and science every three years. The 2015 cycle was selected due to its primary focus on science, offering the most detailed data on science performance, attitudes, and learning environments. In contrast, the 2018 and 2022 cycles focused on reading and mathematics, respectively, and thus provide more limited data for research centred on science education.

PISA employs a stratified two-stage sampling design (OECD, 2017). In the first stage, schools are selected with probability proportional to their size, considering the enrolment of 15-year-olds within the countries. In the second stage, students within each selected school are randomly sampled, ensuring that every student has an equal probability of inclusion in the sample. This study analyses a sample of 5,458 students within 202 schools in Sweden and 5,826 students within 188 schools in Vietnam. For Sweden data, the

average age was 15.72 (SD = 0.28 with an equal gender distribution: 2,731 boys (50.04%) and 2727 girls (49.96%). In the Vietnamese sample, the average age was 15.78 (SD = 0.29) with 2,786 boys (47.82%) and 3,040 girls (52.18%).

3.2 Measures

3.2.1 Academic resilience in science

First, we measure adversity based on students' economic, social and cultural status (ESCS) index. The ESCS index is a composite score which is constructed via principal component analysis of three standardised indicators, including parental education (PARED), highest parental occupation (HISEI), and home possession (HOMEPOS)[1]. Low-SES students are defined as those whose ESCS falls within the bottom third of their country's distribution (see Agasisti & Longobardi, 2017; Cordero & Mateos-Romero, 2021).

Next, we measure academic success based on students' science test scores in PISA 2015. Each of the ten plausible values of achievement was analysed separately to identify students who achieved a score of level 3 or higher. This categorisation is based on a seven-level proficiency scale in scientific literacy as defined by PISA 2015, where being at level 3 or above signifies the ability to understand complex knowledge, construct explanations of familiar phenomena, and draw evidence to support a scientific claim (Agasisti et al., 2018, p. 8).

3.2.2 Students' motivation to learn science and their perceptions of school science

We identified nine science-related factors for analysis and categorised them into two groups: students' motivation to learn science (enjoyment of science, instrumental motivation, and science self-efficacy) and perceptions of school science (teacher support, teacher feedback, sense of belonging, disciplinary climate, teacher-directed science instruction, and inquiry-based science teaching and learning practices). Appendix 1 lists all items used to measure each factor in both categories. The selection was guided by two criteria: their recognition in the literature as potential contributors to enhancing science achievement for disadvantaged students and their availability in the PISA 2015 data from both Sweden and Vietnam. Since PISA lacks linked teacher-student data, we used only student questionnaires for the analysis.

[1] The measures for home possessions in Sweden and Vietnam differ based on three context-specific items. In Sweden, the survey asks about the number of pianos, whirlpools, and espresso machines, while in Vietnam, it asks about the number of air conditioners, motorbikes, and cars at home.

Item response theory was applied to convert categorical response data from the context questionnaires in PISA 2015 into a continuous scale, resulting in a reporting scale standardised across OECD countries with a mean of 0 and a standard deviation of 1 (OECD, 2017). This scaling process ensures that the scale can be uniformly interpreted across different countries, facilitating reliable comparisons.

3.3 Data analysis

Data analyses were conducted using SPSS 29. The Sweden's data had missing values ranging from 2.4% to 16.6%, while Vietnam's data had fewer than 5% missing values at the item level.

To address RQ 1, we identified socio-economically disadvantaged students within the sample of Sweden and Vietnam. These students were categorised into resilient and non-resilient groups based on their ESCS index and science performance (see further details in Figure 2 in Results). Each student had ten plausible values for science achievement, paired with the ESCS, resulting in ten possible outcomes for each student. Consequently, a student's resilient status may vary across these ten outcomes. A student was considered resilient if they met the criteria in at least six out of the ten outcomes. This threshold ensures that the classification reflects a consistent pattern of resilience rather than a single occurrence.

To address RQ 2, we used independent-samples t-tests to compare resilient and non-resilient students Sweden and Vietnam, separately. The comparison focused on factors related to students' motivation to learn science (enjoyment of science, instrumental motivation, and science self-efficacy) and students' perceptions of school science (teacher support, teacher feedback, sense of belonging, disciplinary climate, teacher-directed science instruction, and inquiry-based science teaching and learning practices). Despite the non-normal distribution of our data, the robustness provided by our large sample size justifies the use of a t-test for data analysis based on the central limit theorem (Fagerland, 2012; Fagerland & Sandvik, 2009). Additionally, we assessed the size of these differences using Cohen's d values, with benchmarks of 0.2, 0.5, and 0.8 indicating small, medium, and large effect sizes respectively (Cohen, 2013).

4 Results

4.1 RQ 1: How prevalent are academically resilient students in science in Sweden and Vietnam?

Figure 2 illustrates the procedure for determining the proportion of academically resilient students in science in Sweden and Vietnam. For the Sweden dataset, a relative ESCS cut-off point of 0.0252 identified the bottom one-third of socioeconomically disadvantaged students, resulting in a subsample of N = 1771. Among these students, we classified

academically resilient students in science as those who achieved a proficiency level 3 or higher on the PISA scientific literacy scale with a cut-off point of 484.14. This yielded 641 students (36.2%) as resilient and 1,130 (63.8%) as non-resilient.

Similarly, we identified a subsample of disadvantaged students $N = 1942$ by employing a cut-off point of -2.3331 on the ESCS index for the Vietnam dataset. Within this group, 1163 (59.9%) were classified as academically resilient students in science and 779 as non-resilient (40.1%).

Figure 2. The proportion of academically resilient students in science in Sweden and Vietnam.

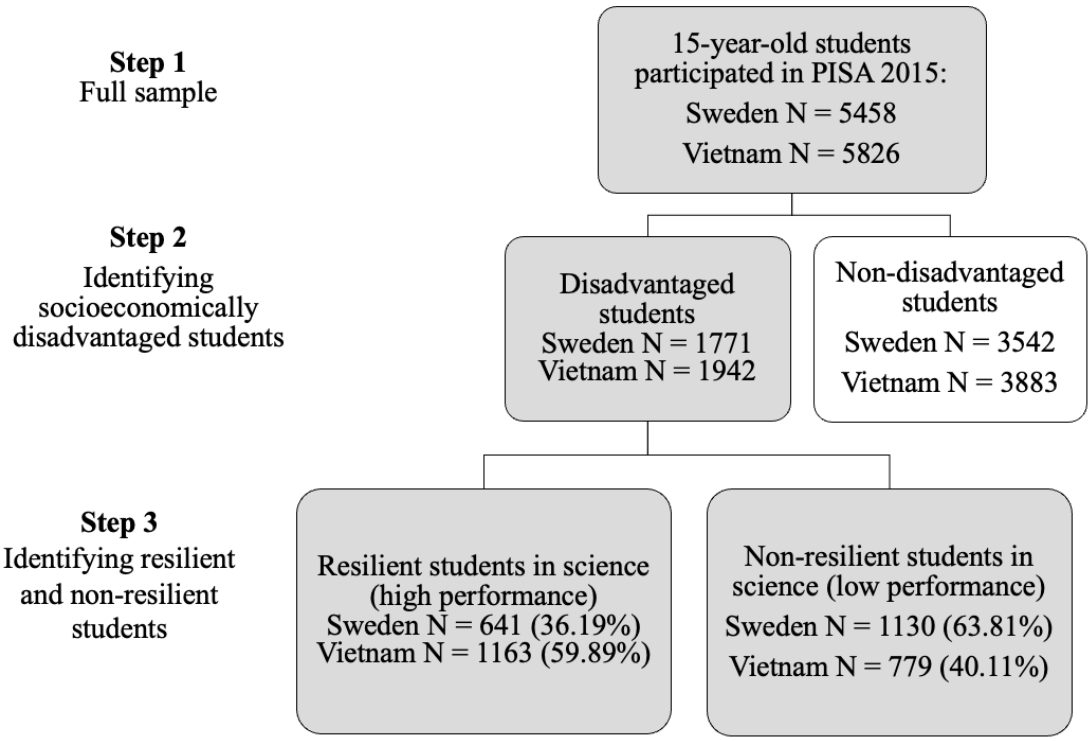


Table 1 provides the distribution of demographic variables for resilient and non-resilient groups. In both countries, the number of boys is lower than girls in both groups. Most resilient students speak their mother tongue in both countries. In Sweden, 82.84% of resilient students are native, and 10.61% are second-generation immigrants, while in Vietnam, 99.48% of resilient students are native.

Table 1. The distribution of resilient and non-resilient students by demographic information.

Demographic information	Category	Sweden		Vietnam	
		Resilient	Non-resilient	Resilient	Non-resilient
Gender	Female	52.26%	51.06%	54.26%	54.17%
	Male	47.74%	48.94%	45.74%	45.83%
Language at home	Mother tongue	85.18%	73.98%	92.52%	87.16%
	Other language	14.82%	25.84%	7.39%	12.20%

Index immigration status	Native	82.84%	66.12%	99.48%	97.82%
	Second-generation	10.61%	16.02%	0.17%	NA
	First generation	5.77%	15.22%	NA	NA

4.2 RQ 2: To what extent do factors related to students' motivation to learn science and their perception of school science vary between resilient and non-resilient students in Sweden and Vietnam?

Table 2 presents the descriptive statistics and the independent sample t-test results of each variable to compare resilient and non-resilient students in Sweden and Vietnam.

In Sweden, resilient students reported significantly higher enjoyment of science, instrumental motivation, and science self-efficacy than non-resilient students, although the effect size ranged from small to moderate (Cohen's d = 0.12 – 0.48). They also reported more positive perception of their school science environment, including greater teacher support, sense of belonging, and more positive disciplinary climate. In contrast, non-resilient students reported significantly higher teacher feedback than resilient students. No significant differences were observed for teacher-directed instrument or inquiry-based science practices.

In Vietnam, resilient students reported significantly higher science self-efficacy, sense of belonging, and more positivie perceptions of teacher support and teacher-directed science instruction, although effect sizes were generally small (Cohen's d = 0.14 – 0.43). Differences in enjoyment of science were statistically significant but small, while instrumental motivation, teacher feedback, discipinary climate, and inquiry-based practices did not differ significantly between resilient and non-resilient students.

Overall, the findings indicated both commonalities and significant differences between resilient and non-resilient students across two countries. In Sweden, seven out of nine factors significantly differentiated the two groups, whereas in Vietnam, only five factors showed significant differences. Notably, inquiry-based science teaching and learning practices did not significantly differ between resilient and non-resilient groups in either country. Four factors were significant in both countries: enjoyment of science, science self-efficacy, teacher support, and sense of belonging. However, certain factors were unique to each country. In Sweden, instrumental motivation towards school science, teacher feedback, and disciplinary climate were significant, while in Vietnam, teacher-directed science instruction was the only unique factor found to be significant.

Table 2. Variation in students' motivation to learn science and their perceptions of school science between resilient and non-resilient students.

Variable	Sweden					Vietnam				
	Total (*N*= 1771)	**Resilient (*N*= 641)**	**Non-resilient (*N*= 1130)**	***t*-test**	**Cohen's d**	**Total (*N*=1942)**	**Resilient (*N*= 1163)**	**Non-resilient (*N*= 779)**	***t*-test**	**Cohen's d**
	M (SD)	***M (SD)***	***M (SD)***			***M (SD)***	***M (SD)***	***M (SD)***		
Students' motivation to learn science										
Enjoyment of science	-0.18 (1.24)	0.18 (1.20)	-0.41 (1.22)	9.26***	0.48	0.58 (0.73)	0.63 (0.74)	0.51 (0.71)	3.45***	0.16
Instrumental motivation	0.16 (0.98)	0.23 (0.94)	0.11 (1.01)	2.35*	0.12	0.48 (0.67)	0.48 (0.67)	0.48 (0.68)	-0.04	-0.002
Science self-efficacy	-0.23 (1.35)	0.08 (1.15)	-0.43 (1.43)	7.23***	0.38	-0.44 (0.92)	-0.28 (0.84)	-0.67 (0.97)	9.35***	0.43
Students' perceptions of school science										
Teacher's support in science classes	0.11 (1.03)	0.21 (0.95)	0.05 (1.07)	3.17**	0.16	0.27 (0.69)	-0.33 (0.68)	0.18 (0.70)	4.84***	0.23
Teacher's feedback	0.06 (1.02)	-0.10 (0.98)	0.16 (1.03)	-5.06***	-0.26	0.53 (0.66)	0.51 (0.66)	0.56 (0.67)	-1.64	-0.08
Sense of belonging	-0.07 (1.14)	0.03 (1.12)	-0.13 (1.14)	2.95**	0.15	-0.13 (0.55)	-0.09 (0.56)	-0.17 (0.55)	3.07**	0.14
Disciplinary climate in science classes	-0.07 (0.96)	-0.00 (0.94)	-0.11 (0.98)	2.35*	0.12	0.45 (0.67)	0.46 (0.70)	0.43 (0.73)	0.93	0.04
Teacher-directed science instruction	-0.10 (1.01)	-0.05 (0.91)	-0.12 (1.07)	1.34	0.07	-0.09 (0.71)	-0.45 (0.69)	-0.16 (0.75)	3.35***	0.16
Inquiry-based science teaching and learning practices	0.26 (1.02)	0.22 (0.85)	0.29 (1.11)	-1.32	-0.07	0.18 (0.67)	0.20 (0.64)	0.15 (0.73)	1.66	0.08

5 Discussion

This study aimed to investigate the prevalence of academically resilient students and examine how students' motivation to learn science and their perceptions of school science differ between resilient and non-resilient students in Sweden and Vietnam. In this context, academically resilient students refer to those who come from underprivileged backgrounds with low SES, yet demonstrate high performance in the PISA science test (OECD, 2017). We discuss the results of this study in the following sections.

5.1 Prevalence of academically resilient students in Sweden and Vietnam

The findings show that the proportion of academically resilient students in science among socioeconomically disadvantaged groups is significantly lower in Sweden than in Vietnam, with 36.19% in Sweden compared to 59.89% in Vietnam (Figure 2). The comparatively low prevalence of resilient students in Sweden may in part be due to recent changes in the Swedish school system, which has become increasingly segregated (Yang Hansen & Gustafsson, 2016). This segregation disadvantages certain student groups and fails to fully support their diverse backgrounds (Swedish National Agency for Education (Skolverket), 2012). The difference between Sweden and Vietnam can also be attributed to the distinct socio-cultural contexts in both countries, which shape the value systems and perceptions of academic success of disadvantaged students. Sweden's cultural orientation towards individualism (Hofstede Insights, 2022) tends to not only focus solely on academic achievement, but also strive to accommodate a holistic competency (e.g., students' talents, interests, and critical thinking). Conversely, Vietnam's adherence to collectivist traditions and Confucian values motivates students to strive for academic excellence not only for personal fulfilment but also as a way to honour their families and communities (Wang & Lin, 2019).

In Vietnam, underprivileged students often believe that academic success, particularly excelling in exams, is key to securing a better future and gaining admission to prestigious universities. This focus on academic achievement is reflected in Vietnamese students' strong performance and competitiveness in international assessments (Dang et al., 2023). In contrast, in Sweden, the educational discourse places greater emphasis on the potential negative effects of grading, highlighting concerns about its impact on students' academic self-esteem and mental health (Högberg et al., 2021). This difference in priorities may also influences how Swedish students perceive international assessments like PISA, which they often view as less significant since these tests do not affect their grades. This leads to a general lack of motivation to perform well on these tests (Skolverket, 2015).

5.2 Common science-related factors between resilient and non-resilient students in Sweden and Vietnam

Our study found several common factors between resilient and non-resilient students in both Sweden and Vietnam (Table 2), despite their cultural differences. Resilient students generally showed more positive motivation to learn science (i.e., enjoyment of science and science self-efficacy), as evidenced in prior research (Thorsen et al., 2021; Wang et al., 2022). Moreover, students' perceptions of school science (i.e., teacher support, sense of belonging) are significantly different between two groups of resilient and non-resilient students in both countries, which is in line with previous literature (Jiang et al., 2024; Wang et al., 2023). These findings suggest that certain factors related to academic resilience are consistent across these countries and are relevant not only for students but also for teachers and their instructional approaches.

However, our study did not reveal significant differences between resilient and non-resilient groups in terms of inquiry-based teaching and learning practices in either country. This result contrasts with previous research which argued that inquiry-based teaching, favoured by individualistic cultures, tends to benefit disadvantaged students (Blanchard et al., 2010; Jiang et al., 2024). One possible explanation is that the benefit of inquiry-based teaching may not directly improve test scores in assessments like PISA (Sjøberg, 2018).

5.3 Differential science-related factors between resilient and non-resilient students in Sweden and Vietnam

Taken together, the cross-country comparison suggests one consistent pattern and one context-dependent pattern (Table 2). Across both Sweden and Vietnam, resilient students report higher enjoyment of science and science self-efficacy, alongside more positive perceptions of teacher support and belonging, which indicates that motivational resources and relational classroom climate co-occur with high performance under disadvantage in both settings. At the same time, the specific school-process indicators that distinguish groups differ by context, which is consistent with the idea that resilience is shaped by national and cultural configurations of schooling rather than by a single universal set of school factors.

Bronfenbrenner's ecological systems theory (1979) is instrumental for guiding our interpretation of the significant variations found between resilient and non-resilient students in Sweden and Vietnam.

First, the significant differences in instrumental motivation between resilient and non-resilient students in Sweden can be interpreted through the lens of the microsystem, where students interact directly with family, peers, and teachers. In individualistic cultures like Sweden, students are more likely to pursue science based on personal interests and career aspirations, which can vary widely between individuals (Bøe &

Henriksen, 2013; Hofstede, 2011). This variation reflects the direct influence of the microsystem in shaping students' motivation in learning science. Resilient students may pursue science for personal and practical reasons, while non-resilient students might be less motivated if they do not see personal relevance or potential for growth. Conversely, collectivist cultures like Vietnam often emphasise communal values and responsibilities (Wang & Lin, 2019). This may lead to similar levels of instrumental motivation across both resilient and non-resilient groups. Here, the broader macrosystem, reflecting societal values and norms, ensures that education is viewed as a means to uplift their family or community, a sentiment likely shared by both groups.

Second, the difference in students' perceptions of teacher feedback between resilient and non-resilient students in Sweden can be attributed to the varying dynamics within the microsystem. Sweden's more personalised and student-centred approach to teaching may enable resilient students to use feedback more effectively for self-reflection and improvement. Previous research also shows that individualistic culture fosters self-directed learning and personal autonomy in school (Chuang, 2012; Jiang et al., 2024). It is reasonable to assume that resilient students may perceive teacher feedback as valuable for their critical thinking and self-reflection. This can lead to significant variations in how feedback is perceived and acted upon between resilient and non-resilient students. Conversely, as in other collectivist societies, the cultural ideologies within the macrosystem in Vietnam emphasise an authoritative approach to education. This often translates into a strong focus on well-prepared lesson plans rather than individualised feedback to students (Lau & Lam, 2017). Teacher feedback generally focuses on ensuring comprehension and correcting errors, which aligns uniformly with most students' expectations, regardless of their resilience. This cultural norm may result in a more homogenous perception of teacher feedback across resilient and non-resilient groups in Vietnam.

Third, there were significant differences in the disciplinary climate between resilient and non-resilient students in Sweden, which were also not observed in Vietnam. The emphasis on student-centred learning in Sweden creates a smaller power distance between teachers and students (Lau & Lam, 2017), which shapes students' disciplinary climate perceptions differently across resilient and non-resilient groups. Resilient students, with their higher engagement and motivation, are more likely to navigate classroom norms, resulting in a more pronounced difference in the perceived disciplinary climate between groups. In contrast, the structured and formal disciplinary climate in Vietnamese schools is likely to be applied consistently across all students, regardless of their resilience status. Vietnamese classrooms emphasise conformity and respect for teachers, fostering a similar disciplinary environment (Jiang et al., 2024). As a result, there is no significant variation in the disciplinary climate between resilient and non-resilient students, as the collective mindset encourages all students to adhere closely to expected behaviours. This variation in two countries reflects how layered environmental influences within the microsystem play out across individualistic and collectivistic

cultures, shaping different academic experiences and outcomes between resilient and non-resilient students.

Lastly, the significant difference in teacher-directed instruction between resilient and non-resilient students in Vietnam—but not in Sweden—can be explained through the role of the macrosystem in shaping instructional norms. In Sweden, where educational practices promote independence, the impact of teacher-directed instruction might be less pronounced among different groups because all students are encouraged to participate actively and take responsibility for their learning (Wang & Lin, 2019). This may explain why no differences were observed between the two groups. In contrast, Vietnam's education system is traditionally more authoritative, with a strong emphasis on teacher-directed instruction (Chuang, 2012). Resilient students may view this approach as providing essential structure and guidance, while non-resilient students might perceive it as restrictive. This can lead to variations in academic engagement and outcomes between both groups, reflecting how teacher-directed instruction impacts their educational experience differently.

Conclusions and Implications

This study has both theoretical and practical significance. Theoretically, it contributes to the literature by highlighting the importance of understanding how individuals navigate cultural norms and environments to overcome challenges in science education. It reinforces the idea that resilience is shaped not only by individual characteristics but also by interactions with the environment, including the roles of teachers and schools.

Our findings further suggest that while certain factors are universally important across various educational and cultural settings, others are unique to specific contexts. This underscores the necessity of considering socio-cultural contexts when examining academic resilience. Furthermore, this study is one of the few studies that focuses specifically on resilience within science education, adding to the argument that academic resilience should be examined within specific disciplines. Resilience in one subject area does not necessarily translate to resilience in others, thereby advocating for a more nuanced understanding of resilience across different academic areas.

Practically, this study identifies both common and unique indicators relevant to academic resilience in science between Sweden and Vietnam. It offers valuable insights for stakeholders and practitioners in designing targeted intervention strategies to reduce the achievement gap between high- and low-SES students. For instance, tailored interventions that enhance disadvantaged students' enjoyment of science may help keep them motivated and improve their performance. Additionally, improving self-efficacy in science can be a powerful lever for enhancing resilience. Teachers can support this by offering regular positive feedback, setting achievable challenges, and creating a supportive learning environment where students feel confident in tackling difficult science tasks.

Finally, this study highlights the need to consider cultural and social contexts in educational policymaking. Contextual sensitivity is crucial to avoid the risks of "policy borrowing," where lower-performing systems adopt policies from other contexts without adapting them to their unique circumstances (Volante & Klinger, 2022).

Limitations and Future Research

One limitation of this study is the scope of the PISA dataset, which did not include all relevant school- and teacher-level variables for both Sweden and Vietnam. For instance, teacher fairness was measured in Sweden but not in Vietnam, limiting cross-national comparisons on some relevant science teaching and learning dimensions. While this study focused on science-related factors, future research could examine a broader range of factors including peer and family influences to offer a holistic picture of diverse support systems and their interplay roles that we should reinforce to promote academic resilience. Additionally, future studies could benefit from incorporating qualitative data to explore the specific challenges students face and the types of support they perceive as crucial. This would provide in-depth insights into how students experience and navigate adversity. Another limitation concerns the interpretation of ESCS across national contexts. Because ESCS is relative to each country, the bottom-third group is not socioeconomically equivalent in absolute terms across Sweden and Vietnam; results should be interpreted as resilience under relative socioeconomic disadvantage within each education system. We also acknowledge that PISA 2015 dataset is now dated. However, it remains the most recent cycle in which science was the major domain, making it an appropriate source for analysing science-related outcomes and providing a useful baseline for future research using the upcoming science-focused PISA 2025 data to be released in 2026.

Research ethics

No ethical approval from an external committee was required for this study. All data from the Programme for International Student Assessment (PISA) 2015 are publicly available and completely anonymised in the Economic Co-operation and Development (OECD) database.

Author contributions

Nhu Truong: conceptualizing and designing of the study, methodology, analysing data, validation, visualization, writing—original draft preparation, writing—review and editing
Nani Teig: intellectually discussion the concept, data analysis, and methods of the study, writing—review and editing
Anna Danielsson: supervision, writing—review and editing.
Per Anderhag: supervision, writing—review and editing.
All authors have read and agreed to the published version of the manuscript.

Artificial intelligence

This article has not been used Artificial Intelligent to involve in writing.

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Data availability statement

The data that support the findings of this study are openly available in the OECD PISA 2015 Database at http://www.oecd.org/pisa/data/2015database/, published by the Organisation for Economic Co-operation and Development (OECD), 2016.

Conflicts of Interest

The authors declare no conflicts of interest. The funders had no role in designing the research setting, analysis procedures or interpretation of the results.

Appendix 1. An overview of the nine science-related variables in PISA 2015

Scale	Variable	Number of items	Item details
Students' motivation to learn science			
ST094	Enjoyment of science	5	How much do you disagree or agree with the statements about yourself below? (Strongly disagree – Disagree – Agree – Strongly agree) I have fun when I am learning <broad science>. I like reading about <broad science> topics. I am happy working on <broad science> topics. I enjoy acquiring new knowledge in <broad science>. I am interested in learning about <broad science>.
ST113	Instrumental motivation towards school science	4	How much do you agree with the statements below? (Strongly disagree – Disagree – Agree – Strongly agree) What I learn in my <school science> subject(s) is important for me because I need this for what I want to do later on. Making an effort in my <school science> subject(s) is worth it because this will help me in the work I want to do later on. Studying my <school science> subject(s) is worthwhile for me because what I learn will improve my career prospects. Many things I learn in my <school science> subject(s) will help me to get a job.
ST129	Science self-efficacy	8	How easy do you think it would be for you to perform the following tasks on your own? (I could do this easily - I could do this with a bit of effort - I would struggle to do this on my own - I couldn't) Recognise the science question that underlies a newspaper report on a health issue. Explain why earthquakes occur more frequently in some areas than in others. Describe the role of antibiotics in the treatment of disease. Identify the science question associated with the disposal of garbage. Predict how changes to an environment will affect the survival of certain species. Interpret the scientific information provided on the labelling of food items. Discuss how new evidence can lead you to change your understanding about the possibility of life on Mars. Identify the better of two explanations for the formation of acid rain.
Students' perceptions of school science			
ST100	Teacher's support in science classes	5	How often does this happen in your <school science> lessons? (Every lesson - Most lessons - Some lessons - Never or hardly ever) The teacher helps students with their learning. The teacher shows interest every student learning. The teacher gives extra help. The teacher continues teaching\students understand. Teacher gives an opportunity to express opinions.
ST104	Teacher's feedback	5	How often does this happen in <school science>? (Every lesson or almost every lesson - Many lessons - Some lessons - Never or almost never)

			The teacher tells me in which areas I can still improve.
			The teacher tells me how I am performing in this course.
			The teacher gives me feedback on my strengths <school science> subject.
			The teacher tells me how I can improve my performance.
			The teacher advises me on how to reach my learning goals.
ST034	Sense of belonging	6	Thinking about your school: to what extent do you agree with the following statements? (Strongly disagree – Disagree – Agree – Strongly agree)
			I feel like an outsider (or left out of things) at school.
			I make friends easily at school.
			I feel like I belong at school.
			I feel awkward and out of place in my school.
			Other students seem to like me.
			I feel lonely at school.
ST097	Disciplinary climate in science classes	5	How often does this happen in your <school science> lessons? (Every lesson - Most lessons - Some lessons - Never or hardly ever)
			Students don't listen to what the teacher says.
			There is noise and disorder.
			The teacher waits long for students to quiet down.
			Students cannot work well.
			Students don't start working for a long time after.
ST103	Teacher-directed science instruction	4	How often does this happen in <school science>? (Every lesson or almost every lesson - Many lessons - Some lessons - Never or almost never)
			The teacher discusses our questions.
			The teacher explains scientific ideas.
			A whole class discussion takes place with the teacher.
			The teacher demonstrates an idea.
ST098	Inquiry-based science teaching and learning practices	9	When learning school science topics at school, how often do the following activities occur? (Every lesson - Most lessons - Some lessons - Never or hardly ever)
			Students are allowed to design their own experiments.
			Students are given opportunities to explain their ideas.
			Students spend time in the laboratory doing practical experiments.
			Students are required to argue about science questions.
			Students are asked to draw conclusions from an experiment they have conducted.
			The teacher explains <school science> idea can be applied.
			There is a class debate about investigations.
			The teacher clearly explains relevance <broad science> concepts to our lives.
			Students are asked to do an investigation to test ideas.

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