



Research article

The middle school transition dip in school science attitudes and identity

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Abstract: The decline in science interest during adolescence is well documented; however, its dynamics within Latin American educational systems remain underexplored. In this cross-sectional study, we investigated the pattern of Attitudes Toward School Science and Science Identity among 1,147 students in grades 4-8 attending public and private schools in a region of Mexico. Using validated instruments, we employed linear regression models to analyze trends and Cohen's *d* to identify critical transition points, with analyses stratified by gender and school type. The results revealed a non-linear pattern, with significantly lower scores in the 7th-grade cohort followed by higher scores in the 8th-grade cohort, suggesting a possible transition dip during the shift into secondary school. This negative association was more pronounced among girls, particularly in Self-efficacy and Science Identity. While both school types showed a similar decrease in Science Identity, private schools exhibited a protective effect on students' Self-efficacy and perceived Utility of science. Our findings indicate that the pattern of attitudinal differences is not linear but concentrated in key educational transitions and is significantly moderated by gender and school context.

Keywords: student attitudes, science identity, school type, school transition, gender differences

1. Introduction

Adolescents' declining interest in and attitudes toward science have been recognized as social

and scientific concerns [1]. During primary education, students typically show interest in school science and perceive it as accessible, relevant, and applicable to their surroundings [2]. However, this interest tends to decrease during adolescence, as students increasingly perceive science as more difficult, less enjoyable, and less relevant [3]. This long-standing global pattern has prompted interventions in Global North countries, including the United States [4,5], the United Kingdom [6], and Canada [7], where scientific development is considered a strategic driver of economic growth [8]. This decline may contribute to a reduced number of STEM professionals [9], slower advances in technology, medicine, and pharmacology [10], and broader challenges to socioeconomic development and the population's quality of life [11].

Attitudes Toward Science are a central construct in science education research, generally defined as learned predispositions to respond favorably or unfavorably to science-related objects or situations. This construct is typically conceptualized as multidimensional, comprising affective (e.g., interest, enjoyment), cognitive (e.g., beliefs about the relevance of science), and behavioral (e.g., participation intentions) components [12]. However, defining and operationalizing attitudes remain challenging, mainly because distinguishing their components from related constructs, such as interests and specific beliefs about science, is difficult [13,14]. Additionally, it is necessary to differentiate the general “Attitudes Toward Science”, understood as a social enterprise and a domain of knowledge, from the “Attitude Towards School Science”, which focuses on the science content, learning experiences, and teachers’ instructional approach [12,15]. Therefore, a student might value the social dimension of science but hold unfavorable attitudes towards classroom science due to pedagogical or curricular factors. Educational experiences, family environment, and media representations may shape both attitudinal dimensions, which are associated with student engagement, academic pathways, and future civic participation in socio-scientific issues [16].

Science Identity, which has become a significant construct for understanding young people’s learning trajectories, presents methodological and analytical complexities. It is defined as an individual’s self-perception of science, encompassing components such as personal interest, perceived self-efficacy in scientific activities [17], perception of oneself as capable in science [18] or as a scientist [19,20], and recognition by others [17,21,22]. This construct develops progressively through lived experiences and daily practices [23,24], involving a continuous interplay between internal factors (e.g., intrinsic interest, scientific self-efficacy) and external factors, such as support and recognition from significant individuals, including teachers, mentors, family members, and peers. Science Identity is also influenced by structural factors, including gender stereotypes, disparities in educational access, and prevailing cultural narratives about who is perceived to belong in science and who can succeed in it [18]. It is considered a key factor for persistence and retention in scientific careers [25,26].

Although Attitude Toward Science and Science Identity are distinct constructs, examining them together is important to understanding how young people’s engagement with science develops [17,27]. A bidirectional relationship has been proposed: A sustained positive attitude can strengthen science identity, which can promote and maintain favorable attitudes. Among the factors that modulate this dynamic, school is a critical period, as it is associated with attitudinal changes that impact student adaptation and interest in science [28,29,30]. The impact of these transitions is mediated by variables such as available social support, pedagogical practices, and individual student characteristics [31,32,33].

The transition to secondary education presents well-documented curricular challenges. It often emphasizes symbolic representations, abstract theoretical models, and greater demands for

mathematical reasoning, particularly in physics and chemistry, which can create cognitive difficulties and weaken students' science self-efficacy [7,34]. Additionally, secondary school pedagogy tends to prioritize the transmission of information over knowledge-construction approaches, such as Inquiry-Based Science Education (IBSE), despite evidence of the latter's positive effects on students' interest and conceptual understanding [35]. These academic and pedagogical changes have been associated with a "transition dip," characterized by an abrupt decline in students' general academic attainment, motivation and engagement during this period [36]. In the context of science education, Potvin and Hasni [37] examined the concept of a "precipitous drop" in science attitudes during the transition to secondary school. They supported this pattern in their findings, reporting a significant decline during this period, followed by a less pronounced decrease or a recovery in later grades. From the perspective of Expectancy-Value Theory [38], the attitudinal decline is explained by a reduction in the value students attribute to science, particularly when the content is perceived as disconnected from their lives or future plans [39,40].

Contextual and social factors also influence attitudes and identity. At the classroom level, teacher training, including pedagogical content knowledge and teachers' attitudes, plays an important role in students' learning experiences [16,41]. Beyond the classroom, family "science capital" [42], exposure to gender stereotypes, and cultural narratives about who is perceived to belong in science shape the development of Science Identity [18]. These stereotypes can trigger stereotype threat, with negative consequences for performance and engagement, particularly affecting students from historically underrepresented groups in scientific fields [21,43].

Studies entailing Attitudes Toward Science and Science Identity in Latin America, particularly in Mexico, remain limited, constraining our understanding of how these constructs develop across educational stages. Nevertheless, a small number of studies have contributed to the regional evidence base. These include the validation of attitudes toward chemistry using the Attitude toward the Subject of Chemistry Inventory version 2 (ASCIv2) and the validation of the Test of Science-Related Attitudes (TOSRA), both conducted among Chilean secondary school students [44,45]. In Mexico, an adaptation of the Attitudes toward Science Protocol has also been implemented in a high school cohort [46], although the instrument lacks formal validation. Despite these contributions, to our knowledge, no studies in the Latin American context have simultaneously examined Attitudes Toward Science and Science Identity through rigorous methodological approaches using validated instruments. This gap is particularly evident at the pre-university level, a critical stage for career decision-making, as most international research has focused on primary or early secondary education.

This variability suggests that context-specific factors are crucial; however, research in this area is further constrained by the use of instruments that often lack psychometric and cultural validation for these populations, thereby restricting their use for cross-cultural comparison [47].

The impact of structural disparities within the educational system on Attitudes Toward Science and Science Identity remains underexplored in Latin America. In this region, the segmentation between public and private schools reinforces social inequities, resulting in disparate science learning environments. In the public sector, high student-teacher ratios and limited resources may limit the implementation of active pedagogies like inquiry-based learning, fostering an abstract perception of science and impeding identification with it [35,39]. However, private institutions typically provide greater resources and higher levels of family science capital [42], thereby facilitating the development of interest and self-efficacy.

To address these gaps, we examine Attitudes Toward School Science and Identity among students

in public and private schools in Mexico across primary and secondary grades. Specifically, we seek to answer the following research questions: (1) How do students' Attitude Toward Science and Science Identity differ across grades as they advance through school grades? (2) Does gender moderate the developmental pattern across grades of Attitude Toward School Science and Science Identity? (3) Are there differences in Attitude toward School Science and Science Identity between students from public and private schools, after controlling for grade level? (4) What are the inflection points or critical transitions in the educational grade-level pattern where Attitude Toward School Science and Science Identity show the greatest variations?

2. Methodology

2.1. Data collection

The sample comprised 1,147 students enrolled in grades 4–8, including the upper levels of primary education (4th–6th grades) and the lower secondary level (7th–8th grades). Each participant was surveyed once and enrolled in a single grade level at the time of data collection. The sample was evenly distributed by gender (50% girls and 50% boys) and included students aged 8 to 15 years (mean age = 11 years). This sampling strategy was intended to capture Attitudes Toward School Science across educational stages from late childhood to early adolescence, rather than to follow the same students over time. Participants were distributed across 33 schools (19 public and 14 private) in urban and rural areas. Schools were randomly selected to increase representativeness and reduce potential selection bias, yielding a heterogeneous sample across school types and sociodemographic contexts.

Data were collected in person using paper-based surveys with 14 items: 11 Likert-scale items and 3 semantic differential items. Each participant completed the survey during a single assessment session. Before the main data collection, a pilot test using the Think Aloud Protocol was conducted with 25 students to ensure the items and response scales were understood as intended. Informed consent was obtained from parents, and assent was obtained from the students prior to participation. The wording of items with possible double negatives was clarified to avoid confusion. Questionnaires were distributed to each student during visits to the participating schools and took approximately 20 minutes to complete. Each item was read aloud, and once it was confirmed that all students had responded, the administrator proceeded to the next one. All sessions were supervised by at least one member of the research team, in addition to the teacher responsible for the group.

2.2. Attitude toward science instrument

Science education research in Mexico is limited by a lack of psychometrically robust instruments validated for local populations. To address this gap, we adapted the Spanish-School Science Attitude Survey (S-SSAS) [48]. The S-SSAS was selected because it is a validated Spanish adaptation of the original SSAS [49], has been tested in a Latin American context (Chile), and evaluates key dimensions of Attitudes Toward Science. This instrument included single-item dimensions: Enjoyability, Difficulty, Self-efficacy, and Intention; and multi-item dimensions: Usability (scientific career usefulness and personal career usefulness; one item each) and Relevance (social relevance, one item; personal relevance, three items), resulting in a 10-item instrument.

The statements were taken directly from the S-SSAS [48], with only two modifications: The

name of the primary school subject was adapted to better reflect the Mexican context (“Ciencias de la naturaleza” to “Ciencias naturales”), and the “Intention” subscale was removed because it was not considered contextually relevant within the Mexican compulsory education system. As a result of this structural modification (from 10 items to 9 items), a new psychometric validation was required. A Confirmatory Factor Analysis (CFA) was performed for the sample, following the recommendation that, in applied research, factor analysis is most informative when performed on the complete dataset [50]. The model evaluation yielded good fit indices (CFI = .956, TLI = .951, RMSEA = .050), consistent with established benchmarks [51], thereby providing evidence for the instrument's structural validity. Finally, the internal consistency for the resulting five-construct scale was high (Cronbach's $\alpha = .833$).

2.3. Science identity instrument

Science Identity was assessed using a five-item scale adapted from Vincent-Ruz and Schunn [17]. The construct was assessed using one item assessing self-recognition as a “science person” (“I am a science person / Me considero una persona de ciencia”) and four items assessing perceived external recognition from others. Three items followed the structure “...thinks of me as a science person” and referred to teachers, friends, and parents. The fourth item stated, “My parents would like it if I choose an engineering career.” This final item was adapted from the RIS-STEM instrument [52] to strengthen the assessment of external recognition. The development of this instrument is within a body of research on Science Identity that includes detailed theoretical frameworks on its formation and loss among high school students [23,53]. For this study, the Vincent-Ruz and Schunn scale [17] was selected for its focus on core, quantifiable components of identity. The adaptation process included a back-translation to Spanish and two modifications: (1) The response format was changed to a five-point scale with a neutral midpoint, and (2) one item was added (“My parents would like me to choose a scientific career”). The psychometric properties of the adapted instrument were then evaluated. The scale demonstrated high internal consistency (Cronbach's $\alpha = .892$). Confirmatory Factor Analysis, conducted on the full sample, demonstrated satisfactory model fit indices (CFI = .980, TLI = .949, RMSEA = .048).

2.4. Analysis

The data were analyzed using a two-stage quantitative approach in R (version 4.4.2). In the first stage, to address the research questions regarding overall trends and the influence of gender and school type, we employed linear regression models. This approach, consistent with foundational studies in the field (e.g., [7]), is appropriate for modeling the linear relationship between a continuous outcome variable and a predictor variable. Because the study employed a cross-sectional design, each student contributed a single independent observation and was enrolled in only one grade level at the time of assessment. Accordingly, school grade was treated as a between-subjects predictor. In each model, the scores of the attitude and identity constructs served as the dependent variables, while school grade at the time of assessment was entered as the independent variable. The regression coefficient (b) represented the average rate of change in attitude or identity per grade level. Separate models were fitted for three groupings: (1) the overall sample, (2) stratified by gender, and (3) stratified by school type to test for differential trends in these subpopulations.

In the second stage, to complement the trend analysis and identify the moments of significant change, we calculated Cohen's *d* effect sizes. Although linear regression estimates an overall trend, it can mask abrupt shifts at specific transition points. Thus, by comparing the mean scores between independent samples from consecutive grade pairs (e.g., grade 4 vs. grade 5, grade 6 vs. grade 7), Cohen's *d* enabled us to quantify the magnitude of change at each educational stage. Effect sizes were interpreted according to established conventions [54]. The statistical significance of the mean differences between each pair was assessed using independent-sample *t*-tests.

3. Results

The results of the linear regression analysis are presented below to address the four research questions. The overall trend of the sample is examined first, followed by analyses by gender and school type. We conclude the section with an analysis of the effect size of the transition between school grades.

3.1. Differences in attitude toward science and science identity across grade levels

The linear regression analysis for the overall sample revealed a statistically significant negative association between school grade and most attitude constructs, including self-efficacy, relevance, and usability, as well as Science Identity (Table 1). The negative slopes observed across these constructs indicate a progressive decline in students' scores as grade level increased. In contrast, perceived difficulty showed a significant positive association with school grades, whereas enjoyability did not show significant changes across grades. Overall, these results suggest that the decline associated with increasing grade level was not uniform across all dimensions of attitudes toward science.

To further examine the relationships among the measured constructs, we conducted Pearson correlation analyses between all pairs of constructs. Statistically significant positive correlations ($p < .001$) were observed among Enjoyability, Self-efficacy, Usability, Relevance, and Science Identity, whereas Difficulty was negatively correlated with all other constructs ($p < .001$), except for Self-efficacy, with which no significant correlation was found (Supplementary Figure S1). The strongest positive correlation was observed between Relevance and Usability ($r = 0.53$), followed by those between Enjoyability and Relevance ($r = 0.47$), and Enjoyability and Usability ($r = 0.44$). These results provide additional insight into the relationships among the measured constructs.

Table 1. Results of the linear regression analysis using school grades as a predictor (independent variable) of Attitude and Identity Toward Science constructs (dependent variable) in the overall sample.

Attitude constructs	N	Intercept	Slope	p
Enjoyableness	1141	4.36	-0.04	0.06
Difficulty	1138	1.61	0.20	<0.001
Self-efficacy	1137	3.75	-0.07	<0.01
Relevance	1143	4.65	-0.09	<0.001
Usability	1147	4.84	-0.12	<0.001
Identity	1128	3.78	-0.14	< 0.001

3.2. Gender moderation of attitude toward science and science identity across grades

The analysis by gender revealed significant interactions between gender and school grade, particularly for the enjoyability and self-efficacy constructs (Table 2). For girls, both constructs showed a statistically significant negative association across school grades, whereas these trends were not significant for boys. Additionally, although both genders showed a significant increase in perceived difficulty and a negative association in usability and science identity, the magnitude of these associations, as indicated by the greater absolute slope values, was considerably steeper for girls.

Table 2. Results of the linear regression analysis using school grades as a predictor (independent variable) of Attitude and Identity Toward Science constructs (dependent variable) in the sample divided by gender.

Attitude constructs	Gender	N	Intercept	Slope	p
Enjoyableness	Girls	564	4.53	-0.06	0.04
	Boys	566	4.16	-0.18	0.58
Difficulty	Girls	559	1.20	0.28	<0.001
	Boys	567	2.03	0.12	<0.01
Self-efficacy	Girls	558	3.99	-0.10	0.01
	Boys	567	3.56	-0.04	0.206
Relevance	Girls	562	4.88	-0.12	<0.001
	Boys	569	4.46	-0.06	0.013
Usability	Girls	564	4.14	-0.16	<0.001
	Boys	571	4.59	-0.07	0.009
Identity	Girls	555	3.90	-0.17	<0.001
	Boys	562	3.68	-0.11	<0.001

3.3. Differences between public and private schools in attitude toward science and science identity

The analysis stratified by school type (Table 3) revealed divergent attitudinal patterns. In public schools, but not in private schools, significant negative associations were observed for self-efficacy (slope = -0.10, $p = .01$), relevance (slope = -0.08, $p < .001$), and usability (slope = -0.12, $p < .001$). In contrast, Science Identity declined significantly in both school types. However, this negative association was more pronounced in public schools (slope = -0.15, $p < .001$) compared to private schools (slope = -0.12, $p = .014$).

Table 3. Results of the linear regression analysis using school grades as a predictor (independent variable) of Attitude and Identity Toward Science constructs (dependent variable) in the sample divided by type of school.

Attitude constructs	Type of school	N	Intercept	Slope	p
Enjoyableness	Public	941	4.36	-0.03	0.14
	Private	197	4.18	-0.03	0.49
Difficulty	Public	937	1.70	0.17	<0.001
	Private	197	1.60	0.26	<0.001
Self-efficacy	Public	938	3.90	-0.10	0.01
	Private	195	3.18	0.03	0.58
Relevance	Public	942	4.68	-0.08	<0.001
	Private	197	4.31	-0.06	0.14
Usability	Public	943	4.90	-0.12	<0.001
	Private	197	4.26	-0.06	0.17
Identity	Public	923	3.81	-0.15	<0.001
	Private	181	3.63	-0.12	0.014

3.4. Critical grade-level transitions in attitude toward science and science identity

To identify the grade levels at which the most substantial differences occur, regression analysis was supplemented with effect-size calculations (Cohen's d). This approach quantifies the magnitude and direction of differences at specific transitions by comparing mean scores for each construct between consecutive grade pairs. The effect size analysis revealed that the most pronounced differences were concentrated during the transition from primary to secondary education (Fig. 1). Specifically, a moderate but consistent lower mean score was observed during the transition from sixth to seventh grade for enjoyability ($d = -0.29$), relevance ($d = -0.27$), usability ($d = -0.44$), and science identity ($d = -0.31$). Notably, this pattern did not continue in the subsequent grade transition, which shifted in the opposite direction. When comparing seventh and eighth grade, positive differences were observed (indicating higher mean scores in the 8th-grade cohort) for enjoyability ($d = 0.27$), self-efficacy ($d = 0.34$), and science identity ($d = 0.27$).

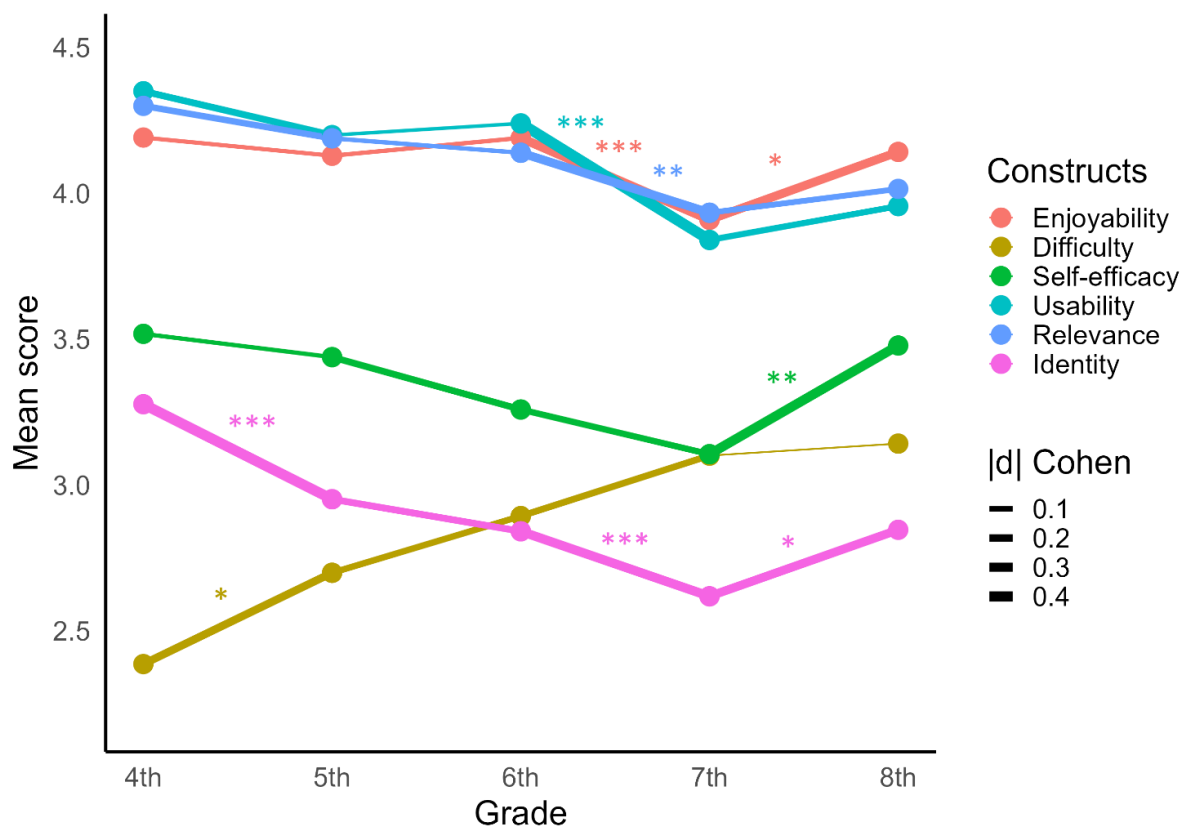


Figure 1. Line plot showing changes in mean construct scores across grade levels. Each colored line represents a construct. The thickness of each segment between consecutive grades is proportional to the absolute value of Cohen's d , indicating the magnitude of change. Asterisks denote significant differences between grades based on Student's t -tests: $*p < 0.05$; $**p < 0.01$; and $***p < 0.0001$.

4. Discussion

Our findings of this study contribute to the literature by indicating a non-linear association with school grades rather than a simple, continuous decline. Specifically, the cross-sectional data showed lower Attitudes Toward School Science and Science Identity scores at the transition to secondary education, followed by higher scores in the grade 8 cohort. In the following discussion, we explore plausible interpretations for this pattern, examining how these differences are moderated by gender and school type.

Our analysis reveals different grade-level patterns across the assessed constructs. Science Identity shows lower scores at an earlier stage (grades 4-5), while Attitudes Toward School Science constructs do not decline until the transition to secondary school (grades 6-7). These results are consistent with research that suggests disconnection from science occurs before the formal transition from primary to secondary education [6,55]. These early lower scores in Science Identity are explained by its relationship to self-concept, which can become more vulnerable in late primary school as social comparison begins to shape beliefs about one's abilities [56,57]. In contrast, constructs such as perceived usability of science, supported by social and familial discourses, may remain stable for longer, as they are less dependent on personal classroom performance.

The development of self-concept does not occur in isolation but interacts with family science capital [41]. Research indicates that identity is built not only on academic competence but also on a sense of belonging and recognition [21,58]. This interpretation is consistent with the observed positive correlations between Science Identity and the other constructs, suggesting that scientific identity is embedded within a broader network of motivational and attitudinal processes. Low scientific capital can generate a “cultural distance” that presents science as an alien field [41,59]. It is this distance that can transform a challenge of academic competence into a problem of identity, as the difficulty is interpreted as a sign of not belonging [23]. This mechanism may help explain the more pronounced decline of identity in the public system (Table 3), where family science capital may, on average, be lower. Therefore, the lack of symbolic resources at home may amplify the vulnerability of identity to academic difficulties [60].

Furthermore, these findings support research that school transitions represent critical periods for attitudinal shifts, influencing post-transition adaptation and interest in science [7]. Fontaine et al. [61] suggests that this transition may be the first significant challenge many young people face, testing their resilience. During this stage, young people construct identities based on their self-perceptions, the social roles they assume, the groups to which they belong, and their beliefs about how they are perceived by “generalized others.” The social norms encountered in secondary school directly influence this process of identity negotiation, particularly in STEM fields [37]. For girls, for example, social pressures can create a conflict in which a “feminine” identity may come into tension with a “scientist” or “engineer” identity.

The higher attitudinal score observed in eighth grade is a counterintuitive finding, as it suggests a non-linear pattern of differences that contrasts with the literature, which often documents continuous declines during school transitions [7,30]. Notably, this non-linear trend is not exclusive to the Mexican context; Potvin and Hasni [37] documented a similar attitudinal rebound during the early years of secondary education (grades 8-9) in Quebec, Canada, following the challenging transition from primary to secondary education. Nevertheless, this finding of elevated scores requires cautious interpretation. As we included only cohorts through eighth grade, we cannot determine whether this pattern persists or reverses in later grades. The explanations for these higher eighth-grade scores differ, highlighting an important distinction between educational systems. For example, the Canadian study attributed the observed rebound to specific external curricular and pedagogical changes. However, this explanation is not readily transferable due to structural differences between Anglo-Saxon and Latin American educational systems.

In contrast, our findings instead suggest a more transferable, internal mechanism, in which students adapt to the school system rather than renewed engagement with the scientific content of the curriculum. This recovery appears selective, emphasizing self-concept-related constructs such as self-efficacy and identity, but not constructs assessing the perceived value of content, including relevance and usability. Two complementary factors may explain this pattern. On the one hand, improvements in self-efficacy can be attributed to mastery experiences [62]. By overcoming the evaluative challenges of their first year in secondary school, students demonstrate competence in navigating the new academic environment, thereby strengthening their confidence regardless of whether the content is perceived as relevant. This interpretation aligns with George’s [9] distinction between attitudes toward “school science” and the “utility of science,” indicating that student adaptation occurs without the school necessarily improving its presentation of the discipline’s value.

On the other hand, the stabilization of the social environment may also contribute. By eighth grade, students have formed new peer support networks and adapted to teacher dynamics, which may facilitate coping with academic demands and reinforce motivation [63].

Given that we employed a cross-sectional design, the results should be interpreted with caution. Thus, it remains unclear whether the higher scores observed in the 8th-grade cohort reflect genuine developmental recovery or a cohort-specific fluctuation. Divergence from findings such as those of Lofgran et al. [30] further highlights the importance of examining the role of specific educational contexts. Therefore, longitudinal research in the region is necessary to track these trajectories and examine the interaction between student adaptation and the structural characteristics of school systems.

Our results indicate a non-gender-neutral pattern of differences in science, with girls and boys experiencing increased perceived difficulty and lower scores on usability and identity. However, the magnitude of this negative association is more pronounced for girls, revealing a gender gap in self-identification as “science people”. This finding aligns with international literature regarding girls’ vulnerability in constructs such as self-efficacy and interest [8,60]. The lack of gender differences in self-efficacy in other studies [48] suggests that these differences may become more evident as students advance into pre-adolescence.

Stereotype threat [64,65] provides one explanation for the decline in attitudinal outcomes observed in girls. During the high-demand transition to secondary school, latent stereotypes associating science with masculinity may be activated, a perception that has been shown to persist from childhood in the region [66]. Under this threat, performance may decline, and both self-efficacy and identification with the field can weaken [52]. These effects may be reinforced by the implicit biases of parents, teachers, and peers [60].

The similar attitudinal patterns observed between public and private schools challenge assumptions about the intrinsic superiority of the private education sector. This result aligns with research conducted in Latin America, which indicates that students’ socioeconomic backgrounds primarily influence cognitive achievement gaps between the two systems. When accounting for this factor, these gaps often diminish or disappear [67]. Likewise, our results show that key constructs such as Science Identity, Enjoyability, and perceived difficulty show similar patterns between the two school types. Our findings on the convergence in students’ Science Identity are consistent with regional research. For instance, when analyzing the appeal of scientific careers, Polino [68] found no significant differences between responses from students in public and private schools, suggesting that school type is not a determining factor in this vocational dimension. Similarly, the lack of difference in enjoyability and difficulty is consistent with the conclusion that the public-private distinction accounts for a minimal portion of the variance in attitudes toward school subjects after adjusting for contextual factors [67].

Collectively, the observed pattern of lower scores in both school systems suggests that, despite differences in resources, they may share a similar pedagogical culture that does not adequately promote positive Attitudes Toward School Science and Science Identity. This educational approach prioritizes the transmission of “science as a body of knowledge” rather than engaging students in scientific inquiry [47]. Consequently, it offers a narrow perspective on science by failing to address the creativity, argumentation, and uncertainty inherent in authentic scientific practice [69]. This disconnect may contribute to the decline in students’ scientific identity, as a lack of opportunities to “act like a scientist” limits their ability to envision themselves in that role [21].

5. Study limitations

Our findings of this study should be interpreted in light of several methodological limitations. First, the cross-sectional design, while effective for identifying patterns and differences across grade levels, does not allow for tracking individual developmental trajectories over time. While we propose plausible mechanisms of adaptation, we cannot definitively rule out potential cohort or survivor bias. Determining whether this pattern reflects an actual individual recovery process requires longitudinal research that follows the same students over time.

Second, although the sampling strategy was designed to ensure a diverse sample, schools' voluntary participation may introduce selection bias. Schools with a stronger interest in science education or greater administrative resources might have been more inclined to participate, and their characteristics may not fully represent all schools in the region.

Third, we used school type (public/private) as a proxy for socioeconomic status and science capital. While this is a common and helpful approach in large-scale educational research, particularly in Latin American contexts where these factors are highly correlated [67,70], it remains an indirect measure. This approach does not capture the socioeconomic heterogeneity that exists within each school system. Researchers would benefit from incorporating more direct measures of family socioeconomic status and science capital to provide a more nuanced analysis of their influence [41].

Finally, all Attitudes Toward School Science and Science Identity constructs were measured using self-report instruments. In the instrument used for this study, we adapted the original wording of the items to refer specifically to natural sciences rather than science in general. While these scales demonstrated strong psychometric properties, self-report measures remain susceptible to social desirability biases [71]. In future studies, researchers could complement these findings with alternative assessment methods, such as observational data of classroom engagement or performance-based tasks, to provide a more comprehensive understanding of student engagement with science.

6. Conclusions

Young people's engagement with science follows a complex, non-linear trajectory, marked by key transitions and shaped by factors such as gender and school context. Our central finding reveals that the separation between Science Identity and Attitudes Toward School Science is fragile, with lower identity scores evident in primary school, before attitudes begin to decline at the transition to secondary school. This suggests that many students, particularly girls and those attending public schools, enter secondary school science classes with an already diminished sense of belonging and identification with science.

These findings highlight the need to consider demographic and educational inequalities when studying students' engagement with science in Mexico. The observed differences by sex and school type indicate that the transition to secondary education does not affect all students equally; rather, it interacts with broader social and institutional factors that may reinforce exclusion from science-related pathways. In this sense, our study contributes to the international literature by showing how the decline in science engagement is shaped by educational and social contexts characteristic of Latin American systems.

This decoupling between Science Identity and Attitudes Toward School Science also calls for

differentiated intervention strategies. Efforts to protect science identity must begin earlier, during upper primary school, to foster competence and a sense of belonging before the demands of a more formal curriculum and social comparison take hold. Furthermore, the finding that a shared, transmissive pedagogy may undermine Science Identity across both school systems reveals a key insight: Fostering Science Identity is a different challenge than improving attitudes. Supporting identity development may therefore require a more substantial pedagogical shift toward inquiry-based and participatory approaches that enable students to actively “do” science rather than passively receive scientific information.

Finally, the higher attitudinal scores observed in eighth grade, whether reflecting adaptation or a selection effect, highlight the limitations of cross-sectional designs. Confirming these trajectories and identifying the mechanisms of resilience requires longitudinal tracking of student cohorts. Understanding not only what drives disconnection but also how and why some students “reconnect” is essential for designing educational systems that foster equitable and lasting scientific engagement.

Author contributions

Angélica Perea: Data curation, Formal analysis, Investigation, Validation, Visualization, Writing -review & editing. Eugenio Leyva-Figueroa: Data curation, Formal analysis, Investigation, Validation, Visualization, Writing -review & editing. Ulises Bardullas: Conceptualization, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing -original draft, Writing -review & editing

Use of Generative-AI tools declaration

The authors declare they have used Artificial Intelligence (AI) tools in the creation of this article. AI tools used: Grammarly & Gemini 3.0

The authors used these tools to refine the English writing, improve grammatical accuracy, and enhance the overall stylistic flow of the manuscript. This process was undertaken because none of the authors' native languages is English. The authors reviewed and edited the suggestions provided by the AI tools and take full responsibility for the final content and the integrity of the article.

Conflict of interest

The authors report there are no competing interests to declare.

Ethics declaration

We obtained all data used in this study with informed consent. The study was under the Ethical Code of the Institution and approved by the Research Ethics and Evaluation Committee with registration number CEEIP/23-09-01.

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