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Comparing the Impact of Non-Cognitive Skills in STEM and Non-STEM Contexts in Kazakh Secondary Education

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Abstract: The role of non-cognitive skills in academic achievement has garnered increasing attention in educational research. This study explores the impact of non-cognitive skills on academic achievement in STEM and non-STEM subjects in secondary education. Survey data from 795 teachers and 12,965 students across 20 STEM schools in Kazakhstan were analyzed to examine the impact of 26 non-cognitive skills on performance in math, physics, first language, and history. Regression and mediation analyses were conducted to investigate how students' self-assessment of non-cognitive skills directly affects academic achievement and how these effects are mediated by teachers' assessments. The findings indicate that non-cognitive skills exhibit varying direct and total effects, with mediated effects showing greater consistency across different subjects. In math and physics, information processing skill and grit show the strongest direct and total effects on academic achievement. In first language and history, responsibility management and teamwork skill are most influential. Except for capacity for optimism and growth mindset, all skills demonstrated mediated effects across the four subjects. This research informs curriculum development and equitable policies by showing how non-cognitive skills impact academic performance across subjects. It studies the case of Kazakhstan, adding to global education discourse and offering valuable insights for enhancing STEM education.

Keywords: non-cognitive skills; secondary education; STEM; student self-assessment; teacher assessment; academic achievement; direct effects; mediated effects; mediation analysis; Kazakhstan

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1. Introduction

The role of non-cognitive skills in academic achievement has garnered increasing attention in educational research. Often labeled "generic competence," "life skills," "21st century skills," and similar terms [1], these attributes go beyond conventional cognitive abilities. They comprise a varied spectrum of personal attributes, social skills, and character traits that impact an individual's capacity to learn and excel in academic environments [2–4]. Understanding the impact of non-cognitive skills is particularly important in secondary education [2,3], where students' academic trajectories are significantly influenced by their ability to manage and apply these skills effectively. Since different skill sets are mastered in distinct contexts, the differentiation between STEM (science, technology, engineering, and mathematics) and non-STEM subjects is crucial for developing appropriate learning approaches and assessment tools. STEM subjects typically emphasize analytical thinking and problem-solving, while non-STEM subjects may place greater importance on creativity and communication skills [5].

Although non-cognitive skills complement traditional cognitive abilities and play a significant role in shaping students' educational outcomes, research exploring their impact across different subject areas remains limited [6–9]. This study addresses this gap by examining a comprehensive array of 26 non-cognitive skills and their direct, mediated, and total effects on academic achievement in both STEM (math, physics) and non-STEM (first language, history) subjects. The study utilizes an existing framework of non-cognitive

skills developed for the national STEM schools in Kazakhstan. Therefore, the justification for including this specific set of non-cognitive skills and their distribution across domains is beyond the scope of this research. The data were collected from a large-scale survey involving 795 teachers and 12,965 students across 20 STEM secondary schools. Using regression and mediation analyses, this study explores how student self-assessment directly affects academic achievement in four subjects and how these effects are mediated by teachers' assessments. The findings reveal significant direct and total effects depending on the subject, with mediated effects being more consistent. In math and physics, information processing skill and grit show the strongest effects on academic achievement. In first language and history, responsibility management and teamwork skill are most influential. Notably, all skills except for capacity for optimism and growth mindset demonstrated mediated effects across four subjects.

The practical implications of this research are manifold. For educators, insights from this study can inform curriculum development and teaching strategies that integrate non-cognitive skill enhancement tailored to specific subjects. For policymakers, the findings provide evidence to support the creation of equitable educational policies that foster comprehensive skill development, addressing the unique needs of students in diverse academic domains. This study also contributes to the theoretical understanding of how non-cognitive skills interact with academic performance, offering a nuanced view of their direct and mediated effects across different subject areas. The context for this research is Kazakhstan, a country undergoing significant educational transformation, particularly in its specialized STEM schools [10]. Despite the national focus on STEM education, there is limited international research on how non-cognitive skills impact academic outcomes in this region [11]. Therefore, this study provides insights into a previously under-researched area by investigating how these skills influence academic success within Kazakhstan's STEM education. By investigating these dynamics within Kazakhstan, this study provides an additional perspective to the global discourse on education and offers valuable guidance on enhancing educational practices, particularly in STEM education settings.

1.1. Non-Cognitive Skills and Academic Achievement

Non-cognitive skills play a vital role in determining academic achievement, often complementing [6,9] and sometimes surpassing [5,12] the importance of cognitive abilities. While cognitive skills such as intelligence and academic knowledge are crucial for learning, non-cognitive skills encompass a range of intrinsic attributes and social–emotional competencies, which significantly impact educational outcomes [13–15]. Perseverance and grit enable students to persist through difficulties and setbacks, promoting a growth mindset that fosters continuous improvement [13–16]. Motivation drives students' desire to learn, leading to active engagement in the learning process and higher achievement levels [17]. Longitudinal studies, such as those by [18], indicate that children with higher levels of self-control achieve superior academic outcomes, even when accounting for cognitive abilities. Self-control and impulse regulation improve time management and goal-setting, which are essential for effective studying and task completion [17]. Additionally, non-cognitive skills foster adaptability, creativity, and critical thinking, empowering students to tackle complex problems and excel in higher education and future careers [17,19].

Non-cognitive skills also enhance social and emotional competencies, fostering positive relationships with peers and teachers. Effective communication, empathy, and cooperation facilitate collaborative learning, group projects, and overall classroom engagement [13,14]. Furthermore, emotional regulation and stress management help students cope with academic pressures, leading to improved focus and overall well-being [17,20]. These skills also contribute to better classroom behavior, increased attendance rates, and reduced dropout rates [13,14]. Beyond merely following rules, they shape how students interact with teachers and peers, manage emotions, respond to challenges, and participate in classroom activities [20]. Research examining the impact of peers' non-cognitive traits on individual learning outcomes identified a significant positive relationship between average

peer conscientiousness and academic performance [21]. Furthermore, the quality of the student–teacher relationship was found to indirectly influence mathematics achievement by mediating anxiety, suggesting that interventions aimed at improving this relationship could help prevent math anxiety and enhance mathematics learning [22]. These findings highlight the potential benefits of school-wide programs aimed at developing non-cognitive skills and enhancing student–teacher relationships to improve academic performance and reduce anxiety.

Understanding the development of non-cognitive skills underscores the pivotal role of teachers. Research consistently demonstrates that teachers wield significant influence over both the academic and non-cognitive development of their students. Studies show that teachers have a notable impact on various non-cognitive aspects of student performance, reflected in measurable outcomes like absences, suspensions, grades, and timely progression through grades [23]. Although the precise mechanisms by which teachers shape these non-cognitive skills remain unclear, their impact is undeniable. A study by [24] further supports this notion, showcasing teachers' crucial role in shaping students' motivation, as seen in mastery and performance achievement goals. Similarly, ref. [25] highlights the significant effect teachers have on student attendance patterns. Collectively, these findings underscore the multifaceted influence teachers have on student development.

Acknowledging the crucial role of non-cognitive skills in fostering long-term academic and life success, educators and policymakers should prioritize their incorporation into educational curricula. By nurturing these skills alongside cognitive abilities, schools can foster the growth of well-rounded individuals who are better prepared to excel academically and thrive outside the classroom [13,14,17]. Efforts have been made to promote the development of non-cognitive skills in secondary education [9,26], including in schools that naturally emphasize cognitive abilities, such as STEM schools.

1.2. Non-Cognitive Skills in STEM Secondary Education

Traditionally, STEM education has predominantly focused on cognitive abilities, prioritizing intellectual aptitude and problem-solving prowess. However, recent research highlights the pivotal role of non-cognitive skills as key determinants of academic success across various disciplines, including STEM [27–32]. While cognitive abilities such as analytical thinking and problem-solving remain essential, non-cognitive skills encompass a diverse range of attributes that significantly contribute to achievement in STEM fields [5,17]. These skills enable students to persevere through challenges, maintain concentration during complex problem-solving tasks, and navigate complex concepts effectively. Productive collaboration is integral to scientific research and engineering projects, making teamwork a vital non-cognitive skill [33]. Likewise, effective communication is critical for knowledge sharing and innovation, whereas creativity fosters the generation of novel ideas and breakthroughs in STEM [34]. Self-regulation skills, including time management and goal-setting, are also fundamental for effective learning in STEM disciplines [35]. A review of 79 publications identified 243 specific STEM skills and competence, which were classified into eight core STEM skills: collaboration, problem-solving, innovation and creativity, critical thinking, disciplinary skills, self-regulation, communication, and metacognitive skills [5,33].

Effective STEM teaching requires a balance between cognitive and non-cognitive learning goals, ensuring that both aspects are integrated into classroom activities and standards-oriented teaching practices, as demonstrated by educational reforms in Germany and elsewhere [36]. By explicitly integrating instruction and support for non-cognitive skills within STEM curricula, teachers can create a learning environment that nurtures both cognitive and non-cognitive abilities [37]. Implementing targeted interventions such as project-based learning, collaborative activities, and opportunities for student choice and voice can further cultivate non-cognitive skills while promoting deep engagement and understanding of STEM concepts [13,38]. A meta-analysis of 66 studies on project-based learning over the past 20 years, using 190 effect values, found that project-based

learning significantly enhances students' academic achievement, affective attitudes, and thinking skills compared to traditional teaching methods [39]. In contrast, non-STEM subjects often place a greater emphasis on developing non-cognitive skills due to their inherent nature. Disciplines such as the arts, humanities, and social sciences frequently nurture attributes like creativity, empathy, and effective communication [40]. These subjects encourage students to engage deeply with diverse perspectives and express their ideas through various mediums, fostering skills such as critical thinking, collaboration, and self-expression [41]. The context of non-STEM subjects inherently supports the development of non-cognitive skills by promoting reflective and communicative activities, allowing students to refine their emotional intelligence and interpersonal skills, which are crucial for holistic development and academic success in these fields [42].

In summary, while cognitive skills are essential for academic success, non-cognitive skills are equally critical, particularly in secondary STEM education. By incorporating non-cognitive skills into STEM education, educators can greatly enhance students' learning experiences. Leveraging the strengths of non-STEM disciplines helps create a more balanced educational approach that supports both cognitive and non-cognitive development. Integrating lessons from non-STEM fields into STEM curricula equips students with the diverse skills necessary to drive innovation and contribute meaningfully to scientific and technological progress. Therefore, nurturing non-cognitive skills within STEM education is essential for developing well-rounded students who can excel in a complex and rapidly changing world.

1.3. Measuring the Impact of Non-Cognitive Skills

Recognizing the critical role of non-cognitive skills in fostering students' holistic development and success, educators and policymakers have increasingly integrated programs and strategies to cultivate these skills alongside traditional academic instruction. They have had to make decisions about frameworks, tools, and methods for assessing non-cognitive skills and measuring their effects on academic achievement in education [13,15,43]. As a result, there has been a growing emphasis on developing comprehensive assessment approaches that capture the multifaceted nature of non-cognitive skills and their impact on students' learning outcomes.

Several frameworks have been established to focus on non-cognitive skills, offering essential tools for understanding and nurturing these skills in secondary education. The Behavioral and Emotional Skills for Success Index (BESSI) is a comprehensive framework designed to assess non-cognitive skills in students, including components like self-management, social awareness, and responsible decision-making [44]. The BESSI provides teachers with a structured approach to develop these skills, promoting supportive learning environments. The Collaborative for Academic, Social, and Emotional Learning (CASEL) enhances social and emotional competence among students, offering guidelines and resources to support the integration of SEL in schools and districts [45]. The Ecological Approaches to Social Emotional Learning (EASEL) emphasizes the impact of diverse settings on social–emotional development, highlighting the importance of relationships, cultural responsiveness, and integrating social–emotional learning across school, home, and community settings [3].

Assessing non-cognitive skills involves multiple methods to evaluate personal attributes, social skills, and character traits that contribute to academic success. Student self-assessment encourages reflection on personal strengths and areas for improvement, fostering metacognitive awareness and a growth mindset [5]. Teacher assessments, based on classroom observations, provide insights into students' behaviors and social–emotional development [46], while peer assessments enhance collaborative learning and empathy by having students evaluate each other's skills [21,47]. Parent or guardian feedback offers a broader perspective on students' behavior outside school, contributing to a holistic understanding [48]. Combining these assessment methods provides a comprehensive view of students' non-cognitive skills, leading to more effective personalized interventions

and support strategies [48]. Research endorses this integrated approach, showing that combining self-assessment with teacher evaluations offers a more nuanced and accurate understanding of students' non-cognitive abilities than relying on self-assessment alone. According to [49], teacher reports are the most predictive of behavioral outcomes in school, followed by child self-reports and then guardian reports.

Non-cognitive skills significantly impact academic achievement through both direct and indirect influences, reflecting their complex contribution to student success. Direct effects include improvements in study habits and productivity, with self-discipline, perseverance, and time management directly enhancing academic performance [50]. Research by [51] highlights how self-regulation skills, such as time management and goal-setting, bolster organizational competence and punctuality, particularly in STEM fields [51]. Academic self-efficacy and motivation also play crucial roles, with high self-control levels correlating with better academic outcomes [18,52]. Social and emotional skills like communication and empathy further contribute to success, fostering positive learning environments [13,14]. The concept of grit, defined by perseverance and commitment, has been shown to be a stronger predictor of academic performance than IQ [16,53]. Indirect effects involve mediating factors such as motivation and self-efficacy, which enhance goal-setting and persistence, thereby improving academic outcomes [54,55].

In summary, measuring the impact of non-cognitive skills is essential for fostering students' holistic development and enhancing academic success. The integration of frameworks such as BESSI [44], CASEL [45], and EASEL [3] provides structured approaches to assessing and nurturing these skills, offering valuable tools for educators. Utilizing a range of assessment methods—including student self-assessments, teacher evaluations, peer feedback, and parental insights—enables a comprehensive understanding of students' non-cognitive abilities. This multifaceted approach reveals the significant direct effects of skills like self-discipline and self-regulation on academic performance, as well as their indirect impact through factors such as motivation and self-efficacy. Research underscores the value of addressing both direct and indirect influences of non-cognitive skills through personalized interventions, ultimately optimizing educational practices and promoting overall student success.

1.4. Research Questions and Hypotheses

The existing literature highlights the importance of non-cognitive skills in improving academic performance. However, research specifically examining their impact in STEM versus non-STEM education remains limited. Additionally, there is a noticeable gap in exploring non-cognitive skills within the unique educational context of Kazakhstan. To address these gaps, this study aims to explore the differences in how non-cognitive skills assessed by students and their teachers influence academic achievement in both STEM and non-STEM subjects. It examines: (1) the variation in the direct effect of students' self-assessment on academic performance across these subjects, (2) the differences in the mediated effect of teachers' assessment on student achievement between STEM and non-STEM fields, and (3) the disparity in the total effect of student self-assessment on academic outcomes in these areas. Based on prior research and theoretical frameworks, the study hypothesizes that (1) there is a difference in the direct impact of students' self-assessment of non-cognitive skills on academic achievement between STEM and non-STEM subjects, (2) there is a difference in the mediated effect of teachers' assessment on academic achievement across these subjects, and (3) there is a difference in the total effect of students' self-assessment on academic achievement between STEM and non-STEM subjects. By empirically testing the hypotheses and employing various analytical methods, the study seeks to enhance the understanding of non-cognitive skills' influence on academic success in STEM secondary education, offering practical insights for educators and policymakers.

2. Materials and Methods

This section outlines the research design and methodology, including the context of Kazakhstan, the conceptual framework, participant selection, data collection procedures, and data analysis methods, to explore the impact of non-cognitive skills on academic achievement in both STEM and non-STEM subjects.

2.1. Context of the Study

STEM schools are becoming increasingly popular in transition economies [56]. Kazakhstan is deeply invested in fostering innovation through the development of STEM schools in secondary education [10]. This strategic focus highlights the nation's commitment to enhancing STEM education by nurturing critical thinking, creativity, and problem-solving skills essential for technological and scientific progress. By advancing STEM schools, Kazakhstan aims to prepare its students with the expertise and capabilities needed to make significant contributions in a rapidly evolving global landscape [57]. Emphasizing non-cognitive skills ensures that students are not only technically proficient but also capable of thriving in diverse and collaborative environments. This focus on developing well-rounded graduates aligns with Kazakhstan's broader educational goals, creating an inclusive and culturally sensitive learning environment that enhances students' global competitiveness and career readiness in STEM fields.

Kazakhstan's educational reforms have drawn heavily on international experiences to align with global standards. The country has studied the educational systems of OECD nations, particularly Finland, to adopt student-centered approaches and inquiry-based learning, while Singapore's focus on STEM education and practical industry partnerships has informed Kazakhstan's push to produce a highly skilled, technology-ready workforce [57]. Partnerships with Cambridge University have been instrumental in reforming STEM curricula, incorporating rigorous assessments and critical thinking methodologies [58]. Additionally, Kazakhstan's engagement with the International Baccalaureate program and the Bologna Process has supported efforts to integrate non-cognitive skills, global-mindedness, and educational comparability. Influences from the United States and East Asian education systems, particularly in fostering innovation and resilience in STEM subjects, have further shaped the nation's commitment to holistic student development [58].

To investigate the impact of non-cognitive skills on academic achievement in secondary education, a group of educators from the national STEM schools developed a theoretical framework encompassing 26 non-cognitive skills organized into four domains [11]. The rationale for selecting specific non-cognitive skills for both student self-assessment and teacher assessments is grounded in the development of a national framework initiated in 2018. This involved a comprehensive study of international practices and the adaptation of frameworks such as BESSI [44], CASEL [45], and EASEL [3] to the cultural context of Kazakhstan through a two-stage approbation process prior to 2023. This process included statistical analyses that validated the inclusion of 26 skills and their distribution across four domains within the national framework. The dual approach of using both self-reported and teacher-assessed data enhances the validity of the study by offering a multidimensional assessment of non-cognitive skills and their impact on academic achievement [49]. By exploring the interplay between skills and performance, this research aims to enhance the understanding of the multifaceted factors influencing student success in STEM education using large-scale data.

2.2. Conceptual Framework

The conceptual framework for this study aims to provide a comprehensive understanding of how non-cognitive skills influence academic achievement in both STEM and non-STEM subjects. By examining the direct and mediated effects of student self-assessment and teacher assessment of non-cognitive skills, this framework seeks to elucidate the specific pathways through which these skills impact educational outcomes. This approach facilitates a comparison of effects across different subject areas, which is essential for testing

hypotheses about the differing impacts of non-cognitive skills in various academic contexts. Utilizing both regression and mediation analyses, the framework ensures the validity and reliability of the findings, offering robust evidence for educational policy and practice. Figure 1 illustrates the relationships between variables within the theoretical model.

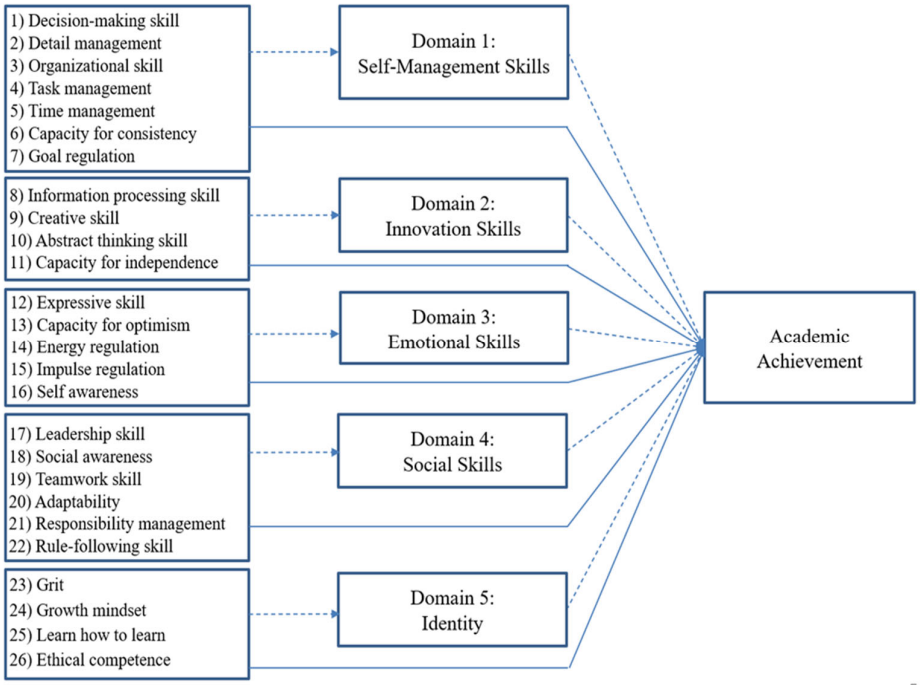

Figure 1. Theoretical model.

To enhance comprehension, the previously organized four domains, including one with two subdomains, were restructured into five distinct domains. This study focused on 26 non-cognitive skills categorized into five domains: Domain 1, self-management skills (7 skills); Domain 2, innovation skills (4 skills); Domain 3, emotional skills (5 skills); Domain 4, social skills (6 skills); and Domain 5, identity (4 skills). These skills were assessed using a comprehensive survey comprising 180 questions adapted from validated instruments. To alleviate the burden on teaching staff, who were required to assess each student individually, the teacher survey was designed to focus on non-cognitive skills at the domain level. Student self-assessment and teacher assessment scores of these skills are key independent variables used to explore their impact on academic achievement, encompassing performance in two STEM subjects, i.e., math and physics, and two non-STEM subjects, i.e., first language and history. This study explored three primary relationships: (1) the direct impact of students' self-assessment of non-cognitive skills on academic achievement in STEM versus non-STEM subjects, (2) the mediated impact of teachers' assessments of these skills on the relationship between student self-assessment and academic achievement across STEM and non-STEM subjects, and (3) the total effect of students' self-assessment of non-cognitive skills on academic achievement in both STEM and non-STEM subjects.

2.3. Participants and Data Collection

The sampling method employed in this study was purposive sampling with a criterion-based variable, where all students from grade 7 to grade 12 at the selected schools were surveyed. Following [59], this approach was chosen to ensure that the sample met specific criteria relevant to the research objectives, specifically focusing on students within a particular educational stage. By involving every student within these grades, the study aimed to comprehensively examine the influence of non-cognitive skills on academic achievement across different stages of secondary education.

Before integrating and generalizing the selected survey items, a pilot study was conducted with a limited sample of students to consider the broader context of the national STEM schools' population. This initial sample comprised 1565 students (56.5% boys and 43.5% girls), with an average age of 15.73 years (ranging from 13 to 19). The pilot study aimed to assess the clarity and comprehensibility of the survey items and to identify any potential ambiguities or issues in data collection. Data were gathered from students in grades 7 to 12 across three diverse STEM schools. Based on the pilot study analysis, necessary revisions were made to enhance the survey's clarity and ensure accurate capture of the intended constructs. By adapting validated survey items, the study leveraged existing research and validation efforts, instilling confidence in the reliability and validity of the data collection tool. Subsequently, the survey was rolled out across all 21 national STEM schools.

The survey data were collected during November 2023. To accommodate participants' linguistic preferences, the survey was offered in both Kazakh and Russian languages. Students answered 180 questions to assess their own skills, i.e., 6 to 18 questions per skill, using a Likert scale (4-, 5-, and 6-point). The 6 items were measured on reversed 5-point Likert scales (1 is "highest, best" and 5 is "lowest, worst") and then recoded to have an expected positive relationship with grades. The 26 non-cognitive skills of students were assessed by teachers using a 9-point Likert scale (1 is "lowest, worst" and 9 is "highest, best"). Teachers answered 5 questions at the domain level to assess whether a student uses self-management (Domain 1), innovation (Domain 2), emotional (Domain 3), social (Domain 4), and identity (Domain 5) skills to effectively pursue goals and complete tasks. The survey involved teachers teaching math, English, and first language. This research adhered to ethical guidelines for research involving human participants. Both students and teachers were briefed on the study's objectives, i.e., aiming to uncover the impact of non-cognitive skills on academic achievement. Informed consent was obtained from all participants, and data collection procedures ensured anonymity and confidentiality.

At the end of December 2023, marking the conclusion of the first half of the 2023–2024 academic year, academic achievement data for students were obtained from school records. Achievement was measured by grades from internal assessments in four subjects: math and physics (STEM subjects) and first language and history (non-STEM subjects). Participants enrolled in the same programs had completed identical assessment tasks relevant to their respective grade levels. Survey data were collected from 13,640 students across 21 schools, but comparable academic achievement data were available for only 20 of these schools. Consequently, regression and mediation analyses to assess the impact of non-cognitive skills on academic achievement were conducted using data from the schools with complete achievement information. The final sample comprised 12,965 students (55.4% boys and 44.6% girls), with a mean age of 15.92 years (ranging from 13 to 19) and distributed across grades as follows: grade 7—2172 (16.75%), grade 8—2176 (16.78%), grade 9—2419 (18.66%), grade 10—2336 (18.02%), grade 11—2269 (17.50%), and grade 12—1593 (12.29%). This comprehensive sampling across different grades and schools provided a robust dataset for analysis, offering valuable insights into the targeted constructs within the STEM educational framework.

2.4. Procedures and Data Analysis

The analysis of survey data was conducted in four steps. First, two instruments for data collection were validated: inter-rater reliability was employed for the teacher survey, and factor analysis was used for the student survey. While exploratory factor analysis (EFA) was utilized to identify 26 non-cognitive skills as underlying factors from the survey data consisting of 180 student responses, confirmatory factor analysis (CFA) was conducted to validate these identified factors [60]. Second, regression analysis, a common method in educational research [9,16], was run for each of the four STEM subjects to explore the direct effects of students' non-cognitive skills on academic achievement. Third, mediation analysis was performed to investigate the indirect impacts of these skills on academic

achievement. Finally, the total effect was calculated as the sum of the direct effect and the indirect effect.

Mediation analysis is a statistical method used to understand the mechanism through which an independent variable influences a dependent variable via a third variable, known as the mediator [61]. Considering multiple perspectives that are often in implicit disagreement, this method has become a widely used approach in psychology [62]. In educational research, mediation analysis helps identify how and why certain educational practices or interventions affect student outcomes, providing deeper insights into the causal pathways involved [63].

Since survey data were collected using different tools, the scores from both student self-assessment and teacher assessment were standardized. This involved transforming the scores into z-scores, ensuring a mean of zero and a standard deviation of one across all metrics. This step enabled direct comparison and integration of data across scales and metrics.

Data analysis was conducted using R version 4.3.3, a powerful and versatile software environment for statistical computing and graphics. Specifically, EFA and CFA were performed using the "psych" and "lavaan" packages, respectively. These packages provide comprehensive tools for conducting robust factor analyses, allowing for the identification and validation of underlying constructs in the data [64,65]. For regression analysis and mediation analysis, the "lm" function and the "mediation" package were utilized. The "lm" function facilitates straightforward linear regression modeling, while the "mediation" package offers advanced capabilities for assessing indirect effects and conducting rigorous mediation analyses. This methodological approach is supported by [66], who highlight the efficacy of R in performing complex statistical analyses, underscoring its applicability and effectiveness in psychological research.

3. Results

In this section, the findings from the data analysis are presented, encompassing descriptive statistics, instrument validation, and the outcomes of regression and mediation analyses to evaluate the impact of non-cognitive skills on academic achievement.

3.1. Descriptive Statistics

The descriptive statistics of the student survey data are outlined in Table 1. Each of 26 non-cognitive skills is individually examined to provide a comprehensive understanding of its distribution and characteristics within the studied population. This detailed analysis illuminates the diverse array of non-cognitive traits and the prevalence of each among the participants, contributing valuable insights to the present research on this crucial aspect of student development.

Most skill scores range between 3.5 and 4, indicating a moderate to high level of self-assessment among students. Notably, grit and capacity for optimism exhibit lower average scores, while growth mindset stands out with a significantly higher average score of 4.45. The standard deviations vary among the skills, with rule-following skill demonstrating the least variability and ggrowth mindset showing the most. The median score for most skills is 4; however, grit and capacity for consistency are lower, with median scores of 3. Overall, students generally rate themselves positively on most non-cognitive skills, with significant exceptions such as grit and capacity for optimism.

Table 1. Descriptive statistics—student survey.

Skill	No. of Questions	No. of Responses	Mean	Std. Dev.	Median
Decision-Making Skill	6	77,790	3.702	1.020	4
Detail Management	6	77,790	3.543	1.068	4
Organizational Skill	6	77,790	3.849	1.070	4
Task Management	6	77,790	3.372	1.107	3
Time Management	6	77,790	3.619	1.147	4
Capacity for Consistency	6	77,790	3.335	1.081	3
Goal Regulation	6	77,790	3.760	1.040	4
Information Processing Skill	6	77,790	3.664	1.053	4
Creative Skill	6	77,790	3.672	1.073	4
Abstract Thinking Skill	6	77,790	3.736	1.116	4
Capacity for Independence	6	77,790	3.800	0.990	4
Expressive Skill	6	77,790	3.533	1.190	4
Capacity for Optimism	9	116,685	3.164	0.779	3
Energy Regulation	6	77,790	3.924	0.990	4
Impulse Regulation	6	77,790	3.730	1.055	4
Self-Awareness	6	77,790	3.895	0.971	4
Leadership Skill	6	77,790	3.899	1.012	4
Social Awareness	6	77,790	3.598	1.156	4
Teamwork Skill	6	77,790	3.498	1.148	3
Adaptability	6	77,790	3.652	1.088	4
Responsibility Management	6	77,790	3.519	1.118	4
Rule-Following Skill	9	116,685	3.186	0.754	3
Grit	10	129,650	2.855	1.224	3
Growth Mindset	8	103,720	4.453	1.417	5
Learn How to Learn	18	233,370	3.825	1.066	4
Ethical Competence	6	77,790	3.835	1.030	4

The descriptive statistics of the teacher survey data provide valuable insights into the distribution and variability of the ratings for the five questions (Q1–Q5) assessing non-cognitive skills of 12,965 students (Table 2). The mean scores for the questions ranged from 7.07 (Q1) to 7.37 (Q5), indicating generally high ratings. The median scores were slightly higher, ranging from 7.33 to 7.50, suggesting that half of the ratings were above these values. The mode for most questions was 8, except for Q1, where it was 7, reflecting the most frequently given scores. The standard deviations ranged from 0.96 (Q3) to 1.12 (Q1), showing moderate variability in the ratings. Correspondingly, the variances ranged from 0.93 (Q3) to 1.24 (Q1). The minimum and maximum ratings spanned from 1.33 to 9.00, highlighting the full range of the Likert scale used. The ranges for the questions were between 6.67 and 7.67, with Q3 having the smallest range and Q1 the largest. The interquartile ranges (IQRs) were close, from 1.33 to 1.67, indicating that the middle 50% of the data points were relatively close. The skewness values were negative, between −0.59 (Q1) and −0.77 (Q5), showing a slight leftward skew, implying that most ratings were clustered towards the higher end. The kurtosis values, ranging from 0.20 (Q1) to 0.66 (Q5), suggest that the distributions are relatively flat, indicating light tails. Overall, the

descriptive statistics suggest that teachers tended to rate students highly on non-cognitive skills, with moderate variability and slight left skewness.

Table 2. Descriptive statistics—teacher survey.

	Question 1	Question 2	Question 3	Question 4	Question 5
Mean	7.07	7.17	7.33	7.31	7.37
Median	7.33	7.33	7.33	7.33	7.50
Mode	7.00	8.00	8.00	8.00	8.00
Std. Dev.	1.12	1.03	0.96	1.02	1.01
Variance	1.24	1.06	0.93	1.03	1.03
Min	1.33	2.00	2.33	2.00	2.00
Max	9.00	9.00	9.00	9.00	9.00
Range	7.67	7.00	6.67	7.00	7.00
IQR	1.67	1.50	1.33	1.33	1.33
Skewness	−0.59	−0.60	−0.70	−0.69	−0.77
Kurtosis	0.20	0.26	0.53	0.50	0.66

The descriptive statistics of the teacher survey data provide a comprehensive overview of the ratings for non-cognitive skills, revealing generally high mean scores. Although most ratings were positive, there were some variations in individual assessments. The observed moderate variability supports the robustness of the collected data.

3.2. Instrument Validation

The following section delves into the thorough process of instrument validation, focusing on the rigorous methods employed to ensure the reliability and validity of the surveys used to assess non-cognitive skills.

3.2.1. Student Survey

To assess the internal consistency of the measurement scale used in the student survey to evaluate non-cognitive skills, Cronbach's alpha (α) and McDonald's omega (ω) analyses were conducted. Cronbach's alpha measures the average correlation among items, indicating how closely related they are as a group, while McDonald's omega accounts for the factor structure and provides a more accurate reliability estimate in some cases [67]. The reliability coefficients for the various domains ranged from 0.92 to 0.97. The α and ω coefficients, both 0.99, surpassed the suggested threshold of 0.70 [67], demonstrating strong internal consistency and reliability of the measurement instrument.

EFA was performed on the selected non-cognitive skill variables to uncover the underlying factor structure. Prior to conducting the analysis, the suitability of the data for factor analysis was verified through the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy, which yielded a value of 0.99, indicating that the data were highly suitable for factor analysis [68]. Additionally, Bartlett's test of sphericity was statistically significant ($\chi^2(16{,}110) = 1{,}687{,}061$, $p < 0.001$), further confirming the factorability of the data [69]. The positive determinant of the correlation matrix (1.095811×10^{-54}) suggested that the factor analysis was likely to proceed without computational issues [70].

The number of factors to extract was determined using multiple methods, including the Kaiser–Guttman criterion (Eigenvalue ≥ 1), scree plot, and parallel analysis [71,72]. Based on these approaches, 26 factors were extracted, explaining 64.1% of the total variance. Table 3 presents the factor analysis outcomes, showing the initial 26 extracted factors and the eigenvalue threshold of 1 supporting the extraction of 26 factors.

Table 3. Exploratory factor analysis results—student survey.

Component	Eigenvalues	Percentage of Variance	Cumulative Percentage	Pred.eig	Optimal Component
1	59.535	0.331	0.331	5.835	
2	5.803	0.032	0.363	5.672	
3	5.641	0.031	0.394	4.823	
4	4.797	0.027	0.421	4.058	
5	4.036	0.022	0.443	3.510	
6	3.491	0.019	0.463	2.591	
7	2.577	0.014	0.477	2.437	
8	2.424	0.013	0.491	2.334	
9	2.321	0.013	0.503	2.098	
10	2.087	0.012	0.515	2.014	
11	2.003	0.011	0.526	1.878	
12	1.868	0.010	0.537	1.806	
13	1.796	0.010	0.547	1.765	
14	1.756	0.010	0.556	1.587	
15	1.578	0.009	0.565	1.494	
16	1.486	0.008	0.573	1.421	
17	1.413	0.008	0.581	1.373	
18	1.366	0.008	0.589	1.352	
19	1.345	0.007	0.596	1.288	
20	1.281	0.007	0.603	1.231	
21	1.225	0.007	0.610	1.187	
22	1.180	0.007	0.617	1.160	
23	1.154	0.006	0.623	1.111	
24	1.105	0.006	0.629	1.060	
25	1.054	0.006	0.635	1.007	
26	1.002	0.006	0.641	0.984	(<OC)

From the analysis, factors emerged to represent a subset of the 26 non-cognitive skills previously identified within the framework. For each skill, Cronbach's alpha (α) and Omega total (ω_t) coefficients were calculated to measure internal consistency and reliability. These coefficients helped determine how well the items within each skill relate to one another. In addition, the split-half reliability, which provides an estimate of the consistency of the test by splitting it into two halves, was calculated for each skill, along with the average split-half correlation (interim r). This approach considers all possible combinations of item allocation to test halves, offering a comprehensive understanding of internal consistency. Cronbach's alpha values ranged from 0.77 to 0.93, demonstrating strong internal consistency across most skills, with the highest values observed for teamwork skill (α = 0.93) and learn how to learn (α = 0.93). The split-half reliability values ranged from 0.58 to 0.94, further supporting the reliability of the instrument. The internal reliability estimates of 0.60–0.70 were considered "acceptable", while those of 0.80 or higher were regarded as "very good" [73]. These findings indicate that the measurement instruments used to assess non-cognitive skills in the student survey are both reliable and consistent. The data analysis results provide valuable insights into the non-cognitive skills of students. The high Cronbach's alpha coefficient indicates that the measurement scale is reliable for

assessing non-cognitive skills. Additionally, the cumulative percentage of total variance in EFA indicates that the 26 factors sufficiently elucidate the underlying construct of the instrument.

To assess factorial validity, a single-factor CFA measurement model was fitted for each of the five subdomains. Each subdomain, comprising a different number of skills, was loaded on a single-factor CFA with its variance fixed to unity for identification purposes. These single-factor models assess the local independence of items relative to the single latent trait and will indicate poor fit if this independence is violated, thus serving as a rigorous test of unidimensionality [74]. Additionally, these models provide information on the factorial validity of each subdomain when treated as a unitary construct.

As an additional statistical measure, average variance extracted (AVE) was computed, indicating the portion of variance in the item set attributed to the latent construct, rather than to uniqueness and random error [75]. AVE serves as a common measure of factorial validity, with [75] suggesting a threshold value of AVE $\geq$ 0.50, though lower values are frequently observed.

All models were estimated using a robust maximum likelihood estimator (MLR) and full-information maximum likelihood (FIML) to manage missing data. Following current standards for assessing model fit [76], evaluation primarily relied on the comparative fit index (CFI), Tucker–Lewis index (TLI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR). Model adequacy was judged based on rules of thumb: CFI > 0.90 (adequate) or >0.95 (good), TLI > 0.90 (good), RMSEA < 0.05 (good) or <0.08 (adequate), and SRMR < 0.05 (good) or <0.10 (adequate). A model was deemed acceptable if at least two of these criteria were met (Table 4).

Table 4. Confirmatory factor analysis results—student survey.

Domain	AVE	CFI	TLI	RMSEA	SRMR
Self-Management Skills	0.58	0.978	0.966	0.065	0.019
Innovation Skills	0.62	0.998	0.990	0.045	0.005
Emotional Skills	0.59	0.979	0.957	0.081	0.021
Social Skills	0.57	0.984	0.970	0.065	0.020
Identity	0.50	0.991	0.946	0.085	0.015

There were no statistically significant differences in the student self-assessment of non-cognitive skills between girls and boys. No gender differences have been reported in achievement in and attitudes towards math either [77]. This consistency across various research findings underscores the importance of focusing on individual non-cognitive skill development, rather than assuming gender-based differences.

3.2.2. Teacher Survey

To evaluate the internal consistency of the measurement scale used in the teacher survey for assessing non-cognitive skills, Cronbach's alpha (α) and McDonald's omega (ω) were calculated. Both coefficients were 0.95, exceeding the recommended threshold of 0.70 [67], indicating strong internal consistency and reliability of the measurement instrument. These high values suggest that the items within the survey are highly correlated, providing confidence in the accuracy and stability of the assessments across different contexts.

Inter-rater reliability (IRR) measures the consistency of assessments made by different raters. In this study, the intra-class correlation coefficient (ICC), a specific measure of IRR, was employed to handle multiple raters (Table 5). The ICC quantifies the degree of agreement among different judges, ensuring that measurements of non-cognitive skills are reliable and not influenced by individual biases [78]. High ICCs indicate consistent ratings across teachers, while low ICCs suggest discrepancies.

Table 5. Average raters' absolute interclass correlation coefficients—teacher survey.

Question	ICC	F	df1	df2	*p*-Value	95% CI
1	0.895	9.50	4	10	0.002	[0.53–0.99]
2	0.860	7.17	4	10	0.005	[0.38–0.98]
3	0.727	3.67	4	10	0.044	[−0.22–0.97]
4	0.931	14.50	4	10	0.000	[0.69–0.99]
5	0.400	1.67	4	10	0.233	[−1.68–0.93]

The ICC analysis indicated that the teacher survey instrument is generally reliable, especially when ratings are averaged across multiple raters. Questions 1, 2, and 4 show high reliability, supporting robust and valid results, although Question 3 has moderate reliability, which is acceptable. Question 5 shows low reliability, which may require cautious interpretation or potential revision. Overall, the improved reliability through averaging supports the instrument's validity and applicability for further research.

3.3. Outcomes of Regression and Mediation Analyses

In this section, the estimates and t-values of the direct, indirect, and total impacts of students' non-cognitive skills on their academic achievement are reported, following the approach employed by [59]. The estimates are interpreted along with their significance levels, where ** $p < 0.01$, and *** $p < 0.001$. Focusing on non-cognitive skills that show significance at thresholds stricter than * $p < 0.05$ is a valid approach, because embracing a stricter *p*-value ensures that observed effects are not merely artifacts of measurement errors [32]. Additionally, applying a more conservative significance level aligns with rigorous statistical standards, ensuring the validity of the results [79].

3.3.1. Average Direct Effects

The values of average direct effects (ADEs) indicated the direct impact of various skills on academic achievement across four subjects, suggesting that students' self-assessed non-cognitive skills had a direct impact on academic achievement in four subjects independently of teacher assessment of students' non-cognitive skills. By examining the ADE estimate values (Table 6), the analysis sought to highlight significant positive and negative impacts of 26 non-cognitive skills on academic achievement and compare trends between two STEM and two non-STEM subjects. The t-value for the direct effects on academic achievement indicated extremely strong and highly significant relationships (Table 6). The direct effects of the 26 non-cognitive skills on academic achievement in math and physics versus first language and history revealed distinct patterns and impacts.

In STEM subjects, 13 skills were significant in math and 12 skills were significant in physics, with most of them having a negative impact (8 skills). Information processing skill demonstrated the highest positive impact on math (0.97 ***, t = 106.799) and physics (0.58 ***, t = 61.510), emphasizing its crucial role in processing and applying new information. Grit also showed notable positive effects on math (0.58 ***, t = 63.472) and physics (0.53 ***, t = 55.831), indicating the importance of perseverance and passion for long-term goals. Task management had significant positive effects on math (0.36 **, t = 39.564) and physics (0.48 ***, t = 50.863), highlighting the value of persistent effort in achieving academic goals. Conversely, leadership skill had a significant negative impact on math (−0.78 ***, t = −87.160) and physics (−0.68 ***, t = −72.415), suggesting challenges in collaborative dynamics. Creative skill also showed negative impacts on math (−0.73 ***, t = −80.498) and physics (−0.69 ***, t = −72.784), indicating potential conflicts with structured problem-solving approaches. Social awareness had negative impacts on math (−0.57 ***, t = −62.443) and physics (−0.66 ***, t = −69.632), emphasizing challenges in understanding and empathizing with others' perspectives.

Table 6. Average direct effects.

Skill	Domain	ADE_math		ADE_phys		ADE_flang		ADE_hist	
		Estimate	t-Value	Estimate	t-Value	Estimate	t-Value	Estimate	t-Value
Decision-Making Skill	1					0.25 ***	28.006	0.39 ***	42.831
Detail Management	1	0.3 ***	33.126			0.4 ***	44.617	0.67 ***	73.483
Organizational Skill	1	−0.29 **	−31.512	−0.35 ***	−37.189	0.57 ***	62.960	0.69 ***	75.939
Task Management	1	0.36 **	39.564	0.48 ***	50.863	0.26 ***	28.750	0.45 ***	49.423
Time Management	1					0.32 ***	35.615	0.45 ***	48.932
Capacity for Consistency	1							0.44 ***	48.439
Goal Regulation	1					0.63 ***	69.596	0.78 ***	85.770
Information Processing Skill	2	0.97 ***	106.799	0.58 ***	61.510				
Creative Skill	2	−0.73 ***	−80.498	−0.69 ***	−72.784				
Abstract Thinking Skill	2	−0.32 ***	−35.403	−0.44 ***	−46.521	0.28 ***	31.448	0.32 ***	34.816
Capacity for Independence	2					0.46 ***	50.279	0.34 ***	37.714
Expressive Skill	3	−0.39 **	−42.390	−0.51 ***	−53.531	0.4 ***	43.806	0.45 ***	49.674
Capacity for Optimism	3	−0.31 **	−34.495	−0.45 ***	−47.384				
Energy Regulation	3					0.28 ***	31.298	0.49 ***	54.316
Impulse Regulation	3					0.23 ***	24.984	0.53 ***	58.279
Self-Awareness	3					0.57 ***	62.682	0.45 ***	49.938
Leadership Skill	4	−0.78 ***	−87.160	−0.68 ***	−72.415	0.56 ***	61.966	0.6 ***	67.173
Social Awareness	4	−0.57 ***	−62.443	−0.66 ***	−69.632	0.46 ***	50.500	0.6 ***	66.532
Teamwork Skill	4					0.77 ***	85.651	0.83 ***	92.348
Adaptability	4	−0.3 **	−33.541	−0.37 **	−39.499				
Responsibility Management	4					0.92 ***	101.784	0.92 ***	101.719
Rule-Following Skill	4	0.3 **	32.918	0.52 ***	54.937	0.87 ***	95.962	0.83 ***	91.331
Grit	5	0.58 ***	63.472	0.53 ***	55.831	0.48 ***	52.780	0.65 ***	71.642
Growth Mindset	5					0.24 ***	26.085	0.43 ***	47.189
Learn How to Learn	5					0.72 ***	79.219	0.82 ***	90.170
Ethical Competence	5					0.46 ***	50.835	0.62 ***	68.761

*** $p < 0.001$, ** $p < 0.01$.

In non-STEM subjects, 21 skills were significant in first language and 22 skills were significant in history, with all of them having a positive direct impact. Responsibility management exhibited the highest positive impacts on first language (0.92 ***, t = 101.784) and history (0.92 ***, t = 101.719), highlighting the importance of fulfilling commitments and promises. Rule-following skill also had substantial positive impacts on first language (0.87 ***, t = 95.962) and history (0.83 ***, t = 91.331), emphasizing the adherence to instructions and norms. Teamwork skill showed significant positive effects on first language (0.77 ***, t = 85.651) and history (0.83 ***, t = 92.348), underscoring the benefits of collaborative efforts in achieving academic success.

The analysis of direct effects revealed distinct patterns in how students' assessment of non-cognitive skills influences academic achievement in STEM versus non-STEM subjects. In STEM subjects, information processing skill emerged as a crucial driver of success, while creative skill and leadership skill presented challenges with their negative impacts.

Conversely, non-STEM subjects benefited significantly from responsibility management and teamwork skill. Notably, only three skills, i.e., task management, rule-following skill, and grit, showed positive significant impacts across both STEM and non-STEM subjects. Task management is vital in both domains due to its role in persistent effort and goal achievement. Rule-following skill is critical across subjects for adherence to instructions and norms, while grit's importance lies in perseverance and passion for long-term goals. These findings underscore the importance of tailoring educational strategies to enhance these specific non-cognitive skills, optimizing academic outcomes across different subject areas and addressing the unique challenges posed by each discipline's educational environment.

3.3.2. Average Causal Mediation Effects

The values of average causal mediation effects (ACMEs) revealed how various non-cognitive skills indirectly influenced academic achievement across four subjects through teachers' assessments of students' non-cognitive skills at the domain level. By analyzing the estimate values (Table 7), the study highlighted significant pathways where non-cognitive skills impact academic outcomes via these teacher-assessed skills. The t-values demonstrated significant and strong relationships for the majority of non-cognitive skills, indicating their critical indirect impact on academic achievement (Table 7). This analysis provides insights into the nuanced contributions of these skills to academic achievement in STEM subjects, revealing overlapping trends and similarities.

In STEM subjects, several skills exhibited notable ACME values, highlighting their crucial roles in indirect pathways to academic success. Leadership skill stood out with substantial ACMEs in math (0.82 ***, t = 7.001) and physics (0.6 ***, t = 5.373), underscoring its strong positive influence on academic achievement through the cultivation of leadership qualities. Teamwork skill also demonstrated significant ACMEs in math (0.78 ***, t = 6.665) and physics (0.57 ***, t = 5.130), emphasizing the collaborative aspects of academic success in these subjects. Information processing skill showed notable ACMEs in math (0.71 ***, t = 6.417) and physics (0.51 ***, t = 4.732), indicating its critical role in processing and applying information effectively across different academic domains. Responsibility management showed significant ACMEs in math (0.67 ***, t = 5.736) and physics (0.48 ***, t = 4.330), highlighting the importance of fulfilling commitments and responsibilities.

In non-STEM subjects, the same non-cognitive skills of students assessed by teachers at the domain level exhibited the most significant ACME values, demonstrating their universal importance for academic success across different subject areas. Leadership skill stood out with substantial ACMEs in first language (0.51 ***, t = 6.784) and history (0.49 ***, t = 5.496), underscoring its strong positive influence on academic achievement through the cultivation of leadership qualities. Teamwork skill exhibited notable ACMEs in first language (0.49 ***, t = 6.540) and history (0.47 ***, t = 5.305), emphasizing the collaborative aspects of academic success in these subjects. Responsibility management showed significant ACMEs in first language (0.43 ***, t = 5.723) and history (0.41 ***, t = 4.633), highlighting the importance of fulfilling commitments and responsibilities. Information processing skill demonstrated substantial ACMEs in first language (0.42 ***, t = 5.731) and history (0.38 ***, t = 4.305), indicating its critical role in processing and applying information effectively across different academic domains.

The analysis of mediated effects reveals that 24 out of 26 non-cognitive skills exerted a significant positive impact on academic achievement in both STEM and non-STEM subjects. Notably, growth mindset and capacity for optimism did not show significant ACME values in any of the subjects analyzed. It is noteworthy that for the skills with significant ACME values, STEM subjects consistently showed higher mediation effects compared to non-STEM subjects. This difference underscores the heightened importance of non-cognitive skills in disciplines requiring strong analytical and problem-solving abilities. When examining the skills with the highest ACME values listed in each respective context, it becomes evident that there was considerable overlap. Skills such as leadership, teamwork, responsibility management, and information processing emerge as critical factors influencing academic

achievement across both STEM and non-STEM domains. This similarity in impactful skills suggests a widespread value placed on these competencies by educators and underscores their relevance in fostering academic success across diverse subject areas.

Table 7. Average causal mediation effects.

Skill	Domain	ACME_math		ACME_phys		ACME_flang		ACME_hist	
		Estimate	t-Value	Estimate	t-Value	Estimate	t-Value	Estimate	t-Value
Decision-Making Skill	1	0.47 ***	4.299	0.34 ***	3.208	0.3 ***	4.178	0.27 ***	3.119
Detail Management	1	0.55 ***	5.009	0.39 ***	3.691	0.34 ***	4.842	0.31 ***	3.617
Organizational Skill	1	0.45 ***	4.105	0.33 ***	3.086	0.28 ***	3.921	0.25 ***	2.952
Task Management	1	0.27 ***	2.521	0.2 ***	1.889	0.18 ***	2.529	0.16 ***	1.861
Time Management	1	0.43 ***	3.993	0.32 ***	3.012	0.27 ***	3.816	0.25 ***	2.892
Capacity for Consistency	1	0.25 ***	2.281	0.2 ***	1.912	0.16 ***	2.269	0.14 ***	1.657
Goal Regulation	1	0.53 ***	4.858	0.39 ***	3.658	0.33 ***	4.638	0.3 ***	3.507
Information Processing Skill	2	0.71 ***	6.417	0.51 ***	4.732	0.42 ***	5.731	0.38 ***	4.305
Creative Skill	2	0.33 ***	2.960	0.24 ***	2.262	0.19 ***	2.648	0.18 ***	1.986
Abstract Thinking Skill	2	0.66 ***	5.981	0.47 ***	4.372	0.38 ***	5.200	0.35 ***	3.907
Capacity for Independence	2	0.62 ***	5.576	0.46 ***	4.283	0.36 ***	4.854	0.32 ***	3.641
Expressive Skill	3	0.26 ***	2.216	0.19 ***	1.663	0.16 ***	2.158	0.14 ***	1.610
Capacity for Optimism	3								
Energy Regulation	3	0.17 ***	1.462	0.14 ***	1.215	0.11 ***	1.441	0.1 ***	1.105
Impulse Regulation	3	0.17 ***	1.495	0.14 ***	1.226	0.11 ***	1.491	0.1 ***	1.134
Self-Awareness	3	0.33 ***	2.781	0.23 ***	2.043	0.21 ***	2.750	0.19 ***	2.083
Leadership Skill	4	0.82 ***	7.001	0.6 ***	5.373	0.51 ***	6.784	0.49 ***	5.496
Social Awareness	4	0.42 ***	3.610	0.31 ***	2.806	0.27 ***	3.651	0.26 ***	2.940
Teamwork Skill	4	0.78 ***	6.665	0.57 ***	5.130	0.49 ***	6.540	0.47 ***	5.305
Adaptability	4	0.45 ***	3.909	0.34 ***	3.085	0.3 ***	3.994	0.29 ***	3.235
Responsibility Management	4	0.67 ***	5.736	0.48 ***	4.330	0.43 ***	5.723	0.41 ***	4.633
Rule-Following Skill	4	0.54 ***	4.623	0.38 ***	3.468	0.35 ***	4.655	0.34 ***	3.787
Grit	5	0.5 ***	4.474	0.37 ***	3.397	0.3 ***	4.146	0.28 ***	3.198
Growth Mindset	5								
Learn How to Learn	5	0.48 ***	4.260	0.35 ***	3.191	0.29 ***	3.979	0.27 ***	3.054
Ethical Competence	5	0.51 ***	4.536	0.36 ***	3.362	0.32 ***	4.286	0.29 ***	3.323

*** $p < 0.001$.

3.3.3. Total Effects

The values of total effects (TEs) indicated the combined direct and indirect impact of various skills on academic achievement across four subjects, suggesting that students' non-cognitive skills influenced academic performance both directly and indirectly. By examining the estimate values (Table 8), the analysis sought to highlight significant positive and negative impacts of 26 non-cognitive skills on academic achievement and compare trends between two STEM and two non-STEM subjects. The t-values indicated significant and strong relationships for the majority of non-cognitive skills across four subjects, highlighting their critical overall impact on academic achievement in both STEM and non-STEM areas

(Table 8). The total effects of the 26 non-cognitive skills on academic achievement across math and physics versus first language and history reveal significant differences in how these skills influence performance in these areas.

Table 8. Total effects.

Skill	Domain	TE_math		TE_phys		TE_flang		TE_hist	
		Estimate	t-Value	Estimate	t-Value	Estimate	t-Value	Estimate	t-Value
Decision-Making Skill	1	0.66 ***	6.017			0.55 ***	7.687	0.66 ***	7.580
Detail Management	1	0.85 ***	7.739	0.67 ***	6.216	0.75 ***	10.441	0.98 ***	11.278
Organizational Skill	1					0.85 ***	11.874	0.95 ***	10.893
Task Management	1	0.63 ***	5.811	0.68 ***	6.383	0.44 ***	6.158	0.61 ***	7.036
Time Management	1			0.4 ***	3.722	0.59 ***	8.295	0.7 ***	7.996
Capacity for Consistency	1					0.29 ***	4.083	0.58 ***	6.731
Goal Regulation	1	0.43 ***	3.906	0.51 ***	4.764	0.96 ***	13.417	1.08 ***	12.464
Information Processing Skill	2	1.68 ***	15.086	1.09 ***	10.036	0.57 ***	7.641	0.53 ***	5.993
Creative Skill	2	−0.4 **	−3.661	−0.44 ***	−4.113	0.21 **	2.831		
Abstract Thinking Skill	2	0.34 **	3.082			0.67 ***	8.992	0.66 ***	7.434
Capacity for Independence	2	0.74 ***	6.632	0.36 **	3.327	0.81 ***	10.956	0.66 ***	7.470
Expressive Skill	3			−0.32 **	−2.859	0.56 ***	7.357	0.6 ***	6.614
Capacity for Optimism	3			−0.38 ***	−3.361				
Energy Regulation	3					0.39 ***	5.160	0.59 ***	6.589
Impulse Regulation	3					0.34 ***	4.456	0.63 ***	7.019
Self-Awareness	3	0.32 **	2.764			0.78 ***	10.186	0.64 ***	7.101
Leadership Skill	4					1.07 ***	14.065	1.1 ***	12.196
Social Awareness	4			−0.35 **	−3.115	0.73 ***	9.703	0.87 ***	9.709
Teamwork Skill	4	0.53 ***	4.503	0.32 **	2.824	1.26 ***	16.659	1.31 ***	14.554
Adaptability	4					0.44 ***	5.840	0.51 ***	5.686
Responsibility Management	4	0.87 ***	7.475	0.51 ***	4.526	1.35 ***	17.853	1.33 ***	14.895
Rule-Following Skill	4	0.83 ***	7.165	0.9 ***	8.097	1.22 ***	16.162	1.16 ***	13.052
Grit	5	1.08 ***	9.585	0.89 ***	8.219	0.78 ***	10.581	0.93 ***	10.540
Growth Mindset	5					0.29 ***	3.970	0.48 ***	5.410
Learn How to Learn	5	0.56 ***	4.975	0.46 ***	4.195	1.01 ***	13.681	1.09 ***	12.318
Ethical Competence	5	0.48 ***	4.299			0.78 ***	10.479	0.92 ***	10.363

*** $p < 0.001$, ** $p < 0.01$.

In STEM subjects, 15 non-cognitive skills exhibited notable TE values, highlighting their crucial roles in academic success, with some of them having negative impact (math—1 skill, physics—4 skills). Information processing skill exhibited the strongest positive effects in both math (1.68 ***, t = 15.086) and physics (1.09 ***, t = 10.036), underscoring its critical role in processing and applying information effectively across STEM subjects. Grit also showed high impacts in math (1.08 ***, t = 9.585) and physics (0.89 ***, t = 8.219), highlighting the importance of perseverance and passion for long-term goals in STEM achievement. Responsibility management shows significant TEs in math (0.87 ***, t = 7.475) and physics (0.51 ***, t = 4.526), highlighting the importance of fulfilling commitments

and responsibilities. Detail management showed substantial positive effects in math (0.85 ***, t = 7.739) and physics (0.67 ***, t = 6.216), indicating its significant influence in maintaining thorough and meticulous work in these areas. On the other hand, creative skill demonstrates negative impacts in math (−0.4 **, t = −3.661) and physics (−0.44 ***, t = −4.113), suggesting that this skill may not align well with the structured and precise nature of these subjects.

In non-STEM subjects, almost all non-cognitive skills displayed significant positive TE values, illustrating their impacts on academic achievement (first language—25 skills, history—24 skills). Responsibility management demonstrated strong positive effects in both first language (1.35 ***, t = 17.853) and history (1.33 ***, t = 14.895), indicating the importance of fulfilling commitments and adhering to rules. Teamwork skill exhibited notable TEs in first language (1.26 ***, t = 16.659) and history (1.31 ***, t = 14.554), emphasizing the collaborative aspects of academic success in these subjects. Rule-following skill also had substantial positive impacts on first language (1.22 ***, t = 16.162) and history (1.16 ***, t = 13.052), emphasizing adherence to instructions and norms. Leadership skill stood out with substantial positive effects in first language (1.07 ***, t = 14.065) and history (1.1 ***, t = 12.196), underscoring the influence of leadership qualities on academic achievement. Learn how to learn demonstrated substantial positive effects in both first language (1.01 ***, t = 13.681) and history (1.09 ***, t = 12.318), highlighting the critical role of effective learning strategies in academic achievement across these subjects.

The analysis of TE values revealed distinct patterns in how non-cognitive skills influence academic achievement in STEM versus non-STEM subjects. In STEM subjects, information processing skill and grit were crucial for success, whereas creative skill may pose challenges. Conversely, non-STEM subjects benefited significantly from responsibility management and teamwork skill. Notably, 10 skills were significant and positive in both contexts. However, some skills had higher values for STEM subjects, such as information processing skill, while most of these skills had higher values for non-STEM subjects, such as responsibility management, teamwork skill, and rule-following skill. These findings emphasize the importance of tailoring educational strategies to enhance specific non-cognitive skills, optimizing academic outcomes across different subject areas.

4. Discussion

This section presents the key findings of the study, explores the implications for educational research and practice, addresses the study's limitations, and suggests directions for future research to further understand and enhance the role of non-cognitive skills in academic success.

4.1. Summary of Findings

The present study investigated the impact of non-cognitive skills on academic achievement, focusing on both STEM and non-STEM subjects. The analysis revealed significant direct effects of non-cognitive skills on academic performance. In STEM subjects, nearly half of the non-cognitive skills were found to be significant. Among these, information processing skill, grit, and task management had positive impacts, while leadership skill and creative skill exhibited negative effects. In contrast, most non-cognitive skills were significant in non-STEM subjects. All these skills positively influenced academic achievement, with responsibility management, rule-following skill and teamwork skill showing the highest effects. Remarkably, task management, rule-following skill, and grit were significant across both STEM and non-STEM subjects, underscoring their universal importance. The analysis of mediation effects demonstrated that almost all non-cognitive skills indirectly influenced academic achievement through teachers' assessments in both STEM and non-STEM subjects, except for capacity for optimism and growth mindset. Leadership skill, teamwork skill, responsibility management and information processing skill showed the most significant values of mediated effects in all four subjects. The analysis of total effects revealed distinct patterns in how non-cognitive skills influenced academic achievement. In

STEM subjects, information processing skill, grit, and responsibility management were critical for success, while creative skill posed challenges. In non-STEM subjects, responsibility management, teamwork skill, and rule-following skill were significant contributors. The findings revealed that the impact of non-cognitive skills on academic achievement differed based on whether these skills were assessed by students or teachers, highlighting the crucial role of teacher evaluations in translating non-cognitive skills into academic success.

4.2. Implications for Research and Practice

The findings from this study underscore the varying impacts of non-cognitive skills on academic achievement across STEM and non-STEM subjects, which have significant implications for both research and practice. This discussion will first address the effects of key non-cognitive skills on academic performance in STEM versus non-STEM contexts. It will then explore the roles of student and teacher assessments in developing and evaluating these skills.

In Domain 1, self-management skills, task management demonstrated a strong positive impact in both STEM and non-STEM subjects. This skill of organizing and prioritizing tasks effectively is crucial for achieving academic goals. Its consistent significance across both types of subjects underscores its universal relevance in academic settings. According to [80], students believe the most critical learning skills acquired at school are intrapersonal skills, particularly self-management, time management, and self-development, which foster their internal motivation and ability for self-directed learning, while also valuing the development of interpersonal skills like communication, collaboration, and teamwork.

In Domain 2, innovation skills, information processing skill exhibited a range of effects across different subjects. In STEM subjects, it showed significant positive direct effects, contributing to academic achievement in both math and physics. This skill is critical for success in STEM fields, as it involves the ability to process and apply new information effectively. In non-STEM subjects, it also demonstrated positive mediated effects through teachers' assessments. However, it was less prominent in terms of direct effects compared to STEM subjects. Overall, information processing skill is consistently recognized for its positive impact on academic performance, particularly in STEM contexts [6,81].

Within the same domain, the negative effects of creative skill in STEM subjects raise important questions about its role in these areas. While creative skill is generally valuable, its integration into STEM education may need to be carefully managed to ensure it contributes positively [19]. Understanding why creative skill may hinder performance in STEM can provide insights into more effective teaching strategies and curriculum design that mitigate these negative effects [38]. A significant drop was observed in mathematical creativity among students from grades 6 to 12 due to personal factors like declining motivation and self-efficacy, as well as process-related factors such as an increased focus on convergent thinking for assessments [82]. Additionally, ref. [83] found a strong positive correlation between engagement in STEM subjects and creativity levels among Maltese students aged 11–16, with both exposure to and enjoyment of STEM subjects significantly predicting creativity, even when accounting for other factors like age, gender, and parental education.

In Domain 3, emotional skills, the capacity for optimism exhibited significant negative direct and total effects in STEM subjects and showed no mediated effects across four subjects. The negative significant direct and total effects of capacity for optimism in STEM subjects might arise from several factors. In STEM fields, which often emphasize analytical and problem-solving skills, an overly optimistic outlook could lead to underestimating the complexities and challenges inherent in these subjects, potentially affecting performance. Additionally, STEM disciplines may place a higher value on resilience and practical problem-solving, rather than purely maintaining a positive outlook. Overemphasis on optimism might also detract from focusing on effective coping strategies crucial for success in rigorous STEM environments. Furthermore, students might apply or perceive optimism differently in STEM contexts, influencing its impact on their academic outcomes. These considerations highlight the need for further research to understand the complex rela-

tionship between capacity for optimism and academic success in STEM subjects. Using a multi-informant and multicohort approach, ref. [48] identified self-control, trust, optimism, and energy as key skills for academic and life success.

Several skills from Domain 4, social skills, proved to be essential for boosting academic performance. To begin with, responsibility management was particularly influential across various contexts. It showed positive direct effects in non-STEM subjects, significantly enhancing academic achievement in first language and history. In STEM subjects, it also contributed positively, although less prominently. This skill was notable for its positive mediated effects in both STEM and non-STEM subjects, emphasizing its critical role in academic success. As for rule-following skill, it showed significant positive effects primarily in non-STEM subjects. It directly influenced academic performance in subjects like first language and history and also had positive mediated effects. In STEM subjects, its role was more limited, but still relevant. Overall, rule-following skill contributed positively to academic achievement, particularly in non-STEM contexts, highlighting its importance in adhering to instructions and norms.

Another skill from this domain, teamwork skill, had notable positive effects, especially in non-STEM subjects, where it directly influenced academic performance. It also showed positive mediated effects, contributing to success in collaborative environments. In STEM subjects, its significance was less direct, but still relevant. Teamwork skill's positive impact across both subject areas emphasizes its value in both collaborative and individual settings, underscoring its role in academic success [39]. Finally, leadership skill displayed a mixed impact. In STEM subjects, it had negative direct effects, suggesting that assertiveness and taking charge may not always align with academic success in these fields. Conversely, in non-STEM subjects, leadership skill had positive mediated effects, reflecting its importance in collaborative and leadership roles. Overall, this skill's impact varies depending on the subject area, indicating a more nuanced role in academic achievement. Leadership skill is multifaceted and complex, requiring a nuanced understanding, particularly in today's era of social networks. A study by [84] found significant differences between social network analysis and respondent nominations in identifying leaders in STEM education, suggesting that relying solely on social network analysis may not be sufficient for identifying effective leaders. Further investigation is needed to better understand the role of leadership skill in STEM and explore potential improvements.

In Domain 5, identity, grit was another non-cognitive skill with varied effects, being more prominent in STEM subjects. Grit had a notable positive impact, significantly influencing performance in math and physics. This trait reflects perseverance and sustained effort toward long-term goals. Grit also showed significant positive effects in non-STEM subjects, suggesting its broad relevance. Both direct and mediated effects highlighted grit as a crucial factor in achieving academic success across disciplines, emphasizing its universal importance. Despite inconsistent findings in past studies regarding its relationship with academic achievement, recent studies also underscore the significance of grit in enhancing STEM education outcomes [54,85]. A meta-analysis of 44 studies involving 60,133 participants showed that both overall grit and its facets—consistency of interest and perseverance of effort—are positively associated with academic achievement, with perseverance of effort having the strongest effect [86].

Belonging to the same domain, growth mindset exhibited significant positive direct and total effects in non-STEM subjects, reflecting its strong impact on academic performance in these areas. However, the lack of mediated effects across the four subjects raises intriguing questions about its role. One possible reason could be that growth mindset may not sufficiently interact with other variables in STEM subjects to enhance performance, as its benefits might be more pronounced in domains where effort and perseverance are directly linked to success. Additionally, the nature of STEM subjects, which often require specific problem-solving skills and technical knowledge, might not align with the general cognitive flexibility promoted by growth mindset. Finally, variations in how growth mindset is implemented or understood across different subject areas could also contribute to

these discrepancies [6]. Further investigation is needed to explore these dynamics and optimize the application of growth mindset in diverse academic contexts. Despite inconsistent findings in past studies regarding its relationship with academic achievement, growth mindset has potential for enhancing STEM education outcomes [85].

The findings underscore that the impact of non-cognitive skills on academic achievement varies significantly depending on whether these skills are assessed by students or teachers. Specifically, the direct effects of these skills on academic achievement assessed by students tended to be less impactful compared to their mediated effects assessed by teachers. This suggests that teachers' perceptions and evaluations of students' non-cognitive skills may play a crucial role in translating these skills into academic success [46], especially in STEM subjects. For these subjects, the indirect effects of non-cognitive skills often had stronger positive impacts on academic performance than the direct effects assessed by students. In non-STEM subjects, the pattern was somewhat different. Here, both direct and mediated effects of non-cognitive skills contributed more uniformly to academic achievement, indicating that these skills are more consistently recognized and valued in non-STEM contexts by both students and teachers. Overall, these findings suggest that the impact of non-cognitive skills on academic achievement varies depending on the subject area, with mediated effects playing a more significant role in STEM subjects [6]. This underscores the importance of teacher evaluations in recognizing and leveraging non-cognitive skills to enhance student performance [49], particularly in subjects where the direct influence of these skills may be less apparent.

The mediating role of teacher assessments in the development of non-cognitive skills offers important contributions to the field of educational psychology, particularly by highlighting the influence of teacher perceptions on student outcomes. Teacher feedback serves not only as an evaluative tool but also as a pivotal mechanism that shapes students' self-perceptions and behavior through feedback, reinforcement, and guidance [87,88]. In the context of this study, the role of evaluations of teachers as mediators adds a nuanced layer to the understanding of how non-cognitive skills influence academic achievement. While much of the existing literature emphasizes direct self-reported measures of non-cognitive skills [44], this research underscores the importance of teacher observations, which can capture dimensions of student behavior and development that may go unnoticed in self-assessments or standardized tests. This approach aligns with recent educational psychology findings that advocate for a more holistic view of student development, incorporating both external evaluations and internal self-perceptions [49]. By focusing on the mediating role of teacher assessments, this study not only expands on the growing recognition of non-cognitive skills in academic achievement but also contributes to the broader literature by demonstrating how teacher input can act as a critical link between skill development and academic success [89].

Educators and policymakers should consider the critical role of teacher assessments in recognizing and nurturing non-cognitive skills. While teachers are interested in integrated STEM approaches, they feel inadequately prepared, highlighting the need for significant redesign of teacher education and professional development to support effective implementation [90]. A method proposed by [91] emphasizes integrating generic and subject-specific non-cognitive skills frameworks to enhance the visualization and improvement of teachers' assessments of non-cognitive skills, with a focus on addressing issues in teacher education to improve assessment practices. Policies supporting social–emotional learning and professional development for teachers can enhance the effectiveness of non-cognitive skill development programs [46]. For instance, training programs should emphasize the importance of accurate assessments of non-cognitive skills and provide strategies for integrating these skills into classroom instruction. To better outline the role of teachers, school efficiency should be measured at the class level to account for unobserved environmental factors [81].

Schools and educational institutions should adopt assessment practices that recognize the importance of non-cognitive skills. These could include using portfolios, self-assessments, and teacher evaluations to provide a more comprehensive view of student

abilities. Peer assessment is also a promising option: a meta-analysis of 19 studies with 43 effect sizes found that peer assessment significantly improved non-cognitive learning outcomes by 0.289 standard deviation units, highlighting its potential for enhancing non-cognitive development [47]. Additionally, observational methods can be valuable for triangulating data sources. For example, a study by [92] compared behavioral measures of social–emotional and motivational skills, derived from PISA assessments, with self-report measures in relation to academic performance. The findings indicated limited correlation between these measures, suggesting that while behavioral measures capture a test taker's current state, self-report measures reflect their self-perception of traits [92].

Parental involvement is also crucial, and schools should offer resources to help parents support their children's non-cognitive skill development [93]. A study conducted by [94] found that both teacher support and parental monitoring positively impacted students' motivation and self-efficacy over time, which in turn enhanced academic performance. Additionally, these factors indirectly influenced academic performance through motivation and self-efficacy, with parental monitoring having the greatest effect on motivation and teacher support on self-efficacy, highlighting the need for targeted interventions to boost these areas for better academic outcomes [94].

Focusing on secondary education is particularly important, because this developmental stage is when students begin forming habits, attitudes, and skills critical to their academic and personal success. Adolescents face increasing academic demands and social pressures, making non-cognitive skills essential for managing these challenges [95]. As secondary education bridges the gap between schooling and the workforce or higher education, fostering these skills helps prepare students for lifelong learning and adaptability [12]. Practically, educators can integrate non-cognitive skills into the curriculum through collaborative projects [39], social–emotional learning programs [42], and targeted skill-building activities [82]. By implementing teaching strategies that promote skills such as resilience, teamwork, and effective communication, schools can equip students with the tools necessary to navigate future academic and professional environments [81]. Moreover, policymakers should prioritize the inclusion of non-cognitive skills in educational standards and assessments, ensuring that all students receive the support they need to develop these competencies [96]. This approach not only enhances individual student outcomes but also contributes to creating a more skilled and adaptable workforce, ultimately benefiting society as a whole.

Kazakhstan's unique educational context plays a crucial role in understanding the impact of non-cognitive skills on academic achievement, particularly in STEM education. As a post-Soviet nation with a rich history of educational reforms, Kazakhstan has navigated a transition from a rigid, centrally controlled system to one that embraces international best practices while retaining distinctive cultural and educational traditions [10]. This blend of Soviet heritage and modern reforms offers a unique lens for exploring how non-cognitive skills interact with academic achievement [56]. The country's ethnically diverse population, comprising over 130 nationalities, further adds to the complexity and richness of the educational environment, creating a microcosm that mirrors global challenges of inclusivity and skill development in education. Kazakhstan's efforts to align its educational goals with international standards, such as those outlined by the OECD and PISA [96], make it a valuable case study for examining the global relevance of non-cognitive skills in academic success. The findings from this context have implications beyond national borders, offering insights into how other countries with diverse and evolving educational systems might benefit from incorporating non-cognitive skills into their curricula.

4.3. Limitations and Future Research

The findings of this study provide valuable insights into the role of non-cognitive skills in academic achievement, but several considerations should be kept in mind when interpreting the results. Firstly, the study's cross-sectional nature restricts the ability to establish causality between non-cognitive skills and academic performance [5,94]. Although

mediation analysis suggested pathways of influence, longitudinal studies are needed to confirm these relationships and observe the long-term impact of non-cognitive skills on academic outcomes [8,9]. Secondly, the assessment of non-cognitive skills relied on teacher evaluations. While effective [46,49], these may not fully capture the complexity and variability of non-cognitive skills across different contexts or individuals. These evaluations may be prone to personal biases or inconsistencies among evaluators, potentially skewing the results. Incorporating a broader range of assessment methods [48], including Likert-based tools [95], could enhance future studies.

Additionally, the sample size, though sufficient for this analysis, limits the generalizability of the findings, particularly given the focus on specific regions and schools within Kazakhstan. Although the study controlled for many relevant factors, other important variables, such as family background or peer influences, were not included [86]. Furthermore, while the measurement tools used were widely validated, they may lack cultural specificity. Future research could explore the adaptation of these tools to better suit the unique educational and cultural context of Kazakhstan.

The study's focus on a specific set of non-cognitive skills offers valuable insights, but future research could explore additional skills that may also play significant roles in academic achievement [44]. The regional focus on secondary schools in Kazakhstan, although informative, may limit the generalizability of the findings, as educational practices, cultural values, and socioeconomic factors differ across regions or countries. Comparative studies in more diverse international contexts are essential to determine the broader applicability of these findings. Additionally, the study sample may not fully represent the broader population, necessitating further research with more diverse and representative samples.

The study's reliance on teacher evaluations as the primary assessment method, while informative, could benefit from the inclusion of alternative methods, such as focus groups, peer assessments, or objective behavioral measures, to provide a more comprehensive understanding of non-cognitive skills [47,48]. Expanding the scope of measurement to include additional non-cognitive domains could offer a more complete picture of their impact on academic achievement [34,44]. Lastly, the language flexibility offered to respondents may have influenced results. Though choosing a familiar language can ease comprehension, it might not have reflected respondents' full academic capacity, potentially skewing the assessment. Subtle differences in interpretation between languages could also have affected how questions were understood and answered, posing a risk of bias [4]. Further research in different educational settings and cultural contexts is necessary to verify the robustness and broader applicability of these findings across populations.

5. Conclusions

The significance of non-cognitive skills in academic achievement has increasingly drawn attention in educational research. This study investigated the effects of student self-assessment and teacher assessment of the 26 non-cognitive skills on academic achievement in STEM and non-STEM subjects in secondary education. Utilizing survey data from 795 teachers and 12,965 students across 20 STEM schools in Kazakhstan, the research examined the direct, mediated, and total effects of these assessments on performance in mathematics, physics, first language, and history. Regression and mediation analyses revealed notable differences in how various non-cognitive skills impacted academic achievement across STEM and non-STEM contexts.

The findings demonstrated that certain non-cognitive skills exerted significant direct and total effects depending on the subject, while mediated effects were more consistent across disciplines. This research represents the first comprehensive assessment of the impact of non-cognitive skills on academic success in this region, emphasizing the necessity of incorporating these skills into curricula. Future studies could explore the complex interactions between different non-cognitive skills, examine additional mediating factors, consider cultural contexts, and conduct longitudinal and intervention research to deepen understanding in this critical area. The insights from this study are essential for shaping policies

aimed at promoting equitable education, underscoring the need for a holistic approach to student development that includes both cognitive and non-cognitive skill enhancement.

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