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ORIGINAL ARTICLE

Investigating Students' Self-efficacy in Science Education through the Interrelationship among, Career Preferences, Anxiety in Science Subjects, Science Competence and Transversal Skills

Janari Teessar*, Jack Holbrook, Regina Soobard, Miia Rannikmäe

Institute of Ecology and Earth Sciences, Faculty of Science and Technology, University of Tartu, Tartu, Estonia

***Corresponding Author:** janari.teessar@ut.ee

ABSTRACT

This study investigates the interrelationships among 10th-grade students' career preferences, science-related anxiety, perceived science competence, and transversal skills using a mixed-methods approach. Data from 95 Estonian students were analyzed through Latent Class Analysis, revealing six distinct self-perception profiles. The largest group (40.6%) exhibited low anxiety, high science competence, and strong transversal skills – characteristics aligned with high self-efficacy and Science, Technology, Engineering, and Mathematics (STEM)-oriented career interest. Other profiles demonstrated more complex combinations, such as elevated anxiety paired with strong transversal skills but low competence, or moderate competence with domain-specific anxieties. Violin plot visualizations illustrated nuanced differences in central tendency, dispersion, and distribution shape across classes, uncovering intra-group variability often obscured by mean comparisons. The findings underscore the need for differentiated educational strategies that address both emotional and cognitive dimensions of learning. Specifically, reducing science-related anxiety and fostering transversal skills may support more equitable and inclusive engagement in STEM education and career exploration.

KEY WORDS: Career choice, perceived anxiety, science competence, self-efficacy, STEM education, student perceptions, transversal skills

INTRODUCTION

In an increasingly science-driven and technology-oriented world, characterized by rapid advancements and global challenges, fostering students' interest and competence in science education is a critical priority for educators and policymakers (OECD, 2020; Bybee, 2010). Global economies and societal demands for skilled professionals in Science, Technology, Engineering, and Mathematics (STEM) fields have intensified the focus on preparing students for careers in these areas (National Research Council [NRC], 2012; World Economic Forum, 2020). Effective STEM education plays a vital role in shaping students' career choices and equipping them with the skills needed to address complex problems in modern society (Bybee, 2010; NRC, 2012).

Career choice plays a pivotal role in shaping students' educational interests and long-term aspirations, particularly within STEM education, where aligning career preferences with educational goals can be transformative (Watson and McMahon, 2005; Gore et al., 2015). A strong foundation in STEM is increasingly relevant across diverse careers – not only in STEM-specific roles, such as engineering and healthcare, but also in fields, such as law and policymaking, where an understanding of STEM concepts is essential for addressing science-driven societal challenges (NRC, 2012). Thus, STEM education equips students with critical thinking and problem-solving skills applicable to a wide range of professions, underscoring its relevance even beyond STEM-oriented careers (Bybee, 2010).

Early exposure to career options can motivate students to engage more deeply with STEM subjects, aligning their academic experiences with future aspirations (Gore et al., 2015). This alignment is particularly important because educational interest and career orientation often influence one another in a dynamic interplay. While some students' career preferences may drive their motivation to excel in STEM subjects, others develop an interest in STEM careers as a result of positive academic experiences (Savickas, 2002; Archer et al., 2014). The wide range of careers in STEM offers not only professional opportunities but also avenues for personal growth and societal impact, making it crucial for educators to bridge the gap between academic content and real-world applications (Savickas, 2002).

However, many students, particularly in secondary education, remain unaware of the diverse opportunities in STEM due to limited guidance and exposure (Archer et al., 2014). This lack of career awareness can result in misalignment between academic preparation and aspirations, contributing

to disengagement from science education (Gore et al., 2015). Addressing this gap requires a dual focus on enhancing students' academic abilities and fostering career-oriented guidance to help them see the value of STEM education in achieving their goals.

Feelings of incompetence in learning are a common challenge for students and can lead to anxiety, particularly in STEM education (Udo et al., 2004; Aydın et al., 2011). While the extent of this challenge varies, anxiety stemming from perceived inadequacy can significantly affect students' engagement and motivation. Students confident in their abilities are more likely to persist in engaging subjects, perform well, and pursue related careers (Britner and Pajares, 2006). Conversely, STEM-related anxiety can lower both academic performance and interest, leading students to avoid science-intensive careers despite their potential (Villafañe et al., 2016). Subjects, such as chemistry and physics, often perceived as abstract and complex, are particularly anxiety-inducing, which further limits participation and persistence in these fields (Mallow, 2006).

Perceived competence in science plays a pivotal role in students' engagement with STEM education (Britner and Pajares, 2006). Students with lower self-assessed competence in subjects, such as biology, chemistry, and physics are more likely to avoid these subjects when given a choice, even if their actual performance does not indicate a lack of ability (Schunk and Pajares, 2002). This gap between perceived and actual competence often leads students to underestimate their capabilities, discouraging them from engaging with what they perceive as more demanding scientific content and, in turn, reducing their likelihood of pursuing science-related careers (Hazari et al., 2010).

Transversal skills are increasingly recognized as critical for employability and adaptability in today's workforce (OECD, 2018). However, many students fail to connect these skills with their science education, leading to a lack of confidence in their ability to apply them effectively in academic and professional contexts (Binkley et al., 2012). Transversal skills – such as communication, teamwork, problem-solving, and self-management – are universally applicable and essential for collaborative work, critical thinking, and addressing complex challenges, regardless of career field (Holbrook and Rannikmäe, 2009). These skills are particularly valuable in STEM careers, where adaptability and interdisciplinary collaboration are crucial.

Insufficient development of transversal skills, such as effective communication and teamwork, can hinder students' success in academic and professional environments (Voogt and Roblin, 2012). Despite their importance, these skills are often undervalued in traditional science curricula, which tend to prioritize content knowledge over skill development (Voogt and Roblin, 2012). This highlights the need for educators, particularly STEM teachers, to emphasize the integration and explicit teaching of transversal skills to support broader learning and career outcomes.

The importance of fostering career choices, reducing anxiety in learning, building perceived science competence, and enhancing transversal skills lies in their collective ability to shape students' engagement and success in STEM education. These attributes are essential for guiding students toward STEM-oriented career pathways. This study investigates the interconnections between 10th-grade students' self-perceptions of their career choices, anxiety in science subjects, perceived science competence, and transversal skills.

The goal of this study is to identify areas for targeted intervention to enhance student engagement in STEM education, fostering interest and preparedness for STEM-related careers that address societal needs. By examining these interrelationships, the study aims to provide insights for developing educational strategies that better align students' abilities, interests, and career aspirations within the STEM context.

Research Questions:

1. What are 10th-grade students' perceptions of their career choices, level of anxiety in science subjects, competence in science subjects and transversal skills?
2. How do students' career choices, perceived level of science anxiety, perceived competence in science subjects, and perceived ability in utilizing transversal skills interrelate?

LITERATURE REVIEW

Self-Efficacy

Self-efficacy, grounded in Bandura's social cognitive theory (1997), refers to students' beliefs about their capabilities to successfully accomplish tasks and goals. It significantly influences student engagement, academic performance, and career choices in STEM education (Britner and Pajares, 2006; Klassen and Usher, 2010). High self-efficacy fosters sustained interest, resilience, and academic persistence, particularly essential for navigating challenging STEM subjects, such as physics and chemistry and strongly predicts career orientation toward science-intensive fields (Lent et al., 1994; Usher and Pajares, 2008; Villafañe et al., 2016). Conversely, low self-efficacy correlates with increased anxiety and disengagement, suggesting the importance of supportive educational practices to foster confidence and reduce barriers to STEM participation (Schunk and Pajares, 2002; Klassen and Tze, 2014).

Career Choice

Career choice significantly shapes students' educational motivation and future aspirations. Adolescents' understanding of career opportunities profoundly affects their academic engagement and vocational trajectories (Super, 1990; Gore et al., 2015). Early exposure to diverse STEM career options enhances students' interest and aligns academic content with real-world applications, which is crucial for fostering sustained engagement (Archer et al., 2014; Savickas, 2002). However, limited awareness often results in disengagement from STEM fields, indicating the necessity of strategic educational interventions that bridge academic competencies and

vocational aspirations (Watson and McMahon, 2005; Ginevra et al., 2015; Schwartz et al., 2005). This study investigates how career preferences interconnect with students' perceived competencies and anxiety levels, influencing their willingness to pursue STEM careers.

Anxiety in Science

Science-related anxiety, characterized by worry and fear when engaging with science subjects, significantly impedes students' performance and interest in STEM careers (Udo et al., 2004; Aydın et al., 2011). Anxiety frequently stems from perceptions of subject difficulty, previous negative experiences, or fear of failure, particularly in abstract sciences, such as chemistry and physics (Mallow, 2006). Unlike stress, which may enhance performance under controlled conditions, chronic anxiety undermines cognitive functions essential for academic success, thus negatively influencing engagement and persistence in STEM (Schwabe and Wolf, 2010; Pekrun and Linnenbrink-Garcia, 2012). Distinguishing between stress and anxiety is critical as it informs targeted interventions, either task-based or psychological, to mitigate these effects (American Psychological Association, 2022; Putwain and Symes, 2018; Tomasik et al., 2017). Thus, this study examines anxiety's role as a mediator influencing students' perceptions of their abilities and career preferences.

Perceived Science Competence

Perceived science competence – the students' self-assessment of their abilities to understand and apply scientific concepts – critically influences academic engagement and career trajectories in STEM fields (NRC, 2012; Capraro and Slough, 2013). Disparities between perceived and actual competence often deter students from pursuing STEM careers due to underestimation of their capabilities (Hazari et al., 2010). Active learning and formative assessments enhance perceived competence, encouraging deeper engagement with scientific topics and facilitating informed decision-making (Black and Wiliam, 1998; Osborne and Dillon, 2008). The ability to apply scientific knowledge practically, involving topics, such as heredity, energy, and chemical reactions, reinforces students' confidence and competence (Roberts and Bybee, 2014). This study assesses how perceived competence relates to students' career aspirations and anxiety levels, identifying potential areas for educational support.

Transversal Skills

Transversal skills, encompassing critical thinking, communication, problem-solving, teamwork, and self-management, are universally applicable competencies essential for adaptability, lifelong learning, and employability in a dynamic workforce (OECD, 2018; Voogt and Roblin, 2012; Trilling and Fadel, 2009). These skills enable students to effectively apply scientific knowledge in interdisciplinary and practical contexts, essential for addressing complex STEM-related challenges (Binkley et al., 2012). Despite their significance, traditional science curricula often neglect explicit instruction in transversal skills, limiting students' preparedness for STEM careers and their broader applicability in professional contexts (Holbrook and Rannikmäe, 2009; Dede, 2010). Enhancing these skills through active learning approaches, such as collaborative projects and problem-based learning is crucial for fostering deeper academic engagement and career readiness (Lin-Siegler et al., 2016). This study explores the relationship between transversal skills and students' confidence, anxiety, and career preferences, providing insights for curricular enhancements aimed at broader educational and career readiness.

METHODOLOGY

This study investigates the relationships among students' self-efficacy in science education, transversal skills, anxiety in science subjects, career preferences, and science competence. These interrelated attributes critically shape students' engagement, confidence, and sustained interest in STEM fields, informing effective science education.

The research consisted of two phases: A pilot phase for validating the instrument and a main study comprehensively exploring the relationships among these areas to inform curriculum and teaching practices.

Participants

- Pilot study: The pilot phase involved a convenience sample of 22 master's students (primarily practicing teachers enrolled in a science education course) and 31 10th-grade students from a secondary school in Estonia. Combining perspectives from educators and students enhanced the instrument's reliability, relevance, and student-friendliness.
- Main study: The main phase included a convenience sample of 95 students aged 15–17 from two Estonian secondary schools, distributed across five 10th-grade science classes.

Instrument Development

The questionnaire was developed and piloted, assessing four critical areas:

- Career Preferences: Two open-ended questions derived from Super's Life-Span, Life-Space Theory (1990) and Holland's Theory of Vocational Personalities (1997), exploring students' vocational aspirations and aversions.
- Anxiety in Science Subjects: Four 4-point Likert-scale items evaluating anxiety in biology, geography, chemistry, and physics, based on Mallow's Science Anxiety Theory (2006) and Zeidner's Test Anxiety Research (1998). Students also identified the subject causing the most anxiety and elaborated on their experiences.
- Perceived Science Competence: Ten 4-point Likert-scale items assessing students' competence perceptions in energy, genetics (previously "heredity"), and chemical reactions. These topics aligned with high school curricula, textbooks, and expert consultations.
- Transversal Skills: Originally 65 Likert-scale items covering five skill categories (communication, research,

thinking, social skills, self-management), derived from Holbrook et al. (2020) transversal skills framework. Feedback led to reducing the items to 60 by merging redundant items, enhancing clarity, and minimizing cognitive load.

Procedures

The study obtained ethical approval from the Research Ethics Committee at the University of Tartu. Informed consent was collected from students, guardians, school administrators, and teachers. Participation was voluntary, with students able to withdraw without repercussions. Data collection for both phases occurred in May 2023 during regular science lessons, supervised by class teachers. The pilot study included follow-up interviews to gather qualitative insights and refine the questionnaire.

Data Analysis

Qualitative data from career preferences and anxiety responses were analyzed using thematic analysis with NVivo software. Quantitative Likert-scale data were analyzed using Latent Class Analysis (LCA) with the poLCA package in R to identify latent student profiles based on response patterns.

LCA was specifically selected for its ability to uncover distinct, unobserved subgroups within heterogeneous populations, effectively capturing nuanced response patterns across anxiety, science competence, and transversal skills. Compared to alternative clustering methods (e.g., k-means, hierarchical clustering), LCA is superior due to its model-based nature, categorical data accommodation, explicit handling of subgroup membership uncertainty, and clear statistical criteria (Bayesian Information Criterion, Vuong-Lo-Mendell-Rubin Likelihood Ratio Test) for optimal model selection. This method aligns precisely with the study's objectives, facilitating meaningful differentiation among student profiles and supporting targeted educational interventions.

Validity

Validity was ensured through multiple methodological strategies. Construct validity was addressed by aligning questionnaire items with established theoretical frameworks: Career preferences with Super's Life-Span, Life-Space Theory (1990) and Holland's Vocational Personalities (1997); science anxiety with Mallow (2006) and Zeidner (1998); science competence with national curriculum standards and school textbooks; and transversal skills with the framework by Holbrook et al. (2020).

The pilot study with both 10th-grade students and master's-level practicing teachers provided critical feedback on terminology, clarity, and structure. This led to modifications, such as replacing technical terms ("anxiety" with "nervousness," "heredity" with "genetics") and merging redundant transversal skill items. These adjustments enhanced age-appropriateness and linguistic accessibility. Expert review by science education specialists confirmed that the revised instrument maintained content accuracy and curricular relevance.

The use of LCA further strengthened validity by identifying empirically supported subgroups within the student population. The six-class model demonstrated optimal fit using statistical criteria (Bayesian Information Criterion, Vuong-Lo-Mendell-Rubin Likelihood Ratio Test), confirming that the resulting profiles reflected meaningful patterns in student perceptions rather than arbitrary clusters.

Reliability

Reliability was supported through consistent instrument design, piloting, and refinement. The Likert-scale format across all sections ensured uniform response structures. The pilot phase was instrumental in identifying confusing or repetitive items – especially within the transversal skills domain – leading to revisions that reduced respondent fatigue and enhanced internal consistency.

Further reliability was achieved through the stability of the LCA model. The six-class solution was confirmed across repeated model estimations and demonstrated statistical robustness. This consistency suggests that the latent profiles are replicable and accurately reflect distinct student subgroups, thus enhancing the reliability of both the analysis and the interpretation of findings.

RESULTS

Career Preferences

Students expressed diverse career aspirations, with many students (48) showing interest in high-status professions, such as IT, engineering, healthcare, and scientific research. These aspirations were often tied to personal goals, including contributing to society or engaging in analytical work. STEM-related careers, such as medicine, engineering, and technology were particularly appealing to students seeking intellectual and practical challenges.

Conversely, students (59) showed strong aversions to jobs perceived as low-skill or monotonous, such as retail, factory work, and sanitation roles. These aversions were linked to desires for upward mobility, career satisfaction, and avoiding undesirable working conditions. STEM education was viewed by many as a pathway to achieving these aspirations.

Anxiety

Students' self-reported anxiety levels toward science subjects were generally moderate, with the majority of responses falling between the middle categories of the Likert scale. While some students expressed low anxiety, a significant portion indicated unease, especially in subjects, such as chemistry and physics. Full item-level frequencies and distributions are provided in Appendix 1.

Violin plot visualizing the distribution of students' self-reported anxiety levels (domain mean) across six latent classes identified through LCA. Each violin represents the density of responses within a class, with embedded boxplots indicating the interquartile range (IQR) and median. Sample sizes for each class are displayed below the x-axis (Figure 1).

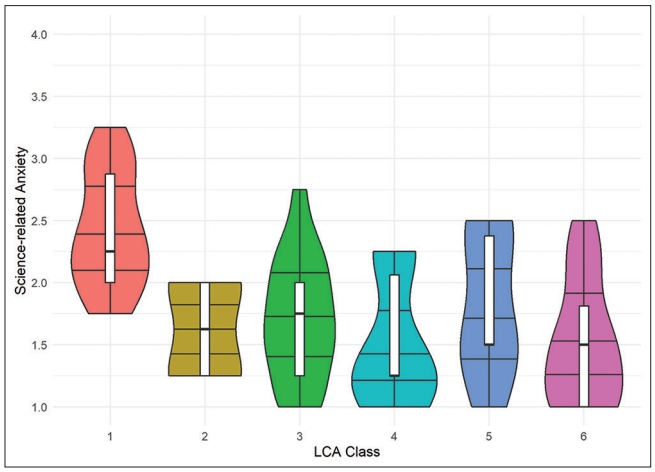

Figure 1: Distribution of students' science-related anxiety levels (B1–B4) across latent classes

Figure 1 illustrates the distribution of self-reported science-related anxiety across six latent classes identified using LCA. While all values fall within the valid response range (1–4), clear differences in central tendency and dispersion indicate latent structural differences in student subpopulations.

The highest average anxiety was observed in Class 1 (M = 2.43, standard deviation [SD] = 0.61, IQR = 0.55, n = 19), suggesting moderate levels of consistent unease with science among its members. Class 3 also showed elevated anxiety (M = 2.20, SD = 0.67, IQR = 0.75, n = 14) but with a broader dispersion, reflecting more heterogeneity in students' emotional experiences.

In contrast, Class 2 exhibited the lowest mean anxiety (M = 1.65, SD = 0.39, IQR = 0.46, n = 14), indicating low and relatively homogeneous anxiety levels. Similarly, Class 6 had a moderate mean (M = 2.06, SD = 0.58, IQR = 0.80, n = 16) but displayed a wider spread, suggesting more diverse internal perspectives within the group.

Class 4 (M = 2.06, SD = 0.64, IQR = 0.85, n = 10) and Class 5 (M = 2.18, SD = 0.73, IQR = 0.86, n = 7) had similar means but higher variability, especially in Class 5, where internal dispersion was the highest among all groups, potentially indicating the coexistence of both highly anxious and low-anxiety individuals.

A Type III ANOVA confirmed a statistically significant effect of latent class on science-related anxiety ($F(5, 92) = 8.06, p < 0.001$). Tukey's *post hoc* tests revealed several statistically significant contrasts:

- Class 1 reported significantly higher anxiety than Class 3 ($p < 0.0001$), Class 4 ($p = 0.0002$), and Class 6 ($p < 0.0001$).
- Class 1 also differed significantly from Class 2 ($p = 0.048$), with lower anxiety reported in the latter.
- Differences involving Class 5 were not statistically significant despite its higher internal variation.

Science Competence

Reported science competence showed a slightly more optimistic trend compared to anxiety. Students most often rated themselves in the upper-mid range, particularly in foundational topics, such as heredity and energy. However, confidence appeared to drop for more abstract or unfamiliar concepts. A detailed breakdown of item-level responses can be found in Appendix 1.

Violin plot visualizing the distribution of students' self-reported competence scores (mean of items C1–C10) across six latent classes identified through LCA. Each violin represents the density of responses within a class, with embedded boxplots indicating the IQR and median (Figure 2).

Figure 2 illustrates the distribution of perceived science competence scores across six latent classes. The domain scores, based on the mean of ten self-assessed science topics, range approximately between 1.5 and 3.5 across the classes, revealing substantial variation in students' confidence in science learning.

Class 4 exhibits the highest average competence (M = 3.06, SD = 0.33), with an IQR of 2.83–3.25 and a narrow, symmetric distribution – indicating strong and consistent confidence within this group. Similarly, Class 6 also demonstrates high competence (M = 2.96, SD = 0.53), though with a wider spread (IQR = 2.59–3.33) and visible skew toward higher scores.

On the other end, Class 2 shows the lowest perceived competence (M = 1.53, SD = 0.29), with a compact distribution (IQR = 1.31–1.67), suggesting a uniformly low self-assessment among students in this group. Class 5 presents a moderate mean (M = 2.27), but with one of the largest dispersions (SD = 0.49; IQR = 2.00–2.67), revealing internal heterogeneity – possibly indicating mixed levels of science confidence within the class.

Classes 1 and 3 report intermediate means (M = 2.38, SD = 0.31 and M = 2.61, SD = 0.37, respectively). Class 1's violin shows a tight IQR (2.17–2.58), whereas Class 3's wider IQR (2.34–2.86) suggests greater variation. The skew of the density in Class 3 leans slightly toward higher competence, whereas Class 1 remains relatively symmetric.

Post hoc Tukey comparisons reveal significant differences between most class pairs (e.g., Class 2 vs. Class 4: p <.001; Class 2 vs. Class 6: p <.001), confirming meaningful between-group differences in students' self-perceived science competence.

Transversal Skills

Communication skills

Communication skills were rated relatively highly by students, with the majority indicating that they often engage in activities, such as expressing ideas clearly, listening actively, and participating in group discussions. The frequency distribution for each item in this domain is documented in Appendix 1.

Violin plot visualizing the distribution of students' self-reported communication skills across six latent classes identified through LCA. Each violin represents the density of

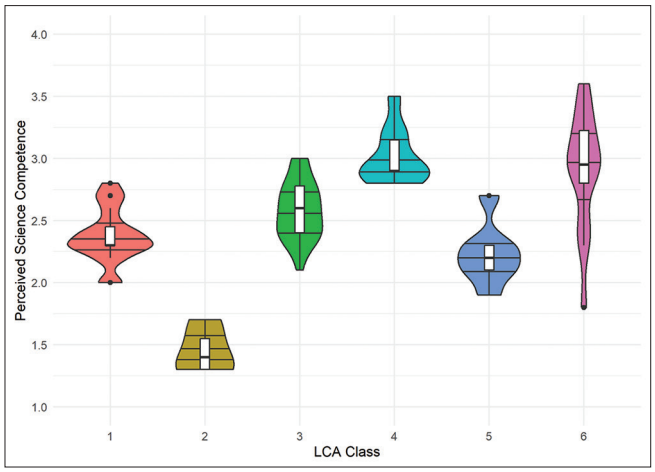

Figure 2: Distribution of perceived science competence (C1–C10) across latent classes

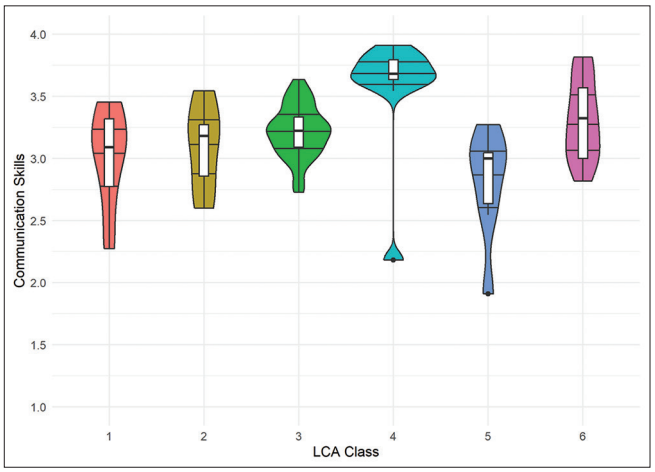

Figure 3: Distribution of students' communication skills (D1–D11) across latent classes

responses within a class, with embedded boxplots indicating the IQR and median (Figure 3).

Figure 3 displays the distribution of communication skill self-assessments across the six latent classes. Domain scores, computed as the mean of eleven communication-related items, show variation in both central tendency and internal consistency across student profiles.

The highest mean score is observed in Class 4 (M = 3.72, SD = 0.21), with a compact IQR (3.59–3.85) and a sharply peaked violin shape, indicating strong and consistent perceived communication abilities within this group. This is closely followed by Class 6 (M = 3.56, SD = 0.30; IQR = 3.33–3.79), which also exhibits high perceived communication competence but with a slightly broader internal spread.

Classes 1, 2, and 3 demonstrate moderately high means (M = 3.30, SD = 0.42; M = 3.31, SD = 0.37; and M = 3.31, SD = 0.34, respectively), with IQRs roughly spanning 3.00–3.60. While their average scores are similar, subtle differences in violin shape and IQR suggest Class 1 may contain more low-scoring outliers than Classes 2 and 3.

In contrast, Class 5 reveals the lowest mean (M = 2.95, SD = 0.47; IQR = 2.65–3.30), accompanied by the widest spread. This suggests high internal variability and highlights a group with both confident and less confident communicators. Despite a modest median, the density pattern reveals a substantial tail on the lower end, pulling the mean downward.

Post hoc Tukey analysis confirms statistically significant differences in communication skill ratings between key class pairs (e.g., Class 5 vs. Class 4, $p < 0.001$; Class 5 vs. Class 6, $p < 0.01$), reinforcing the value of LCA-based segmentation for identifying and addressing group-specific educational needs.

Research skills

Research skills were rated less confidently than communication skills. Many students selected mid-scale values, reflecting uncertainty about their ability to conduct independent investigations, interpret data, or formulate questions. These response patterns are summarized in Appendix 1.

Violin plot visualizing the distribution of students' self-reported research skill levels across six latent classes identified through LCA. Each violin represents the density of responses within a class, with embedded boxplots indicating the IQR and median (Figure 4).

Figure 4 illustrates the distribution of student-reported research skills across six LCA-derived classes, highlighting substantial heterogeneity in perceived competencies. The mean values for span from 2.78 (Class 5) to 3.76 (Class 4), reflecting a generally high self-assessed ability in research-related tasks, though some groups exhibit broader internal variability.

Class 4 reports the highest average research skill score (M = 3.76, SD = 0.30, IQR = 3.61–3.97), with a compressed distribution and minimal internal dispersion, indicating a consistently strong research self-efficacy within this group. Similarly, Class 6 also demonstrates high perceived research ability (M = 3.50, SD = 0.44, IQR = 3.26–3.77), though with a wider spread.

By contrast, Class 5 presents the lowest domain average (M = 2.78, SD = 0.51, IQR = 2.41–3.19), coupled with greater internal variability. This distribution suggests the presence of a wider spectrum of students – some expressing lower confidence in research competencies, while others report moderately strong skills.

Classes 1, 2, and 3 fall within a middle band of research skill perception. Class 1 reports a mean of 2.98 (SD = 0.63, IQR = 2.56–3.41), Class 2 a mean of 3.00 (SD = 0.50, IQR = 2.73–3.38), and Class 3 a mean of 3.14 (SD = 0.43, IQR = 2.87–3.47) – all indicating moderate but relatively consistent levels of research self-assessment.

Post hoc Tukey comparisons revealed statistically significant differences between several groups. Notably:

- Class 4 scores significantly higher than Class 1 ($p = 0.011$), Class 2 ($p = 0.020$), Class 3 ($p = 0.044$), and Class 5 ($p < 0.001$).

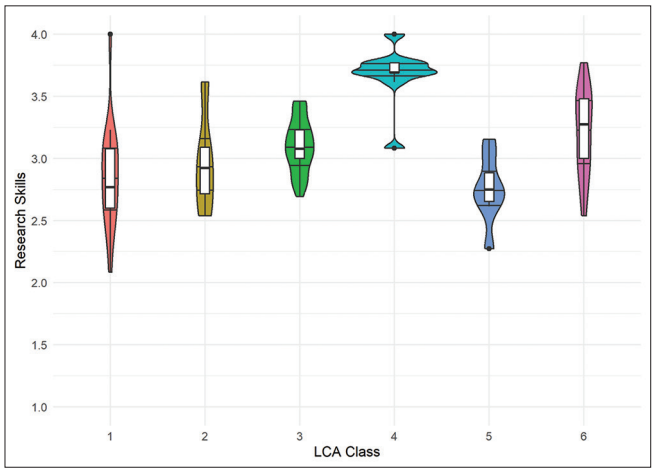

Figure 4: Distribution of students' research skills (D12–D24) across latent classes

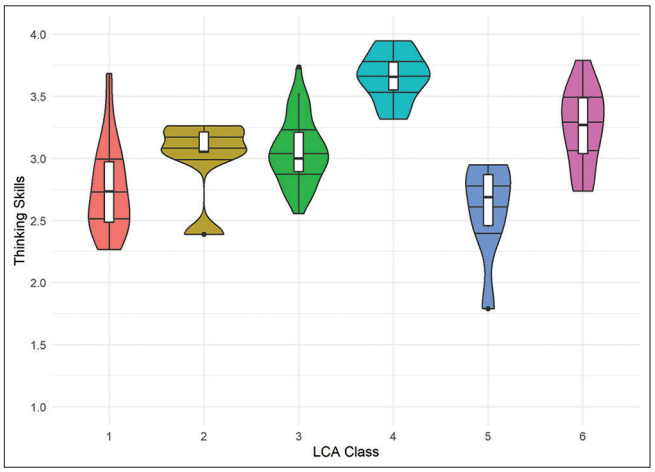

Figure 5: Distribution of students' thinking skills (D25–D43) across latent classes

- Class 6 also differs significantly from Class 5 ($p = 0.003$), reinforcing the interpretation that Class 5 students require targeted support in research-oriented tasks.

Thinking skills

Students expressed moderate confidence in their thinking skills. Basic analytical and problem-solving tasks were rated more positively, while higher-order thinking items – such as evaluating evidence or drawing conclusions – had more evenly distributed responses. Further detail is available in Appendix 1.

Violin plot visualizing the distribution of students' self-reported thinking skill levels across six latent classes identified through LCA. Each violin represents the density of responses within a class, with embedded boxplots indicating the IQR and median (Figure 5).

Figure 5 shows the distribution of self-assessed thinking skills across the six LCA-derived classes. Overall, reported means range from 2.61 (Class 5) to 3.78 (Class 4), with most students perceiving themselves as moderately to highly skilled in cognitive and analytical thinking tasks.

Class 4 demonstrates the highest perceived thinking skill level (M = 3.78, SD = 0.21, IQR = 3.67–3.88), with a tightly clustered response pattern indicating high internal agreement. This suggests that students in Class 4 consistently view themselves as confident and capable in higher-order cognitive tasks. Similarly, Class 6 presents a high average (M = 3.37, SD = 0.32, IQR = 3.16–3.66), with a moderate spread that reflects slight internal diversity in confidence levels.

In contrast, Class 5 reports the lowest average thinking skill rating (M = 2.61, SD = 0.49, IQR = 2.24–2.96), with considerable variation in responses, possibly indicating a mixture of struggling and moderately capable learners within this group. Class 1 also presents a lower mean (M = 2.80, SD = 0.53, IQR = 2.50–3.24), reflecting modest levels of perceived competence.

Classes 2 and 3 cluster toward the middle. Class 2 reports M = 3.14 (SD = 0.32, IQR = 3.00–3.38) and Class 3 reports M = 3.03 (SD = 0.41, IQR = 2.73–3.36), indicating moderate thinking skill self-assessments with some spread in perceived ability levels.

Tukey *post hoc* comparisons revealed that Class 4 outperformed all other classes:

- The difference was statistically significant in comparisons with Class 1 ($p < 0.001$), Class 2 ($p = 0.004$), Class 3 ($p = 0.004$), Class 5 ($p < 0.001$), and Class 6 ($p = 0.007$).
- In addition, Class 6 scored significantly higher than Class 1 ($p = 0.038$) and Class 5 ($p = 0.004$).

Social skills

Social skills received generally favorable ratings. Items measuring teamwork, cooperation, and empathy tended to cluster in the higher range, suggesting students perceive themselves as socially competent. Appendix 1 provides the full item-level distributions.

Violin plot visualizing the distribution of students' self-reported social skill levels across six latent classes identified through LCA. Each violin displays response density, with embedded boxplots showing the IQR and median (Figure 6).

Figure 6 presents the distribution of students' self-reported social skill levels across six latent classes derived from the LCA. Overall, reported scores fall between approximately 1.4 and 4.0, with most medians above 3.0, indicating generally high perceived competence in social skills across the sample.

Among the six classes, Class 4 exhibits the highest central tendency in social skills (M = 3.81, SD = 0.26), with the narrowest IQR (0.26), indicating that students in this group perceive their social abilities as uniformly strong. Similarly, Class 6 demonstrates a high mean score (M = 3.19, SD = 0.46), though with a broader distribution (IQR = 0.56), suggesting greater variability within the group.

By contrast, Class 5 reports the lowest average social skill level (M = 2.69, SD = 0.56), paired with a large IQR (0.80), suggesting that this group includes students with more diverse and often lower self-perceptions of social interaction capability. Class 1 (M = 3.04, SD = 0.57) and Class 2 (M = 3.06,

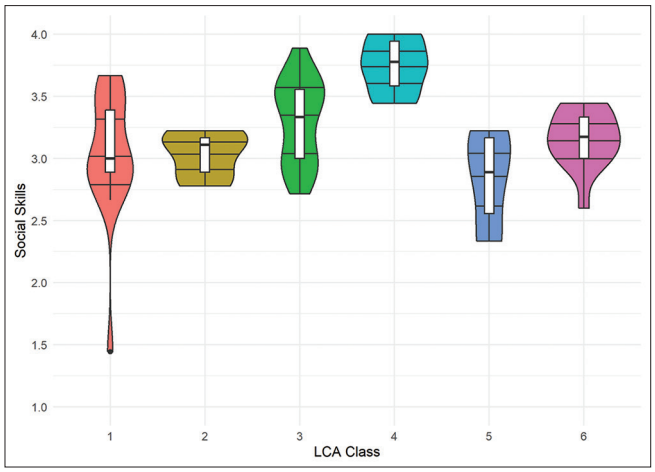

Figure 6: Distribution of students' social skills (D44–D52) across latent classes

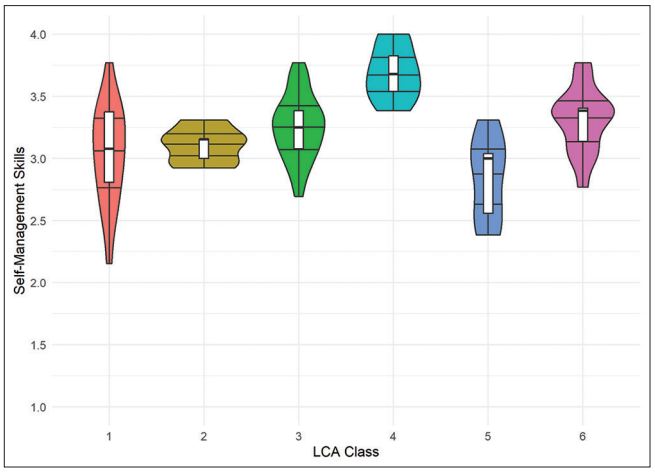

Figure 7: Distribution of students' self-management skills (D53–D65) across latent classes

SD = 0.33) show more moderate scores, with relatively compact distributions for Class 2 (IQR = 0.35) and a wider spread in Class 1 (IQR = 0.85).

Class 3 holds a distinct profile with a high average score (M = 3.41, SD = 0.56) and an IQR of 0.87, indicating a generally positive but heterogeneous self-assessment of social skills. The distribution for Class 3 spans nearly the full possible scale range, reflecting internal subgroup variation.

Self-management skills

Self-management skills showed the widest spread of responses among the transversal domains. While some students reported strong time management and goal-setting abilities, others indicated struggles with persistence and emotional regulation. The item-level patterns are outlined in Appendix 1.

Violin plot visualizing the distribution of students' self-reported self-management skill levels across six latent classes identified through LCA. Each violin displays response density, with embedded boxplots showing the IQR and median (Figure 7).

Figure 7 presents the distribution of self-reported self-management skills across the six latent classes established through LCA. Overall, most groups report perceived self-management levels clustered between 2.5 and 3.9, with generally moderate to high means and variable internal consistency.

Class 4 stands out with the highest mean score in self-management (M = 3.84, SD = 0.22), coupled with a compact IQR (0.20), suggesting a tightly clustered group of students who consistently perceive themselves as highly competent in managing tasks, responsibilities, and personal behavior. Class 1 follows with a high but more dispersed profile (M = 3.16, SD = 0.57; IQR = 0.83), indicating strong self-management overall but greater internal heterogeneity.

Class 6 (M = 3.19, SD = 0.42; IQR = 0.50) and Class 3 (M = 3.22, SD = 0.43; IQR = 0.59) both present solid performance, with relatively narrow ranges that point to above-average and fairly consistent perceptions of self-regulatory competence.

In contrast, Class 5 shows the lowest average score (M = 2.80, SD = 0.63), and a wider IQR (0.95), marking it as the most internally variable class in this domain. The spread suggests that while some students perceive themselves as capable, others struggle significantly with time management, planning, and follow-through. Class 2 (M = 3.05, SD = 0.33; IQR = 0.35) represents a more modest but stable middle-ground profile.

DISCUSSION

RQ1: What are 10th-grade students' perceptions of their career choices, level of anxiety in science subjects, competence in science subjects, and transversal skills?

Findings reveal substantial variation in students' self-perceptions across all domains, with six distinct latent profiles illustrating how students view their STEM-related abilities, emotional engagement, and broader skill sets.

Anxiety

The violin plots highlight both inter- and intra-class variability in science-related anxiety. Class 3 and Class 1 demonstrate the highest mean anxiety levels, though their dispersions differ – Class 3's broader spread suggests internal diversity, while Class 1 is more homogeneous in its elevated anxiety. In contrast, Class 2 stands out with the lowest mean anxiety and a narrow distribution, pointing to a cluster of students confident in their emotional regulation within science contexts. These findings resonate with prior literature indicating that subject-specific anxiety, particularly in physics and chemistry, often deters students from engaging in STEM learning (Villafañe et al., 2016 and Mallow, 2006). Physics and chemistry elicited the highest individual anxiety scores, aligning with the free-response item where these subjects were most frequently identified as anxiety-inducing.

Perceived Science Competence

Perceptions of competence display a clear upward trajectory across classes, with Class 3 reporting the highest average scores and narrowest variance. This suggests that students in this class possess not only high confidence but a shared perception of

capability. On the other hand, Class 5, which had the lowest mean competence, displayed the widest range of responses – signaling heterogeneity and potential identity tension (e.g., students who feel competent in some topics but not others). As students' perceived competence increased, so did their alignment with STEM-oriented career paths, supporting the literature on the centrality of self-efficacy in science engagement (Britner and Pajares, 2006; Schunk and Pajares, 2002).

Transversal Skills

Perceived transversal skills – measured across five domains – followed a stratified yet domain-sensitive pattern. Communication and research skills were strongest in Classes 5 and 6, where self-ratings were high and tightly clustered. This may indicate stable self-concepts among high-functioning learners. Class 2 presented a notable exception: While exhibiting low competence and high anxiety, students reported high transversal skills, particularly in communication. This profile might reflect a perceived disconnection between cognitive and interpersonal domains. Thinking and self-management skills were lowest in Class 2 and Class 1, suggesting these students might struggle not only with academic content but also with metacognitive and regulatory processes that support learning.

RQ2: How do students' career choices, perceived level of science anxiety, perceived competence in science subjects, and perceived ability in utilizing transversal skills interrelate?

The latent class structure uncovers clear interdependencies among the domains:

Anxiety and Competence

An inverse relationship was evident between perceived competence and anxiety across groups. Students with higher perceived competence (e.g., Classes 3 and 6) also reported lower anxiety levels, whereas those in Class 1 exhibited both low competence and high anxiety. This reinforces the idea that science-related anxiety is not only a psychological barrier but an experiential reflection of students' cognitive self-assessments (Aydın et al., 2011). Importantly, Class 5 students, despite showing moderate competence, demonstrated wide dispersion in anxiety, indicating subgroup variability and the need for personalized interventions.

Anxiety and Transversal Skills

While most high-skill groups (e.g., Class 6) also reported low anxiety, Class 2's profile (high transversal skills, low competence, and high anxiety) challenges a simplistic relationship. It suggests that possessing interpersonal and communication skills does not automatically buffer against anxiety in science contexts. Rather, students might compartmentalize their strengths, feeling competent in social interactions while remaining insecure about their academic abilities – a phenomenon also noted in earlier studies on self-concept differentiation (Usher and Pajares, 2008).

Competence and Career Preference

Students who reported strong science competence and low anxiety (e.g., Class 6) aligned with ambitious and creative career paths in engineering, medicine, or entrepreneurship. In contrast, those with low competence and high anxiety (Class 1) expressed unclear or narrowly defined career goals, often avoiding STEM. This supports prior research emphasizing that confidence in science knowledge is a crucial pre-cursor to considering science-based careers (Hazari et al., 2010; Lent et al., 1994).

Transversal Skills and Career Preference

Students in Classes 5 and 6, who rated themselves highly across all transversal domains, expressed interest in careers requiring leadership, innovation, and self-direction. Meanwhile, those in Class 3 and Class 4 showed moderate-to-high transversal skills and leaned toward more structured roles in IT and finance. The strong alignment between transversal skills and envisioned professional environments underscores the foundational role of these skills not just in academic success, but in career envisioning – especially in increasingly interdisciplinary STEM fields (OECD, 2018; Voogt and Roblin, 2012).

CONCLUSION

This study explored the interrelationship between 10th-grade students' career aspirations, perceived science-related anxiety, science competence, and transversal skills. Using LCA, six distinct student profiles were identified, revealing substantial heterogeneity in students' self-perceptions across cognitive, emotional, and skill-based domains.

Students exhibit distinct self-perception profiles that co-vary across anxiety, science competence, and transversal skills. These profiles were predictive of students' career preferences, particularly in relation to STEM fields.

High perceived competence and low anxiety were consistently associated with interest in science-intensive or innovative careers. Students in these profiles also reported strong transversal skills, suggesting a holistic self-concept that supports both academic engagement and professional aspiration.

Low competence and high anxiety profiles were associated with career indecision or avoidance of STEM, indicating that negative affect and low self-efficacy restrict students' perceived options.

Transversal skills functioned as both independent and interacting factors – supporting career orientation directly, and moderating the impact of anxiety and competence in several cases.

Violin plot visualizations offered a refined perspective on profile structure, revealing skewed distributions, bimodal shapes, and wide dispersions that point to intra-class variability – critical for tailoring educational responses beyond group averages.

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REFERENCES

American Psychological Association. (2022). *Stress and Anxiety: What's the Difference?* Available from: https://www.apa.org [Last accessed on 2025 Dec 11].

Archer, L., DeWitt, J., & Osborne, J. (2015). Is science for us? Black students' and parents' views of science and science careers. *Science Education*, 99(2), 199-237.

Aydın, Y.Ç., Uzuntiryaki-Kondakci, E., & Tarkin, S. (2011). A cross-cultural study of science anxiety among Turkish and US students. *International Journal of Science Education,* 21(4), 387-391.

Bandura, A. (1997). *Self-Efficacy: The Exercise of Control*. United States: W. H. Freeman.

Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M., & Rumble, M. (2012). Defining twenty-first-century skills. In: Griffin, P., McGaw, B., & Care, E. (Eds.), *Assessment and Teaching of 21st Century Skills.* Berlin: Springer, pp. 17-66.

Black, P., & Wiliam, D. (1998). Assessment and classroom learning. *Assessment in Education Principles Policy and Practice*, 5(1), 7-74.

Britner, S.L., & Pajares, F. (2006). Self-efficacy beliefs, motivation, and achievement in writing: A review of the literature. *Reading and Writing Quarterly*, 19(3), 213-231.

Bybee, R.W. (2010). Advancing STEM education: A 2020 vision. *Technology and Engineering Teacher*, 70(1), 30-35.

Capraro, R.M., & Slough, S.W. (Eds.). (2013). *Project-Based Learning: An Integrated Science, Technology, Engineering, and Mathematics* (*STEM*) *Approach*. Netherlands: Sense Publishers.

DeBoer, G.E. (2000). Scientific literacy: Another look at its historical and contemporary meanings and its relationship to science education reform. *Journal of Research in Science Teaching*, 37(6), 582-601.

Dede, C. (2010). Comparing frameworks for 21st century skills. In: Bellanca, J., & Brandt, R., (Eds.), *21st Century Skills: Rethinking How Students Learn.* United States: Solution Tree Press, pp. 51-76.

Ginevra, M.C., Nota, L., & Ferrari, L. (2015). Career adaptability and satisfaction: A mediational model in the Italian context. *Journal of Vocational Behavior*, 91, 113-123.

Gore, J., Holmes, K., Smith, M., Southgate, E., & Albright, J. (2015). Socioeconomic status and the career aspirations of Australian school students: Testing enduring assumptions. *The Australian Educational Researcher*, 42(2), 155-177.

Gutiérrez, F.G. (2019). Science education and anxiety: Exploring the connections. *Education Sciences*, 9(3), 234-248.

Hazari, Z., Sonnert, G., Sadler, P.M., & Shanahan, M.C. (2010). Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study. *Journal of Research in Science Teaching*, 47(8), 978-1003.

Holbrook, J., & Rannikmäe, M. (2009). The meaning of scientific literacy. *International Journal of Environmental and Science Education*, 4(3), 275-288.

Holbrook, J., Rannikmäe, M., & Soobard, R. (2020). STEAM education-a transdisciplinary teaching and learning approach. In: Akpan, B., & Kennedy, T.J. (Eds.), *Science Education in Theory and Practice: An Introductory Guide to Learning Theory*. Cham: Springer. pp. 465-477.

Holland, J.L. (1997). *Making Vocational Choices: A Theory of Vocational Personalities and Work Environments.* 3rd ed. Odessa, FL: Psychological Assessment Resources.

Klassen, R.M., & Usher, E.L. (2010). Self-efficacy in educational settings: Recent research and emerging directions. In: Urdan, T.C., & Karabenick, S.A., (Eds.), *The Decade Ahead: Theoretical Perspectives on Motivation and Achievement (Advances in Motivation and Achievement)*. Vol. 16A. Bingley, UK: Emerald Group Publishing. pp. 1-33.

Klassen, R.M., & Tze, V.M.C. (2014). Teachers' self-efficacy, personality, and teaching effectiveness: A meta-analysis. *Educational Research Review*, 12, 59-76.

Lent, R.W., Brown, S.D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice, and performance. *Journal of Vocational Behavior*, 45(1), 79-122.

Lin-Siegler, X., Ahn, J.N., Chen, J., Fang, F.F., & Luna-Lucero, M. (2016). Even Einstein struggled: Effects of learning about great scientists' struggles on high school students' motivation to learn science. *Journal of Educational Psychology*, 108(3), 314-328.

Mallow, J.V. (2006). Science anxiety: Research and action. In: Mintzes, J., & Leonard, W., (Eds.), *Handbook of College Science Teaching*. California: NSTA Press, pp. 19-26.

Mallow, J.V. (2006). Science anxiety: Research and action. In: Mintzes, J.J., & Leonard, W.H., (Eds.), *Handbook of College Science Teaching*. Arlington, VA: National Science Teachers Association (NSTA) Press, pp. 3-14.

National Research Council. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Washington, DC: The National Academies Press.

OECD. (2018). *The Future of Education and Skills: Education 2030*. France: Organisation for Economic Co-operation and Development.

OECD. (2020). *PISA 2018 Results: What Students know and Can Do*. France: Organisation for Economic Co-operation and Development.

Osborne, J., & Dillon, J. (2008). *Science Education in Europe: Critical Reflections*. Nuffield Foundation. Available from: https://www.nuffieldfoundation.org [Last accessed on 2025 Dec 11].

Pajares, F. (1996). Self-efficacy beliefs in academic settings. *Review of Educational Research*, 66(4), 543-578.

Pekrun, R., & Linnenbrink-Garcia, L. (2012). Academic emotions and student engagement. In: Christenson, S.L., Reschly, A.L., & Wylie, C., (Eds.), *Handbook of Research on Student Engagement.* Berlin: Springer, pp. 259-282.

Putwain, D.W., & Symes, W. (2018). Does increased effort compensate for performance debilitating test anxiety? *School Psychology Quarterly*, 33(3), 482-491.

Roberts, D.A., & Bybee, R.W. (2014). Scientific literacy, science literacy, and science education. In: Lederman, N., & Abell, S., (Eds.), *Handbook of Research on Science Education.* Vol. 2. London: Routledge, pp. 545-558.

Savickas, M.L. (2002). Career construction: A developmental theory of vocational behavior. In: Brown, D., (Eds.), *Career Choice and Development.* United States: Jossey-Bass, pp. 149-205.

Schunk, D.H., & Pajares, F. (2002). The development of academic self-efficacy. In: Wigfield, A., & Eccles, J.S., (Eds.), *Development of Achievement Motivation.* New York: Academic Press, pp. 15-31.

Schwabe, L., & Wolf, O.T. (2010). Learning under stress impairs memory formation. *Neurobiology of Learning and Memory*, 93(2), 183-188.

Schwartz, S.J., Côté, J.E., & Arnett, J.J. (2005). Identity and agency in emerging adulthood: Two developmental routes in the individualization process. *Youth and Society*, 37(2), 201-229.

Super, D.E. (1990). A life-span, life-space approach to career development. In: Brown, D., & Brooks, L., (Eds.), *Career Choice and Development: Applying Contemporary Theories to Practice.* United States: Jossey-Bass, pp. 197-261.

Trilling, B., & Fadel, C. (2009). *21st Century Skills: Learning for Life in Our Times*. United States: Jossey-Bass.

Tomasik, M.J., Knecht, M., & Freund, A.M. (2017). Some evidence for the usefulness of an optimal foraging theory perspective on goal conflict and goal facilitation. *Journal of Personality and Social Psychology*, 113(6), 962-980.

Usher, E.L., & Pajares, F. (2008). Sources of self-efficacy in school: Critical review of the literature and future directions. *Review of Educational Research*, 78(4), 751-796.

Villafañe, S.M., Xu, X., & Raker, J.R. (2016). Self-efficacy and academic performance in first-semester organic chemistry: Testing a model of reciprocal causation. *Chemistry Education Research and Practice*, 17(4), 737-752.

Voogt, J., & Roblin, N.P. (2012). A comparative analysis of international frameworks for 21st century competences: Implications for national curriculum policies. *Journal of Curriculum Studies*, 44(3), 299-321.

Watson, M., & McMahon, M. (2005). Children's career development: A research review from a learning perspective. *Journal of Vocational Behavior*, 67(2), 119-132.

World Economic Forum. (2020). *The Future of Jobs Report*. Available from: https://www.weforum.org [Last accessed on 2025 Dec 11].

Zeidner, M. (1998). *Test Anxiety: The State of the Art.* New York: Plenum Press.

Zimmerman, B.J. (2000). Self-efficacy: An essential motive to learn. *Contemporary Educational Psychology*, 25(1), 82-91.

APPENDIX

Appendix 1: Instrument Development and Responses given in the Pilot and Main Study

Question No.	Questions in Phase 1	Pilot Responses (Master's Students) N=22	Pilot Responses (10th-Grade Students) N=31	Final Study Responses N=98	Change after Pilot
Career Choices (Free-form)		Career (number of mentions)			
1	What career or job do you plan to associate yourself with in the future, and why?	IT (No answer/5/20) Doctor (No answer/6/11) Finance (No answer/2/10) Office worker (No answer/0/9) Unsure (No answer/5/8) Marketing (No answer/1/6) Nurse (No answer/1/6) Scientist (No answer/3/6) Engineer (No answer/4/5) Entrepreneur (No answer/1/4) Influencer (No answer/0/4) Teacher (No answer/0/3) Architect (No answer/1/2) Musician (No answer/1/2) Artist (No answer/0/2) Athlete (No answer/3/1)			No change
2	Which career or job would you most avoid working in, and why?	Retail (No answer/22/59) Driver (No answer/2/52) Sanitation (No answer/13/51) Manual labour (No answer/5/44) Warehouse worker (No answer/3/41) Customer service (No answer/17/38) Factory worker (No answer/12/32) Security Worker (No answer/0/11)			No change
Perceived Anxiety (Likert scale 1-4)		**Number of responses indicating 1- Yes, I do; 2- Rather yes; 3- Rather no; 4- No**			
3	I feel anxious going to Biology class	1/3/9/9	5/7/10/9	51/41/5/0	No change
4	I feel anxious going to Geography class	2/4/8/6	4/6/12/9	64/28/5/0	No change
5	I feel anxious going to Chemistry class	0/4/2/16	0/6/3/22	25/44/20/8	Change (see text)
6	I feel anxious going to Physics class	0/5/4/13	1/5/3/21	28/35/23/11	Changed (see text)
Questions about Perceived Anxiety (Free-form Choice)		**Number of responses (Physics/Chemistry/Biology/Geography)**			
7	Choose one subject that causes you the most anxiety and explain why	5/6/2/1	5/7/3/0	40/32/5/2	Simplified instructions
Perceived Competence in Science Topics		**Number of responses (1/2/3/4) 1- Yes, I am competent; 2- Rather yes; 3- Rather no; 4- No**			
8	Natural diversity	0/6/6/10	2/5/7/17	4/31/56/4	No change
9	Energy and energetics	1/4/7/10	3/6/8/14	16/51/30/0	No change
10	I am competent in the topic: Heredity and genetics	0/3/3/16	1/2/3/25	9/27/53/7	Changed (see text)
11	I am competent in the topic: Atoms and molecules	0/3/4/15	0/2/3/26	11/42/35/9	No Change
12	I am competent in the topic: Chemical reactions	0/4/3/15	0/3/4/24	15/42/33/7	No Change
13	I am competent in the topic: Weather and climate	0/3/6/13	1/3/6/21	2/26/58/11	No change
14	I am competent in the topic: Forces and motion	1/5/7/9	2/4/5/20	16/41/32/8	No change

(*Contd...*)

Appendix 1: (*Continued*)

Question No.	Questions in Phase 1	Pilot Responses (Master's Students) N=22	Pilot Responses (10th-Grade Students) N=31	Final Study Responses N=98	Change after Pilot
15	I am competent in the topic: Population and migration	0/3/5/10	1/3/5/17	3/22/50/22	No change
16	I am competent in the topic: Development of organisms	1/4/4/9	1/5/5/14	5/31/52/8	No change
17	I am competent in the topic: The solar system	1/4/6/7	1/4/5/15	5/26/47/19	No change
Questions about Perceived Competence in Transversal Skills		**Number of responses 1- Yes, I can; 2- Mostly can; 3- Mostly cannot; 4- Cannot**			
18	I can listen to others patiently	0/4/9/5	1/2/12/16	0/1/52/45	No change
19	I can understand verbal information	0/3/8/7	1/3/10/17	0/8/61/28	No change
20	I can convey information understandably to listeners	0/5/8/5	2/3/11/15	2/12/64/17	No change
21	I can understand information hidden in the text	0/4/9/5	2/3/10/16	3/14/65/13	No change
22	I can convey written information understandably	0/4/8/6	2/3/9/17	0/7/64/26	No change
23	I can present information understandably using modern technology	1/3/7/7	1/3/8/15	1/4/36/55	No change
24	I can notice and understand others' body language and facial expressions	0/5/6/7	1/4/9/13	3/7/41/45	No change
25	I can express my emotions through body language and facial expressions	0/4/7/7	1/5/8/13	1/5/41/48	No change
26	I can show interest through body language or facial expressions	1/4/6/7	1/4/9/12	2/6/45/40	No change
27	I can ask meaningful questions based on given information	0/6/6/6	2/3/10/11	4/28/54/7	No change
28	I can ask understandable questions based on given information	0/5/7/6	1/4/11/10	0/14/64/19	No change
29	I can interpret events meaningfully	1/4/5/8	2/3/9/12	0/10/58/19	No change
30	I can investigate occurred events	0/5/5/8	1/3/10/12	1/10/61/22	No change
31	I can use information obtained from observation	1/4/6/7	1/3/9/13	0/6/63/25	No change
32	I can use information obtained during an experiment	0/5/6/7	1/3/8/14	2/12/55/25	No change
33	I can formulate a reasoned plan for conducting an experiment	0/6/4/8	2/3/9/12	3/27/52/9	No change
34	I can follow my investigative plan	1/5/5/7	1/3/8/14	0/18/57/17	No change
35	I can find the necessary information for my studies from reliable sources	0/3/5/10	1/2/7/16	1/3/51/42	No change
36	I can identify reliable sources of information	0/3/5/10	1/3/7/15	1/6/52/35	No change
37	I can categorize the collected information understandably	1/4/5/8	1/2/9/14	0/6/63/19	No change
38	I can sort the collected information	1/4/5/8	1/3/9/13	1/7/61/24	No change
39	I can understand information displayed in graphs or diagrams	0/5/6/7	1/3/8/14	2/12/50/34	No change
40	I can describe information displayed in graphs or diagrams	0/6/5/7	2/3/9/12	2/16/52/27	No change
41	I can present information understandably and engagingly to others	0/6/5/7	1/3/9/13	2/21/58/13	No change
42	I can understand new information	1/3/7/7	1/4/9/12	0/7/69/21	No change
43	I can comprehend new information and remember it understandably	0/5/6/7	1/3/9/13	4/21/62/10	No change

(*Contd...*)

Appendix 1: (*Continued*)

Question No.	Questions in Phase 1	Pilot Responses (Master's Students) N=22	Pilot Responses (10th-Grade Students) N=31	Final Study Responses N=98	Change after Pilot
44	I can correlate information from different sources	0/4/6/8	1/3/9/13	0/11/55/25	No change
45	I can relate new information to global events	0/5/5/8	1/4/8/13	1/13/49/29	No change
46	I can logically and meaningfully connect new and previous knowledge	0/5/6/7	1/4/9/12	0/10/52/31	No change
47	I can link new knowledge with previous ones	0/4/6/8	1/3/9/13	0/12/47/38	No change
48	I can use my knowledge and skills to solve new problems	0/4/6/8	1/3/9/13	1/9/60/25	No change
49	I can apply my knowledge and skills in unfamiliar situations	1/3/5/9	1/3/8/14	1/16/55/22	No change
50	I can understand the reasoning used in making decisions	1/4/5/8	1/3/9/13	1/6/60/22	No change
51	I can understand the justifications contained in outcomes	0/5/5/8	1/3/8/14	0/5/68/19	No change
52	I can compare information from multiple sources	0/6/4/8	1/2/9/14	1/3/57/37	No change
53	I can make reasoned decisions based on sources and arguments	0/5/5/8	1/3/9/12	1/10/55/24	No change
54	I can choose data with justification	1/4/5/8	1/3/8/13	1/10/61/17	No change
55	I can select data based on its origin and reasons	1/5/5/7	1/3/8/13	1/14/55/19	No change
56	I can approach new knowledge critically	0/6/4/8	1/3/9/12	0/18/46/29	No change
57	I can identify errors in new knowledge	0/5/5/8	1/4/9/11	3/27/46/15	No change
58	I can think of learning as a conscious process	0/6/4/8	1/3/9/12	3/21/45/19	No change
59	I can continuously improve my learning process	1/5/5/7	1/3/9/12	6/22/49/14	No change
60	I can apply different strategies in learning	1/5/5/7	1/3/8/13	2/30/50/15	No change
61	I can make decisions that lead to positive outcomes	1/5/5/7	1/4/9/12	1/9/64/22	No change
62	I can consider others before making decisions	1/4/5/8	1/3/9/12	2/3/54/39	No change
63	I can be supportive of others' ideas	1/5/5/7	1/3/8/13	2/4/42/49	No change
64	I can be supportive of others' thoughts with which I do not agree	0/5/5/8	1/3/9/12	7/14/47/25	No change
65	I can work with others toward a common goal	0/6/4/8	1/2/9/13	0/4/41/53	No change
66	I can make effective decisions	0/5/5/8	1/3/9/12	0/9/57/27	No change
67	I can make reasoned decisions	0/5/5/8	1/3/8/13	0/12/52/31	No change
68	I can understand my future choices logically	1/5/5/7	1/3/8/14	4/8/34/39	Changed (see text)
69	I can analyze various professional choices critically	1/4/5/8	1/3/9/12	4/10/40/28	Changed (see text)
70	I can identify potential problems in decision-making processes	0/6/4/8	1/3/8/14	1/10/55/24	No change
71	I can work collaboratively to find solutions to problems	1/4/5/7	1/3/8/14	0/12/47/38	No change
72	I can act as a mediator in team discussions	0/5/5/8	1/3/8/13	0/18/46/29	No change
73	I can understand different perspectives during group work	1/5/5/7	1/3/8/14	3/27/52/9	No change

(*Contd...*)

Appendix 1: (*Continued*)

Question No.	Questions in Phase 1	Pilot Responses (Master's Students) N=22	Pilot Responses (10th-Grade Students) N=31	Final Study Responses N=98	Change after Pilot
74	I can manage time effectively during group activities	0/6/4/8	1/3/8/14	1/14/55/19	No change
75	I can follow through on commitments made to a team	1/5/5/7	1/3/8/13	0/18/46/29	No change
76	I can apply learned skills in practical situations	0/5/5/8	1/3/8/14	1/14/55/19	No change
77	I can evaluate the effectiveness of solutions in team projects	1/5/5/7	1/3/8/14	3/27/52/9	No change
78	I can adjust my approach based on feedback from others	1/5/5/7	1/3/8/14	1/10/55/24	No change
79	I can use my strengths to contribute to team success	0/6/4/8	1/3/8/14	0/18/46/29	No change
80	I can take on leadership roles when necessary	0/5/5/8	1/3/8/14	1/14/55/19	No change
81	I can support others in reaching a common goal	1/5/5/7	1/3/8/14	1/14/55/19	No change
82	I can recognize when adjustments need to be made to plans	0/6/4/8	1/3/8/14	1/10/55/24	No change
83	I can analyze data from multiple sources effectively	1/5/5/7	1/3/8/14	4/8/34/39	Changed (see text)
84	I can act independently when solving problems	1/5/5/7	1/3/8/14	4/10/40/28	Changed (see text)