Why High-Achieving Students Avoid STEM Careers: A Q-methodology Study in China and Scotland

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Abstract

Studying students' STEM (science, technology, engineering, and mathematics) career aspirations has been a critical area of research for understanding students' perspectives, motivations, and attitudes. However, many countries face a significant shortage of STEM talent, compounded by the concerningly low proportion of high-achieving students aspiring to STEM-related careers. To investigate why some high-achieving students opt against STEM pathways, this study focuses on China and Scotland—two nations with a high proportion of academically high-achieving students but a comparatively low interest in STEM careers. Despite these shared characteristics, the contrasting educational and cultural contexts of China and Scotland provide unique perspectives for understanding students' career aspirations.

This study employs Q-methodology to explore students' perspectives on STEM careers, combining Q-sorting and interviews to collect data. A systematic literature review and a questionnaire were used to develop 31 statements for the Q-sorting activity, representing potential reasons for students' lack of interest in STEM careers. These reasons were framed using the Expectancy-Value-Cost (EVC) model and Social Cognitive Career Theory (SCCT). A total of 15 Chinese and 10 Scottish students participated in the Q-sorting exercise, ranking the statements based on their personal views. Post-sorting interviews followed to allow participants to elaborate on their reasoning and provide additional insights. Data from the Q-sorts were analysed using PQMethod 2.35 software, while the interviews underwent thematic analysis using NVivo 14.

The analysis identified three distinct factors among Chinese participants: I Lack Competitiveness, I Prefer a Non-STEM Career, and STEM Careers Come at a High Cost.

For the Scottish participants, two factors emerged: I Don't Belong to STEM Fields and STEM Is Not My Dream Job. The findings highlight nuanced perspectives within and across the two cultural contexts, revealing both similarities and differences in how students perceive STEM careers. Findings further revealed the application of the EVC model in describing students' intention to avoid or leave STEM careers.

This study concludes by emphasising the significant value of the EVC and SCCT frameworks in understanding students' STEM career aspirations. In particular, the EVC framework proved instrumental in analysing the lack of career aspirations or intentions to withdraw from STEM pathways. Practical recommendations for educators, policymakers, and researchers are proposed, including strategies to overcome barriers to STEM career aspirations, foster deeper student engagement with STEM disciplines, and design educational policies that are better aligned with students' motivations, aspirations, and needs. Furthermore, the study addresses its limitations, offering a solid foundation for future research to examine the intricate relationships between motivational factors, perceptions, and contextual influences within diverse cultural and educational landscapes.

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Author's Declaration

I declare that, except where explicit reference is made to the contribution of others, that this dissertation is the result of my own work and has not been submitted for any other degree at the University of Glasgow or any other institution.

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Abbreviations

BFLPE	Big-Fish-Little-Pond Effect
CFA	Centroid Factor Analysis
EVC	Expectancy-Value-Cost
EVT	Expectancy-Value Theory
OECD	Organization for Economic Cooperation and Development
PISA	Programme for International Student Assessment
PCA	Principle Component Analysis
PRISMA	Preferred Reporting Items for Systematic Review and Meta-Analysis
SCCT	Social Cognitive Career Theory
SLR	Systematic Literature Review
STEM	Science, Technology, Engineering, and Mathematics
TIMSS	Trends in International Mathematics and Science Study

Chapter 1: Introduction

1 Background

In the technology-driven world, STEM (Science, Technology, Engineering, and Mathematics) education is essential for preparing a workforce capable of driving innovation and supporting economic growth. The importance of STEM for economic growth and global competitiveness has been well-recognised (Caprile et al., 2015; Feller, 2011), especially with the transition from Industry 3.0 to Industry 4.0. This transition has created a pressing demand for individuals with STEM skills and literacy, both to meet the needs of the evolving STEM labour market and to prepare future citizens with the competencies required to succeed in an increasingly digital world. As advancements in automation, artificial intelligence, and data analytics reshape industries, a strong foundation in STEM is essential for fostering innovation and maintaining global leadership.

Despite the growing demand for STEM talent, many countries are struggling to meet these workforce needs. For example, the United Kingdom faces a shortfall of 173,000 workers in STEM (Institution of Engineering and Technology, 2023) and a shortage of up to 59,000 engineers (Engineering UK, 2022). This shortage underscores the critical need to cultivate a skilled STEM workforce to support future economic growth and technological advancement. A key factor in addressing these workforce challenges lies in understanding students' STEM career aspirations (Du & Wong, 2019). By examining students' expectations and aspirations (individual's ideal career choice) regarding STEM careers, researchers can gain valuable insights into their perceptions, enabling policymakers and educators to develop targeted policies and curricula that align with these interests. Aligning educational programs with students' career goals can make learning more engaging, improve student retention, and better prepare a motivated future STEM workforce.

PISA (Programme for International Student Assessment) data (OECD, 2019) highlights a gap between academic achievement and STEM career aspirations. For example, 48.4% of students from B-S-J-Z (China)[1] are top performers in mathematics and science, compared to an OECD (Organization for Economic Cooperation and Development) average of 13.1%. Despite this high level of proficiency, only 24% of these high-achieving Chinese students expressed an interest in pursuing a STEM-related career—significantly lower than the OECD average of 42% (OECD, 2016). While Western countries, on average, tend to show higher proportions of students aspiring to STEM careers compared to their Eastern counterparts, some of these figures remain concerning. For example, in the United Kingdom, 32.5% of students express interest in a STEM-related career; although this percentage is higher than that of top-performing Chinese students, it is still lower than the OECD average. Furthermore, only 16% of UK students rank as top performers in mathematics and science. These figures underscore the challenge many countries face in translating high academic performance in STEM subjects into sustained interest in STEM careers, ultimately impacting the future STEM talent pipeline.

Concerns have been raised about high-achieving students, who may face unique career development challenges and exhibit different characteristics in their aspirations (Kim, 2010). This study aims to explore the career aspirations of students from China and Scotland (part of the UK), focusing specifically on the attitudes and barriers that influence their decisions to pursue STEM-related careers. China and Scotland were chosen for several reasons. First, both countries face unsatisfactory levels of STEM career aspirations despite efforts to

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[1] B-S-J-Z (China) refers to the four PISA-participating provinces/municipalities of China: Beijing, Shanghai, Jiangsu, and Zhejiang

promote STEM education, making them critical contexts for examining this issue; Second, China and the UK, as medium- and high-achieving countries, offer a compelling comparison due to their distinct cultures and education systems, which may yield unique insights into the factors shaping students' attitudes toward STEM careers. Finally, convenience sampling influenced the selection, as the researcher's background in China and current academic work in the UK afford both practical accessibility and relevant data sources for this study. By examining both contexts, the study offers a richer understanding of the mechanisms deterring STEM career aspirations and helps determine whether these barriers are universal or specific to cultural and educational settings.

2 Problem statement

Scholars have researched the topic of STEM career aspirations by identifying factors that determine students' STEM career choices or aspirations. Self-efficacy (belief in one's ability to succeed at a task), enjoyment of science, and the practical value of science are some of the well-recognised factors that influence students' STEM career aspirations or choices (Archer et al., 2020; Britner & Pajares, 2006; Lauermann et al., 2017; Zhang et al., 2021). Whilst many studies investigate how specific factors contribute to students' STEM career aspirations, few have explored why students may lose interest or leave STEM pathways. For instance, Minutello (2016) examined why undergraduates decided to leave their initial STEM majors, finding that the primary obstacles included disengaging curricula, competitive culture, disappointing grades, high time demands, and unappealing career options. Similarly, Seymour and Hewitt (1997) challenged the belief that students leave STEM solely due to academic difficulties, revealing that even high-performing students were likely to change majors due to factors like waning interest, perception of STEM careers as misaligned with personal goals, dissatisfaction with faculty support, and frustration over rigorous workloads and rapid course pacing.

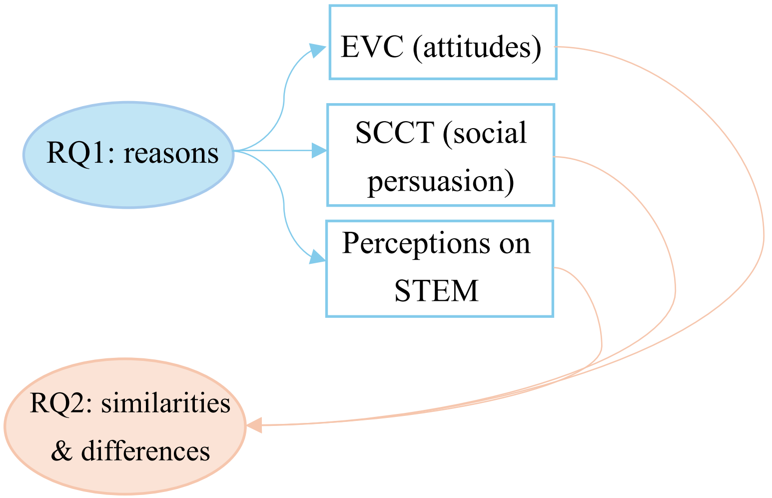
Moreover, little research has focused on high-achieving students and their reasons for choosing not to pursue STEM careers (Heilbronner, 2011; Kim, 2010), even when they demonstrate strong academic abilities in these subjects. Studies that concentrate on students who leave or switch from STEM majors reveal factors distinct from those that inspire STEM career aspirations, underscoring a notable gap in the literature: there is limited understanding of the lack of motivations that lead high-achieving students to opt out of STEM careers. Therefore, it is of great importance to understand students' reasons for not aspiring to STEM-related careers from their perspectives.

This study seeks to address this gap by examining the perspectives of high-achieving students regarding the discouraging and unmet motivational factors shaping their career aspirations. The findings offer valuable insights for educators, parents, policymakers, and other stakeholders, helping them understand how high-achieving students' perspectives are formed and informing strategies to support and encourage STEM career consideration among this group.

3 Research aims and research questions

Research indicates that high-achieving students, particularly in regions like China and Scotland, often do not translate their academic strengths in mathematics and science into STEM career aspirations (OECD, 2019). This gap in career aspirations calls for a deeper exploration of the factors influencing such decisions. The research questions in this study were developed based on theoretical frameworks (see Section 4, Chapter 1), with a particular focus on students' motivations to avoid STEM careers through the lens of the Expectancy-Value-Cost (EVC) theory and the Social Cognitive Career Theory (SCCT). The EVC theory explores how students' motivation is influenced by their expectations of success, the value they place on STEM careers, and the costs (the effort, stress, and sacrifices of doing a task) they associate with pursuing these fields. RQ1 explores students' reasons primarily through this lens, while also considering additional perspectives. SCCT extends the EVC framework by incorporating the role of social persuasion, such as the influence of family, teachers, and peers, in shaping career aspirations. By comparing the experiences of Chinese and Scottish students, this study seeks to uncover similarities and differences in the factors influencing their decisions, with particular attention to how cultural, educational, and societal differences (RQ2). Refer to Figure 1-1 for an overview that integrates the research questions, theoretical frameworks, and key focus areas of this study.

Figure 1-1 Overview of research questions, theoretical frameworks, and study focus areas



Specifically, RQ1 investigates the reasons students provide for not aspiring to STEM careers, exploring the alignment—or misalignment—of their attitudes (see Section 6, Chapter 1 for definition) toward these fields. RQ1a broadens this enquiry by examining students' perceptions of STEM subjects and careers (how individuals view STEM based on knowledge, beliefs, and stereotypes), aiming to identify whether their views align with the realities of STEM fields. Together, RQ1 and RQ2 aim to provide actionable insights for educators, parents, and policymakers, enabling them to design strategies that inspire high-achieving students to consider and pursue STEM pathways, ultimately unlocking their full potential in these critical fields.

Consequently, this study seeks to understand not only the motivational factors that deter high-achieving students from pursuing STEM careers but also how these factors are prioritised in the context of students' perceptions of STEM fields. While much research has explored the career aspirations of students in general, there is limited focus on high-achieving students who actively avoid STEM careers. This gap in the literature underscores the importance of examining the specific barriers that deter top-performing students from pursuing STEM pathways, despite their academic strengths in these subjects. Therefore, the aim of this study is to:

> **To investigate the factors that discourage high-achieving students in China and Scotland from pursuing STEM careers.**

The **research questions** for this study are:

> **RQ1. What reasons do high-achieving Chinese and Scottish students provide for not aspiring to STEM-related careers?**
>
> **RQ1a. What perceptions do high-achieving Chinese and Scottish students hold towards STEM careers?**
>
> **RQ2. How do the reasons for not aspiring to STEM-related careers differ or align between high-achieving Chinese and Scottish students?**

4 Overview of theoretical framework

This section provides an overview of the theoretical framework, establishing a strong foundation for this study by grounding the research in well-established principles. This study is anchored in Barron and Hulleman's (2014) EVC model and the SCCT (Lent et al., 2002). The EVC is an extension of the Expectancy-Value Theory (EVT) of motivation and is particularly relevant to understanding the multifaceted nature of student motivation. It emphasises three key components: expectancy of success, task value, and cost. This framework is chosen for its comprehensive approach to capturing both the positive and negative influences of motivation, making it well-suited for analysing the complexities of students not aspiring to STEM careers. Complementing this, SCCT provides a broader perspective by integrating personal and contextual factors—such as family background and significant others' influence—that shape students' motivations and attitudes, allowing for an in-depth exploration of how social contexts impact career decision-making. Together, these frameworks enable a nuanced analysis of the multifaceted reasons influencing high-achieving students' reluctance toward STEM careers.

4.1 Expectancy-value theory (EVT)

Eccles et al.'s (1983) EVT model is rooted in social psychology and takes into account social, psychological, and cultural aspects to explain motivational behaviour in educational and career contexts. EVT posits that personal choices, persistence, and performance are driven by two primary beliefs: how well they will perform in a particular activity (i.e., expectancy for success) and the extent to which they value the task (i.e., subjective task value) (Wigfield & Eccles, 2000).

Expectancies for success denote individuals' anticipation of either success or failure following their performance (Wigfield & Eccles, 2002). A significant determinant of these expectancies is students' current ability beliefs, which, though conceptually distinct, align empirically with expectancies for success (Eccles et al., 1993; Eccles & Wigfield, 1995). Research consistently demonstrates that expectancies for success strongly predict students' academic achievement and influence decisions in academic and career contexts, from elementary school to college (Durik et al., 2006; Pintrich & De Groot, 1990; Simpkins et al., 2006).

Subjective task value, as defined by Wigfield and Eccles (2002), refers to the relative attractiveness of succeeding or failing on a task. Eccles and Wigfield (2002) identified four elements of subjective task value: (1) attainment value, or the importance of doing well for self-identity; (2) intrinsic value, or personal enjoyment of the task; (3) utility value, or the task's relevance to current or future goals; and (4) cost, or the potential negative consequences of task engagement. Research shows that expectancy beliefs strongly predict performance, while task values are more closely linked to choices, including career decisions (Durik et al., 2006; Rosenzweig & Wigfield, 2017).

4.2 Expectancy-value-cost theory (EVC)

The EVC model (Barron & Hulleman, 2014) builds on EVT by isolating cost as a distinct component of motivation, which influences both expectancy and task value. While traditionally conceptualised as a part of subjective task value, recent scholarship has underscored the significance of cost as a separate, first-order latent construct (Flake et al., 2015; Kosovich et al., 2015; Luttrell et al., 2010; Perez et al., 2014), Regarding the conceptual evidence, Eccles-Parsons and colleagues (1983) stated that individuals think about the cost-benefit ratio of undertaking an activity when determining its value to them. Barron and Hulleman (2014) further contend that cost does not only contribute to the value component, it also contributes to overall expectancy. For example, task difficulty—often linked to cost—can reduce expectancy if individuals perceive the effort required as too great (Eccles & Wigfield, 2002). Moreover, cost, as the potential negative effect of performing a task, contradicts the definition of task value, which emphasises the advantages and positive outcomes that can be attained from completing a task (Rosenzweig et al., 2019). Empirical evidence supports the differentiation of cost as a separate construct. Analysis by Eccles and Wigfield (1995) and more recent studies (e.g., Conley, 2012; Flake et al., 2015) found that their cost factors, such as effort and time, function independently of task value, reinforcing cost's unique role in the EVC model.

Despite the ongoing debate about renaming EVT to EVC, as suggested by Eccles and Wigfield (2020), this study prioritises the practical relevance of cost as an influential factor. The EVC model, with its distinct emphasis on cost, offers a more nuanced perspective on motivation, particularly in understanding why some high-achieving students avoid STEM careers.

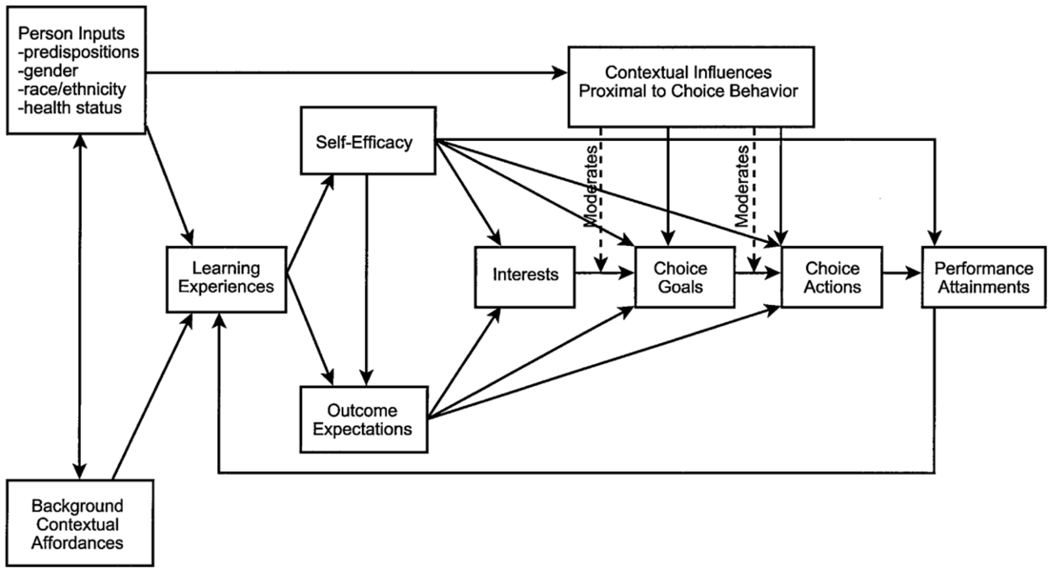
Herzberg's (1966, 1982) motivator-hygiene theory further helps to illustrate this approach by distinguishing between motivators, which drive satisfaction, and hygiene factors, which prevent dissatisfaction. Translating this to students' career choices, motivators such as self-efficacy and interest may attract students to STEM careers, while perceived costs deter them. Importantly, the presence of motivators does not counteract the influence of high costs, and low costs alone are insufficient to motivate. This perspective aligns with the EVC model, which treats cost as a distinct influence on approach and avoidance behaviours.

In this study, we adopt the EVC model as the central theoretical framework, recognising expectancy, value, and cost as critical to understanding the career aspirations of high-achieving students. Through this lens, we aim to explore how these components, alongside some external factors, shape students' STEM career intentions.

4.3 Social cognitive career theory (SCCT)

As illustrated in the SCCT model (Lent et al., 2002; see Figure 1-2), attitudinal factors like self-efficacy and interest are identified as direct influences on students' career goals and serve as key mediators between learning experiences and career aspirations. This model provides a structured approach to understanding how personal and contextual factors shape students' self-efficacy and outcome expectations, which in turn influence their career interests and choices.

Figure 1-2 Model of social cognitive career theory (Lent et al., 2002, p268)



In this model, attitudinal factors are seen as direct influences on career aspirations, making it essential to study students' attitudes toward STEM careers. These attitudes, however, are shaped by a range of experiences, including schooling, family influences, and personal characteristics like age and gender. Rather than examining every possible factor, this study focuses on students' self-reflected reasons for not aspiring to STEM careers, as personal experiences are more directly relevant to their expressed motivations. Factors like gender and socioeconomic status, while impactful, are less likely to surface as self-reflected reasons since they influence attitudes indirectly. Here, SCCT is instrumental in clarifying how students' attitudes are shaped by personal experiences, particularly through interactions with parents and teachers, providing deeper insight into the roots of students' expressed attitudes.

5 The research context

The two target nations, Scotland and China, differ significantly in their educational systems, economic priorities, and cultural attitudes toward STEM, all of which play a crucial role in shaping students' experiences and perceptions of STEM education. These differences not only influence how students engage with STEM subjects in school but also provide a critical lens for examining the factors behind their aspirations—or lack thereof—for STEM-related careers. By exploring the unique educational structures, workforce needs, and cultural narratives within each country, this section aims to uncover the contextual drivers of students' attitudes toward STEM.

5.1 STEM education in Scotland

Scotland's population was 5.4 million in 2022 as recorded by Scotland's Census (2023). In 2011, 26.1% (1.1 million) of people aged 16 and over had a university degree or professional qualification. The pupil-to-teacher ratio in Scotland was 79.9 in nursery schools, 16.5 in primary schools, 12.2 in secondary schools, and 3.5 in special education (Scottish Government, 2013).

Scotland's national curriculum, known as Curriculum for Excellence, was introduced to equip children and young people with the knowledge, skills, and attributes essential for thriving in the 21st century (Education Scotland, 2024). This curriculum is divided into two main phases: the Broad General Education and the Senior Phase. Broad General Education starts with early learning and childcare and extends up to the end of S3 (the third year of secondary school). During this period, students cultivate the knowledge, skills, attributes, and capabilities outlined in the four capacities of Curriculum for Excellence. The Senior Phase spans from S4 to S6, where students focus on building a portfolio of qualifications while continuing to develop the competencies defined in the four capacities of the curriculum.

Scotland places significant emphasis on STEM due to its long and distinguished history of discovery and innovation, dating back to the Industrial Revolution, and recognising STEM as a critical driver of economic prosperity. For instance, the Scottish Government has identified energy and life sciences as two of its "priority sectors" in its overall economic strategy (The Scottish Government, 2017). A growing shortage of skills among STEM employers existed before the coronavirus pandemic (COVID-19). As reported by the Scottish Government (2019), the proportion of STEM employers in Scotland with skills shortage vacancies was 7.7%, higher than the average for all sectors (6%), suggesting that STEM skills are difficult for STEM employers to obtain. To ensure that Scotland has a highly educated and skilled population equipped with the necessary STEM skills, knowledge, and capability to adapt to a fast-changing world and economy, a great number of initiatives have been made to help promote STEM education in Scotland. A comprehensive policy has been issued focusing on enhancing STEM skills from early years to higher education and lifelong learning. Initiatives include providing continuous professional development for teachers, establishing STEM professional learning networks, and developing resources and support tools for educators.

Scottish students pursue qualifications under the Scottish Qualifications Certificate (**SQC**), managed by the Scottish Qualifications Authority (SQA). Highers, a key qualification level, are essential for entry into further education, such as university or college, comparable to A-levels in England, Wales, and Northern Ireland. University admission requirements vary by institution, and the number and level of certificates students achieve depends on individual progression and goals.

In the Scottish system, students in S4 can take National 3 (N3), National 4 (N4), and National 5 (N5) qualifications. By S5, students typically progress to N4, N5, or Higher courses, and in S6, the final year, they have the option of N5, Higher, and Advanced Higher courses (SQA, 2024). Each course is graded on a scale from A to D, with “no award” given for ungraded outcomes. Typically, students choose five subjects at Higher level, including a compulsory course in English. Admission to highly competitive courses, especially at top universities, often requires S5 students to achieve at least four A grades.

5.2 STEM education in China

China has the second-largest population globally, with 1.41 billion people in 2021. By 2020, 15.4% of the population had obtained a degree from junior college or higher, 15% had completed senior secondary school (including secondary technical school), and 34% had finished junior secondary school (China Population Census, 2021). The rapid development of the Chinese economy and education witnessed a sharp drop in the illiteracy rate from 33.58% in 1964 to 2.67% in 2020. Education levels in China vary significantly among provinces and districts. For instance, the proportion of the population with a junior college degree or higher is 41.9% in Beijing, 33.8% in Shanghai, 18.6% in Jiangsu Province, and 10.9% in Guizhou Province. In China, all citizens must complete nine years of compulsory education, which includes six years of primary school followed by three years of junior secondary school.

The importance of STEM education in China has been recognised over the past decade, garnering attention from education researchers, teachers, and policy-makers who are actively working to strengthen and expand STEM programs across various educational levels. Although no national policy mandates the implementation of STEM courses as part of the national curriculum, some local educational authorities have taken significant steps to incorporate STEM courses into school curricula and invest in teacher training.

In the context of China's transformation into an innovation-driven economy, STEM education is seen as crucial for meeting the country's need for skilled talent and fostering innovation. This focus on STEM aims to equip students with the knowledge and skills required for the 21st century, positioning them to contribute to and thrive in a rapidly evolving technological landscape. Although the number of workforces in STEM industries reached 91 million people by 2018, there are shortages of high-end scientific and technological talent in China in fields such as artificial intelligence, information technology, new materials, and biomedicine (China Association for Science and Technology, 2018).

In 2017, the Chinese National Institute of Education Sciences established the Centre for STEM Education. This centre is dedicated to the promotion and research of STEM education and has published a White Paper on STEM Education in China. The White Paper (National Institute of Education (NIES), 2017) proposed the China STEM Education 2029 Innovation Action Plan, a vision for the next decade of STEM education. Developed by experts and academics in response to China's national context, this plan provides clear direction for the popularisation of STEM education and offers concrete examples to address current challenges in the field.

China's evaluation system for high school students differs significantly from that of Scotland. At the end of their final year, Chinese high school seniors take the National College Entrance Examination, commonly known as the **Gaokao**. Mathematics and Chinese are mandatory subjects for all students, who must also choose between two academic tracks: Arts or Science. For Arts track students, history is compulsory, while Science track students must take physics. Before attempting the Gaokao, students must pass the Academic Proficiency Test, or Huikao, for subjects not chosen as part of their Gaokao exam. Only students who pass the Huikao are eligible to sit the Gaokao. Although Huikao results do not contribute to the Gaokao score, they are provided to colleges for consideration in the admission process.

The Gaokao is the primary factor in college admissions, with a total score usually capped at 750 points. Students from all provinces take the Gaokao on the same date each year, but some aspects of the exam differ across provinces. While it is administered by the Ministry of Education, each province tailors its examination to fit regional needs, which has led to variations in grading scales and admission criteria. This provincial approach aims to mitigate educational and economic disparities, allowing more opportunities for students from less developed regions. Consequently, university admissions are highly competitive within each province, creating an environment where students primarily compete with peers from their own regions.

In 2021, the General Office of the Central Committee of the Communist Party of China and the General Office of the State Council introduced the *Opinions on Further Reducing the Burden of Homework on Students in Compulsory Education and the Burden of Out-of-School Training*, commonly known as the Double Reduction Policy (Ministry of Education of PRC, 2021). This initiative aimed to alleviate the academic pressures faced by students in compulsory education and to address issues related to their emotional well-being. The policy targeted two key areas: (1) Out-of-School Training: It sought to regulate unqualified training institutions and reduce the additional academic burden created by excessive tutoring. (2) Homework Load: It focused on limiting the amount of homework assigned to students, ensuring they had more time for rest, leisure, and personal development. Although the

Double Reduction Policy marked a significant step towards reducing the study burden for students, it applied only to those in compulsory education—primary and junior high school students from Grades 1 to 9. Importantly, it did not extend to high school students, who continue to face intense academic pressures under the existing system.

6 Definition of terms

Attitude toward STEM. This describes a person's feelings about STEM subjects and careers, shaped by their beliefs about these fields (Kind et al., 2007). In this study, attitudes toward STEM include a range of factors such as interest, value, self-efficacy, motivation, and perceived barriers.

Career aspiration. Career aspiration refers to the representative of an individual's ideal occupational choice (Mau & Li, 2018).

Cost. Cost refers to the negative consequences related to engaging with a task as perceived by individuals (Wigfield & Eccles, 1992). It includes aspects such as emotional cost, time and effort cost but excludes the financial cost associated with learning.

Perceptions on STEM. Refers to individuals' understanding of STEM, including their knowledge, beliefs, and stereotypes about STEM careers and subjects.

Social persuasion. It refers to the active role of human communication and interaction in shaping attitudes or behaviours (Li et al., 2021).

STEM. An acronym for science, technology, engineering, and mathematics, encompassing both individual fields of study and interdisciplinary combinations of these areas. STEM encompasses areas including science (physics, chemistry, and biology), technology and computer science, engineering, mathematics, and medicine. It also extends to related domains, including science education and applied sciences, reflecting its broad relevance across academia, industry, and societal advancement.

Merged method. The merged method refers to the integration of both qualitative and quantitative research techniques within a single study.

7 Structure of the thesis

In Chapter 1, a general overview of the research is provided. This includes an introduction to the background of researching STEM career aspirations, an explanation of the researcher's focus on the topic, and an overview of the two countries being studied. The research aim and questions are then stated and explained, along with definitions of important terms used in the study.

Chapter 2 is a literature review of studies on the topic. It begins by examining research on the motivational factors that influence students' academic performance and career aspirations, framed through the lens of EVC. The chapter then explores the impact of perceptions on STEM fields, followed by a discussion on the role of social persuasion in shaping students' career choices.

Chapter 3 provides a detailed description of Q-methodology, including the rationale for its use and how it is applied in the research design of this study.

Chapter 4 presents the analysis and findings of the data, establishing connections between the results with the research questions and previous literature.

Chapter 5 discusses the key aspects highlighted in this study and explores the implications of the research findings in light of existing literature, providing insights for future studies. It concludes with recommendations for relevant stakeholders, suggestions for directions in future research, and the limitations of this study.

Chapter 2: Literature Review

0 Introduction

This chapter presents an extensive literature review of research on the factors influencing students' aspirations for STEM-related careers, organised into three sections: the EVT and EVC, perceptions of STEM, and social persuasion. As stated in Chapter 1, this study is grounded in two key theoretical frameworks: the EVC and the SCCT. The EVC framework primarily focuses on students' attitudes, such as self-efficacy, interest, and cost; while the SCCT extends the EVC by emphasising the role of social persuasions such as the influence of teachers and parents. Alongside looking at students' attitudes and the influence of social persuasion, this chapter also explores students' perceptions of STEM careers to provide a comprehensive understanding of the factors shaping STEM career aspirations. The literature review chapter is structured following the guidance provided in Figure 1-1.

Although this study focuses on the STEM career aspirations of secondary school students, the review encompasses research spanning from primary school pupils to students in colleges and universities. This broader scope offers valuable insights into developmental trends and contextual factors, contributing to a deeper understanding of the key theoretical frameworks in the field.

Specifically, the chapter begins by reviewing the literature that utilises either the EVT or EVC framework, followed by an in-depth examination of its core components—value, expectancy, and cost—along with their sub-components in relation to their impact on students' motivation and aspirations for STEM careers. Following this, the chapter delves into the students' perceptions of STEM, exploring how these perceptions may shape their career aspirations. This is followed by an analysis of social persuasion factors, including the influence of parents, teachers, and peers. Although this study does not primarily focus on cultural comparisons, the inclusion of students from two nations allows for a consideration of cultural influences to enrich the findings. The chapter acknowledges the broader and more nuanced nature of cultural factors, which fall beyond the scope of this investigation due to insufficient evidence for comprehensive analysis. Consequently, while cultural influences are not addressed in a dedicated section, key insights from previous research are incorporated when relevant. By synthesising existing research, this review highlights key gaps and informs the study's methodology and focus, ensuring that the investigation addresses the most relevant factors affecting students' STEM career aspirations.

1 EVT and EVC

Since the EVC model serves as the overarching theoretical framework for this study, it is crucial to examine how it has been applied in previous research. As discussed in Section 4, Chapter 1, the EVC model is an extension of the EVT, a longstanding and widely used framework for studying student motivation and career aspirations. However, given the relatively limited application of the EVC model, it becomes necessary to delve into how the EVT has been implemented in previous studies. This exploration provides a foundational understanding for this study by leveraging the rich body of research on EVT to contextualise and support the application of the EVC model.

1.1 EVT using a STEM lens

In investigating STEM attitudes, Christopher Ball and colleagues (2016) demonstrated the effectiveness of EVT in predicting American students' motivational behaviours and academic achievement, especially in computer studies. Their study encompassed students from urban areas with high poverty rates and predominantly ethnic minority backgrounds. Among EVT constructs, intrinsic value (personal enjoyment of the task) emerged as the most influential predictor of STEM affinity while utility value emerged as the strongest predictor of STEM importance among the constructs of EVT. Interestingly, expectancy beliefs solely forecasted students' perceptions regarding the significance of technology, underscoring the nuanced roles these constructs play in shaping STEM attitudes.

Lauermann et al. (2017) explored the intricate dynamics of expectancy and subjective task value beliefs, revealing their impact on adolescents' career aspirations. Their research uncovered compelling reciprocal associations, demonstrating the positive connection between career plans in math and science and self-concept regarding abilities, alongside the correlation between the perceived utility of math and career intentions. Despite these illuminating findings, the evidence for reciprocal relationships between intrinsic interest in math and career aspirations in math or science lacked substantial support. Furthermore, the study unveiled the long-term significance of adolescents' expectancy and subjective task value beliefs on math-related career achievements, demonstrating their predictive power even 15 years after high school graduation.

Guo et al. (2017) validated the interactive impact of self-concept and value in forecasting science aspirations across four OECD countries (Czech, Hungary, Slovenia, and Sweden) utilising TIMSS (Trends in International Mathematics and Science Study) data. Specifically, they observed a substantial interaction between self-concept and value, effectively predicting aspirations in science, while also illustrating the interaction effects between the utilitarian motive for learning science and self-efficacy in science learning among students. Another significant discovery concerning the development of self-concept and intrinsic values is that students engage in negative dimensional comparisons across contrasting domains (e.g., physics vs. geography) but exhibit positive dimensional comparisons within similar domains (e.g., physics vs. chemistry). In essence, this implies that outcomes in any specific science subject are influenced not only by self-concept beliefs and achievements within that domain but also by intra-individual comparisons of achievements and self-concept beliefs across various science subjects.

These insights underscore the importance of considering the interplay between various psychological factors when examining students' STEM aspirations, rather than viewing them in isolation. The research also emphasises the distinct roles that different components within EVT play in shaping students' beliefs about STEM careers, their achievements, and their career aspirations. Additionally, caution is warranted when treating STEM subjects as a homogeneous group. While STEM fields are often viewed collectively, the distinct differences between subjects like science, technology, engineering, and mathematics—and the unique interactions within and across these domains—should not be overlooked.

1.2 EVT with cultural influences

Researchers have increasingly recognised the influence of cultural contexts on motivation and engagement, particularly within the framework of EVT. Eccles and Wigfield (2020) highlighted the cultural characteristics underpinning the EVT model, underscoring how factors like individualism versus collectivism and diverse parent-child interaction styles influence motivation and engagement (Tonks et al., 2018). For instance, interviews conducted by Wigfield et al. (2004) with Chinese professionals highlighted that career decisions in collectivist cultures are often guided by community needs for specific skills, rather than being solely influenced by personal talents and interests. Similarly, Japanese interviewees prioritised company reputation over the alignment between individual talents and interests and specific job roles, underscoring the influence of cultural norms on vocational preferences.

Comparisons between Western and Eastern contexts further highlight the limitations of EVT when applied across diverse cultural landscapes. For instance, Smith and Otsuka (2005) observed that the EVT, initially developed from a Western viewpoint, faced limitations in explaining the motivation of students from East Asian societies. These students tended to attribute their success more to effort and perseverance rather than ability, contrasting with the tendencies observed among their Western counterparts, who tended to attribute their achievement to ability. Such findings align with the work of Sun et al. (2013), who concluded that U.S. students had higher expectancy beliefs, while Chinese students emphasised attainment and utility values. Such insights reveal the need for culturally nuanced adaptions of EVT to account for distinct attitudes and values shaped by cultural norms.

Cultural influences extend to constructs such as self-efficacy (Eaton & Dembo, 1997; Lau & Ho, 2020) and intrinsic motivation (Ho, 2009; Mullis et al., 2012). While East Asian students consistently outperform their Western counterparts in cognitive performance on assessments like PISA (OECD, 2019) and TIMSS (Mullis et al., 2020), they report lower self-concepts and self-efficacy (Eaton & Dembo, 1997; Klassen, 2004; Lau et al., 2015; Lau & Ho, 2020). This discrepancy may stem from Confucian values emphasising modesty and effort as key routes to success, leading Chinese students to underestimate their ability or attribute achievements to effort rather than their ability (Chan & Rao, 2010; Lau et al., 2015).

Researchers have also focused on intrinsic and extrinsic motivation. Asian students tend to show lower levels of intrinsic motivation than students from Western countries, despite achieving high academic performance (Mullis et al., 2012; OECD, 2013). This phenomenon challenges traditional motivation theories that link higher intrinsic motivation with greater achievement (Schiefele & Winteler, 1992). One explanation is that the competitive school environment and norm-based evaluation in Asian countries (e.g., China, Korea, and Japan) make students study and achieve for extrinsic reasons such as future success (Tauer & Harackiewicz, 1999; Tyler et al., 2006).

Interventions have demonstrated the potential to leverage cultural differences in motivational dynamics. Shechter and colleagues (2011) revealed that highlighting the utility value of learning a subject encouraged East Asian students to perform better on tasks even when they had low intrinsic value at the start; Westerners, on the other hand, did not benefit from the utility value information. Since factors like grade level, gender, and discipline were not considered when the conclusions were reached, the outcomes may have been different. In light of the findings above, more research should be done to determine how various patterns of students' attitudes and motivation are formed and how they relate to their aspirations for STEM careers in different countries.

In conclusion, the interplay between cultural context and motivation highlights the need for further research into how cultural norms shape students' attitudes, self-efficacy, and motivation patterns. Understanding these dynamics is crucial for tailoring educational strategies that support diverse learners' aspirations, particularly in STEM disciplines in different contexts.

1.3 EVC using a STEM lens

Lee et al. (2022) utilised the EVC framework to explore the motivational characteristics of undergraduate students enrolled in introductory chemistry courses at a Canadian research-intensive university, with the sample composed of 44.2% Asian and 43% White individuals. The study identified four distinct motivational profiles, offering a deeper understanding of the nuanced reasons behind students' engagement in STEM studies: (1) High levels of task value and self-efficacy alongside moderate psychological costs; (2) moderate to high levels of task value and self-efficacy with moderate to low costs; (3) moderate to low levels across all motivational factors; and (4) moderate to high levels across all factors. Notably, students exhibiting moderate-high values and self-efficacy with moderate-low costs and high values and self-efficacy with moderate psychological cost profiles achieved the highest grades. Additionally, the research observed that Asian students were more prevalent in the moderate-high all profile, characterised by the highest psychological costs, compared to their white counterparts. This phenomenon has been found among other person-centred studies investigating U.S. and Australian high school students, with girls less likely to be classified into positive motivational profiles (Fong et al., 2021; Watt et al., 2019).

Despite these insights, a gap remains in understanding how these motivational profiles, especially regarding cost, impact academic performance and career aspirations across different cultural contexts beyond the mentioned countries. Additionally, the application of the EVC model in STEM fields is under-explored, particularly given the perception that STEM subjects and careers involve higher psychological costs compared to other fields.

1.4 Subjective task value

In this section, components of subjective task value including intrinsic value, self-value, and utility value are discussed, as well as similarities and differences between these components and some other factors. Subjective task value is considered a fundamental component of the expectancy-value model because students have to answer the question of ‘Do I want to do the task?’ or ‘Why do I want to do the task?’ before deciding whether they will do the task.

1.4.1 Intrinsic value

Intrinsic value, also referred to **as interest value** or **enjoyment value**, is defined as the enjoyment one gains from doing a task (Wigfield & Eccles, 2000). Before looking at the literature on intrinsic value, it is necessary to discuss the relationships between intrinsic value and other related concepts. In the early stages of motivational research, task value (Wigfield & Eccles, 1992), intrinsic/extrinsic motivation (Deci, 1975; Deci & Ryan, 1985; Lepper et al., 1973), and interest (Hidi, 1990; Hidi & Baird, 1986) were studied separately, with limited overlap between some of the clusters. However, interest can be considered an implicit aspect of intrinsic motivation and intrinsic value (Deci, 1992), as Deci (1998) argued that "intrinsically motivated is done because it is interesting." Intrinsic motivation refers to doing something because it is inherently interesting or enjoyable (Deci & Ryan, 1985). From this standpoint, when an individual is intrinsically motivated to do a task, he or she also perceives the intrinsic motivation of the task. Thus, intrinsic value and intrinsic motivation could be regarded as synonyms. In this study, interest, intrinsic motivation, and intrinsic value are viewed as synonyms, literature on the three factors is reviewed together in this section.

Empirical findings have shown that interest is a key factor concerning academic achievement, persistence, and graduation trajectories (Cerasoli et al., 2014; Froiland & Worrell, 2016; Howard et al., 2017; Taylor et al., 2014). When children are intrinsically motivated to complete a task, they often become deeply engaged in it and can persist in it for a long time, as Dewey (1916, p. 126) stated, "In interest, self and the world are engaged with each other in a developing situation." Csikszentmihalyi (1975) developed the concept of flow as a means to describe and understand the enjoyment and intrinsic motivation that people sometimes experience when engaging in various activities; he explained that people can enter a state of flow (the holistic sensation that people feel when they act with total involvement), and people in flow are highly focused on a task and feel totally in control of their actions. Research (Landhäußer & Keller, 2012) has shown that higher levels of flow promote higher performance as learning flow leads to more focused time on learning tasks and motivates learners to use productive behaviours during learning (Rheinberg et al., 2000).

Studies across several developed countries have indicated that students' interest in mathematics and science starts to decline during late primary school and it drops sharply at the primary-secondary transition (Jenkins & Pell, 2006; Potvin & Hasni, 2014; Tytler et al., 2008). Marosco and Bahjat (2013) stated that students have lost interest in the domain of STEM subjects as early as elementary school (before reaching high school) and believe that they are not innovative or creative. The causes of the decline, however, are quite ambiguous and no consensus has been reached. The different factors found are summarised as the lack of relevance of school science in students' lives, gender bias (Logan & Skamp, 2008), the shift to an increasingly impersonal nature of teacher-student relationships and curriculum, and the transition from activity-based science to transmissive approaches (Lyons, 2006). Krajcik and Czerniak (2014) emphasised that students came into schools with an innate interest in science and the decline of their interest stems from the way science is taught, for instance, the predominant use of textbooks that teach science by emphasising memorisation of science facts. Anderhag et al. (2016) proposed the possibility that primary students do not lose their interest in science, but rather that an interest in science is never constituted. Although it remains uncertain whether students' interests in school science and mathematics decline over time or fail to develop, understanding the factors that hinder the cultivation or sustainment of this interest is essential.

A number of studies have found that females lose interest in science faster than males, or that they prefer disciplines other than science (Christidou, 2006; Hendley et al., 1995; Simpson & Oliver, 1985, 1990). Kerger et al. (2011) explained that scientific subjects are perceived to be genuinely masculine and that girls' interest in science may jeopardise their self-perception as well as the femininity of their self-image; they further suggested that presenting concepts in the context of feminine topics could significantly increase girls' interest in science. However, the pattern that boys tend to have more interest in science than girls is not ubiquitous (Lindahl, 2003; Murphy & Beggs, 2003), and gender differences are more likely to be influenced by a variety of curriculum, pedagogical, and other factors.

In addition, several studies have indicated that interest is one of the most important elements influencing educational and occupational choices in STEM subjects (Archer et al., 2010; Bøe, 2012; Hipkins & Bolstad, 2006). Researchers (Ahmed & Mudrey, 2019; Cairns & Dickson, 2021; Rowan-Kenyon et al., 2011) found that science, math, and STEM interests are predictors of total STEM career aspirations, with interest being a stronger predictor for males than females. However, because these conclusions were reached using PISA data from the United States and Arabia, it is important to further investigate whether they hold true for all nations. Based on the assumption that interest is an important predictor of STEM career aspirations, many interventions try to attract more people to pursue science by making science classes more interesting. However, an interest in learning does not guarantee career aspirations. As revealed by the ASPIRES project, a majority of students aged 10 to 18 agreed that they learn interesting things in science classes, yet only 16% of the surveyed students agreed that they hoped to become scientists in the future (Archer et al., 2012, 2020). They went on to explain that the failure to translate students' interest in science into high levels of science aspirations is due to a lack of science capital or identity. This suggests that although interest is one of the most essential factors in students' development of STEM career aspirations, it is not reasonable to conclude that a lack of interest is the primary cause of students' low career aspirations.

1.4.2 Utility value

Utility value or **usefulness** refers to how a task fits into an individual's future plans (Eccles & Wigfield, 1995; Wigfield et al., 2016, p. 57). Closely related to extrinsic motivation, utility value refers to behaviours performed due to a separate consequence such as receiving rewards or avoiding punishment (Vallerand, 1997). Extrinsically motivated students, for example, attempt to complete a task because they perceive the task's utility value, such as receiving rewards, pleasing their parents and teachers, or gaining permission to pursue better employment opportunities, rather than because they are interested in or enjoy the task. In addition, it was argued by Wigfield et al. (2016) that utility value also connects to personal goals and sense of self, and thus has some connections to self-value. In this sense, when an individual is extrinsically motivated to do an activity, he/she perceives the utility value of the activity based on his/her sense of self. In this study, extrinsic motivation is examined as an integral component of utility value. This section explores the influence of utility value on career aspirations, as well as the relationship between extrinsic and intrinsic motivation.

Utility value often emerges as an important reason for the choice of subjects in upper secondary school (Angell et al., 2004; Bøe, 2012; Hutchinson et al., 2009). Studies have shown that the utility value of science acts as an important predictor of STEM career aspirations (Maltese & Tai, 2011; Simpkins et al., 2006). Some students choose secondary STEM disciplines because they typically serve as "gatekeepers" for admittance into prestigious higher education programmes such as medicine and engineering science (Bøe & Henriksen, 2015), leading to a secure and well-paid job for some individuals. However, STEM programmes are unlikely to be viewed as easy paths to economic security or other job benefits for some other students because scientific subjects and mathematics are viewed as "inherently difficult" subjects that require students to cope with multiple forms of representations at the same time and manage the formation of these representations (Angell et al., 2004; Gafoor & Kurukkan, 2015). In an examination of the need to achieve external goals, a great majority of respondents in Pellegrini and Segafredo's (2015) study stated that these courses were “demanding, tiring, and difficult” (p. 268); however, it is tolerable when there is a high level of professional utility and passion for the subject. Based on these findings, it appears that characteristics such as self-efficacy, interest, and cost influence students’ perceptions of the utility value of engaging in a task.

Various research has looked at the relationship between extrinsic and intrinsic motivation, especially the impact of extrinsic rewards on students’ intrinsic motivation. The predominant psychological view proposes that extrinsic motivation works in opposition to intrinsic motivation (Deci & Ryan, 1985; Lepper et al., 1973), resulting in a dichotomy between intrinsic and extrinsic motivation. For example, Deci (1999) and others’ research (e.g., Lepper et al., 1973; Lepper & Greene, 1975) found that when extrinsic rewards are introduced for doing an intrinsically interesting activity, people tend to feel controlled by the rewards, leading to a shift in the perceived locus of causality for the behaviour from internal to external. A meta-analysis of 128 studies spanning 3 decades confirmed that not only monetary rewards but also all contingent tangible rewards, significantly undermined intrinsic motivation (Deci et al., 1999).

However, early theorists mainly looked at how extrinsic motivators deteriorate intrinsic motivation when they are misused, with the positive effect of extrinsic motivators on intrinsic motivation being ignored. Deci and Ryan’s work (1980) clarified that when rewards are a vehicle for controlling people’s behaviour, they will undermine intrinsic motivation; but when rewards convey information or feedback that affirms or supports people’s competence, then rewards will maintain or enhance intrinsic motivation. Amabile (1993) argued that if the extrinsic factors support one’s sense of competence without undermining one’s sense of self-determination, these factors are viewed as “synergistic extrinsic motivation” which could positively contribute to intrinsic motivation. According to Amabile and Pratt (2016), intrinsic and extrinsic motivation can interact and have a positive cumulative effect. They argue that while intrinsic motivation predicts higher quality performance, extrinsic incentives are better at driving the quantity of performance. These findings challenge the traditional dichotomy, suggesting that intrinsic and extrinsic motivators are not necessarily antagonistic and should be considered together. This gap underscores the need for deeper investigation into how utility value and its interaction with different motivational factors shape students' sustained engagement and future goals. We will now look at self-value and how it affects students' career aspirations.

1.4.3 Self-value

Self-value is the value an individual attaches to achieving the goals they set for themselves, as measured by how well a subject or profession choice fits into their identity and self-worth (Bøe & Henriksen, 2015; Wigfield & Cambria, 2010). In EVT and EVC studies, this concept is often termed **attainment value**. However, in this study, the term **self-value** is used instead to avoid potential confusion with expectancy—as the word "attainment" might imply an expected outcome or completion of a task. The term self-value better captures the concept's essence, emphasising the central role of self-identity and self-worth. When tasks are viewed as central to an individual's sense of self or as a means to express or confirm important aspects of self, they are viewed as having a high self-value. This section examines how self-value shapes students' academic success and career goals through the lenses of self-identity and self-worth.

Individuals develop an image of who they are and what they want to be as they grow up; this image is central to self-definition and influences the value they place on various educational and vocational options, which in turn influences their achievement-related choices (Eccles, 1994; Markus & Nurius, 1986). Constructing a distinctive identity is of great importance to students during the phase of choosing a future career (Illeris et al., 2002). For instance, if students perceive physics to be for brainy and unpopular geeks and thus reject such an identity trait, physics will have low self-value for them; conversely, if students see physics as a way to learn the truth about the world and treat physics as a "life choice," then the subject's inevitable problems, as well as the workload, can be overcome by their strong recognition of the importance of the subject being studied (Pellegrini & Segafredo, 2015, p. 267). Given that self-value is obtained when a subject or occupation fits into one's identity and self-worth, it is reasonable to examine self-identity theory and self-worth theory to determine how self-value is obtained.

Self-identity. According to self-identity theory, whether one chooses a STEM major is determined by the degree to which one embraces a science or math identity (Zhang et al., 2021). Science identity refers to how a person identifies with a scientific field and is recognised as belonging to that field (Rodriguez et al., 2020). Zhang et al. (2021) found that science identity has the strongest association with students' choice of a STEM major among all other motivational, STEM course-taking, and achievement variables. In a similar vein, Stets and her colleagues (2017) investigated how an individual's science identity determines their decision to choose a science career using national panel data that followed minority college students in STEM disciplines from 2005 to 2013. They found that having a science identity was positively associated with students' likelihood of entering a science occupation after controlling for factors including science self-efficacy, STEM GPA, science activities and demographic background.

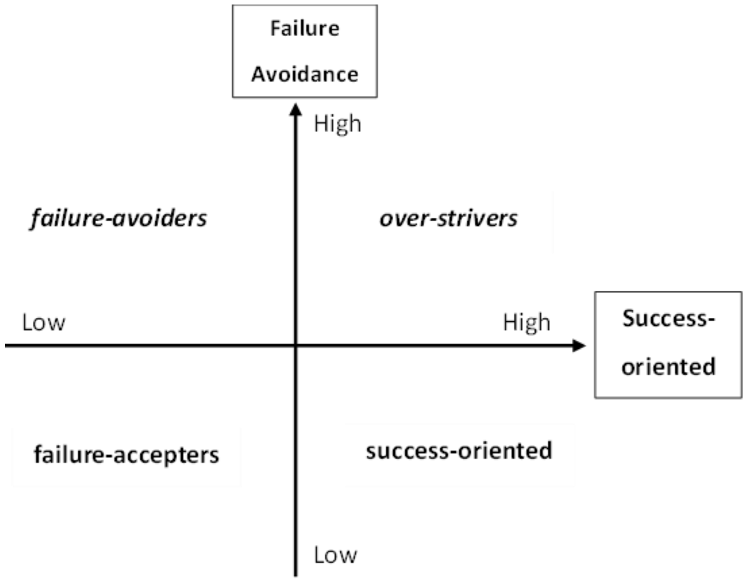
The interplay between self-identity and other variables has caught the attention of some researchers. Carlone and Johnson (2007) conceptualised an individual's scientific identity into three components: performance, competence, and recognition. They hypothesised that individuals with higher degrees of self-efficacy beliefs in their abilities to master STEM-related subjects and content would be able to better carry out STEM-related tasks and professions, reaffirming a science identity through personal experience and feedback. It was explained by Zhang et al. (2021) that even though identities are more important in predicting role-related outcomes than self-efficacy, self-efficacy is necessary to buttress and support our role identities. These two studies indicate that self-efficacy and self-identity are intertwined, and their mutual interaction is manifested by a stronger predictor of self-identity on students' STEM career aspirations.

Many studies have found that STEM career identities are less appealing to young people (Archer et al., 2010; Hazari et al., 2010; Schreiner, 2006; Taconis & Kessels, 2009). Some aspects of science culture appear to reduce young people's willingness to associate with it because students see school science as "dull, authoritarian, abstract, theoretical, fact-oriented, and fact-overloaded, with little room for fantasy, creativity, enjoyment, and curiosity" (Schreiner, 2006, p. 57). Schreiner (2006; Schreiner & Sjøberg, 2007) concluded that most young people in late modern societies, particularly women, prefer to have an identity that is unrelated to science and science culture. Taconis and Kessels (2009) further explained that, because late-modern identity projects are often centred on the notion of self-realisation, aspects of science culture that are distinguished by being "useful" or "obedient" may no longer serve as a guideline for students' biographies. Due to the importance of self-identity in influencing students' career aspirations, one of the reasons for students' low STEM career aspirations could be a lack of STEM identity, which will be investigated in this study. Let us now move on to self-worth, another factor concerning self-value.

Self-worth. Self-worth refers to the belief that one is capable of achieving competitively (Covington, 2009, p. 142). According to self-worth theory, individuals strive to give their lives meaning by seeking the approval of others, which requires being competent and able while avoiding the implication of failure—that one is incompetent and thus unworthy (Covington, 2009).

Atkinson's (1964) model of achievement motivation identified two individual difference dimensions: the tendency to approach success and the tendency to avoid failure. Within these two dimensions, all students can be classified into four quadrants with different combinations of high/low approach/avoidance tendencies regarding their achievement motivation (see Figure 2-1). Students who have both high approach and high avoidance are labelled as "over-strivers" (Covington & Omelich, 1991) and are drawn to the prospect of success while being repelled by the prospect of failure. These failure-threatened students adopt a defensive posture in order to avoid failure by succeeding, they must expend enormous amounts of energy studying in order to ensure repeated success and avoid failure (Covington, 2009, p. 147; De Castella et al., 2013). However, the burden of sustaining success would increase, and the strategy of overpreparation might fail sometimes. Evidence from the self-worth hypothesis has shed light on the fact that some seemingly successful students lack a feeling of self-worth because they are under great pressure to maintain consistent achievement and avoid failure, causing their self-worth to deteriorate. When given the opportunity to select a major or a job, they may choose to avoid majors in which they struggle to maintain their self-worth. This may assist in explaining why some seemingly successful students opt not to continue with the courses or careers in which they excel.

Figure 2-1 A quadripolar model of achievement motivation (Covington & Omelich, 1991)



Both self-identity and self-worth serve as a connection between individuals' sense of self and worth, but self-identity is more closely associated with the sense of accomplishment one feels from the fit between their role and task, whereas self-worth is more closely linked to their sense of competence one gets from performing a task or pursuing a career. In this study, self-identity and self-worth are viewed as two distinct components of self-value.

1.5 Expectancies for success

Expectancies for success (expectancy for short) were defined by Eccles et al. (1983) as students' beliefs about how well they will perform on future achievement tasks. Expectancy incorporates both students' ability beliefs (individuals' perception of their current competence) and their perceptions of task difficulty. Aside from evaluating their abilities to do a task, students have judgments over how difficult the subjects are. For example, physical science and mathematics are often regarded as particularly difficult and demanding subjects

(Angell et al., 2004; Osborne & Collins, 2001a; Tytler et al., 2008). Hence, students need to be particularly confident in their abilities to succeed in subjects like mathematics and physical science to form expectancies of success in STEM fields.

Although ability beliefs are conceptually distinct from expectancies, the two constructs often overlap empirically (Eccles & Wigfield, 1995). As a result, many EVT researchers combine measures of ability beliefs and measures of expectancy, or substitute one for the other. Self-efficacy, which is defined as students' beliefs about their capabilities to do the actions necessary to complete a given task (Bandura, 1997), overlaps with expectancies in much empirical research, and many researchers found that the two constructs are nearly indistinguishable (Eccles & Wigfield, 1995; Guo et al., 2017; Wigfield et al., 2006). Thus, in this study, self-efficacy will be used synonymously with expectancies for success, with slight differences between them considered.

However, it is important to notice that ability belief or expectancy is a necessary but not sufficient factor in predicting educational and career choices (Eccles & Barber, 1996; Joyce & Farenga, 2000; Wang, 2012). Subjective task values are found to be stronger predictors of future academic choices and enrolment than expectancy beliefs (Durik et al., 2006; Gasco & Villarroel, 2014; Nagengast et al., 2011). This implies that simply being talented or good at a subject, as well as believing one has the potential to succeed in a field, does not always imply an individual's willingness to pursue a career, as students may lack perceptions of the value of the career. This section provides a detailed explanation of self-efficacy and an effect derived from self-efficacy.

1.5.1 Self-efficacy

Self-efficacy is defined as individuals' subjective conviction in their capabilities to perform a specific task successfully to achieve the desired outcome (Bandura, 1997). Self-efficacy was found to be a positive predictor of performance outcomes in different subjects such as mathematics, science, and writing (Klassen & Usher, 2010; Pintrich et al., 2008; Usher & Pajares, 2008). Students who are more efficacious in their learning should be more likely to participate in self-regulation (e.g., setting objectives and using effective tactics) and create an effective learning environment (e.g., eliminating or minimising distractions). In turn, self-efficacy can be impacted by the outcomes of behaviours (e.g., accomplishment and goal progress) as well as environmental input (e.g., feedback from teachers and social comparisons with peers). Therefore, compared to students with low self-efficacy, those with high self-efficacy participate more readily, work harder, persist longer, and show greater interest in learning (Bandura, 1997; Schunk & Pajares, 2005).

Although students with higher skills and abilities tend to be more self-efficacious, there is no necessary relation between self-efficacy and academic ability (Dale & Frank, 2016). As Bandura (1997) stated, skill is not synonymous with self-efficacy. Collins (1982) divided students in mathematics into high-, average-, and low-ability groups, and identified students with high and low efficacy within each level. Students were asked to solve problems and they could rework those they missed. It turned out that ability related positively to achievement, but, regardless of ability level, students with high self-efficacy solved more problems correctly and chose to rework more of the problems they missed. Self-efficacy appears to have an indirect influence on students' academic development, with academic behavioural and psychological processes functioning as moderators.

Perceived task difficulty refers to students' beliefs about the demands of a particular task and the effort required to succeed (Eccles & Wigfield, 2002). While task difficulty and self-efficacy are distinct constructs, they are closely interrelated. Self-efficacy pertains to self-related knowledge and emotions, whereas perceived task difficulty involves task-related knowledge and emotions. Despite these distinctions, students often consider their own abilities when evaluating a task's difficulty. Research has consistently demonstrated a negative relationship between students' perceived task difficulty and self-efficacy. For instance, Mangos and Steele-Johnson (2001) found that as students perceive a task to be more difficult, their self-efficacy tends to decrease. The level of perceived difficulty also has varying effects on student motivation. For example, tasks perceived as too easy can lead to a loss of interest and engagement (Rotgans & Schmidt, 2014; Street et al., 2017). In contrast, tasks with moderate difficulty levels often enhance motivation and improve performance (Brunstein & Schmitt, 2004). However, tasks perceived as overly challenging are likely to induce negative emotions such as frustration, reducing motivation and potentially hindering performance (Steensel et al., 2019).

Self-efficacy (Brown & Lent, 2006; Nauta & Epperson, 2003; Zarrett & Malanchuk, 2005), or math/science self-efficacy (Luzzo et al., 1999), has been found to predict students' major and career choices. Bandura et al. (2001) tested a structural model of the network of socio-cognitive influences that shape children's career aspirations and trajectories and discovered that children's perceived efficacy, rather than their actual academic achievement is the key determinant of their preferred choice of career. This may be because self-efficacy beliefs mediate the effects of prior achievement, knowledge, and skills on subsequent achievement (Schunk, 1985). Because self-efficacy develops in competitive environments such as classes and schools, the following section will look at how competitive environments influence students' perceptions of their abilities.

1.5.2 Big-fish-little-pond effect (BFLPE)

Social comparison is one of the most powerful sources of evaluative information for judging self-concept, which is formed through experience and the interpretations of one's environment (Shavelson et al., 1976), students in high-ability schools often experience a loss in their academic self-efficacy (Marsh, 1990). Marsh (1987) discovered that, after controlling for individual differences in ability, school-average ability had a negative effect on students' academic self-concept. This social comparison effect was named the big-fish-little-pond effect (BFLPE) by Marsh and Parker (1984). The BFLPE has been shown to have a negative impact on a variety of additional educational outcomes, including educational aspirations, general self-concept, and occupational aspirations (Marsh et al., 1991). Guo et al. (2017) found that aspirations in a scientific field depend not only on the competence, self-concept and intrinsic value of that field but also on the relative competence and motivation of other scientific fields. The BFLPE stresses the negative influence of class or school average on students' academic self-concept and provides some insight into the importance of relative ability in predicting students' career aspirations. This study will take into consideration the role relative ability plays in determining students' career aspirations.

1.6 Cost

As previously explained (see Section 4, Chapter 1), the tendency of students seeking to avoid STEM degrees or occupations requires more investigation to determine the impact on career decisions. In the EVT model, **cost** refers to students' perceptions of the negative consequences of participating in a task (Wigfield & Eccles, 1992) and encompasses a more negative dimension of motivation than competence beliefs and task value. The construct of cost has raised the interest of researchers and was proposed to play a significant role in STEM talent retention by researchers such as Ball et al. (2017) and Luttrell et al. (2010).

Recent research that looked at cost as a separate variable has revealed that it is crucial in identifying middle school students' motivational patterns for learning and predicting their academic achievement and behaviours (Conley, 2012; Jiang et al., 2018; Robinson et al., 2019; Trautwein et al., 2012). For example, Conley (2012) found that middle-school students' motivational patterns in mathematics were significantly differentiated by cost and that students whose motivations included high cost tended to perform worse in mathematics courses. Robinson et al. (2019) and Flake et al. (2015) reported that cost relates negatively to college students' academic performance.

In addition, Jiang et al. (2018) argued that cost emerges as an important factor in predicting adolescent students' (8^{th} and 11^{th} graders) adoption of avoidance goals, negative classroom effects, procrastination, and intentions to avoid studying. Students who adopt these avoidance-oriented academic behaviours perform poorly in school (Senko, 2016). Conley (2012) conducted cluster analyses of middle school students' self-efficacy, task value, and cost in math. She found that the groups of students whose patterns of motivation included high cost performed worse in math than their peers, and that cost was a crucial factor in identifying groups of students who had adaptive vs. maladaptive patterns of motivational beliefs, values, and goals. These findings highlight the predicted effect of cost on avoidance-related behaviours more than on academic achievement.

Cost was also found to negatively predict plans to pursue science careers or graduate school and college students' drop-out intentions (Battle & Wigfield, 2003; Kirkpatrick et al., 2013; Perez et al., 2014). As for specific subject domains, Perez et al. (2014) found that college students who perceive higher costs for STEM majors reported higher intentions to leave STEM majors. But conclusions are only drawn from research on college and university students, it is unclear how secondary school students' STEM career choices are influenced by cost.

1.6.1 Components of cost

No agreement has been reached on the components of cost, but in general, researchers have a consensus about the three factors of cost: effort cost, loss of valued alternatives cost, and psychological cost (Eccles et al., 1983; Kosovich et al., 2015; Perez et al., 2014).

Effort cost was described as students' perception of how much effort is needed to be successful at a task, with the cost being high if that effort is not perceived to be worth the benefit. Measuring cost objectively as the amount of effort or task difficulty is insufficient, to be perceived as cost; it must be perceived negatively by the respondent (Barron & Hulleman, 2014). According to Perez et al. (2014), effort cost has a stronger correlation with students' intention to leave STEM majors than the cost of lost valued alternatives and psychological cost. Students are more likely to drop out of STEM majors if they believe the effort required to succeed is not worthwhile. The results suggest that if individuals believe the effort to succeed in a task is worthwhile, other costs may seem less important because "it is all worth it."

Loss of valued alternatives cost, or opportunity cost, was hypothesised by Eccles et al. (1983) to occur when engaging in one activity prevents an individual from being able to participate in other valued activities (e.g., spending time with friends and family). In their measurement of cost among university students, Flake et al. (2015) noted that loss of valued alternatives is only salient in courses where college students were least motivated, with no descriptions of giving up or sacrificing other valuable activities in courses where they were most motivated. For this reason, when an activity is regarded as valuable, devoting time and effort to it is not regarded as a sacrifice. However, doing an activity represents a loss only if there are negative appraisals of the subject. Tuominen et al. (2020) studied the subject-specific achievement goal orientation profiles of upper secondary school students in math and English simultaneously to better understand how different profiles relate to perceived subject-specific costs. Opportunity cost in mathematics was found to be relatively high among the success-oriented and indifferent students and low among the avoidance and mastery-oriented students. The findings suggest possible connections between cost and orientation profiles, and orientation profiles are associated with students' academic performance and motivation (Schwinger et al., 2016; Zhang et al., 2016).

Psychological cost was described as the anxiety related to the potential of failure at the task (Eccles et al., 1983). Psychological cost has received less attention as it has a less predictive effect on students' intention to leave STEM majors compared with effort cost and loss of valued alternatives (Perez et al., 2014). But Flake et al. (2015) found that psychological cost was more related to final grade than any other construct or cost component, emotional stress may be more predictive of outcomes whereas other types of costs may be more predictive of motivation such as persistence in a subject.

Some researchers extended the cost construct by proposing a fourth element: outside effort cost. Outside effort cost is defined as the time, money, energy or effort put forth for tasks other than the one of interest (Barron & Hulleman, 2014; Flake et al., 2015). In contrast to the definition of loss of valued alternatives, the definition of outside effort emphasises how other tasks or activities undermine students' motivation towards a task or activity. Barron and Hulleman (2014) gave an example of a student who excels in math and finds it to be one of her favourite classes, but she has difficulty finding time to finish her maths homework due to an ambitious academic and extracurricular schedule and thus her motivation is diminished. This is an example showing how outside effort cost damage students' motivation. The student is unable to make time for math homework due to objective factors rather than subjective factors such as "I don't want to do it" or "I don't think I can do it." Additionally, outside effort is caused by tasks or activities other than those we target, as a result, it is not accepted as a component of cost in this study.

Even though researchers have gained more experience in measuring costs, more research is still needed to fully grasp how costs relate to students' academic success and career aspirations. Now, we will turn our attention to studies focusing on students' attitudes and motivation towards STEM careers conducted in various countries.

2 Perceptions of STEM

The previous section explored students' attitudes using the EVC model, highlighting how they align their interests, abilities, self-concepts, and other traits with STEM careers when making career choices or forming aspirations. However, understanding students' perceptions of STEM careers and professionals is equally crucial. By examining whether these perceptions align with the realities of STEM fields, we can gain deeper insights into the factors driving students' motivation, ultimately enabling more effective support for their career development.

Students' positive perceptions of STEM careers and professionals are widely recognised as influential factors in shaping their aspirations to pursue STEM careers (Chan et al., 2019; Chen et al., 2024; Scholes & Stahl, 2022). When students view STEM professionals as intelligent, innovative, or successful, they are more likely to express interest in STEM-related jobs and consider pursuing such careers. However, research also suggests that these seemingly positive perceptions can have counterproductive effects. For instance, perceiving scientists as exceptionally intelligent or successful might inadvertently deter students, as these attributes may make STEM professionals seem unattainable or difficult to emulate (Morgenroth et al., 2015). Similarly, Giannantonio and Hurley-Hanson (2006) note that students' beliefs about the image of engineers can influence their willingness to approach or avoid the profession, depending on how closely they identify with that image. Therefore, understanding how students perceive STEM professionals and how those perceptions misalign with their self-image is crucial for researchers aiming to design effective career guidance programs and create STEM curricula that resonate with students' aspirations and identities.

Among students' perceptions of STEM exist stereotypes regarding STEM careers, which are over-generalised beliefs regarding a group of people that are often negative (Matsumoto, 2009). Research has shown that students commonly associate scientists and engineers with trait-based stereotypes (such as STEM being for socially awkward geniuses) that can diminish their interest in pursuing STEM careers (Capobianco et al., 2011; Lachapelle et al., 2012) and such stereotypes were found to have a negative impact on students' STEM career aspirations (Archer et al., 2013; DeWitt et al., 2013; Van Tuijl & Van Der Molen, 2016). Surveys conducted by the OECD revealed that students tend to view science and engineering professionals as "doing boring, uninteresting work in unpleasant surroundings, cut off from other people" (OECD & Development, 2008). Similarly, Masnick et al. (2010) found that high school students perceived STEM-related occupations as less people-oriented and creative when compared to non-STEM careers. Archer et al. (2013) noted that students reject science as a career choice because they perceive people working in science as "geeks" or "boffins". Additional stereotypes, such as social skills deficits, obsessiveness, poor hygiene, and dull lifestyles, perpetuate negative perceptions of STEM professionals (Barbercheck, 2001; Cheryan et al., 2011; Nassar-McMillan et al., 2011).

Gender-related stereotypes are prevalent among students, particularly in how STEM careers are perceived. These fields are frequently associated with men and masculine traits, reinforcing the notion that they are inherently male domains. For example, Hand et al. (2017)

found that high school students and teachers tended to attribute traditionally masculine characteristics, such as analytical thinking and assertiveness, to individuals in science-related fields, while assigning more feminine traits, such as creativity and empathy, to those in the humanities. Such perceptions contribute to a bias that frames girls as less capable or suited for excelling in STEM disciplines (Moss-Racusin et al., 2012). This biased framework influences not only how students view their own potential but also how educators and peers perceive and treat women in STEM. These stereotypes can lead to systemic discrimination by educators and colleagues, as highlighted by Rice and Barth (2016), which further discourages girls from pursuing STEM careers, perpetuating a cycle of underrepresentation and lost potential.

Students' career perceptions and stereotypes rely on the career knowledge they obtained, which directly impacts their intentions to pursue STEM careers (Compeau, 2016; Zhang & Barnett, 2015). A lack of knowledge about STEM careers can lead students to dismiss these paths, reducing their willingness to participate in career-related activities (Blotnicky et al., 2018). Among the various sources of career knowledge, media has emerged as a crucial influence on students' STEM career aspirations (Haun-Frank, 2011; Li et al., 2021; Myers et al., 2011). For instance, Haun-Frank (2011) noted that media portrayals, especially in healthcare careers, often exaggerate exciting storylines, creating tension and unrealistic expectations. Moreover, students may avoid careers like chemistry if they mistakenly believe such roles lack opportunities for altruism or humanitarian work, despite these possibilities existing within STEM fields. Li et al. (2021) suggest that researchers and career counsellors should recognise the powerful role of social media (such as TV and the Internet) in shaping students' career choices, often outweighing guidance from parents or teachers.

The reviewed studies in this section highlight the importance of examining students' perceptions of STEM to fully understand how they view STEM careers and professionals.

By examining whether students hold inclusive and realistic views of STEM, researchers can better understand the underlying reasons for students' lack of aspirations in STEM-related careers and develop strategies to address these barriers effectively. While much of the existing research focuses on factors influencing students' aspirations, how students perceive STEM careers and the professionals in these fields is often overlooked. To address this gap, this study will explore students' perceptions of STEM careers and professionals in addition to examining their reasons for not aspiring to STEM-related careers.

3 Social persuasion

As introduced in the SCCT framework (see Section 4.3, Chapter 1), personal experiences are greatly influenced by external influences, including those from parents, teachers, and peers. In this study, we use the term **social persuasion** (Li et al., 2021) instead of external influence to emphasise the active role of human communication and interaction in shaping attitudes or behaviours, unlike *external influence*, which suggests passive influence from any outside factor, social persuasion underscores the intentional, dynamic process of interpersonal engagement that drives meaningful change. This section reviews previous literature on the influences of parents, teachers, and peers.

3.1 Parents

Parents have been widely studied for their significant influence on students' career aspirations, achievement, and engagement in STEM fields (Archer et al., 2012; Gilmartin et al., 2006; Jacobs et al., 2006; Schmidt et al., 2012). This influence manifests through various behaviours, such as involvement in science schoolwork (Bhanot & Jovanovic, 2009), encouragement of effort in science and maths (Zhang & Barnett, 2015), and the provision of information about STEM careers (Mohd et al., 2010).

Beyond direct interactions between parents and children, Archer et al. (2013) emphasised the concept of "STEM capital", emphasising the crucial role it plays in affecting the likelihood of students aspiring to science-related careers. STEM capital encompasses the resources, skills, and knowledge related to science education, and students from families of higher STEM capital are more inclined to aspire to STEM-related careers (Archer et al., 2020). The interplay between science capital and habitus (the ways and settings in which families operate) allows parents to shape attitudes, values, and expectations, ultimately influencing children's STEM career aspirations (Šimunović et al., 2018).

Parental expectations have been investigated as a factor influencing children's STEM career choices, but findings on their impact remain mixed. Several studies (Jones et al., 2021a; Šimunović et al., 2018; Šimunović & Babarović, 2020) highlight a positive effect, showing that parental values and expectations can encourage children's behaviours or motivations. Conversely, other research (Jacobs et al., 2006; Leung et al., 2011; Ma et al., 2018) reveals a potential negative impact on parental expectations. For instance, Ma et al. (2018) found that students who perceived high parental academic expectations were more likely to face difficulties in career decision-making. Additionally, Chen et al. (2022) noted that the impact of parental expectations is mediated by the internalisation process, wherein children absorb their parents' expectations through interactions such as observing STEM-related activities or listening to discussions about careers (Adya & Kaiser, 2005; Gibson & Papa, 2000).

Parental influence appears to be particularly pronounced in cultures guided by Confucian or Taoist values, where family obedience is emphasised (Leung et al., 2011; Wan & Lee, 2017). In such contexts, parents often hold and express higher expectations compared to other cultural settings (Yamamoto & Holloway, 2010). For instance, traditional Chinese cultural norms suggest that parents tend to have greater expectations for sons than daughters (Shek, 2008). These cultural nuances highlight the need to explore how students internalise parental expectations, how these expectations shape their career aspirations, and how the role of parental expectations differs across cultural contexts.

3.2 Teacher

Teachers play a significant role in influencing students' interest and motivation to study science and mathematics. Their influence extends through the delivery of subject content, the implementation of diverse teaching methods, the creation of an engaging learning environment, and the provision of support and encouragement to students (Bergin, 2016; Maltese & Tai, 2010; Regan & DeWitt, 2014; Tytler & Osborne, 2012). Additionally, teachers can potentially influence students' STEM career aspirations through these mechanisms (Bahar & Adiguzel, 2016; Cerinsek et al., 2013).

The teaching methods of teachers are significant in affecting STEM career aspirations in that STEM teachers are responsible for making STEM courses appealing and sustaining students' attainment (Tytler & Osborne, 2012). Education-based themes were found to be the second most common topic influencing students' interest in science apart from intrinsic interest, wherein class content together with teacher demonstrations and projects were the most common source where their interest came from (Maltese & Tai, 2010). Teachers are prominent in affecting interest in STEM through interactions (Regan & DeWitt, 2014) and the variety of teaching methods they employ are associated with their students' motivation, enjoyment, and views of science careers (Cerini et al., 2003; Christensen & Knezek, 2017; Osborne & Collins, 2001a).

Beyond instructional methods, teachers also serve as role models and sources of support. Their encouragement plays a pivotal role in fostering students' engagement with science and mathematics (Wang & Degol, 2013). Although some studies suggest that family and peers might have a stronger influence on career aspirations (Paa & McWhirter, 2000), teacher support has been consistently linked to essential outcomes such as academic achievement and motivation (Goodenow, 1993).

The influence of teachers is also mediated by their expectations for students' performance. High teacher expectations can lead to increased support, thereby fostering both achievement and a sense of competence in students (Eccles, 2009). The impact of teacher expectations on students is mediated through teacher-student interactions, underscoring the importance of supportive and aspirational relationships.

While the overall impact of teacher support on STEM career aspirations may appear limited when compared to other factors, such as family influence, its significance increases over time. Farmer (1985) discovered that teacher support, although playing a small role, significantly affects career aspirations, surpassing the influence of parents by the 12th grade. Some researchers have uncovered the impact of teachers on STEM career interests through students' self-reported data (Bahar & Adiguzel, 2016; Christensen et al., 2015; Knowles et al., 2018).

In conclusion, despite discrepancies in findings across various studies, there is strong evidence that they are significant contributors. Teachers play an essential role in fostering students' interest, motivation, and positive attitudes toward STEM. Through effective teaching practices, encouragement, and high expectations, they serve as vital influencers, helping to shape students' career aspirations.

3.3 Peer

The adolescent stage is a crucial period during which individuals shape their self-identity, especially in the field of science (Vedder-Weiss & Fortus, 2013). While the exact process of peer influence remains somewhat unclear, researchers (Jackson & Seiler, 2013; Olitsky et al., 2010) have uncovered that peers can have a motivational impact by influencing each other's identity development. This influence is likely facilitated through interactions within peer groups, as youth associating with highly engaged peers tend to increase their involvement in science and mathematics over time (Kindermann, 1993, 2007). Additionally, support from peers plays a crucial role in influencing students' inclination to participate in science and mathematics, driven by peer norms among teenagers (Crosnoe et al., 2008; Wang & Degol, 2013). Those with peers who strongly support science are more likely to perceive themselves as scientists compared to those lacking such supportive peers (Stake & Nickens, 2005).

While peers play a substantial role in shaping students' motivation and identity, their direct influence on students' career choices or aspirations appears to be limited. For instance, Blenkinsop et al. (2006) found that when asked to rate a number of influences on their career decisions, students tended to prioritise school-based factors such as individual conversations with teachers and access to career guidance over external influences such as friends and family. Although participants often discussed career choices with friends, these discussions did not strongly determine their career decisions or subject choices, suggesting that peer influence in this domain is indirect. Therefore, whilst peer groups play an essential role in fostering motivation and shaping identity in science and mathematics, their impact on career decisions is more nuanced. Peer influence appears to function primarily through creating a supportive environment and establishing norms that encourage engagement in STEM, rather than directly steering career aspirations.

4 Conclusion

Taken together, the review highlights the critical roles of various factors including attitudinal factors (EVC), perceptions of STEM, and social persuasion in shaping students' achievement and career aspirations, while illuminating the relationships between these factors. The review also uncovers three significant research gaps that warrant further exploration:

Firstly, the majority of the attitudinal factors discussed here are positively correlated with students' aspirations for STEM careers, with the exception of cost, which is negatively correlated. It is worth noting that most researchers attempt to investigate the motivating factors that enable students to pursue STEM careers, whereas the factors that drive students to avoid STEM-related careers are largely ignored in career aspiration studies. It would be beneficial to identify the mechanisms by which avoidance factors affect students' career aspirations in order to better understand how students' career aspirations are undermined.

Secondly, very few studies have looked at the STEM career aspirations of high-achieving students; instead, most researchers conduct surveys of all the students in a class or a school without distinguishing students' levels of ability as a way to get a comprehensive picture of students' perspectives. As a result, findings from the general student population may not apply to this particular group.

Third, while some studies have looked at students' attitudes from different cultural backgrounds, there is a gap in how the interaction between students' attitudes and STEM career aspirations varies across countries. While EVT and EVC frameworks acknowledge cultural differences, they often reflect Western-centric perspectives, neglecting unique dynamics in collectivist cultures like China, where success is often attributed to effort rather than ability. Additionally, differences in education systems—particularly between Western and Eastern countries—suggest that factors influencing students' motivation to avoid STEM careers may also differ significantly across cultural contexts. Specifically, the intersection of cultural norms with motivational factors such as self-efficacy, intrinsic/extrinsic motivation, and perceived costs remains underexplored, particularly in competitive educational environments. Addressing this gap could enhance our understanding of how educational structures and cultural expectations impact students' motivation for or against pursuing STEM careers, offering insights for more culturally responsive interventions.

To address these gaps, this study will investigate the factors influencing high-achieving students' decisions to pursue or avoid STEM-related careers, with a focus on how these factors differ across cultural contexts in China and Scotland. By examining these dimensions, the research aims to contribute to a deeper understanding of the barriers and motivations unique to high-achieving students while offering culturally informed recommendations to promote STEM career aspirations. The next chapter presents the methodology, detailing how Q-methodology is employed to address the identified research gaps effectively.

Chapter 3: Methodology

0 Introduction

This chapter presents a detailed explanation of the philosophy underpinning this study, alongside an in-depth explanation of Q-methodology and the specific procedures employed to fulfil the research aim and answer the research questions. Specifically, it begins by discussing how the researcher's ontological and epistemological position supports a pragmatic, philosophical methodology. Then, a justification will be made on how a merged method design fits into the research aim and the research questions. Next, Q-methodology, the main method used in this study, will be introduced and the procedures of developing the instrument, piloting, sampling, data collection, and data analysis will be elaborated and justified while considering limitations.

1 Research philosophy

In social research, ontology and epistemology are two key philosophical issues that require consideration (Lincoln et al., 2011). These concepts help clarify the researcher's assumptions about the nature of reality (ontology) and the nature of knowledge and its acquisition (epistemology).

Ontology seeks to determine whether reality is objective or a construct of individual cognition. Therefore, social scientists should decide "whether 'reality' is given 'out there' in the world, or a construct of one's mind" (Burrell et al., 2016). Two significant gaps are to be addressed in this study: (1) investigating why high-achieving high school students do not aspire to STEM careers and (2) comparing students' perspectives from two distinct cultural contexts, Scotland and China.

This study adopts a **pragmatic ontological perspective**. Pragmatists view reality as both singular and multiple, which makes it well-suited for investigating complex social phenomena (Burrell et al., 2016). On one hand, there may be overarching theories explaining general phenomena and trends (the "singular" aspect), such as why STEM careers appeal less to students. On the other hand, pragmatism also emphasises the need to explore individual perspectives and subjective experiences, recognising that each student (or students from different contexts) may bring unique insights to understanding this career-choice phenomenon (the "multiple" aspect). This approach allows for an investigation that considers broad explanatory theories while also valuing diverse personal experiences and cultural influences.

Epistemology involves knowledge and embodies a certain understanding of what is entailed in knowing, which represents how we know and what we know (Crotty, 1998); Guba and Lincon (1994) explained that epistemology asks the question, what is the nature of the relationship between the would-be knower and what we know?

This study is grounded in **pragmatic epistemology**, where knowledge is always based on experience. Experiences create meaning by bringing beliefs and actions in contact with each other (Morgan, 2014). Inquiry, as a specific kind of experience, is a self-conscious decision-making process which requires thoughtful reflection (Goldkuhl, 2012). Pragmatism replaces the traditional way of thinking about the differences between research approaches and treats these differences as social contexts for inquiry (Morgan, 2014). Pragmatism is often associated with mixed methods that combine both qualitative and quantitative methods to capture the complex and dynamic nature of the research topic. The focus is on the consequence of research, on the primary importance of the question asked rather than the methods, and on the use of multiple methods of data collection to inform the problems under study. Thus, it is pluralistic and oriented toward "what works" and real-world practice. In this study, the Q methodology was chosen by reflecting on the research questions, and the different techniques and methods in Q-methodology were employed to serve the research aim and research questions.

2 Researcher's positionality

In this study, the researcher aims to investigate the factors that discourage high-achieving students in China and Scotland from pursuing STEM careers. To address the "what" and "why" questions central to this topic, the researcher will gather data by asking students about their opinions, interpretations, and personal stories, treating these narratives as evidence of their viewpoints and the reasons behind them.

As a researcher with a background in education and teaching, I inevitably bring certain preconceptions and biases to this study. My interest in the attitudes and motivations of high-achieving students in STEM is partly shaped by my own experience as a STEM student and as a physics teacher. While this experience provides me with a valuable level of familiarity and understanding, it also requires me to be vigilant to ensure my personal views do not influence the research outcomes.

I will maintain the stance of an objective **outsider**, refraining from any actions that might influence the students' experiences or responses. By positioning myself as a listener and interpreter, I will ensure that students' voices are authentically captured and analysed without external interference. To enhance the rigour of my interpretations, I will engage in regular discussions with peers and advisors to critically examine my assumptions and findings. This approach allows for a comprehensive and unbiased understanding of the factors driving high-achievers towards STEM careers. By acknowledging and reflecting upon my positionality, I aim to maintain transparency and credibility in the research process, ultimately contributing to the integrity and depth of the study.

3 Research type

In the preceding section, we examined how a pragmatic philosophy aligns with this study. In the present section, we will delve into the application of a “merged” method that draws from a pragmatist perspective.

The utilisation of the “merged method” approach originated from a discussion on defining mixed methods, which refers to research techniques that combine both quantitative and qualitative approaches within a single project to optimise the strengths of each and minimise their limitations (Tashakkori & Teddlie, 1998). The goal of mixed methods research is to gain a more comprehensive and profound understanding of a topic while verifying results. However, the exact method of synthesis is not clear (Baškarada & Koronios, 2018). For instance, some studies use “multiple methods” in mixed methods research by simply employing various strategies within the same program without intending to integrate them. One variation of a mixed method approach that tries to address these concerns is a “merged method”. Merged methods are those that effectively combine qualitative and quantitative methodologies within a single research instrument, drawing on the strengths of both approaches to create a powerful technique (Gobo et al., 2021).

One example of a merged method is Q-methodology, which employs Q-sorting activities to gather quantitative data and interviews to collect qualitative data, and then integrates both types of data to analyse subjective viewpoints. Q-methodology goes beyond simply combining quantitative and qualitative approaches but instead fully integrates them to produce a more nuanced and comprehensive understanding of the research topic. By utilising both types of data, researchers can triangulate their findings and provide a more in-depth analysis of the subjective experiences of the participants. This methodology will be discussed further below in Section 4. As a result of our selected methodology, this study will adopt the term “merged method” over the “mixed method” to accurately define Q-methodology’s characteristics.

The abductive reasoning process in Q-methodology further solidifies its status as a merged method rather than a simple mixed method. Q-methodology is abductive in nature in that it begins with effects and pursues potential causes (Brown, 1980). This epistemological approach—where quantitative factor analysis (effects) guides qualitative interpretation (causes)—demonstrates the method’s seamless fusion of quantitative and qualitative dimensions. Unlike deductive approaches, where researchers predefine theoretical dimensions and test their emergence through factor analysis, Q-methodology does not impose a priori hypotheses. Conversely, it also diverges from inductive methods, which avoid pre-existing frameworks entirely and rely solely on researcher intuition to interpret emergent factor structures without substantive qualitative elaboration. Thus, Q-methodology occupies a unique epistemological space, blending quantitative detection with qualitative understanding in a truly synergistic manner.

4 Q-methodology

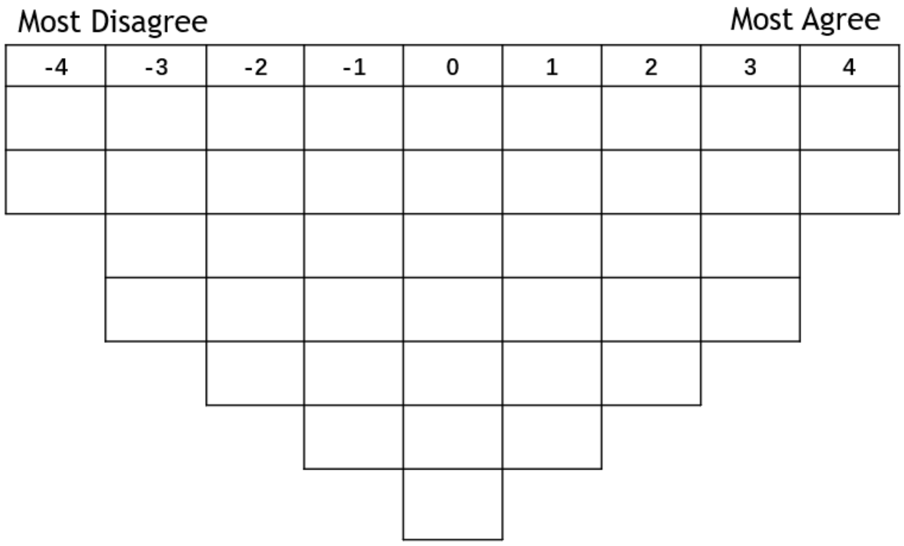
4.1 Overview of Q-methodology

Q-methodology was initially developed by William Stephenson (1935) with the intention to investigate subjective factors, such as attitudes, viewpoints, and perspectives (McKeown &

Thomas, 1988; Hutson & Montgomery, 2011; Watts & Stenner, 2005). Q-methodology uses a by-person factor analysis to identify groups of participants who make sense of a pool of items in similar ways according to subjective criteria (Shemmings, 2006; Watts & Stenner, 2005). As such, the aim of Q-methodology is to gather a wide range of perspectives by sampling diverse viewpoints from participants' self-references. It emphasises the exploration of various viewpoints rather than the individuals themselves.

Typically, Q-methodology involves six key steps. The first step is to create a "concourse" consisting of predefined statements or items that reflect diverse viewpoints on the topic being studied (Brown, 1980; Stephenson, 1993). This concourse helps identify the communication flow and various attitudes, vantage points, and perspectives related to the issue. The second step involves developing a balanced and representative collection of statements, known as the Q-set, drawn from the concourse to represent the full range of viewpoints (Watts & Stenner, 2012). The third step is the selection of participants, which involves deciding on the number of participants and their characteristics (gender, age, etc.). Fourthly, participants are administered a Q-sorting activity, sorting the statements relative to each other into a pre-determined Q-grid (e.g., see Figure 3-1), providing a holistic configuration of the participants' views (Stephenson, 2014). The fifth step is the Q-sort factor analysis, which entails computing the correlations of all the participants' Q-sorting data and then running a by-person factor analysis. The sixth step is factor interpretation, in which clusters generated by factor analysis are given meaning. These steps are described in more detail below. Nevertheless, while these six steps are essential in a Q-study, they do not encompass the entire Q-study process. Additional steps, such as post-sorting interviews, could be integrated to further elucidate the process of Q-sorting data.

Figure 3-1 An example of the quasi-normal distribution of the Q-sorting statements



Q-methodology is suitable for scenarios where a single “issue” is composed of sub-dimensions and the researcher is unsure how these sub-dimensions fit together (Donner, 2001; Stephenson, 1993). Given the multitude of factors explored as influential in students’ STEM career aspirations in the literature review, the aim of this study is not to pinpoint the most significant factors influencing students’ career aspirations. Instead, it seeks to identify general perspectives among participants by discerning various combinations of different factors. Q-methodology could provide a robust and systematic method to reveal consensus and disagreement among respondents.

Compared with traditional Likert scales, which use questionnaires to assign abstract scores and obtain isolated ratings, Q-sorting may provide participants with a more holistic thinking process by allowing them to make a systematic comparison between all of the items presented simultaneously (Klooster et al., 2008). The Q-sorting technique forces a specific number of items to be assigned to each ranking value, making it a forced-choice approach. This structure compels participants to assign specific ranks to items, promoting the prioritisation of different perspectives and thereby revealing underlying patterns of perceptions.

Additionally, Q-methodology provides a more structured means of eliciting viewpoints than interviews alone. By sorting statements with specific values, participants are able to quantitatively express their perspectives. This approach not only introduces objectivity through ranking but also allows for a broad range of statements to be considered, capturing a wide spectrum of possible reasons for each participant's viewpoints. Consequently, participants can express their perspectives more comprehensively, supporting a more nuanced understanding of their views on the issue.

The unique nature and advantages of Q-methodology make it an ideal overarching methodology for this study, as it aligns closely with the research aim and supports answering the research questions. By enabling a structured yet flexible exploration of diverse perspectives, Q-methodology facilitates a nuanced understanding of participants' viewpoints, which is essential for addressing the study's objectives.

4.2 Concourse

In Q-methodology, statements are sentences or words that reflect various points of view or perspectives on the topic under investigation. While alternative formats like pictures, audio or video files, and objects can be used to convey information, this study specifically opts for written statements (Kelly, 2007). A **concourse** refers to a collection of statements or items relevant to a particular research topic (Brown, 1980; Stephenson, 1993). In Q-methodology, a concourse is crucial because it ensures that the Q-set (see 3.4.3) is comprehensive and covers as many possible perspectives as possible on the topic (Watts & Stenner, 2012).

The statements in the concourse should be sourced from a diverse range of perspectives and cover as many sub-issues within the themes as possible to allow participants to effectively express their thoughts. Statements are frequently gathered from sources such as interviews, focus groups, literature analysis, social media, and so on (Brown, 1996; Coogan & Herrington, 2011; McKeown & Thomas, 2013). The collected materials represent existing opinions and arguments, laying the foundation for the development of the Q-set.

4.3 Q-set

The subsequent step involves presenting participants with a **Q-set**, a subset of concourse, consisting of statements selected to be balanced, representative, and unbiased towards any particular viewpoint or opinion (Watts & Stenner, 2012). This ensures that all participants can respond effectively to the research question without feeling limited by a lack of balance or coverage in the Q-set. The Q-set serves as the data collection instrument and participants will be asked to sort the statements in the Q-set.

Coverage and balance are the two most important characteristics of an effective Q-set. After gathering all potential statements into the concourse, they need to be sorted into categories and sub-categories. Maintaining balance in the number of statements in each category ensures that the statements do not favour one aspect over another. For example, if there are ten statements regarding students' interest in STEM but only two about students' utility value toward STEM, the composition of statements may introduce significant bias in the Q-sort. This bias could potentially influence the outcome, suggesting that interest in STEM has a greater impact on students' STEM career aspirations compared to their utility value.

Ambiguity may arise among participants as they could interpret a given statement in multiple ways. Therefore, a pilot study is required to determine the ease of sorting the statements and participants' understanding of the meaning of the statements (Coogan & Herrington, 2011).

Participants will comment on how well they understood the statements, and any unclear parts of the statements will be rephrased.

4.4 P-set

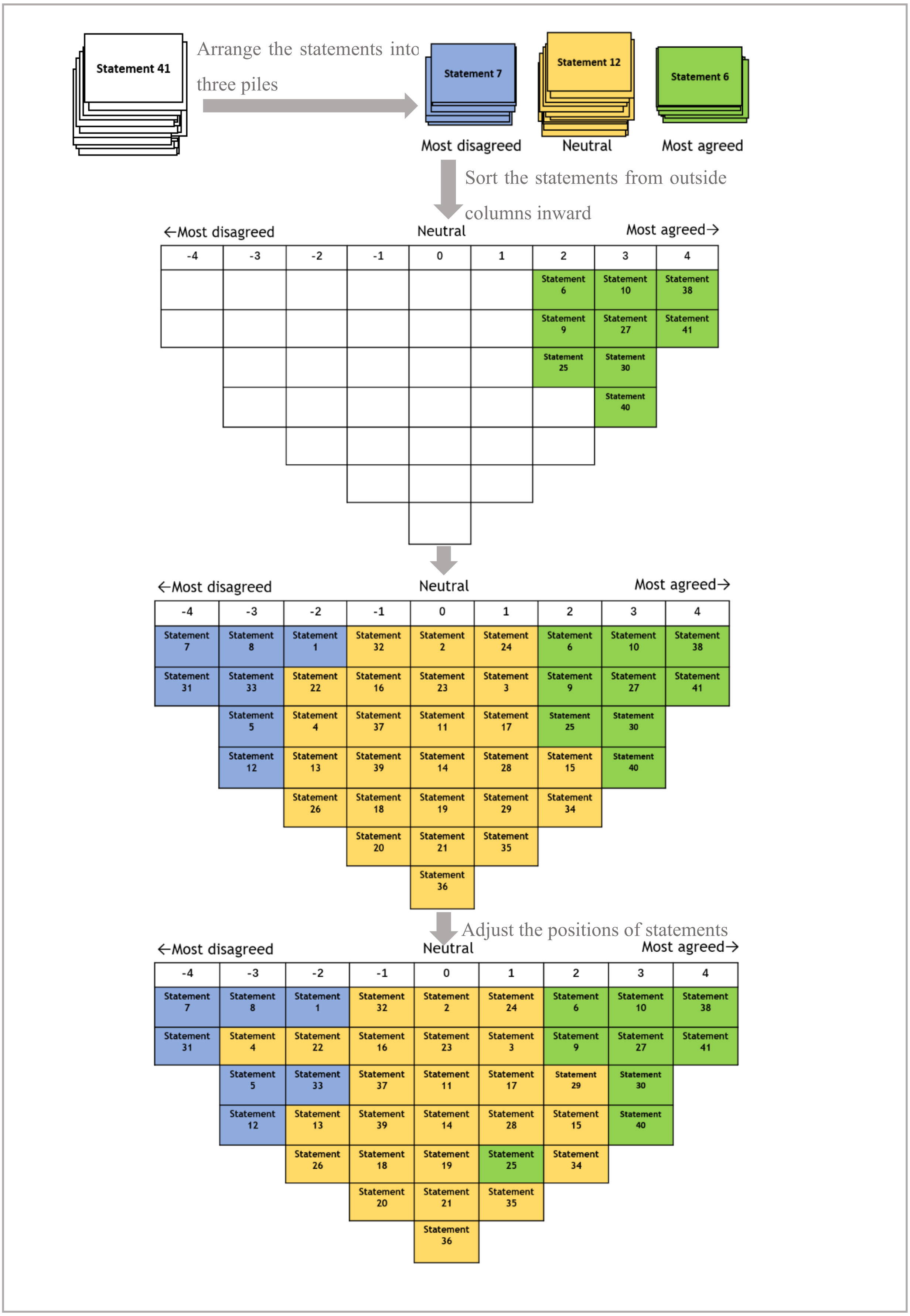
The individuals who sort the statements in Q-methodology are referred to as the **P-set** or P-sample. Unlike conventional research, Q-methodology does not require a large number of participants as the individuals themselves are the variables of the study (Watts & Stenner, 2012). This is because by-person factor analysis is utilised in Q-methodology to identify clusters of participants who interpret a pool of items in a similar way based on subjective criteria (Shemmings, 2006; Watts & Stenner, 2005). This means that Q-methodology focuses on identifying patterns of participants who produce similar outcomes, rather than significant factors among all participants or how many people think a particular way (Brown, 1980a, 1996b; Valenta & Wigger, 1997a). Brown (2003, p. 3) proposed that the number of participants needed in Q-methodology is typically no more than 40, with a typical range between 12 and 36. Some researchers have suggested determining the number of participants based on the number of statements or variables in the Q-set, recommending that the number of participants is more than half and less than the total number of statements in the Q-set (Thompson, 2010). Kline (1994) proposed a guideline recommending a minimum ratio of two Q-set statements for every participant, implying that ideally, a Q-set should comprise no more than twice the number of items as there are participants. Given the variability in suggestions regarding the number of participants, it is advisable to maintain a participant count lower than the number of statements in the Q-set.

4.5 Q-grid and Q-sorting

The **Q-grid** is a crucial tool used in Q-sorting to collect data, which is later analysed through factor analysis. The Q-grid has a symmetrical distribution, ranging from positive to zero and negative values, with an increasing number of spaces available at each value from the poles to the middle. This is based on the assumption that individuals will have strong feelings about a small number of issues or statements (Watts & Stenner, 2012, p. 80). Brown (1980) suggests using a nine-point distribution for Q-sets with 40 items or fewer, an 11-point distribution for Q-sets numbering 40-60 items, and a 13-point distribution for Q-sets with 60 items and above.

During the **Q-sorting** process (see Figure 3-2 for a demonstration), participants sort statements into three piles: "most agreed", "most disagreed", and "neutral". Sorting begins at one end of the Q-grid, with participants instructed to select statements to fill out the most extreme columns and then arrange them from the outside columns inward. Participants then assess the positions of the statements and adjust them based on instructional conditions. Finally, one recommended approach to gathering more comprehensive information about participants' perspectives is by conducting post-sorting activities, such as interviews or written responses. These activities aim to elicit detailed information about the reasoning behind their rankings, their thoughts, experiences, and any other pertinent information that could provide insight into their perspectives (Shemmings & Ellingsen, 2012; Watts & Stenner, 2012).

Figure 3-2 A demonstration of the process of Q-sorting



4.6 Data analysis and interpretation

After the Q-sorting data has been collected, the data will undergo factor analysis. Factor analysis is fundamental to Q-methodology in that it comprises statistical means by which respondents are grouped (McKeown & Thomas, 2013). Q factor analysis operates by correlating and factoring statement scores against the variables. This process begins with the computation of Pearson product-moment correlations. As each participant assigns scores for individual statements, the scores are then used to calculate correlations between the ratings given by different participants for the same statements, which are subsequently aggregated into total correlations. The correlations reveal to what extent each two respondents is similar in their perspectives. However, Q-methodology does not utilise correlation in the same manner as the R-type factor analysis, a commonly used statistical method for examining correlations among variables to detect variable clusters among various subjects (Burger, 2004). Examples of methods used in R-type analysis include logistic regression and ordinal logistic regression. In this approach, the principle is that the more subjects (respondents) there are, and the more representative they are, the better each variable (question) is described by the data, resulting in more valid results (Gobo et al., 2021, p. 155). As opposed to atomising individual perspectives across variables, Q-methodology preserves them, and a large number of statements across a smaller number of sorters can provide the same statistical validity as the traditional R-type approach.

As Watts and Stenner (2012) say, factors are like slices of a cake though there are infinite solutions to slice the whole cake into slices, we are trying to find a preferable way to divide the cake into sensible and easily digested portions. Similarly, in Q studies, factor analyses also have a potentially infinite number of acceptable solutions and the researchers have to decide which is the best solution in a particular context. One key step in utilising factor analysis is determining how many factors (perspectives) to retain. By convention, factors should be kept when they meet three criteria: first, factors with eigenvalues greater than 1.00, this determining factor is sometimes referred to as the Kaiser-Guttman rule (Guttman, 1954; Watts & Stenner, 2012, p. 106); second, the Humphrey's rule, which states that the cross-product of a factor's two highest loadings exceeds twice the standard errors (Brown, 1980a). The third criterion is that an interpretable Q-methodological factor must ordinarily have at least two Q-sorts that load significantly upon it alone. However, even if factors do not reach an eigenvalue level of above 1.00, they are not always discarded; instead, when selecting factors, the coherence of the factor is more important than the reported eigenvalue (Coogan & Herrington, 2011). Details of these criteria as well as how they are applied to retain the factors will be presented in Section 1.2 Chapter 4.

The analysis is not totally computerised, and the researcher plays an important role in deciding how many factors are to be extracted. Although factor analysis is an objective analysis, the researcher's subjective decision is still required because the value of the eigenvalue may be inflated by a large number of participants and thus may not be accurate in confirming the significance of the factor. For instance, the eigenvalue for a rotated factor with 6% variance when there were only 15 participants would be calculated at 0.9, whereas the eigenvalue for the same variance when there were 162 participants would be calculated at 9.72. Therefore, even though the eigenvalue's significance is evaluated, additional factors should be taken into account before a final decision is made regarding the number of factors to be accepted (Coogan & Herrington, 2011).

After the factor analysis, a rotation method will be used to find simpler and more easily interpretable factors (Denison & Montgomery, 2012; McKeown & Thomas, 2013). Rotation is aimed at enhancing the clarity and concentration of as many variables (Q-sorts) as feasible on either of the initially extracted factors (McKeown & Thomas, 2013). PQMethod 2.35 (Schmolck, 2021) provides two methods of factor extraction which are by-hand rotation and varimax rotation. McKeown and Thomas (2013) noted that the choice of factoring method makes virtually no difference because the resultant factors differ little from one another in any appreciable respects. By-hand rotation, also known as manual rotation or hand rotation, is a method more suitable for conditions when you are taking an openly deductive approach to analysis or if you are otherwise convinced that you know what to look for in the data (Watts & Stenner, 2012). However, I did not have any prior knowledge of any participant's characteristics over others. Specifically, I chose not to have any information about the Q-sorts before completing the factor analysis. Therefore, manual rotation was not considered.

Varimax rotation is an automatic calculation that maximises the number of Q-sorts that load on only one factor, therefore, the factors are positioned so that the overall solution maximises the amount of variance explained (Watts & Stenner, 2012). Varimax extracts factors in a way that places as much variance as possible on the first factor, the next largest amount on the second factor, and so on, in a way that explains the most variance in the fewest possible factors. In this study, varimax was chosen as the rotation method as it accounts for as much of the common variance in the study as possible.

The goal of factor interpretation is to discover, understand, and fully explain the perspectives captured by the factor and shared by the significantly loading participants (Watts & Stenner, 2012, p. 181). Steps will be taken to provide a complete and holistic process of factor interpretation, including the naming of factors, comparison of statement placements, and demographic and interview analysis. Naming factors allows researchers to develop an understanding of results by comparing across factors, as well as provide an identity for factors, making them more memorable to a reader (Watts & Stenner, 2012, p. 163). The themes will then be explained and supported using demographic information and post-sorting interview data.

4.7 Limitations and delimitations

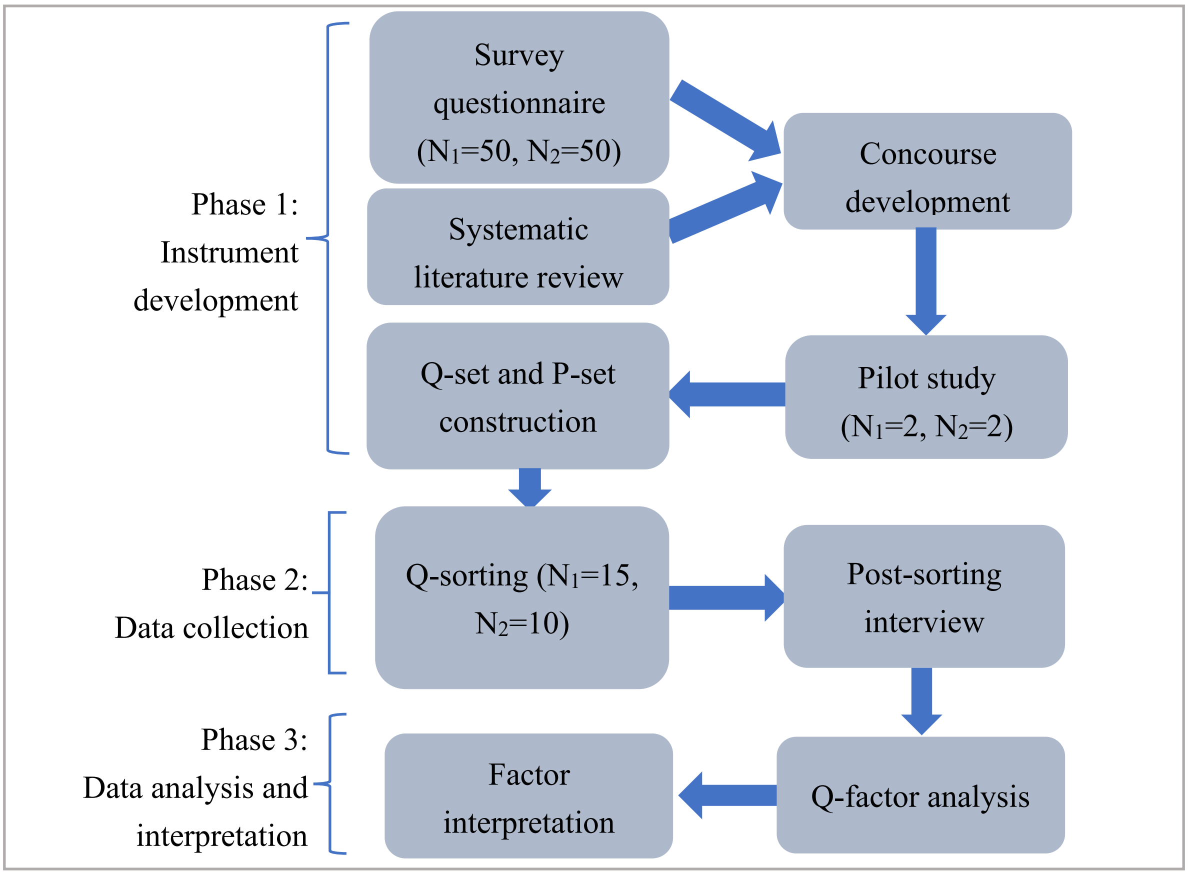
In general, Q-methodology studies are more exploratory and qualitative in nature and tend not to use random sample designs and big sample sizes, therefore, generalisations rarely occur beyond the immediate set of participants and are typically not based on the numerical distribution of study participants among factors (Valenta & Wigger, 1997b). In addition, the interpretation of Q-sort data is subjective and relies on the researcher's judgement, which may introduce bias into the analysis.

The current study aims to examine the perspectives and perceptions of high-achieving high school students. While the results may not be generalisable to the entire population, they can still provide valuable insights into the experiences and attitudes of these particular groups. By using a Q-methodology approach, the study can capture the richness and complexity of the participants' views and identify unique patterns that may not have been apparent with other research methods. To minimise bias, additional reviewers will be involved in the data analysis process, allowing for cross-checking to determine agreement or disagreement, ensuring that the conclusions are not solely based on the primary researcher's knowledge, experience, and opinions.

5 Research design

In general, this study involves seven steps, which can be categorised into three phases: (1) instrument development, (2) data collection, and (3) data analysis and interpretation, as illustrated in Figure 3-3.

Figure 3-3 Research design



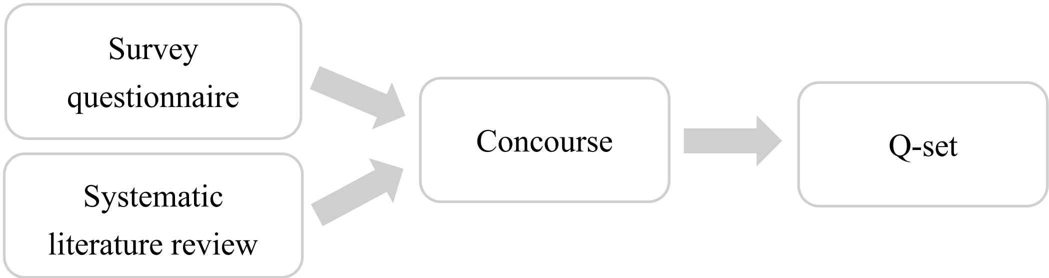
The first phase, instrument development, involves generating a concourse and subsequently, a Q-set that accurately reflects the research issue. The statements in the concourse are sourced from two main areas: a systematic literature review that utilises a systematic approach to identify and screen previous studies examining factors influencing students' STEM career aspirations, and a survey questionnaire that gathers reasons for pursuing or aspiring to a STEM career. The second phase involves collecting Q-sorting data and post-sorting interview data from high-achieving high school students who lack interest in STEM careers. The third phase, data analysis and interpretation, involves analysing and interpreting the data collected in the previous phase to address the research questions.

Ethical approval for the study was granted by the University of Glasgow Ethics Committee (Application No. 400220122) on 8 March 2023 (see Appendix A). Data collection commenced promptly following this approval.

5.1 Phase 1: Instrument development

Two approaches were employed in creating the concourse, namely a survey questionnaire and a systematic literature review. The development of the concourse served as the groundwork for constructing the Q-set (see Figure 3-4).

Figure 3-4 Process of developing a Q-set

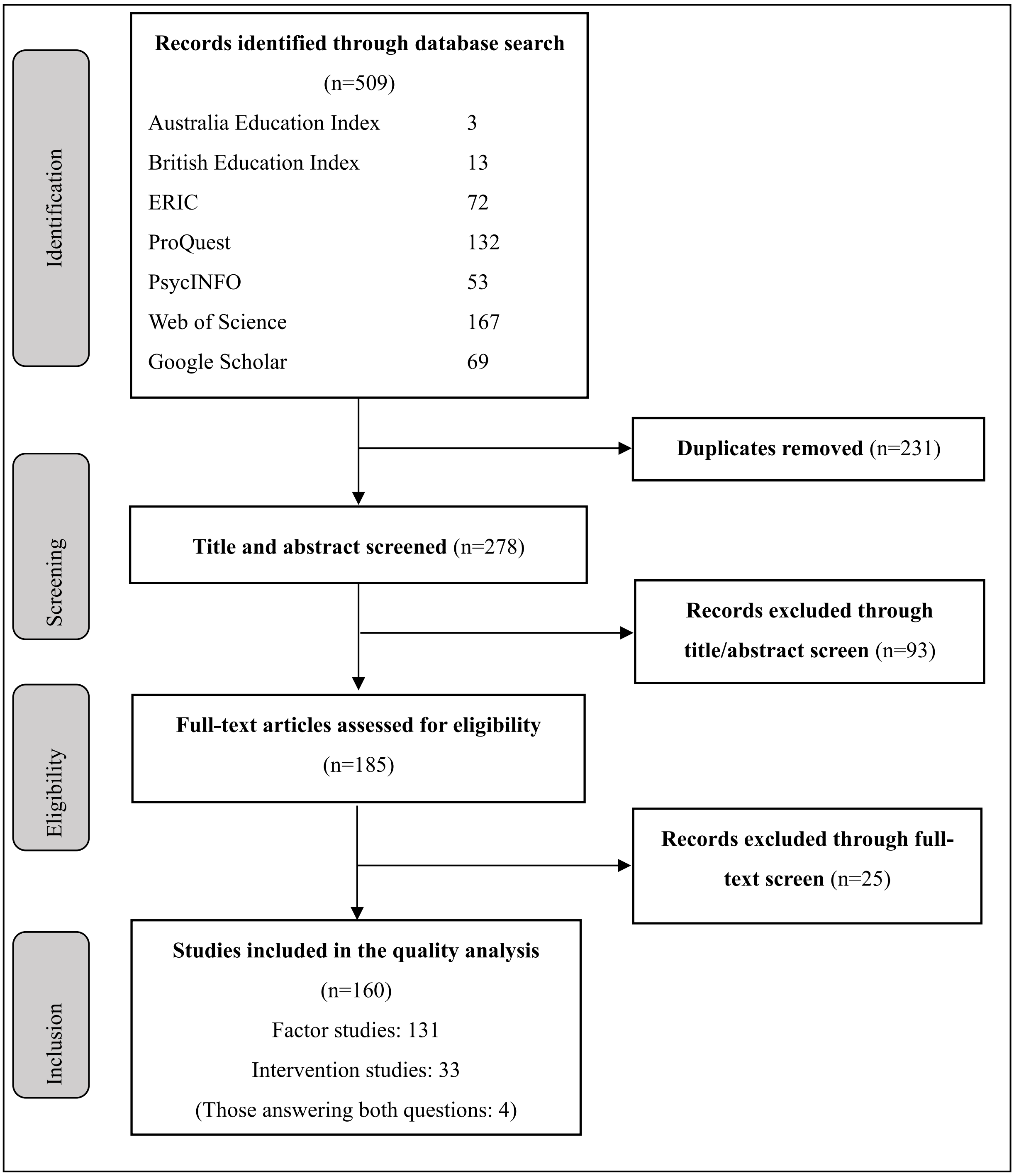


5.1.1 Systematic literature review

To develop a comprehensive understanding of the factors influencing the STEM career aspirations and choices of young people (secondary students aged 11-19 and undergraduates) from existing literature, a systematic literature review (SLR) was conducted. Unlike the narrative review presented in Chapter 2, this SLR was chosen for its rigorous, structured approach, which ensures comprehensiveness—a critical requirement for developing the concourse and subsequent Q-set. The SLR focused on academic papers published between 2009 and 2022, and followed the Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA) protocol (Liberati et al., 2009). By focusing on post-2008 research, this study provides an updated understanding of the factors influencing Generation Z students' STEM career choices and decisions. While Tripney et al. (2010) laid important groundwork, their findings were not incorporated into the development of the Q-set for this study. Instead, their work served as a boundary marker, ensuring that only research published after theirs was included in the analysis.

The four-step process used in this review included identification of relevant records, screening, determining their eligibility, and inclusion of studies (see Figure 3-5). The author expanded this SLR into a detailed paper that examines the key factors influencing students' STEM career aspirations and choices, as revealed through self-reported reflections (Zhou & Shirazi, 2025).

Figure 3-5 Paper selection process following PRISMA



To search for relevant papers, "STEM", "career", "aspiration", and "young people" as well as their synonyms, were used as keywords. The screening process followed certain inclusion and exclusion criteria which are outlined in Table 3-1. Out of the initial pool of papers, 160 were considered eligible for analysis. Among the 160 papers, only 131 of the papers were related to factors influencing students' STEM career aspirations or career choices, while 29 were excluded as they solely focused on interventions. These 131 papers were then used for thematic analysis. The various factors studied by these papers were then extracted to build the concourse. Thematic analysis was utilised to extract factors from the data by recognising and documenting patterns and themes. The procedure entails: (1) reading and re-reading the data to record preliminary ideas; (2) systematising the coding of the data's intriguing features across the entire set and collecting data for each code; (3) gathering data relevant to each potential theme by merging codes into prospective themes; (4) verifying if the themes are functional concerning the coded extracts and the entire data set and constructing a thematic map of the analysis; (5) continuous analysis to enhance the specificity of each theme by producing precise definitions and names for them (Braun & Clarke, 2006).Specifically, after identifying 131 relevant studies, each paper was thoroughly reviewed to extract key "factors" influencing students' STEM career aspirations. For studies using interviews, each emergent factor was documented. In studies employing questionnaires, the factors under investigation and any statements used to assess their impact were recorded. For example, Garriott et al. (2017) assessed students' STEM stereotypes using the prompt, "When I think of people who work in STEM jobs, I think of people who…," followed by eight statements (such as "are weird" and "do not have many friends") that were carefully noted to capture specific stereotypes.

Inclusion Criteria	Exclusion Criteria
1. Is full text written in English	1. Full text not available or full text not written in English
2. Is research published after January 2009	2. Is research published before 2009
3. Is a peer-reviewed academic article or a conference paper	3. Is not a peer-reviewed academic article nor a conference paper
4. Is empirical research including quantitative research and qualitative research or is intervention research	4. Is theoretical research like review, guidelines, manual, and policy document
5. Is a study focusing on factors influencing STEM career choices or STEM career aspirations	5. Is a study that is not about the factors influencing STEM career choices or STEM career aspirations
6. Contains data relating to students in education aged 11-19 years and undergraduate students	6. Does not contain data relating to young people in education aged 11-19 years or undergraduate students
7. Includes at least one aspect of STEM (e.g., science, technology)	7. Does not include any aspect of STEM

Table 3-1 Inclusion and exclusion criteria of SLR

Only factors that could be meaningfully expressed by students about their STEM career aspirations were retained. For instance, Zorlu & Zorlu's (2017) measured science process skills and their correlation with STEM aspirations using a Science Process Skills Test; factors like these were excluded, as they cannot be directly articulated by students. After reviewing and extracting factors from each study, duplicates were removed, and factors were organised into thematic categories. Factors that appeared in only a few studies and showed minimal impact on students' STEM career aspirations in the literature were also excluded. The remaining 87 statements were retained for inclusion in the concourse (see Appendix B).

5.1.2 Survey questionnaire

This questionnaire aims to collect individuals' opinions regarding STEM-related careers, thus contributing to the development of the concourse. Whilst the SLR has explored a broad spectrum of research on factors influencing students' STEM career aspirations, relying solely on this method to construct the concourse might introduce bias. This is because factors with statistically significant results are more likely to be investigated, potentially leading to an overestimation of their impact, while less-studied factors may be overlooked. This strategic approach was essential to address the potential bias of researchers unintentionally overlooking certain aspects due to predetermined notions. Following the thematic analysis of the SLR, the factors drawn were used as options in the questionnaire. This questionnaire targets a wide range of participants, including students in secondary education, further, or higher education as well as people who are employed.

This questionnaire is comprised of three core questions. The first question aims to learn about participants' career aspirations and occupations, categorising them as either within STEM or out of STEM fields. To do this, students were asked, "What is the job or occupation that you expect or plan to have at age 30?", while employed individuals were asked, "Which of the following occupations are you working in?" Some studies have found that people generally become established in their careers between the ages of 25 and 45, which is why we chose to ask about participants' expected occupation at the age of 30 (Mau & Li, 2018; Niles & Harris-Bowlsbey, 2017; OECD, 2019). To provide options for participants, I used the International Standard Classification of Occupations (ISCO-88[3]), which includes a range of occupations classified under many categories. I also included two additional options, "other STEM occupation" and "other non-STEM professions", with open boxes for

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[3] https://www.ilo.org/public/english/bureau/stat/isco/isco68/major.htm

participants to write done their occupations. Participants who are uncertain about their future plans have the option to select “I am not sure/I don’t know”.

Participants’ responses to the first question were used to categorise students into three groups: those with STEM career aspirations, those without, and those unsure of their career aspirations. Employed participants were grouped into those working in STEM and non-STEM fields.

The second question asked participants to provide their reasons for either aspiring to or not aspiring to a STEM career, or for choosing or not choosing a STEM occupation. Participants were given three spaces to write their reasons, but only two of them were compulsory.

Since the second question was open-ended, participants may have only provided reasons that immediately came to mind, while neglecting some other important reasons. Therefore, the third question provided options generated from the SLR, aiming to assist the researcher in determining which factors are generally more important and should be included in the Q-set. The options of reasons were drawn from a narrative literature review that recorded attitudinal factors concerning people’s STEM career aspirations or careers. These factors included interest value (DeWitt et al., 2013), utility value (Glynn et al., 2011; G. Yang et al., 2017), general value (Smit et al., 2020), self-identity (Stets et al., 2017), national identity (Chiu & So, 2022a), self-efficacy (Glynn et al., 2011), expectancy (Murcia et al., 2020; Pellegrini & Segafredo, 2015), approach goals and avoidance goals (Jiang et al., 2018), stereotypes and images of STEM professionals (DeWitt et al., 2013; Garriott et al., 2017), cost-effort (Watt et al., 2019), and cost (Smit et al., 2020). Not all factors described in the papers were utilised, as an overabundance of options could result in participant impatience. To ensure coverage, I included as many factors as feasible while minimising redundancy, selecting only the most pertinent descriptors for each factor. The descriptors for each participant group varied a bit;

for instance, only those who opted to engage in non-STEM occupations or those with no interest in a STEM career received descriptors related to the "cost" factor. To avoid overwhelming or tiring participants with a large number of answers, the total number of the third question was limited to approximately 20 (19–21). The draft questionnaire was reviewed by peers and supervisors, and minor revisions were made based on feedback.

Questionnaires were developed on Qualtrics,[4] with one in English and the other in Chinese (see Appendix C for the full questionnaire). The questionnaire was then electronically distributed through various social media platforms, including WhatsApp, Facebook, Twitter, and WeChat[5]. A total of 100 questionnaires were completed and considered valid, with 50 responses from the English version and 50 from the Chinese version. The results were analysed using a method similar to the thematic analysis of the SLR. The initial step in processing questionnaire results involved extracting factors and statements related to participants' written responses, which were then categorised according to the same thematic framework used in the SLR. 53 statements were drawn from the questionnaires (see Appendix D).

5.1.3 Concourse construction

Following a thematic analysis of both the SLR and the survey questionnaire results, a total of 140 statements were identified, which revealed 21 distinct themes related to students' reasons for pursuing or not pursuing a STEM profession. The 140 statements were a combination of 87 from the SLR and 53 from the questionnaire. To systematically structure the concourse and then build the Q-set, the statements were categorised using the EVC model

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[4] https://www.qualtrics.com

[5] WeChat is a Chinese instant messaging and social media application that is the most popular social media in China

and the SCCT model as guiding frameworks. Emerging themes that did not align with either model were grouped into new categories. These statements offered a comprehensive overview of the various viewpoints regarding STEM career aspirations and choices. However, the concourse contained numerous repetitions and redundancies, resulting in a larger number of statements than necessary for the Q-set.

The refinement process involved discarding statements that were not greatly researched in the existing literature and were not emphasised by questionnaire participants. Through an in-depth analysis of the included studies and insights gained from conducting the narrative literature review (Chapter 2), I developed a clearer understanding of which factors are consistently identified as influential in shaping STEM career choices and which hold lesser significance. For instance, statements like “I don’t think STEM is important for society” were excluded from the Q-set because it was mentioned only in one research paper (Chiu & So, 2022a), selected by one respondent in the third questionnaire question, and were not found in the written responses to the second question. The statements that were both frequently found in the SLR and written/chosen in the questionnaire were retained in the Q-set.

By using both the SLR and questionnaire results, the statements were refined and reduced to a more concise and relevant set. Repeated statements were discarded, and statements with close similarities were merged. The draft Q-set was a structured sample of 28 statements covering 10 sub-issues explaining why high-achieving students do not aspire to STEM-related careers.

5.1.4 Pilot study

Before completing the Q-set development, a pilot study was conducted to refine the Q-set, instruction, Q-sorting procedure, and the interview questions. 28 items from the concourse pool constituted an unstructured Q-set with a nine-point scale with 28 slots.

Four PhD students from the School of Education, University of Glasgow, including both English and Chinese native speakers, were selected as participants for the pilot study. These individuals were chosen for their experience in education research and their ability to provide insightful suggestions on the clarity of instructions and statements during the Q-sorting process.

The researcher instructed the participants to sort the cards, and the participants reported any issues to the researcher immediately, feedback was collected right after the Q-sorting and interviews. The researcher asked questions like "Do you think there's any problem during the Q-sorting process regarding the statements and the instructions?" and "Are there any questions that should be added to the interview?" Feedback from the pilot study was used to revise the interview outline and the instructions. For instance, it was suggested that statements concerning students' future plans should be added to the Q-set and more spaces should be made for the utmost points.

5.1.5 Q-set construction

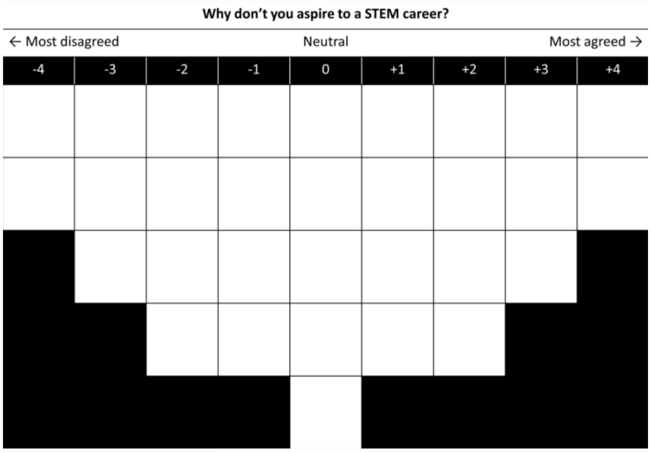
The statements selected for the Q-set can be either structured or unstructured. A structured Q-set follows a systematic approach and is based on a preconceived theory or a deductive research design (Watts & Stenner, 2012). It requires the researcher to use a technique by breaking down the relevant subject matter into a series of component themes or issues and include a roughly equal number of items relative to each demarcated sub-theme. For example, a Q-set with ten themes will result in a Q-set with 50 statements that include five statements for each theme. Some Q methodologists prefer to retain a little more fluidity in the sampling process, and the construction process is done by understanding the subject matter as a whole rather than for purposes of subsequent dissection, this result is an unstructured Q-set. This study used a structured Q-set of 31 statements which covered 10 key themes with an average of three statements per theme (see Appendix E).

5.1.6 Q-grid construction

The Q-grid is a tool that enables participants to rank statements, assigning each a value within a specific range (see Figure 3-6). Based on previous research (Brown, 1980a), a nine-point distribution is recommended for Q-sets with 40 items or fewer. Given that this study includes 31 statements, a nine-point distribution (-4 to +4) is deemed appropriate.

In designing the Q-grid, it was essential to ensure a symmetrical quasi-normal distribution while also considering the number of ranking points. Initially, the grid allowed for only one space each for the +4 and -4 values. However, during the pilot study, a participant suggested adding one more space to each extreme value, as students may have more than one factor or reason they strongly agree or disagree with. The final grid maintains 31 spaces while ensuring a balanced distribution. The number of spaces increases progressively from the extremes (-4 and +4) toward the centre, with spaces under ±2 and ±1 remaining equal. This adjustment ensures that the grid is both practical for participants and adheres to the quasi-normal distribution standard.

Figure 3-6 A Q-grid with 31 statements for the Q-sorting



5.1.7 P-set construction

The number of participants in the P-set should be considered after determining the number of statements in the Q-set (see Section 4.3, Chapter 3). With 31 statements, the number of participants should be no more than 31. Participant selection criteria included three requirements: (1) students were in Year 11 or 12 (ages 16-18) and had chosen to study mathematics and science in high school, (2) they should be among high-achieving students in science and maths subjects as verified by schoolteachers, and (3) they should have expressed no aspirations for STEM-related career. There are different ways to define high-achieving students in China and Scotland due to the differences in education and assessment systems (see Section 5, Chapter 1).

In China, students sit the National College Entrance Examination (Gaokao) only once at the end of high school, with their grades assessed based on the average of mid-term and final exams for that academic year. To qualify as high achievers in science and mathematics, these students must be within the top 25% of their year group in these subjects. In Scotland, high-achieving students in STEM are defined as those who have selected at least two subjects in these areas and meet one of the following criteria: (1) S5 students who have completed

National 5 exams in their selected STEM subjects and have achieved grades at the A or B level in each, or (2) S6 students who have completed Higher exams in their selected STEM subjects with at least two A or B grades.

To conduct the study, high-achieving students in both nations were provided with a Participant Consent Form (Appendix F), a Participant Information Sheet (Appendix G), Privacy Notice (Appendix H), and a Participant Demographic Information Sheet (Appendix I). Additionally, parents received a Parental Consent Form (Appendix J) and a Parental Information Sheet (Appendix K). Participant demographic data, including age and current grade level, were collected through the Demographic Information Sheet. Academic performance records were obtained from teachers with appropriate consent. STEM career aspirations were assessed via a single-choice question in the Consent Form, where students indicated whether they envisioned pursuing a STEM-related career in the future. Following the informed consent procedures involving both students and their parents, a total of **15 participants from China** and **10 from Scotland** who met the study criteria were selected for the study, all of whom completed both the Q-sorting activity and follow-up interviews. The demographic information of the participants are listed in Appendix L.

5.1.8 Interview questions

Participant interviews provide a way to go beyond the numbers recorded in quantitative analysis and uncover the richness of real social experience. Interviews are necessary in this study due to the nature of the research questions and the Q-sorting methodology. While Q-sorting could effectively address RQ1 by capturing students' perspectives and the reasons for not aspiring to STEM-related careers, it does not explore their perceptions of STEM subjects or careers in sufficient depth. Interviews are therefore critical for answering RQ1a, which highlights students' perceptions of STEM.

It is important to note that the quantitative data (Q-sorts) provides the foundation for understanding students' perspectives, while the qualitative data (interviews) complements this by allowing participants to offer additional explanations that could enrich these perspectives. Accordingly, the development of the interview questions revolves around the quantitative data. To gain a deeper understanding of students' STEM career aspirations, I developed some semi-structured interview questions. These questions are designed to encourage participants to articulate their thoughts on various aspects of STEM careers, including their rankings, comments on statements, ideal occupations, perceptions and knowledge of STEM fields, and the influence of past experiences and significant individuals on their career aspirations. The interview questions are outlined below:

1. Could you please explain the +4 cards located on the far right? Why have they been prioritised as the most significant factors influencing your decision not to pursue a career in STEM?
2. Could you please explain the -4 cards located on the far left? Why have they been ranked as the least significant?
3. Are there any additional cards you believe should be added to these cards as crucial factors in influencing career choices?
4. Were there any cards that posed challenges for you during the ranking process? If so, could you share your thoughts on them?
5. Can you describe your ideal occupation and the reasons behind your choice?
6. How would you characterise STEM careers, and what are your perceptions of professionals in STEM fields?
7. Has there been a particular life experience or someone significant who has had a substantial impact on your career aspirations?

The first four questions were developed for the Q-sorting as students would explain their reasons for their rankings, and comment on the integrity of the Q-set in covering the aspects that might help to express their perspectives. Question 3 allows participants to voice factors that may not have been included in the Q-set, permitting elaborate expressions that are not limited by the Q-set. Even though the added factor may not be incorporated into the Q-set immediately, it could inform further researchers of the potential gaps in the Q-set design and highlight additional influences that warrant further exploration in subsequent studies.

As this study focuses on STEM career aspirations among participants who lack such aspirations, Question 5 provides an opportunity for students to articulate their ideal occupations and the reasons behind their choices. This question was developed for two key reasons: first, reflecting on why participants lack interest in STEM careers and why they aspire to other occupations offers two sides of the same coin, presenting an alternative perspective that enhances our understanding of their thoughts and motivations. Second, understanding how students form their career aspirations sheds light on their priorities in making career choices, offering valuable insights into the factors they deem most important when envisioning their future.

Question 6 aligns with RQ1a, which focuses on students' perceptions of STEM subjects or careers. This question differs from the others as it encourages students to provide more objective perspectives based on their knowledge of STEM jobs, including the requirements, working environment, and other relevant aspects. To draw an analogy, asking an individual why they might not become friends with someone could elicit different responses compared to asking how they would describe or comment on that person. Similarly, Question 6 allows students to step back from their personal choices and provide a broader evaluation of STEM careers, offering valuable insights into how these careers are perceived beyond individual preferences.

Lastly, Question 7 focuses on exploring how students' attitudes are influenced, directly or indirectly, by social and contextual factors that shape their career aspirations. This aligns with the study's emphasis on social persuasions, including the roles of parents, teachers, and peers in career decision-making. By identifying significant life experiences or influential individuals, this question provides deeper insights into the external factors that contribute to students' career choices and aspirations.

5.2 Phase 2: Data collection

Q-methodology utilises both quantitative and qualitative data collection to explore the attitudes and perspectives of participants fully. First, quantitative data was collected through the Q-sorting activity; participants were able to provide their perspectives on the most and least important factors in their STEM career aspirations by giving each statement a value. The qualitative data collection followed the Q-sorting activity with interviews being conducted to enhance the findings and explore the subjective nature of the decision process (Schutt, 2012).

Approval for data collection in secondary schools was granted by the Dumfries and Galloway Council (see Appendix M). In China, no additional approval was required to engage secondary school students. I first contacted head teachers and schoolteachers, providing them with an overview of the project along with the Privacy Notice (see Appendix H). Teachers volunteered to assist with data collection in their respective schools. Upon receiving their consent, teachers distributed the necessary information sheets to students who met the criteria of being high-achieving in STEM subjects and not aspiring to STEM careers. Once parental and student consent was obtained, I coordinated with teachers to schedule times for conducting the Q-sorting activity and follow-up interviews on school campuses. All data collection activities were conducted solely by the author, Yingying Zhou.

5.2.1 Q-sorting

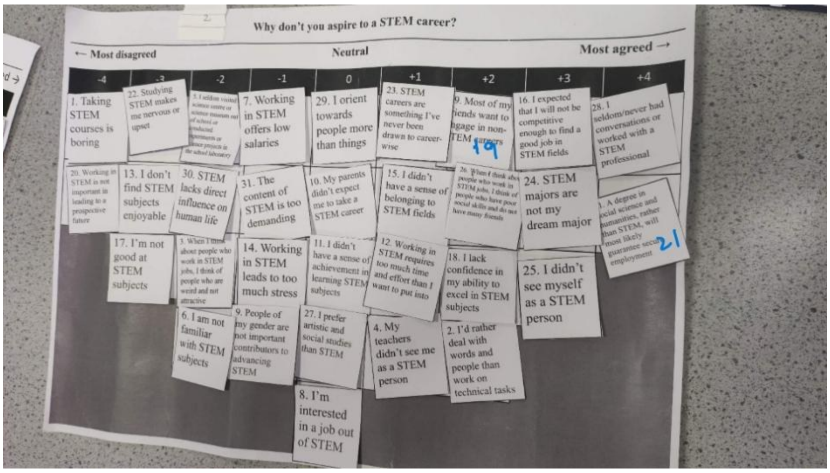
The Q-sorting process commenced with the grouping of every three students. I invited each group of three participants to a quiet classroom, where the Q-grid and Q-set were prepared on three separate tables. The 31 statements were printed on individual cards with the Q-grid printed on a large sheet of paper for ease of use. Each participant was assigned a number so that the Q-sorts could be tracked back to them individually. The Q-sorting activities were conducted solely by the author.

Instruction for the card-sorting was also provided and explained for clarity. I explained that the Q-sort was designed to capture participants' perspectives on why they did not aspire to STEM-related careers. Each student received a Q-grid and the 31 statement cards, which they were to sort onto the grid based on their personal views. The central question on the Q-grid (see Figure 3-6) read: "Why don't you aspire to a STEM career?"—guiding participants as they arranged the statements.

Participants were initially instructed to group the cards into three categories: "Agreed," "Disagreed," and "Neutral." Following this, they were asked to arrange the statements on a 9-point Q-grid based on their personal significance. Participants were provided with suggestions for sorting, such as beginning with the "most agreed" statements from the right side of the grid and progressing to the less agreed ones; or starting from the opposite end by selecting the "most disagreed" statements and then the less disagreed ones, followed by the neutral ones. Since some participants may have had more "agreed" statements than "disagreed" ones, they were advised to sort all the cards comparatively while reducing the value. For example, the neutral statements could be rated under -1 and -2 if the participant had more agreed statements than disagreed ones. Throughout the activity, I observed participants' sorting behaviours, noting any hesitations over specific statements. These instances were later explored in follow-up interviews to gain deeper insights. After completing the initial sort, participants were encouraged to review their grid, ensuring that the statements followed a logical descending order from right (most agreed) to left (most disagreed) and that higher-ranked statements were not less agreed upon than lower-ranked ones. After the Q-sorting was completed, I documented the responses of each participant by taking a picture of the sorted cards on the Q-grid (see Figure 3-7, an example of a Q-sort). Each Q-sorting session lasted for approximately 10-15 minutes.

While participants sorted the statements, I carefully observed their processes, noting any notable behaviours—such as prolonged deliberation over specific statements or quick, decisive ratings. These observations helped identify statements that warranted deeper investigation. During follow-up interviews, I asked targeted questions about participants' reasoning, particularly focusing on statements that elicited hesitation, strong agreement, or disagreement. This approach provided valuable insights into their decision-making processes and underlying perspectives.

Figure 3-7 An example of a completed Q-sort



5.2.2 Post-sorting interview

When students were invited to participate in this project, the Consent Form (see Appendix F) included a question asking whether they would like to participate in a post-sorting interview and if they consented to their audio being recorded. All participants who consented to participate in the Q-sorting also agreed to be interviewed, therefore, all 15 Chinese and 10 Scottish participants took part in the interviews. Following the Q-sorting activity, individual interviews were conducted with each participant. These interviews lasted approximately 10-15 minutes each, during which audio recordings were made with participants' consent. The recorded audio was subsequently transcribed by the author, and the responses from the Chinese participants were translated into English so that they could be reported in the thesis. The entire process of data collection, including the recording, transcription, translation, and analysis was carried out by the author to maintain continuity and control over the research process. Member-checking was integrated into the interview cause when students reflected on their reasons for ranking in the Q-sorting, it is the process by which the author verifies that the researcher has accurately captured the perspectives of students and the intended meaning.

During the interview process, I chose not to rigidly adhere to the predetermined interview questions. Instead, I adopted a more flexible approach, allowing for the emergence of more specific questions based on the participant's responses. This approach enabled the researcher to delve deeper into certain points, seek clarification, or encourage elaboration, fostering a more natural and conversational interaction between the researcher and participant while ensuring that key topics were covered. The answers will shed light on the reasoning behind participants' sorting and ultimately increase the richness and quality of data (Gallagher & Porock, 2010).

5.3 Phase 3: Data analysis and interpretation

Both the quantitative data (Q-sorts) and the qualitative data (interviews) were analysed to answer the research questions.

5.3.1 Quantitative data analysis

The quantitative data comprised distribution metrics obtained through Q-sorting and subsequently input into PQMethod 2.35, a specialised software for Q-sort analysis. Initially, users manually input statements and Q-sorts, generating a correlation matrix reflecting the similarity between each Q-sort pair. PQMethod 2.35 then generated initial eigenvalues for eight unrotated factors, indicating each factor's variance contribution.

Factor extraction can be performed using either Principal Component Analysis (PCA) or Centroid Factor Analysis (CFA). The key distinction lies in their approach: PCA yields a single, mathematically optimal solution, whereas CFA allows researchers to determine the number of factors based on theoretical considerations rather than purely statistical criteria (Watts & Stenner, 2012). This study employed PCA because of its statistical rigour. It aims to transform a high-dimensional dataset into a lower-dimensional representation while preserving the most important information present in the data. PCA extracts factors in a way that places as much variance as possible on the first factor, the next largest amount on the second factor, and so on, in a way that explains the most variance in the fewest possible factors.

By employing a PCA method, users were prompted to specify the number of centroids (factors) to extract, with a maximum of eight offered. Iterations were conducted, starting with an appropriate number of factors, and decisions on retention were guided by extraction results (see Section 1, Chapter 4 for details). Upon deciding on the solution, the factors underwent varimax rotation to maximise saturation purity across as many Q-sorts as possible (McKeown & Thomas, 2013). PQMethod 2.35 then produced factor loadings, factor scores, factor arrays, distinguishing statements, and consensus statements useful in the interpretation of factors. The results and the decision-making processes are presented in detail in Section 1, Chapter 4.

5.3.2 Qualitative data analysis

The interview data was analysed using NVivo 14, a qualitative data analysis software to manage, organise, and interpret qualitative datasets. Thematic analysis technique was used to analyse the data which incorporates procedures including familiarising with the data, generating initial codes, searching for themes, reviewing themes, and defining and naming themes (Riger & Sigurvinsdottir, 2016).

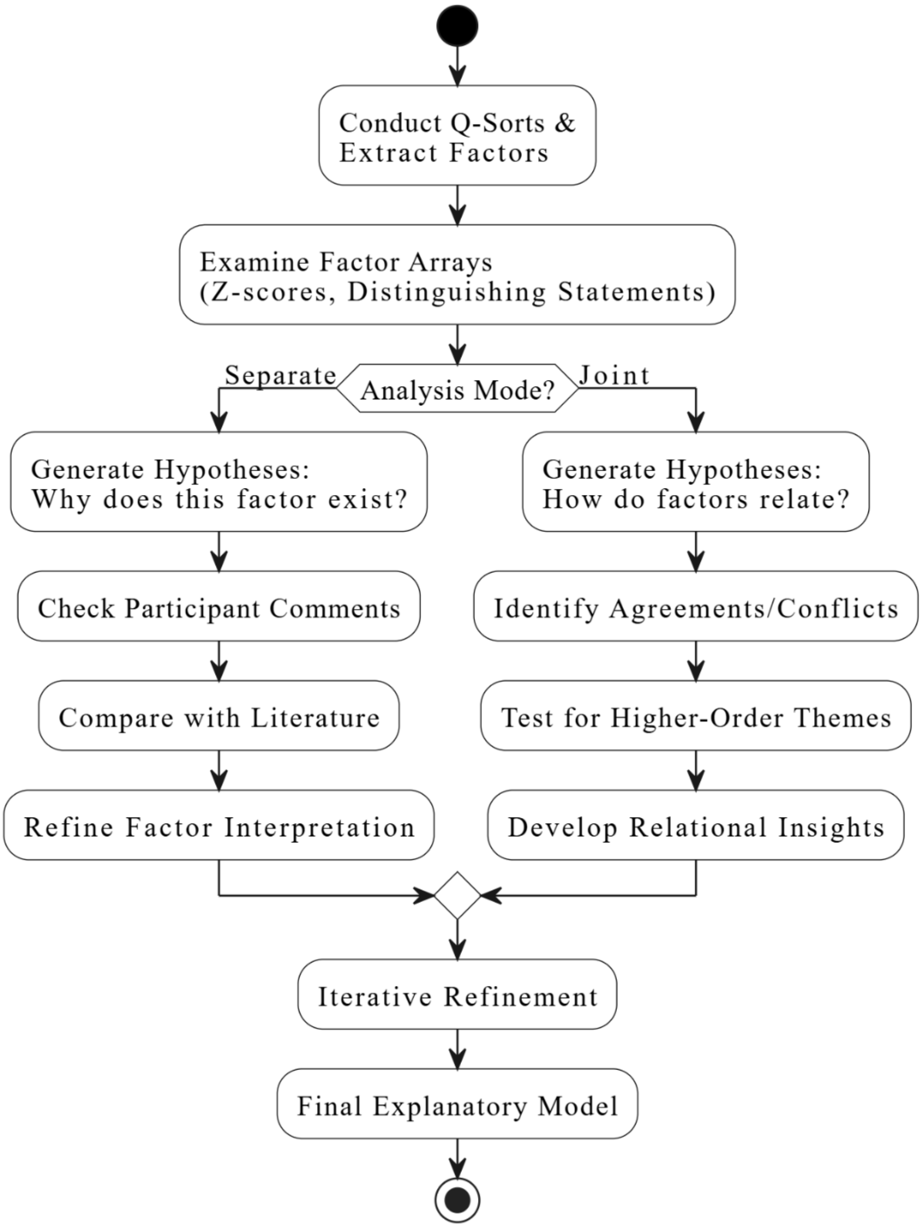
The themes in this study are more "theory-driven" than "data-driven" ones, in this sense, the data is approached with specific questions in mind and with the aim of coding to identify particular features of the data set (Braun & Clarke, 2006). Notably, the primary objective of interviewing participants was to enhance our comprehensive understanding of the Q-sorting data, which was developed in alignment with the EVC and the SCCT frameworks. Consequently, the initial coding process was structured around the factors and sub-factors within these frameworks while also capturing participants' perceptions of STEM. Although the EVC and the SCCT frameworks, along with their respective factors and sub-factors, have been validated in previous studies, the analysis was sensitive to nuances and variations within the data. In some cases, these nuances revealed that the original frameworks did not fully encapsulate the complexities of the interview data. These variations prompted a deeper investigation, leading to the subdivision of some themes into more granular categories to better capture specific patterns and dynamics.

5.3.3 Factor interpretation

The factor interpretative process (see Figure 3-8) starts by identifying surprising or noteworthy configurations in the factor arrays through close examination of Z-scores and distinguishing statements. These patterns prompt abductive hypothesis generation—asking, "What underlying perspective or logic best explains why these statements cluster together?" From here, the process diverges into two complementary pathways: (1) separate factor analysis, which tests emerging hypotheses against participant comments and existing literature to refine interpretations, and (2) relational analysis, which seeks the most coherent explanation for how factors interact.

Both pathways rely on abductive logic—selecting the best available explanation when faced with ambiguous or conflicting evidence while remaining open to revision as new insights emerge. This iterative cycle continues until theoretical saturation is reached, yielding a final explanatory model that optimally integrates quantitative configurations (Q-sorts) and qualitative nuances (interviews). The resulting interpretation remains grounded in participants' perspectives while extending beyond them to achieve broader theoretical coherence. Further details on the analysis process, including specific examples and outcomes, are presented in Section 1.6, Chapter 4.

Figure 3-8 A flow chart describing the abductive reasoning process of factor interpretation



6 Summary of chapter

This chapter started by explaining why pragmatism is appropriate for this study and justified the use of a "merged" methods methodology and corresponding research design. The researcher then described her role in this study as an "outsider" focused on capturing and explaining students' voices, followed by an introduction and rationale for Q-methodology.

Details are provided on the development of research instruments, with a survey questionnaire and an SLR used to develop the concourse and Q-set. Thematic analysis refined these statements, leading to the development of the Q-set. A pilot study was conducted to gain insights into how the Q-sorting instruction could be improved and feedback from this stage informed the revisions to statements and instructions. Interview questions were designed for the post-sorting interviews to collect interview data. The quantitative data will be analysed using PQMethod 2.35, while the interview data will undergo thematic analysis to interpret the perspectives revealed in the Q-sort results. This chapter has offered an overview of the research design and implementation aimed at addressing the research questions. The subsequent chapter will delve into the results and findings derived from the data analysis.

Chapter 4: Findings

0 Introduction

The previous chapter offered an in-depth explanation of Q-methodology, including the design of the Q-set for data collection and the approach to data processing. Building on that foundation, this chapter first details the decision-making process that led to the results. It then explains how the collected data were analysed to derive the key findings, highlights how these findings compare or contrast with earlier studies, and directly addresses the research questions.

This study is motivated by the observation that both China and Scotland have relatively low proportions of high-achieving STEM students aspiring to STEM careers (OECD, 2019). Despite facing similar challenges in fostering STEM career aspirations, these two nations have distinct cultural and educational systems, which may contribute to unique factors influencing students' lack of interest in STEM careers. Moreover, existing literature highlights that students' attitudes and motivations regarding STEM career aspirations vary across cultures. In response, this study seeks to examine the reasons Chinese and Scottish students provided for not pursuing STEM careers and to explore how these reasons differ between the two contexts. Beyond identifying barriers, the research examines students' attitudes and understanding of STEM careers, delving into their broader perceptions, knowledge, and stereotypes about such careers.

Q-methodology was used to address these questions. Factor analysis identifies the overarching reasons why high-achieving students avoid STEM careers (RQ1), including three factors (perspectives) from the Chinese participants and two from the Scottish participants. These insights were primarily derived from the Q-sorting process, where students ranked their reasons for not aspiring to STEM-related careers. While Q-sorting provided the foundation for identifying these perspectives, interview data was incorporated to further explain and contextualise the findings. The perspectives were grouped into personal attitudes (informed by the EVC model) and social persuasion. Whilst distinct perspectives were identified among Chinese and Scottish students respectively, the analysis also uncovered similarities and differences, answering RQ1a.

Additionally, students' interview data provided insights into their perceptions towards STEM careers (RQ2). These attitudes were reflected in their comments about what they know about STEM careers, their perceptions of these professions, and the stereotypes they associate with STEM.

This chapter is organised into three main sections. The first section details the data analysis processes and results. The Q-sort data were entered into a software, PQMethod 2.35, for a comprehensive quantitative analysis that yielded crucial outputs including correlation matrices, unrotated factor matrices, rotated factor matrices, eigenvalues, correlation arrays, factors, z-scores, and factor loadings. Principle Component Analysis was conducted to determine the number of factors to be retained. After deciding on the number of factors, varimax rotation was carried out to account for the common variance in the study as possible. Qualitative data obtained from post-sort interviews were analysed thematically using NVivo 14 software. The second section describes the factors analysed from the Chinese and Scottish data, integrating both quantitative and qualitative analyses to provide a comprehensive view of these factors, to answer RQ1. The third section addresses RQ2, exploring students' perceptions toward STEM careers by exploring students' knowledge about STEM careers and the related stereotypes.

1 Data analysis

In the previous chapter, a Q-set consisting of 31 statements was designed to capture students' perspectives. The process involved asking students to sort all these statements—each presented on a card—onto a grid with 31 spaces, assigning values ranging from -4 to +4 based on how strongly they agreed or disagreed with the statements. This sorting activity, known as **Q-sorting,** allowed participants to rank the statements, assigning a specific value to each one. The resulting set of values assigned by a participant is a **Q-sort**, representing the quantitative data in this study.

To analyse the quantitative data, I used the PQMethod 2.35 (Schmolck, 2021) software, which is specifically designed for Q-methodology research. This software enables users to import Q-sorts and conduct automatic factor analysis to identify the number of distinct factors (or perspectives) within the dataset. In the context of a Q-study, a **factor** represents a pattern of shared viewpoints among participants. These factors emerge through the analysis of Q-sorts, where clusters of similar sorts indicate shared or aligned views on the subject matter.

PQMethod 2.35 begins by calculating the correlations between all pairs of Q-sorts, indicating the similarity in how participants ranked the statements. Next, factor analysis is performed to identify underlying factors, with the number of factors to extract guided by eigenvalues and theoretical considerations. The factors are then rotated to achieve a clearer structure, and factor loadings are calculated to indicate the degree to which each Q-sort is associated with a factor. Once the factors are identified, factor arrays, distinguishing statements, and consensus statements are generated and included in the report. In this section, the quantitative analysis processes—including correlation matrix, factor analysis, factor rotation, and factor loadings and scores—will be presented separately from the qualitative data analysis.

1.1 Correlation matrix

Pairwise correlations are computed across all Q-sorts, resulting in a **correlation matrix** that shows the similarity between participants' viewpoints. Each Q-sort is regarded as an individual variable in that the correlations between pairs of Q-sorts are calculated based on the rankings given to each statement. In this way, each participant's Q-sort represents a single composite variable that can be correlated with others to uncover common patterns of thought. This correlation matrix forms the foundation for the subsequent factor analysis, which seeks to identify common underlying factors among these correlations. By grouping Q-sorts that correlate strongly with each other, Factor analysis can identify clusters of participants who share similar viewpoints (Watts & Stenner, 2012).

For the 15 Chinese participants, the correlation matrix is a 15×15 array (see Table 4-1), while for the 10 Scottish participants, a 10×10 array (see Table 4-2) is generated. The intercorrelations between any two Q-sorts remain consistent regardless of whether the analysis involves a larger or smaller matrix. This is because the correlation between each pair of Q-sorts is calculated independently, based solely on the rankings within those two Q-sorts, without being influenced by the presence of other Q-sorts in the dataset. However, the dimensionality (i.e., the number of Q-sorts in a cohort) significantly affects how these correlations are grouped and interpreted when identifying factors. For instance, a higher-dimensional solution allows for more distinct groupings, capturing finer nuances between perspectives.

PQMethod 2.35 displays the correlation coefficients ranging from -100 to +100 although they typically range from -1.00 to +1.00, as the coefficients are transferred by shifting the decimal two places to the left. A -1.00 score indicates a perfectly opposed sort, a 0 score indicates two noncorrelated Q-sorts and a +1.00 score indicates two perfectly matched Q-sorts. For example, in Table 4-1, the correlation coefficient between Q-sort 3 and Q-sort 7 is 0.73, indicating a high positive correlation or similar choices in how these two participants sorted the statements (Valenta & Wigger, 1997a). In contrast, Q-sort 4 and Q-sort 13 displayed no correlation, with a coefficient of 0.00. The completion of the correlation matrix functions to yield the data for the factor analysis (McKeown & Thomas, 2013, p. 51) as described below.

Q-SORTS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.00														
2	0.15	1.00													
3	-0.05	0.21	1.00												
4	0.51	0.14	-0.03	1.00											
5	0.23	0.29	0.56	0.20	1.00										
6	-0.09	0.44	0.59	0.19	0.55	1.00									
7	-0.25	0.14	0.73	-0.20	0.42	0.62	1.00								
8	-0.09	0.31	0.55	0.06	0.43	0.56	0.61	1.00							
9	0.63	0.38	-0.22	0.29	0.25	0.15	-0.30	-0.07	1.00						
10	0.37	0.19	0.61	0.14	0.57	0.43	0.49	0.51	0.24	1.00					
11	0.42	0.18	0.14	0.41	0.26	0.23	0.24	0.41	0.18	0.54	1.00				
12	0.53	0.19	0.21	0.66	0.40	0.27	0.10	0.30	0.35	0.46	0.59	1.00			
13	0.05	-0.04	-0.01	0.00	0.16	-0.03	0.08	-0.13	-0.06	0.15	0.20	0.22	1.00		
14	0.04	0.24	0.36	0.23	0.42	0.43	0.56	0.39	-0.11	0.30	0.36	0.14	0.27	1.00	
15	-0.02	0.26	-0.20	0.22	0.34	0.21	0.07	-0.03	0.16	-0.15	-0.03	0.27	0.27	0.28	1.00

Table 4-1 Correlation matrix of Chinese Q-sorts. This table shows the correlations between Chinese Q-sorts. A correlation close to +1 indicates highly similar perspectives, a correlation near -1 suggests opposing views and a value close to zero means little to no relationship between the participants' rankings.

Q-SORTS	1	2	3	4	5	6	7	8	9	10
1	1.00									
2	-0.13	1.00								
3	0.30	-0.70	1.00							
4	0.46	0.28	0.28	1.00						
5	0.28	0.36	0.34	0.46	1.00					
6	0.51	-0.03	0.06	0.45	0.09	1.00				
7	-0.14	-0.23	0.06	-0.03	-0.02	0.08	1.00			
8	0.30	-0.16	-0.23	0.34	-0.05	0.43	0.04	1.00		
9	0.42	0.20	0.23	0.26	0.13	0.47	-0.25	0.37	1.00	
10	0.27	0.11	-0.18	0.06	-0.13	0.37	-0.21	0.49	0.47	1.00

Table 4-2 Correlation matrix of Scottish Q-sorts. This table shows the correlations between Scottish Q-sorts. A correlation close to +1 indicates highly similar perspectives, a correlation near -1 suggests opposing views and a value close to zero means little to no relationship between the participants' rankings.

1.2 Factor analysis

Factor analysis is a critical step in grouping participants based on the similarities of their Q-sorts, thereby identifying distinct perspectives or viewpoints. It begins with examining correlation matrices, which reveal how similarly participants have ranked the statements. Factor analysis then identifies groups of Q-sorts that share common patterns, effectively highlighting shared viewpoints among participants. This process involves applying specific criteria to ensure the validity and interpretability of the factors, allowing the researcher to discard irrelevant or minor factors that do not contribute meaningfully. Once this refinement is complete, the researcher determines the appropriate number of factors to retain, focusing on those that best capture the underlying structure of the data and represent meaningful patterns within the group.

Watts and Stenner (2012) liken factor analysis to a cake-cutting process: the Q-sorts represent a large cake filled with a mix of meanings and perspectives. The challenge is to determine the number of slices the cake has, with the goal of dividing it into sensible and easily digestible portions. The slices of cake representing shared meanings are the factors in a study. Factor analysis is applied by rotating the factor matrix and identifying eigenvalues. This rotation also assesses the strength of each factor, allowing for a more accurate interpretation of the results. Additionally, calculating factor scores helps determine standard errors and the factor characteristics of each factor. To determine whether a factor should be retained, three criteria can be employed:

The first criterion is that a factor should be retained if its eigenvalue exceeds 1.00. PQMethod 2.35 can produce a maximum of eight factors by default. This initial number serves as a starting point, after which additional criteria are applied to refine the selection to a reasonable and meaningful set. **Eigenvalues** play a crucial role in determining the significance of factors. They are calculated by summing the squared loadings of all the Q-sorts on a given factor, representing the amount of variance explained by that factor. Factors with higher eigenvalues account for more variance in the data, making them more significant factors. Eigenvalues less than 1.00 are weak relationship indicators and eigenvalues greater than 1.00 are significant (McKeown & Thomas, 2013). For example, of the eight factors extracted from the Chinese data, four resulted in eigenvalues greater than 1.00 with two of them greater than 2.00. The top four factors accounted for 70% of the variance. The unrotated factor matrix eigenvalues are given in Table 4-3 and Table 4-4. However, this does not mean that any factor with an eigenvalue higher than 1.00 should be retained, instead, this is a threshold that the factor could be considered for extraction and rotation.

In addition to the criteria determined by eigenvalues, a second criterion is **Humphrey's rule** (Brown, 1980a, p. 223). Humphrey's rule states that "a factor is significant if the cross-product of its two highest loadings exceeds twice the **standard error (SE)**". The SE of a statistic is the standard deviation of its sampling distribution or an estimate of the standard deviation. It demonstrates the validity and reliability of the data. The SE for a zero-order factor loading is SE = $1/\sqrt{N}$, where N is the number of statements in the Q-set. Since the Q-set contains 31 statements, the SE of factor loadings is SE = $1/\sqrt{N} = 1/\sqrt{31} = 0.18$. Hence, the product of the two highest loadings should exceed 0.36. The unrotated factor matrices (see Table 4-3 and Table 4-4) show the loadings of each Q-sort on the eight factors. For example, in the Chinese data, the Q-sorts displaying the highest loadings on Factor 1 were Q-sort 5 (0.76) and Q-sort 10 (0.77). The cross-product of these two highest loadings is $0.76 \times 0.77 = 0.58$, which satisfies the criterion. Based on this criterion, the first three factors from the Chinese data, as well as the first two factors from the Scottish data are retained for further analysis.

A third rule is that factors with two or more significant factor loadings could be retained. Factor loadings are correlation coefficients in essence, indicating the extent to which each Q-sort is similar or dissimilar to the composite factor array (see Section 1.5, Chapter 4). Factor loadings are considered statistically significant ($p < .01$) if they are more than ± 2.58 times the SE. The *p*-value shows how likely it is to get the observed results if the null hypothesis is true. A *p*-value less than .01 means there is less than a 1% chance that the results happened by random chance, making the findings more trustworthy and reliable. So, factors loadings over ±.463 were considered statistically significant (Watts & Stenner, 2012).

Factor	**Eigenvalue**	**% of variance**	**Cumulative % of variance**
1	4.8361	32.24	32.24
2	2.8678	19.11	51.35
3	1.5707	10.47	61.83
4	1.3844	9.22	71.06
5	0.9681	6.45	77.51
6	0.7800	5.20	82.71
7	0.6285	4.19	86.90
8	0.5236	3.49	90.39

Table 4-3 Unrotated factor matrix eigenvalues of Chinese Q-sorts. This table shows the amount of variance accounted for by each factor before any rotation has been applied.

Factor	**Eigenvalue**	**% of variance**	**Cumulative % of variance**
1	3.0296	30.2958	30.2958
2	1.8712	18.7116	49.0075
3	1.4460	14.4597	63.4672
4	1.0491	10.4908	73.9580
5	0.7217	7.2171	81.1751
6	0.5327	5.3271	86.5022
7	0.4927	4.9270	91.4292
8	0.3999	3.9987	95.4279

Table 4-4 Unrotated factor matrix eigenvalues of Scottish Q-sorts. This table shows the amount of variance accounted for by each factor before any rotation has been applied.

1.3 Factor rotation

The unrotated factor matrix provides a basic overview of the viewpoints in the data but is not clear enough for detailed analysis. Rotation adjusts the factor axes, bringing each Q-sort closer to one specific factor. This simplifies interpretation by ensuring each Q-sort strongly aligns with one factor while having minimal association with others.

The decision-making process of determining the number of factors to retain, along with a summary of the results are presented in Table 4-5 and Table 4-6. Explained variance reflects the extent to which the most important patterns or relationships in the data are captured by the factors extracted. A higher explained variance suggests that more viewpoints among the participants are represented by the factors. However, while increasing the number of factors can enhance coverage, this approach has diminishing returns. For instance, a 15-factor solution would theoretically explain 100% of the variance if there are 15 participants, but excessive factors often overlap, reducing their distinctiveness. Therefore, when deciding how many factors to retain, it is essential to balance the similarity of factors (as shown by correlations among factors in Tables 4-5 and Table 4-6) with the need for comprehensive participant coverage.

For the Chinese Q-sorts, as the first four factors are retained for rotation, a 4-factor solution was employed as a starting point. This solution yielded four factors, with significant loadings representing 71% of the total variance. However, five Q-sorts possessed significant factor loading in relation to more than one factor and it is typically recommended that confounded Q-sorts are not used in the construction of any of the factor estimates (Watts & Stenner, 2012). Consequently, this solution will result in the exclusion of one-third of the 15 Q-sorts from further analysis. Notably, statistically significant correlations of 0.37 and 0.38 were observed between Factor 2 and Factor 4 and between Factor 3 and Factor 4, respectively. These correlations suggest that Factor 2 and Factor 4, as well as Factor 3 and Factor 4, may be regarded as alternative manifestations of the same underlying factor (Watts & Stenner, 2012). Therefore, this 4-factor solution was rejected, and solutions using fewer factors were subsequently carried out.

Thereafter, a 3-factor rotation was employed in this analysis. The three extracted factors accounted for a satisfactory proportion of the total variance, specifically 62%. This solution resulted in a total of 13 Q-sorts that exhibited significant loadings on only one factor. The decision to accept this solution was informed by the moderate level of correlations and an appropriate number of participants retained.

Finally, a 2-factor solution was tried but also rejected due to its limited ability to account for diverse viewpoints. Additionally, this solution necessitated the exclusion of three participants whose Q-sorts did not display significant loadings on either of the two factors.

Factor Rotation Solution	Eigen Value Included	Explained Variance	No. of Participants Loaded	No. of Confounded Q-sorts	Correlation among Factors	Reasoning
4 factors	4.8, 2.9, 1.6, & 1.4	71%	15/15	5	0.16, 0.19, 0.30, 0.18, 0.37, & 0.38	Correlation too high, Number of confounded Q-sorts too high
3 factors	4.8, 2.9, & 1.6	62%	14/15	1	0.07, 0.09, & 0.14	Moderate correlation
2 factors	4.8 & 2.9	51%	12/15	0	0.10	Rejected too many participants; Didn't account for enough viewpoints in the study

Table 4-5 Information used to determine the factor rotation of Chinese Q-sorts

In the Scottish Q-sorts analysis, the rotation initially centred around a 4-factor solution. This choice stemmed from the observation that solutions comprising four factors or fewer exhibited eigenvalues surpassing the threshold of 1.00. Interestingly, the correlations among the Q-sorts remained relatively moderate across rotations involving 4, 3, and 2 factors. However, upon closer examination, both 4- and 3-factor rotations were dismissed and this decision was made based on a key criterion: for a factor to be considered interpretable in Q-methodological terms, it typically necessitates significant loading from at least two Q-sorts exclusively (Watts & Stenner, 2012, p. 106). Finally, a 2-factor solution was retained for the Scottish data rotation.

In this study, the retained three factors derived from the Chinese data are designated as **Factor 1**, **Factor 2**, and **Factor 3**, while the two factors identified from the Scottish data are labelled **Factor A** and **Factor B**. The labels following the sequence of numbers and letters are intended to differentiate between Chinese and Scottish factors.

Factor Rotation Solution	Eigen Value Included	Explained Variance	No. of Participants Loaded	No. of Confounded Q-sorts	Correlation Among Factors	Reasoning
4 factors	3.0, 1.9, 1.4, & 1.0	74%	10/10	5	0.13, -0.05, 0.09, 0.13, & 0.25	Only one Q-sort loaded significantly on Factor 3
3 factors	3.0, 1.9, & 1.4	63%	9/10	1	0.02, 0.17, & 0.17	Only one Q-sort loaded significantly on Factor 3
2 factors	3.0 & 1.9	49%	9/10	0	0.16	More than one Q-sort loaded significantly on both factors

Table 4-6 Information used to determine the factor rotation of Scottish Q-sorts

1.4 Factors and factor loadings

Factor loadings are in effect correlation coefficients; they indicate the extent to which each Q-sort is similar or dissimilar to the composite factor array for that type, or in other words, they indicate the initial correlation of each Q-sort with each factor. The rotated factor matrices display the loadings of each Q-sort on each factor. Additionally, the corresponding factor scores for each participant, relative to the factors, are detailed in Table 4-7 and Table 4-8.

Q-sort	Factor 1	Factor 2	Factor 3
1	-0.0830	0.8727X	-0.0877
2	0.2939	0.2640	0.3460
3	0.8721X	-0.0598	-0.1332
4	-0.0030	0.7088X	0.2285
5	0.6218X	0.3062	0.3558
6	0.7402X	0.0821	0.2933
7	0.8724X	-0.2606	0.1194
8	0.7988X	0.0667	-0.0425
9	-0.1497	0.7197X	0.0970
10	0.7174X	0.4546	-0.1804
11	0.4030	0.6035X	-0.0063
12	0.2693	0.7630X	0.1999
13	0.0194	0.0556	0.4843X
14	0.5608X	0.0242	0.4915X
15	-0.0667	0.0673	0.9068X
% of total variance explained	29	21	12
X for .01 significance SE = 0.463 at or above sig. p<.01, 99% confidence			

Table 4-7 Rotated factor matrix of the Chinese Q-sorts. This table displays the factor loadings for each Q-sort across the identified factors, with higher loading indicating stronger associations between Q-sorts with a particular factor. An "X" marks the defining Q-sort, highlighting those that best represent the shared viewpoints within each factor.

As a result, three factors were extracted and rotated for the Chinese Q-sorts, collectively accounting for 62% of the explained variance. Fourteen of the 15 Q-sorts loaded significantly on one or two of the factors. Factor 1 demonstrated significant loadings (p<.01) for seven participants, Factor 2 for five participants (p<.01), and Factor 3 for three participants (p<.01). All 15 participants were labelled from Participant 1 to Participant 15. Among them, Participant 14 showed significant loadings on two factors, indicating a Q-sort with ambiguous factor involvement. In contrast, Participant 2 did not exhibit significant loadings on any factor. Therefore, Participant 2's data was excluded from the study's analysis and findings, as it did not contribute to the identified patterns or viewpoints represented by the factors. This exclusion suggests that Participant 2's viewpoints may differ from or not align well with the factors identified in the study. Upon revisiting Participant 2's data after interpreting and explaining the three factors, it was observed that Participant 2's viewpoint encompassed elements from all three factors, resulting in no significant loading on any single factor.

Q-sort	Factor 1	Factor 2
1	0.6412X	0.3881
2	0.0095	0.4019X
3	-0.0261	0.6823X
4	0.4729	0.6339X
5	0.0497	0.8082X
6	0.7564X	0.1307
7	-0.1767	-0.0519
8	0.7522X	-0.2569
9	0.7184X	0.1962
10	0.7296X	-0.2970
% of total variance explained	29	20

X for .01 significance SE = 0.463 at or above sig. $p<.01$, 99% confidence

Table 4-8 Rotated factor matrix of the Scottish Q-sorts. This table displays the factor loadings for each Q-sort across the identified factors, with higher loading indicating stronger associations between Q-sorts with a particular factor. An "X" marks the defining Q-sort, highlighting those that best represent the shared viewpoints within each factor.

In the Scottish cohort, two factors were identified and rotated, collectively explaining 49% of the variance observed in the data. Factor loadings of ±0.46 or above were significant at the $p<.01$ level and were marked with an X as defining Q-sorts. Factor A displayed significant loading for five participants, while Factor B exhibited significant loading for four participants. However, one participant (Participant 7) did not exhibit significant loading on either factor, leading to its exclusion from the data analysis.

1.5 Factor arrays and factor interpretation

The generation of factor arrays and factor scores typically marks the endpoint of factor analysis. The preceding steps have enabled us to identify the factors, transforming raw data into interpretable factors. Following this, the transition from factors to factor arrays takes place, effectively representing each factor in the original format of a Q-sort (Brown, 1980a). A **factor array** is a single Q-sort configured to represent the viewpoint of a particular factor (McKeown & Thomas, 2013) (see Appendix N and Appendix O). In the original Q-sorting process, each participant assigns a value (i.e., from -4 to 4) to each statement. Similarly, a factor array consists of values that are weighted averages of the scores given to each statement by each participant whose Q-sorts significantly load onto the same factor (McKeown & Thomas, 2013). The values are in fact **factor scores** which are standardised measures reflecting the extent to which participants associated with a particular factor agree with specific statements in the Q-set. These scores are initially computed as z-scores and then converted into whole numbers within the range of the Q-sorting process (-4 to +4) to facilitate interpretation (McKeown & Thomas, 1988). The factor arrays are provided in Appendix N and Appendix O.

However, in interpreting the factors, the factor array will not be the primary source for factor interpretation. Although factor arrays offer a comprehensive overview of rankings, they do not explicitly highlight the most defining or important statements, thereby making the explanation less focused and more complex. Instead, distinguishing statements will be prioritised for factor interpretation. **Distinguishing statements** are those with substantial differences in z-scores, which help differentiate between distinct factors. For example, in Table 4-10, Statement No. 16 serves as a distinguishing statement for Factor 1, with a z-score of 1.62, indicating a strong positive loading. In contrast, its z-scores for Factors 2 and 3 are 0.53 and -0.85, reflecting a lightly positive and moderate negative correlation, respectively. These statements are critical for defining each factor because they distinguish it from others with statistical significance. In each section, the distinguishing statements, along with their ranks and z-scores, are presented to clarify and exemplify the unique characteristics of each factor.

Anchor statements, marked with values of +4 or -4 in the factor array, indicate the most strongly agreed and disagreed statements and are crucial in defining the factors. For instance, in Table 4-11, Statements No.16 and 22 are ranked as +4, while Statement No. 7 is ranked as -4 for Factor 1. Together, these three anchor statements strongly influence the characterisation of Factor 1. **Consensus statements** are statements that "do not distinguish between any pair of factors" (Watts & Stenner, 2012, p. 128). In contrast to distinguishing statements, which highlight differences by assigning distinct rankings to various factors based on participants' perspectives, consensus statements do not show such differentiation. While distinguishing statements are essential for clarifying differences between perspectives, not all statements receive distinct rankings from participants across all factors. As a result, these statements are referred to as consensus statements. For instance, in Table 4-14, Statement No. 10 serves as a consensus statement, with ranks of -3, -2, and -2 for Factors 1, 2, and 3, respectively. The similar ranks across all three factors classify this statement as a common perspective shared among them. While distinguishing statements highlight what sets one factor apart, consensus statements reflect common perspectives shared across all factors. Distinguishing statements and consensus statements are generated automatically by PQMethod 2.35 after the Q analysis of the rotated factors. Together, these quantitative data—anchor, distinguishing, and consensus statements—help clarify the perspectives represented by each factor.

Demographic data helped to gain insights into individual Q-sorts by considering each person's background. However, knowing the demographics in advance can cause us to misinterpret the data to fit our expectations. Therefore, it is better to let the items and their specific configurations guide us toward relevant demographics or away from them when they are not pertinent (Watts & Stenner, 2012, p. 160). Consequently, rather than examining the demographic data immediately after collection, I first focused on the qualitative and quantitative data, striving to explain the findings on their own merits. If any patterns emerged that seemed connected to students' personal traits or family backgrounds, I then revisited the demographic data for further context.

1.6 Qualitative data analysis and interpretive process

As outlined in Section 1.4, Chapter 4, the study included 15 Chinese and 10 Scottish participants. However, not all responses were analysed, as participants whose Q-sorting did not load onto any of the retained factors were excluded. This resulted in the exclusion of one participant from each group, leaving 14 Chinese and 9 Scottish participants whose Q-sorting and interview data were included in the analysis. Participants' interview data were used to complement the quantitative data, enriching the perspectives represented by each factor and addressing the research questions. The interview data were subject to thematic analysis using NVivo 14, a specialised software for qualitative data examination. This analysis involved a systematic process that included becoming acquainted with the data, generating codes, formulating themes, assessing potential themes, and ultimately defining and labelling these themes, following the framework outlined by Terry et al. (2017, p. 23).

The interview data was first transcribed, with the Chinese interviews translated into English. I began by familiarising myself with the data and reading the transcripts repeatedly. Next, the interview data was coded into meaningful units. The coding process was guided by the research questions framed by the EVC model and SCCT. The Q-set was developed based on these frameworks, and the interview data was collected to provide deeper insights into the patterns revealed by the Q-set. In addition to framework-based codes, some data-driven codes emerged during repeated readings of the transcripts. For example, the code "access to university" was not initially identified as a sub-factor of the *utility value* theme in the Q-set, but surfaced as an important aspect during the analysis of the interview data and was incorporated into the coding scheme. Initially, the data was coded manually, with different colours used to highlight data relevant to various codes. After several iterations of coding, the codes were refined and categorised into distinct themes. A codebook (see Table 4-9) was developed, and the data was input into NVivo 14 to systematically code and categorise all relevant information. The themes were then reviewed and named to ensure clear coherence within each theme. This process ensured that the codes within each theme fit together and that the themes collectively captured the entire data set.

While interpreting the factors, the Q-sorting and interview data played complementary but distinct roles in deriving the findings. Q-methodology, centred around the Q-sorting process and Q-set, provided a quantitative foundation, identifying objective perspectives expressed by participants. Initial factor interpretations were based on distinguishing and consensus statements, which outlined the key traits of each factor. These preliminary sketches were then enriched by corresponding themes from the qualitative analysis. For instance, when statements about different topics loaded together on a factor, participant explanations helped identify the connecting logic that made sense of this pattern. Interview data was systematically integrated with Q-sorting results, providing deeper insights into students' reasoning behind their sorts. Where apparent contradictions arose between sorting patterns and interview discussions, abductive reasoning was employed to reconcile the discrepancies—rather than dismissing either source, I sought interpretations that coherently accounted for both.

The analysis proceeded iteratively: provisional explanations from the Q-sorts were tested against interview evidence, with hypotheses refined or revised until the most plausible and consistent account emerged. After analysing and interpreting each factor individually, I examined the relationships between factors, particularly factors within the two cohorts. First, I identified consensus statements to determine areas of agreement among factors within each cohort. Next, I compared factors across cohorts, addressing key questions such as: How do these factors relate? Where conflicting factors emerged, I assessed whether they reflected fundamental disagreements or merely differences in emphasis.

Theme	Code	Example
Interest value	Leaning process interesting	I don't like doing experiments and things like that
	Difficult problems and exams caused a loss of interest	The overwhelming tests and difficult problems made studying STEM subjects boring
	Orientation towards technical or art jobs	I prefer dealing with things like language and interpersonal tasks rather than technical tasks
Utility value	Good prospect and high salary	STEM jobs generally offer high salaries and promising futures
	Access to University	Learning STEM subjects can help pass the college entrance exam and provide more future opportunities
	Secure and stable job	I believe working as a civil servant offers job stability, which is quiet important to me
Self-value	Sense of belonging	I don't have a sense of belonging to STEM fields
	Self-identity	I've never imagined myself doing a STEM job
Cost	Effort and time cost	STEM jobs can be quiet demanding and need significant effort
	Emotional cost	Working in STEM can be quiet stressful
Self-efficacy	Self-efficacy	STEM subjects are quiet challenging and I struggle with that
	Expectation	I expect I may not make significant progress in a STEM career
	Relative ability among classmates	Some of my classmates perform better in STEM subjects than I do
Perceptions of STEM	Knowledge about occupations within STEM	I am unsure about the types of jobs available within STEM fields
	Image of STEM professionals and jobs	I think STEM professionals are highly skilled and intelligent
	Source of image of STEM professionals and jobs	My image of STEM professionals come from TV shows and online videos
Prior experiences	Mastery experience	Successfully solving a challenging math problem gave me confidence in my abilities
	Vicarious experience	My cousin's experience working in STEM drove me away from considering a STEM career
Social utility	Impact on human life	I believe STEM plays a crucial role in driving human society forward

Social persuasion	Parental influence	My mom doesn't see me as a STEM person
	Parental occupation	Having a parent in STEM would help children step into STEM fields more easily
	Teacher influence	My teacher encourages me to pursue a STEM career in the future

Table 4-9 Codes and illustrative examples from qualitative interview analysis.

2 Research question 1: Factors contributing to lack of STEM career aspirations

2.1 Chinese students' findings

In this section, the combination of anchor statements, distinguishing statements together with data from the post-sorting interviews will provide us with the three factors (namely, Factor 1, 2, and 3) and the evidence that supports the explanation of the factors derived from the Chinese participants. Table 4-10 offers a concise overview of the key characteristics of these factors. The first three sections present the analysis of the three factors, while the fourth section presents the consensus statements—those statements that are not significantly different across the three factors and reflect shared views among Chinese participants.

Factor	Factor Name	Number of Participants	Variance explained	Features of Factor
1	I lack competitiveness	7	29%	(a) STEM careers are important and prospective careers which offer high salaries. (b) I am not competitive enough to excel in future STEM careers. (c) STEM careers are demanding and difficult.
2	I prefer a non-STEM career	5	21%	(a) I prefer a career in non-STEM careers. (b) I am unfamiliar with STEM-related jobs and find STEM careers distant from my daily life. (c) I am good at learning STEM subjects.
3	STEM careers come at a high cost	3	12%	(a) Working in STEM fields costs too much time and effort. (b) I do not enjoy learning STEM subjects.

Table 4-10 The three main factors and their features of Chinese participants.

2.1.1 Factor 1: I lack competitiveness

A total of seven participants loaded significantly at the $p<.01$ level on Factor 1. This factor represents 46.7% of the study's participants (7/15) and 29% of the variance. Five female and two male participants loaded significantly on this factor. The education levels of the participants' parents varied, with one participant's parents both having a bachelor's degree and another participant's parents both having completed only junior high school. Generally, most of the participants had at least one parent who had completed high school education. As for the parents' occupations, most of the parents work in non-STEM fields and only Participant 3 has a parent working in a STEM field. Table 4.11 shows the distinguishing statements chosen by participants associated with Factor 1.

Statement	Statement No.	Factor 1		Factor 2		Factor 3	
		Rank	Z-scores	Rank	Z-scores	Rank	Z-scores
I expected that I will not be competitive enough to find a good job in STEM fields	16	4	1.62*	1	0.53	-2	-0.85
Studying STEM makes me nervous or upset†	22	4	1.27	-3	-1.37	2	0.60
I lack confidence in my ability to excel in STEM subjects	18	3	1.25	-1	-0.47	1	0.41
I didn't see myself as a STEM person	25	3	1.18*	-4	-1.48	-1	-0.40
The content of STEM is too demanding	31	3	1.14*	-1	-0.31	-3	-1.20
I didn't have a sense of belonging to STEM fields	15	2	1.07	-1	-0.39	1	0.35
I'm not good at STEM subjects	17	2	1.05*	-2	-0.99	-1	-0.55
I didn't have a sense of achievement in learning STEM subjects	11	2	0.92*	-2	-0.95	-3	-1.45
I prefer artistic and social studies than STEM	27	1	0.82*	4	1.56	-1	-0.40.
I'd rather deal with words and people than work on technical tasks	2	1	0.53*	3	1.41	-4	-1. 66
I'm interested in a job out of STEM	8	1	0.43	4	1.79	3	1.25
I am not familiar with STEM subjects	6	0	0.13	2	0.77	-2	-0.75
I seldom visited science centre or science museum out of school or conducted experiments or science projects in the school laboratory	5	0	-0.11	2	0.63	-2	-0.81
STEM majors are not my dream major	24	-1	-0.20*	3	1.44	4	1.71
Taking STEM courses is boring	1	-1	-0.27	1	0.38	3	1.21
People of my gender are not important contributors to advancing STEM	9	-1	-0.28*	-4	-1.76	2	1.15
STEM careers are something I've never been drawn to career-wise	23	-2	-0.88	0	-0.25	0	-0.20
Most of my friends want to engage in non-STEM careers	19	-2	-1.01	0	-0.10	0	-0.20
Working in STEM is not important in leading to a prospective future	20	-2	-1.29*	2	0.97	0	0.00
When I think about people who work in STEM jobs, I think of people who have poor social skills and do not have many friends	26	-3	-1.54*	-2	-0.74	1	0.50
Working in STEM offers low salaries	7	-4	-1.79*	-3	-1.04	0	-0.20

Note. *Statement was significant at $p < .01$. †Statement was not distinguishing for that factor but was rated a ±4

Table 4-11 Distinguishing statements for Factor 1 (I lack competitiveness). Z-scores reflect how strongly each statement aligns with the factor, while ranks (-4 to 4) indicate the priority of the statement, with higher ranks showing stronger agreement (4 being completely agreed, 3 being strongly agreed, 2 being mostly agreed, 1 being slightly agreed, 0 being neutral, -1 being slightly disagreed, -2 being mostly disagreed, -3 being strongly disagreed, and -4 being completely disagreed).

A primary reason that Factor 1 participants did not aspire to STEM-related careers was their perceived lack of competitiveness in future STEM workplaces and their current ability to excel in STEM subjects. This can be explained by the combination of their low self-efficacy and the high difficulty of the tasks, leading to a lack of a sense of achievement among students. For example, one participant expressed,

I used to think about being a doctor or a programmer because I thought those professions were very noble and I was interested in science and math, but then I realised that the STEM subjects were very challenging, and I struggled with that.

They might be willing to pursue a STEM career if they could perform better in STEM. For example, one participant said, *I think STEM professions generally offer high salaries and good prospects; I would really want to pursue a STEM career if my grades in STEM subjects were better*. This highlights that improving their self-efficacy in STEM could potentially shift their career aspirations toward STEM fields. Low self-efficacy was greatly linked to the demanding content of STEM subjects, with prior learning experiences playing a significant role. Participants generally expressed that they struggle to perform well in STEM subjects, and they sometimes fail to reach their expectations. As one participant expressed, *I think I have given my all to study STEM subjects, yet I still feel a lack of scientific thinking skills, which would guarantee my competitiveness in finding a good job in the future.* This finding echoes with Bandura's (1986, 1997) theory that students often assess their self-efficacy by evaluating the effort required for tasks and the perceived difficulty of those tasks.

STEM subjects, particularly science and mathematics subjects are often viewed as particularly demanding and difficult subjects (Angell et al., 2004; Osborne & Collins, 2001b; Tytler et al., 2008), and students would feel more efficacious in history than in physics if they achieved significantly higher in history with the same amount of time or effort devoted to both subjects. When students with low self-efficacy face difficulties in STEM subjects, they may see these challenges as more daunting, lowering their confidence and reinforcing a negative feedback loop.

Another crucial reason why Factor 1 students did not aspire to STEM-related careers was feeling nervous or upset when studying STEM subjects. This emotional distress is often linked to the negative psychological effects brought by learning in a stressful environment and the high pressure to excel. For example, one student stated, *I get nervous about studying STEM, especially during math classes and this was caused by our maths teacher. Studying STEM subjects can be quite stressful because the math classes cover a lot of content and are very challenging.* This finding reinforces earlier findings that suggest a strong relationship between task difficulty and perceived cost, as significant effort is often required to succeed in STEM fields (Eccles & Wigfield, 2002; Toma, 2022). Furthermore, this aligns with recent research showing that high levels of perceived difficulty in tasks are strongly associated with negative emotions, such as frustration and anxiety, which can further deter engagement in STEM (Steensel et al., 2019).

It is important to highlight that these high-achieving students were among the top 25% of their year group but still lack confidence and have negative feelings when studying STEM subjects. Their reflections on comparisons with classmates also play a role, as students tend to gauge their competence by comparing themselves with their similarly capable classmates. For instance, one participant explained, *I am in the middle rank of my class in maths and physics subjects, and I don't feel myself competitive enough to excel in future work fields.* This resonates with the BFLPE proposed by Marsh & Parker (1984), which illustrates the social comparison effect and its influence on students' academic self-efficacy and career aspirations. This finding emphasises that students' perceptions of their abilities are not only influenced by their absolute accomplishments but also by their relative position within a competitive setting. Such dynamics play a crucial role in shaping their confidence, underscoring the need to foster supportive environments that minimise the negative impacts of social comparisons on self-efficacy and career planning.

Although low self-worth was not identified as the primary factor, it emerged as a significant underlying issue for Factor 1 participants. Many Factor 1 participants expressed a lack of belonging and did not perceive themselves as "STEM people," feeling unacknowledged and disconnected from these fields due to a perceived lack of competence. This reflects the findings revealed in previous studies that self-efficacy reinforces self-identity and performance and competence are important components of identity (Carlone & Johnson, 2007). This experience also reflects Atkinson's (1964) model of achievement motivation, which describes "over-strivers" as individuals driven by both high approach and high avoidance tendencies. For some Factor 1 participants, this intense pressure to maintain a high-achieving status fuelled a belief that only exceptional performance was acceptable. Consequently, while this over-striving mindset can be motivating, it may also act as a barrier, deterring students from fields they perceive as too demanding.

Turning the spotlight onto the other side of the grid, participants generally agree that STEM jobs offer high salaries and promising prospects for a good future. They do not hold negative stereotypes towards STEM professionals. For instance, one participant expressed his view on STEM careers: *The salary [of STEM careers] is quite good, and it seems that once you gain the necessary knowledge and skills, job opportunities are readily available.* This finding highlights that alongside considering the benefits of doing a task, individuals also require a sense of competence in pursuing a STEM career and feel the effort and time invested to be worthwhile. Interestingly, the combination of low utility value and high self-efficacy identified in this study was not reported in previous person-centred research, which typically found similar levels of self-efficacy and values across different profiles (e.g., Andersen & Chen, 2016; Perez et al., 2019). This deviation may stem from the unique participant pool in this study. The inclusion of high-achieving students who lack STEM career aspirations represents a relatively small and uncommon subset of students, revealing a distinct pattern not previously observed.

Overall, participants who selected Factor 1 view STEM careers as promising and full of potential; however, they do not feel competitive enough to pursue these careers. This sentiment is largely due to their perceived low self-efficacy, heightened by the demanding nature of STEM subjects, stressful learning environments, and comparisons with classmates, all of which contribute to diminishing their confidence. To summarise, Factor 1 participants are those who consider (a) STEM as important, prospective careers which offer high salaries; (b) themselves to be uncompetitive enough to excel in future STEM careers; (c) STEM careers to be demanding and difficult.

2.1.2 Factor 2: I prefer a non-STEM career

A total of five participants loaded significantly at the $p<.01$ level on Factor 2. This percentage represents 33.9% of the study's participants (5/15) and 21% of the variance. Factor 2 is represented by two female and three male participants. Their parents generally have lower education levels compared to the other two factors, with an average education around junior high school and only one parent having completed high school. In regard to their parents' occupations, only one of them pursued a career in STEM, while the others were in non-STEM fields. Distinguishing statements associated with Factor 2 are listed in Table 4-12.

Statement	Statement No.	Factor 1		Factor 2		Factor 3	
		Rank	Z-scores	Rank	Z-scores	Rank	Z-scores
I prefer artistic and social studies than STEM	27	1	0.82	4	1.56*	-1	-0.40
I'd rather deal with words and people than work on technical tasks	2	1	0.53	3	1.41*	-4	-1.66
A degree in social science and humanities, rather than STEM, will most likely guarantee secure employment	21	-1	-0.31	2	1.27*	1	0.25
Working in STEM is not important in leading to a prospective future	20	-2	-1.29	2	0.97*	0	0.00
I am not familiar with STEM subjects	6	0	0.13	2	0.77	-2	-0.75
I seldom visited science centre or science museum out of school or conducted experiments or science projects in the school laboratory	5	0	-0.11	2	0.63	-2	-0.81
I seldom/never had conversations or worked with a STEM professional	28	0	-0.06	1	0.54	0	-0.15
I expected that I will not be competitive enough to find a good job in STEM fields	16	4	1.62	1	0.53*	-2	-0.85
Taking STEM courses is boring	1	-1	-0.27	1	0.38	3	1.21
STEM lacks direct influence on human life	30	-4	-1.68	0	-0.05*	-4	-1.51
Working in STEM leads to too much stress	14	2	0.82	0	-0.30*	3	1.41
The content of STEM is too demanding	31	3	1.14	-1	-0.31	-3	-1.20
I didn't have a sense of belonging to STEM fields	15	2	1.07	-1	-0.39	1	0.35
I lack confidence in my ability to excel in STEM subjects	18	3	1.25	-1	-0.47	1	0.41
When I think about people who work in STEM jobs, I think of people who have poor social skills and do not have many friends	26	-3	-1.54	-2	-0.74*	1	0.50
Working in STEM offers low salaries	7	-4	-1.79	-3	-1.04	0	-0.20
Studying STEM makes me nervous or upset	22	4	1.27	-3	-1.37 *	2	0.60
I didn't see myself as a STEM person	25	3	1.18	-4	-1.48*	-1	-0.40
People of my gender are not important contributors to advancing STEM	9	-1	-0.28	-4	-1.76*	2	1.15

Note. *Statement was significant at $p < .01$

Table 4-12 Distinguishing Statements for Factor 2 (I prefer a non-STEM career). Z-scores reflect how strongly each statement aligns with the factor, while ranks (-4 to 4) indicate the priority of the statement, with higher ranks showing stronger agreement (4 being completely agreed, 3 being strongly agreed, 2 being mostly agreed, 1 being slightly agreed, 0 being neutral, -1 being slightly disagreed, -2 being mostly disagreed, -3 being strongly disagreed, and -4 being completely disagreed).

As can be seen from Table 4-12, having a preference for non-STEM careers was ranked as the most significant reason. This could be explained by the fact that participants favour non-STEM subjects over STEM, prefer working with words and people over technical tasks, and believe that degrees in social sciences and humanities offer more secure employment than STEM jobs. This resonates with the findings of previous studies which emphasise the influence of orientation, particularly people-thing orientation, on individuals' preferences for job opportunities and career choices (Coetzee & De Villiers, 2010; Gerber et al., 2009; Graziano et al., 2012; Ngo & Hui, 2018). These three statements collectively indicate that the prospect and appeal of careers in artistic and social studies, which emphasise communication and interpersonal skills, resonate more strongly with the participants than pursuits in STEM fields. For example, one participant stated that *I prefer tasks involving communicating with people because I enjoy meeting new friends and find communicating with people more interesting than working on technical work alone.* Furthermore, he added, *I consider jobs like civil servants as very stable jobs and I realised the importance of 'a job secured for life', especially after experiencing the COVID-19 pandemic.*

This finding underscores the complexity of utility value in students' decision-making. Utility value is not a one-size-fits-all concept; it encompasses different aspects that students might prioritise based on their personal goals, socio-cultural context, and perceptions of the job market. In this sense, utility value is also connected to personal goals and sense of self and thus has some connections to self-value (Wigfield et al., 2016). For instance, while some students may prioritise high salaries or social status—benefits often associated with certain STEM careers—others might find greater value in the promise of long-term job stability, even if it means accepting a lower salary. This divergence is particularly notable in contexts where economic uncertainty has recently become a significant concern, as seen in the aftermath of the pandemic. Moreover, although extensive research employing EVT or EVC models has examined students' motivation and career aspirations (e.g., Ball et al., 2016; Lauermann et al., 2017), the complexity of the utility value factor often remains underexplored. Notably, utility value may consist of contrasting sub-factors, such as the trade-off between stability and financial reward or between personal fulfilment and external validation. These internal contrasts underscore the importance of adopting a nuanced approach when studying how utility value influences students' choices and behaviours.

Participants in Factor 2 often express a negative view of STEM, largely due to frustrations with its binary, success-or-failure approach to problem-solving. For instance, one participant highlighted this sentiment, explaining, *The binary nature of solving STEM problems, where you either succeed or fail, was frustrating. If I were to pursue a career in STEM, for example, nuclear physics, I would have to continuously delve into research for many years and not know if I would succeed.* This perception of definitive outcomes in STEM can feel limiting and discouraging for individuals who prefer fields with more flexible interpretations of success. Similarly, another common perspective among Factor 2 participants is that while STEM careers are often pictured as "important", they feel somewhat "distant" from their personal lives. As one participant noted,

We have access to technology-related products in our daily lives such as smartphones and cars. Although the innovation and production of these products rely on STEM knowledge and skills as users, we typically focus only on their practical use without understanding their technical structure or scientific significance. I perceive the role of

STEM professionals as conducting extensive research, but my understanding of their rigorous work comes solely from what I've read.

These perspectives highlight how the appeal of non-STEM careers, with their emphasis on stability, communication skills, and less deterministic outcomes, contrasts sharply with the challenges and uncertainties perceived in STEM disciplines. Participants who selected Factor 2 often viewed STEM careers as predominantly technical, requiring personal effort but lacking in communication skill demands. This limited understanding of STEM roles was common among them, leading to a sense of disconnect from STEM professions. As expressed by one participant, *I feel that I don't have much understanding of careers in STEM fields, I'm not familiar with the prospects, salary, or work environment.* This unfamiliarity with STEM careers is often connected to a lack of experience in STEM (both in school and out of school) or a lack of access to people who are taking STEM careers. As a participant explained, *I have very few relatives studying STEM subjects at university or pursuing STEM careers, so I lack information from those around me related to STEM careers.*

The limited exposure, combined with factors like low parental education levels, indicated low STEM capital among Factor 2 participants. These findings align with those of Jones et al. (2021) and Archer et al. (2013), who observed that youth who have low science capital are less likely to perceive the task value of future science. The limited knowledge and understanding of STEM careers observed in Factor 2 students can be explained by Claussen and Osborne's (2013) findings, which indicate that when families lack capital, their children are less aware of potential career pathways, placing them at a disadvantage in pursuing science-related fields. However, they diverge from the findings of Jones et al. (2019), who reported that students with low science capital often lack confidence in their ability to succeed in science. In contrast, Factor 2 participants demonstrated relatively high self-efficacy in STEM subjects compared to those in Factors 1 and 3. Their strong academic performance and confidence appeared to mitigate the negative effects of low STEM capital on their self-efficacy. These insights suggest that increasing STEM participation requires more than classroom instruction; it calls for a multifaceted approach that broadens students' understanding of and access to STEM career paths.

In contrast to participants who selected Factor 1, who emphasised low self-efficacy and found studying STEM subjects to be demanding and stressful, Factor 2 participants did not indicate a lack of self-efficacy, nor did they perceive STEM subjects as overly demanding or stressful. By contrast, they have a sense of achievement and belonging when learning STEM subjects. These statements imply that those participants tend to enjoy learning STEM subjects and view themselves as STEM people. These findings align with the literature, which posits that self-efficacy, while necessary, is not a sufficient predictor of career choices or aspirations. Being skilled or capable in an activity does not inherently lead to pursuing it as a career (Joyce & Farenga, 2000; Wang, 2012; Wang & Degol, 2013).

In summary, participants who selected Factor 2 tend to value non-STEM careers for their potential to offer greater career stability and a less intense working environment. They are attracted to non-STEM careers because these fields offer opportunities to work with people rather than focusing solely on tedious technical tasks. Additionally, while a high level of self-efficacy can greatly influence an individual's career choices and may make them more inclined to pursue a particular field, it does not guarantee that they will ultimately choose that field as a career. Some participants also reported their limited knowledge of STEM careers and hence viewed STEM careers as something distant from their daily lives. Participants who selected Factor 2 are those who (a) prioritise non-STEM careers for stability and a working environment involving interpersonal interactions over technical tasks; (b) consider themselves unfamiliar with STEM-related jobs and find STEM careers distant from their daily life; (c) are good at learning STEM subjects.

2.1.3 Factor 3: STEM careers come at a high cost

Three participants loaded significantly at the $p<.01$ level on Factor 3, which corresponds to 20% of the study's participants (3/15) and contributes to 12% of the variance. This factor included two males and one female participant, whose parents, on average, had bachelor's degrees, none of whom worked in STEM fields. Distinguishing statements of Factor 3 are shown in Table 4-13.

Statement	Statement No.	Factor 1		Factor 2		Factor 3	
		Rank	Z-scores	Rank	Z-scores	Rank	Z-scores
Working in STEM requires too much time and effort than I want to put into	12	1	0.38	1	0.28	4	1.96*
Taking STEM courses is boring	1	-1	-0.27	1	0.38	3	1.21
I don't find STEM subjects enjoyable	13	0	-0.09	0	-0.10	2	1.16*
People of my gender are not important contributors to advancing STEM	9	-1	-0.28	-4	-1.76	2	1.15*
Studying STEM makes me nervous or upset	22	4	1.27	-3	-1.37	2	0.60
When I think about people who work in STEM jobs, I think of people who have poor social skills and do not have many friends	26	-3	-1.54	-2	-0.74	1	0.50*
I lack confidence in my ability to excel in STEM subjects	18	3	1.25	-1	-0. 47	1	0.41
I didn't have a sense of belonging to STEM fields	15	2	1.07	-1	-0.39	1	0.35
Working in STEM is not important in leading to a prospective future	20	-2	-1.29	2	0.97	0	0.00*
Working in STEM offers low salaries	7	-4	-1.79	-3	-1.04	0	-0.20
I didn't see myself as a STEM person	25	3	1.18	-4	-1.48	-1	-0.40*
I prefer artistic and social studies than STEM	27	1	0.82	4	1.56	-1	-0.40*
I am not familiar with STEM subjects	6	0	0.13	2	0.77	-2	-0.75*
I seldom visited science centre or science museum out of school or conducted experiments or science projects in the school laboratory	5	0	-0.11	2	0.63	-2	-0.81
I expected that I will not be competitive enough to find a good job in STEM fields	16	4	1.62	1	0.53	-2	-0.85*
The content of STEM is too demanding	31	3	1.14	-1	-0.31	-3	-1.20
I'd rather deal with words and people than work on technical tasks	2	1	0.53	3	1.41	-4	-1.66*

Note. *Statement was significant at $p < .01$

Table 4-13 Distinguishing Statements for Factor 3 (STEM careers come at a high cost). Z-scores reflect how strongly each statement aligns with the factor, while ranks (-4 to 4) indicate the priority of the statement, with higher ranks showing stronger agreement (4 being completely agreed, 3 being strongly agreed, 2 being mostly agreed, 1 being slightly agreed, 0 being neutral, -1 being slightly disagreed, -2 being mostly disagreed, -3 being strongly disagreed, and -4 being completely disagreed).

As shown in Table 4-13, participants in this category emphasised the cost associated with pursuing a career in STEM including the time, effort, and emotional cost. For instance, one participant conveyed, *learning STEM subjects demands considerable mental exertion, and failing to solve problems after investing effort can be frustrating, diminishing my interest and making the learning process tedious*. This aligns with prior research suggesting a strong relationship between task difficulty and perceived cost, as success in STEM fields often demands considerable, sustained effort (Eccles & Wigfield, 2002; Toma, 2022).

Further, Factor 3 participants highlighted the emotional cost of studying STEM, describing feelings of nervousness and stress—indicating that the psychological pressure brought by learning STEM contributes to a sense of high cost. Together, these two aspects of costs—effort and time cost together with emotional cost, form the primary reason Factor 3 students hesitated to pursue STEM-related careers. This finding emphasises the critical role perceived cost plays in shaping students' motivation, particularly in influencing their intentions to disengage from or develop negative perceptions of STEM careers. It also reinforces the need to prioritise cost as a first-order factor in the EVC model (Barron & Hulleman, 2014; Jiang et al., 2018; Lee et al., 2022).

In contrast to Factor 1 participants, who felt STEM subjects were overly difficult and thus questioned their own competence for STEM careers, Factor 3 participants did not express doubt about their abilities. This difference suggests that Factor 3 participants view the costs of STEM not as a barrier due to lack of self-efficacy, but rather as inherent demands of STEM fields, which they anticipate will continue into their careers. In other words, their concerns are not about capability but about the ongoing demands they expect to encounter.

Additionally, a notable reason Factor 3 participants expressed for hesitating to pursue STEM careers is the low interest and enjoyment value they find in learning STEM subjects. The combination of high perceived cost and low interest echoes findings from previous research (Perez et al., 2014), which suggests that when individuals do not find value in a task, the associated effort may feel less justified. This highlights a potential barrier to STEM career pathways for these individuals: unless they perceive the effort as meaningful or rewarding, the high costs may deter their pursuit of a STEM career.

In general, participants who selected Factor 3 were characterised by their concerns about the high time, effort, and emotional cost that such careers might demand. They were neither drawn to STEM careers nor had a clear preference for non-STEM careers. The viewpoints of participants who selected Factor 3 could be summarised as (a) working in STEM fields costs too much time and effort, and (b) I do not enjoy learning STEM subjects.

2.1.4 Consensus statements

As consensus statements are statements that participants placed in similar positions with comparable z-scores across all three factors within a cohort of participants, the examination of consensus statements helps to understand the commonly shared views of all the participants in this study. In other words, apart from trying to understand what distinct perspectives exist within a cohort, we can get to know the generally agreed ideas. While Q-methodology typically focuses on distinguishing statements that differentiate between factors, consensus statements offer a balanced perspective by highlighting areas of agreement. The PQMethod 2.35 identified five consensus statements which are presented in Table 4-14.

The z-scores of these consensus statements were all negative or zero across the three factors (see Table 4-14). Both Statement No. 23 and 28 were neutral factors in forming STEM career aspirations. Statement No. 23 pertained to exposure to STEM professionals while Statement

No. 28 encompassed the future career plans of participants. This means that participants have no strong feelings about their lack of exposure to STEM professionals or being attracted to STEM careers.

Statement No. 3 is a statement that most participants strongly disagreed with, demonstrating no obvious stereotypes regarding STEM professionals. Both statements No. 4 and 10 indicate that participants strongly, slightly, or mostly disagreed that negative beliefs from significant others (e.g., teacher recognition and parental expectation) are driving factors influencing their STEM career aspirations. In other words, it makes no difference to STEM career choice if parents or teachers have negative or positive beliefs about the student taking a STEM career.

Statement	**Statement No.**	**Factor 1 Value**	**Factor 2 Value**	**Factor 3 Value**
When I think about people who work in STEM jobs, I think of people who are weird and not attractive	3*	-3	-3	-3
My teachers didn't see me as a STEM person	4*	-2	-1	-1
My parents didn't expect me to take a STEM career	10*	-3	-2	-2
STEM careers are something I've never been drawn to career-wise	23	-2	0	0
I seldom/never had conversations or worked with a STEM professional	28	0	1	0

Note. *Statement was significant at $p > .05$.

Table 4-14 Consensus Statements among Chinese participants. This table shows the statements with which all Chinese participants strongly disagreed, mostly agreed, or slightly disagreed (-3 being strongly disagreed, -2 being mostly disagreed, -1 being slightly disagreed, 0 being neutral, and 1 being slightly agreed).

2.2 Scottish students' findings

Using the same analytic techniques as those employed in the analysis of the Chinese data above, this section presents the two significant factors (namely Factor A and Factor B) reported by the Scottish participants. A summary of the characteristics of these two factors is shown in Table 4-15.

Factor	Factor Name	Number of Participants	Variance explained	Features of Factor
Factor A	I don't belong to STEM fields	5	29%	(a) I lack a sense of belonging to STEM fields (b) STEM subjects are not attractive or enjoyable due to personal preferences (c) I prioritise personal fulfilment and a sense of belonging, despite recognising the utility value of STEM careers
Factor B	STEM is not my dream major	4	20%	(a) STEM majors are not my dream major (b) I have a stronger interest in non-STEM fields (c) Social influence from parents and teachers significantly shapes my career aspirations

Table 4-15 Summary of factors of Scottish participants.

2.2.1 Factor A: I don't belong to STEM fields

Five participants loaded significantly at the $p<.01$ level on Factor A and this factor represents 50% of the study's participants (5/10) and 29% of the variance. The five participants are comprised of three female and two male participants. Two of the participants had parents with bachelor's degrees, while the other three had parents holding secondary school diplomas. The distinguishing statements for Factor A are detailed in Table 4-16.

Statement	Statement No.	Factor A		Factor B	
		Rank	Z-scores	Rank	Z-scores
I didn't have a sense of belonging to STEM fields	15	4	1.68*	1	0.50
STEM careers are something I've never been drawn to career-wise	23	4	1.37*	0	0.46
Studying STEM makes me nervous or upset	22	3	1.32*	-3	-1.27
I don't find STEM subjects enjoyable	13	3	1.13*	-4	-1.57
The content of STEM is too demanding	31	2	1.07*	0	-0.29
I orient towards people more than things	29	2	0.78*	0	-0.19
STEM majors are not my dream major	24	2	0.78	4	1.56
Working in STEM leads to too much stress	14	1	0.75*	0	-0.10
I didn't see myself as a STEM person	25	1	0.55*	4	1.50
I expected that I will not be competitive enough to find a good job in STEM fields	16	1	0.39	3	1.22
I lack confidence in my ability to excel in STEM subjects	18	0	-0.03*	2	1.08
I seldom/never had conversations or worked with a STEM professional	28	0	-0.16*	3	1.48
I'm not good at STEM subjects	17	0	-0.16*	-3	-1.56
I seldom visited science centre or science museum out of school or conducted experiments or science projects in the school laboratory	5	-1	-0.21	-2	-0.88
When I think about people who work in STEM jobs, I think of people who are weird and not attractive	3	-1	-0.34*	-4	-1.57
Taking STEM courses is boring	1	-1	-0.37*	-3	-1.28
My parents didn't expect me to take a STEM career	10	-1	-0.41*	2	0.83
My teachers didn't see me as a STEM person	4	-2	-1.04*	2	0.71
Most of my friends want to engage in non-STEM careers	19	-3	-1.35*	1	0.70
A degree in social science and humanities, rather than STEM, will most likely guarantee secure employment	21	-3	-1.47*	3	1.15
Working in STEM offers low salaries	7	-4	-1.62*	-1	-0.45
STEM lacks direct influence on human life	30	-4	-2.02*	-2	-0.75

Table 4-16 Distinguishing Statements for Factor A (I don't belong to STEM fields). Z-scores reflect how strongly each statement aligns with the factor, while ranks (-4 to 4) indicate the priority of the statement, with higher ranks showing stronger agreement (4 being completely agreed, 3 being strongly agreed, 2 being mostly agreed, 1 being slightly agreed, 0 being neutral, -1 being slightly disagreed, -2 being mostly disagreed, -3 being strongly disagreed, and -4 being completely disagreed)

Lacking a sense of belonging to STEM fields was the reason these students agreed as their primary reason, highlighting the crucial role of self-identity in shaping their career aspirations. Failure to establish a STEM identity could be attributed to multifold reasons, such as feeling nervous and finding the subjects unenjoyable. For example, one participant stated*, I don't like doing experiments and things like that.* This dislike of practical activity in STEM subjects disrupts the connection between students and potential STEM careers. This finding aligns with the research of Hazari et al. (2010), who emphasised the importance of interest as a key dimension in the formation of students' physics identities. Interest, as a motivational driver, has a profound influence on self-concept and aspirations within STEM. Haussler and Hoffmann (2002) further illustrated this by showing how curriculum interventions tailored to the interests of girls significantly enhanced their physics self-concept and engagement.

Additionally, some participants showed a preference for non-STEM subjects, which they found more interesting and enjoyable. As one explained, *I've never really liked math or any of those subjects. I think just because I'm much more interested in subjects like history and art.* This inclination toward non-STEM disciplines, such as the humanities or creative arts, may reflect not only a lack of interest in STEM but also an active pursuit of subjects that resonate more deeply with their personal identities and passions. This preference towards people-oriented careers aligns with the idea that career orientation is closely intertwined with interest and often viewed as an expression of it (Lee et al., 2015; Su et al., 2009; Yang & Barth, 2015).

Another reason, although expressed by only one participant, is the reduced connection to STEM due to a lack of a scientific background in his family. He explained:

I suppose I never imagined myself doing a scientific job, and I think part of that is because I don't come from a scientific family at all. So I never even really had a sense of what kind of jobs there were in science, whereas I actually come from a family of teachers, but I think part of that was just from knowing people growing up that did those kinds of jobs, I just understood them a bit better.

Despite recognising the utility value of STEM careers—particularly the potential for high salaries and secure, prospective jobs—Factor A participants were not compelled to aspire to STEM-related careers. This disconnect suggests that while utility value is acknowledged, it alone is insufficient to overcome the lack of interest value and self-value associated with STEM disciplines. For these participants, the appeal of practical benefits does not translate into a genuine desire to engage with STEM fields as a career choice. On the other hand, social persuasion from teachers, parents, or friends was highlighted as an insignificant factor in shaping their career aspirations. Factor A participants generally rely on their own perspectives when deciding on their career paths compared to Factor B participants, with parents and teachers typically supporting their decisions. For example, one participant stated,

I don't think anyone's ever put me off it, and I don't think I've actually been that influenced by other people and more just by myself, because my parents are very open to any jobs that I'd like to do, and my teachers, I don't think my teachers have discouraged me at all, so if anything, they've probably encouraged me to do so [pursue a STEM career].

Factor A participants are those who feel that (a) I lack a sense of belonging to STEM fields; (b) STEM subjects are not attractive or enjoyable due to personal preferences; (c) I prioritise personal fulfilment and a sense of belonging, despite recognising the utility value of STEM careers. Considering that participants loading on Factor A lack an inherent attraction to STEM careers and feel disconnected from STEM fields, they do, however, recognise the utility value inherent in such occupations. They acknowledge the significance of STEM careers in enhancing human life, ensuring job security, and providing high salaries. What becomes evident from the perspective of these participants is that while they acknowledge the utility value of STEM careers, they place greater importance on the fulfilment and sense of belonging derived from their chosen occupations.

2.2.2 Factor B: STEM is not my dream major

Four participants loaded significantly on this factor, accounting for 40% of the Scottish participants (4/10) and 20% of the variance. This group includes two female and two male students. Among the parents of these participants, three had both parents with secondary school diplomas, while one participant had a parent with a master's degree and the other parent with a bachelor's degree. None of the parents were working in STEM fields.

Statement	Statement No.	Factor A		Factor B	
		Rank	Z-scores	Rank	Z-scores
STEM majors are not my dream major	24	2	0.78	4	1.56
I didn't see myself as a STEM person	25	1	0.55	4	1.50*
I expected that I will not be competitive enough to find a good job in STEM fields	16	1	0.39	3	1.22
I seldom/never had conversations or worked with a STEM professional	28	0	-0.16	3	1.48*
A degree in social science and humanities, rather than STEM, will most likely guarantee secure employment	21	-3	-1.47	3	1.15*
I lack confidence in my ability to excel in STEM subjects	18	0	-0.03	2	1.08*
My parents didn't expect me to take a STEM career	10	-1	-0.41	2	0.83*
My teachers didn't see me as a STEM person	4	-2	-1.04	2	0.71*
I didn't have a sense of belonging to STEM fields	15	4	1.68	1	0.50*
Most of my friends want to engage in non-STEM careers	19	-3	-1.35	1	0.70*
STEM careers are something I've never been drawn to career-wise	23	4	1.37	0	0.46*
The content of STEM is too demanding	31	2	1.07	0	-0.29*
I orient towards people more than things	29	2	0.78	0	-0.19*
Working in STEM leads to too much stress	14	1	0.75	0	-0.10*
Working in STEM offers low salaries	7	-4	-1.62	-1	-0.45*
I seldom visited science centre or science museum out of school or conducted experiments or science projects in the school laboratory	5	-1	-0.21	-2	-0.88
STEM lacks direct influence on human life	30	-4	-2.02	-2	-0.75*
Studying STEM makes me nervous or upset	22	3	1.32	-3	-1.27*
I'm not good at STEM subjects	17	0	-0.16	-3	-1.56*
Taking STEM courses is boring	1	-1	-0.37	-3	-1.28*
When I think about people who work in STEM jobs, I think of people who are weird and not attractive	3	-1	-0.34	-4	-1.57*
I don't find STEM subjects enjoyable	13	3	1.13	-4	-1.57*

Table 4-17 Distinguishing Statements for Factor B (STEM is not my dream major). Z-scores reflect how strongly each statement aligns with the factor, while ranks (-4 to 4) indicate the priority of the statement, with higher ranks showing stronger agreement (4 being completely agreed, 3 being strongly agreed, 2 being mostly agreed, 1 being slightly agreed, 0 being neutral, -1 being slightly disagreed, -2 being mostly disagreed, -3 being strongly disagreed, and -4 being completely disagreed).

Unlike the Factor A participants, whose lack of self-identity with STEM was primarily driven by a lack of interest, Factor B participants did not see themselves as "STEM people" for different reasons. They mostly disagree with the notion that STEM subjects fail to bring interest, in other words, it is not a lack of interest resulting in their inability to see themselves as STEM persons. For example, one participant expressed, *I love going and doing experiments and stuff. So, it's just something I always like doing, but I never actually see myself doing it [in the future].*

Factor B participants strongly agree that STEM jobs are not their dream jobs, and this sentiment often stems from their clear orientation for non-STEM careers. For example, one participant explained, *I think I'm interested in a job outside of STEM, in arts or social studies because I have a clear idea of the job and the course I want to pursue.* Another expressed, *I'm interested in a job outside of STEM and I'd like to work in museums and art galleries.*

Despite their interest in STEM subjects, their lack of career identity remains a significant barrier to pursuing STEM fields professionally. When asked why they would continue studying STEM subjects despite aiming for a non-STEM career, a participant responded, *It's only been like a recent thing that I've decided on my job, but I've found all the STEM subjects I've taken so far really interesting, and so I want to keep doing these studies.* This response reflects a disconnect between their interest in STEM subjects and their career aspirations—a gap that suggests an inability to transform interest in STEM into a meaningful career pathway. This finding aligns with research by Archer et al. (2012, 2020), who argue that students' interest in science often fails to develop into high levels of science career aspirations due to a lack of science capital or identity. For Factor B participants, an established career identity outside STEM prevents them from envisioning a future in STEM, despite their academic interest. This underscores the importance of fostering a stronger sense of STEM identity and capital if STEM interest is to translate into career goals.

Expectations from parents and teachers were commonly recognised by Factor B participants as key influences on their career decisions. Notably, these influences were not observed among Chinese participants. Beyond general expectations, the occupation and guidance of parents, as well as open parent-child communication, played a particularly significant role in shaping Factor B participants' perspectives on STEM and non-STEM careers. One participant illustrated the influence, explaining, *I think my parents definitely helped me choose my job and why I want it. I did want to stay in STEM fields a while ago, but they helped me realise maybe it wasn't the sort of thing for me and I wouldn't enjoy it as much as something else.* This reflects how parental insights can steer students away from STEM, especially if parents question the alignment of STEM careers with their child's interests or long-term satisfaction.

Another participant described how his parents' occupations shaped his viewpoints on education as well as STEM careers, saying, *My dad is a farmer, so education hasn't been a big focus for us. It's more about practical work. My mom is an accountant, and seeing her job made me realise I don't want to be stuck behind a desk, working on computers all the time. It just doesn't appeal to me at all.* This comment highlights how family background and parental career experiences can create either alignment or divergence with STEM pathways, reinforcing or diminishing students' interest in these fields.

The experiences shared by Factor B participants align with existing literature that indicates how parental influence on STEM aspirations often comes through encouragement, open communication, and active involvement in educational and educational guidance (Mohd et al., 2010; Young et al., 1991; Zhang & Barnett, 2015). In this context, the combination of explicit guidance and implicit influence from parents' career backgrounds helps to shape how Factor B participants view their own career paths, frequently redirecting their focus away from STEM. This underscores the importance of family dynamics and parental attitudes in either nurturing or diminishing STEM aspirations. Interestingly, this finding contrasts with previous studies focusing on Western, individualistic cultures, where parental influence is more likely to emphasise fostering independence and autonomous decision-making (Rothbaum & Trommsdorff, 2007; Ryan & Deci, 2000; Tamis-LeMonda et al., 2008). In such contexts, parents typically encourage children to explore personal interests and make career choices based on individual preferences rather than familial expectations. By contrast, in Eastern or collectivist cultures, where familial interdependence and shared decision-making are more prevalent (Leung et al., 2011), was not found among the Chinese participants.

Regarding the expectancy aspects, Factor B participants had low expectations regarding their competency in future STEM careers, despite being satisfied with their current achievement and ability in STEM subjects. Although time, effort, or emotional costs were not ranked high as reasons for low expectancies, their reflections on the reasons were closely tied to the perceived cost of future STEM careers. Their low expectations stemmed from their lack of confidence in their long-term dedication and skill development, compounded by their perception that STEM subjects are more challenging than others. This creates an apparent conflict: Factor B participants exhibited high self-efficacy in their present abilities but low expectancy for future success. Interestingly, this discrepancy was not driven by high costs but rather by a preference for careers where they could succeed more easily, rather than pursuing a path where their strengths might lie but would require greater effort and time to excel. Their uncertainty about sustaining current success in a more demanding STEM career context explains this conflict. While they feel capable now, they are cautious about whether they can continue meeting the higher standards they believe future STEM roles will require. For instance, one participant expressed that he could manage STEM subjects and achieve good grades, but it was never easy and relied heavily on their effort, stating, *I think I wouldn't* *be good enough at it. I think I could maybe do kind of okay, but I think there are a lot of people who are a lot more dedicated to wanting a job in STEM, they would do a lot better.*

To summarise, students in Factor B do not identify as STEM people despite enjoying activities like experiments. Instead, they have strong career aspirations in arts or social studies, which they connect with their identity. They attribute these career preferences significantly to parental influence. Their key characteristics could be summarised as follows: (a) STEM majors are not my dream major; (b) I have a stronger interest in non-STEM fields; (c) Social influence from parents and teachers significantly shapes my career aspirations.

2.2.3 Consensus statements

The consensus statements identified by PQMethod are listed in Table 4-18. Students generally did not consider STEM as their dream job and they were more attracted to non-STEM jobs, particularly those in the arts and social studies. This preference is influenced by the perception that non-STEM careers involve working with words and people more than engaging in technical tasks. Participants had no strong opinions about Statements No. 11 and 12, suggesting that they do not view the cost of pursuing STEM careers or the sense of achievement as significant factors influencing their aspirations.

Nevertheless, both groups acknowledged the good prospects of STEM careers. They largely disagreed with Statements No. 9 and 26, rejecting common stereotypes that STEM professionals have poor social skills or limited friendships, and did not endorse gender stereotypes associated with these fields, aligning with attitudes observed among Chinese students. Similarly, both groups disagreed with Statements No. 5 and 6, which relate to the concept of *STEM capital*. They did not perceive a lack of STEM resources or capital as a significant influence on their career choices. Statement No. 20, which refers to the utility value of STEM careers, was also mostly disagreed with, indicating that participants do recognise the practical benefits of pursuing a career in STEM.

Statement	**Statement No.**	**Factor A Value**	**Factor B Value**
I'd rather deal with words and people than work on technical tasks	2*	1	1
I seldom visited science centre or science museum out of school or conducted experiments or science projects in the school laboratory	5	-1	-2
I am not familiar with STEM subjects	6*	-2	-1
I'm interested in a job out of STEM	8*	2	2
People of my gender are not important contributors to advancing STEM	9*	-3	-2
I didn't have a sense of achievement in learning STEM subjects	11*	0	-1
Working in STEM requires too much time and effort than I want to put into	12*	0	0
I expected that I will not be competitive enough to find a good job in STEM fields	16	1	3
Working in STEM is not important in leading to a prospective future	20*	-2	-2
STEM majors are not my dream major	24	2	4
When I think about people who work in STEM jobs, I think of people who have poor social skills and do not have many friends	26*	-2	-1
I prefer artistic and social studies than STEM	27*	3	1
Note. *Statement was significant at $p> .05$			

Table 4-18 Consensus statements among Scottish participants. This table shows the statements with which all Scottish participants strongly disagreed, mostly agreed, or slightly disagreed (4 being completely agreed, 3 being strongly agreed, 2 being mostly agreed, 1 being slightly agreed, 0 being neutral, -1 being slightly disagreed, -2 being mostly disagreed, and -3 being strongly disagreed)

2.3 Summary

Taken together, three main factors have emerged about STEM career aspirations from Chinese participants: (a) I lack competitiveness, (b) I prefer a non-STEM career, and (c) STEM careers come at a high cost. These three factors resonate with the three key components of the EVC model, which emphasises expectancies for success, task value, and perceived cost as crucial influences on students' career aspirations. Rather than pinpointing a single dominant reason for each factor, the analysis revealed holistic viewpoints among participants. These viewpoints reflect not only the reasons participants cited for not aspiring to STEM careers but also other interconnected variables and reasons they did not endorse. This approach offers insights into how the most significant reasons were formed and how they interacted with other variables. For instance, the low self-efficacy of Factor 1 participants is closely linked to the perceived difficulty of STEM subjects and their comparisons with classmates, which diminished their sense of achievement and motivation.

Two factors about STEM career aspirations were identified among the Scottish participants: (1) Factor A: I don't belong to STEM fields and (2) Factor B: STEM is not my dream major. Both factors highlight a lack of self-identity or self-value in relation to STEM fields, serving as primary reasons for not aspiring to STEM-related careers across both groups. Despite this, different reasons accounted for the lack of identity in STEM fields. For the Factor A group, the primary reason relating to a lack of belonging in STEM fields is that they failed to be attracted to STEM careers. They make career decisions based on personal preferences, with minimal influence from parents or teachers. In contrast, the Factor B group maintained an interest in learning STEM subjects but did not envision themselves in STEM careers due to low expectations of long-term success in such demanding fields. They are confident in their current abilities to study STEM subjects but doubt their capacity to sustain this in future STEM roles. Social influences, particularly from parents, seem to play a significant role in shaping their career aspirations, unlike Factor A participants who rely on their own perspectives.

3 Research question 1a: Perceptions of STEM

In the preceding two sections, the factors derived from the Chinese and Scottish participants were thoroughly examined, addressing the overarching research question of why do high-achieving Chinese and Scottish students not aspire to STEM-related careers? In addition to this aspect, this study also seeks to look into participants' perceptions toward STEM careers, defined as a person's feelings and perceptions about STEM subjects and careers, shaped by their beliefs, knowledge, and stereotypes about these fields (Kind et al., 2007). While students' reasons for not aspiring to STEM-related careers and students' perceptions towards STEM or STEM careers are crucial in answering both RQ1 and RQ2, there is a distinction between these two questions. RQ1 is a problem-oriented question that seeks to uncover the specific reasons why students do not aspire to STEM careers. In contrast, RQ1a takes a broader view of overall perceptions, knowledge, and stereotypes, which complements the more targeted investigation of the barriers identified in RQ1. In this section, students' perceptions of STEM are analysed primarily through their interview responses, focusing on their knowledge of STEM, together with their stereotypes associated with STEM careers and professionals.

3.1 Knowledge of STEM

During the interviews with Chinese participants, it was found that students generally had very limited knowledge about STEM occupations. While they could name specific areas within STEM fields they were familiar with, their perceptions of STEM jobs were mostly confined to particular domains such as scientific research, aerospace technology, physicists and chemists. This suggests that Chinese students may not fully recognise the broad range of career opportunities available within STEM. On the other hand, Scottish participants demonstrated a broader understanding, mentioning more general occupations such as mathematicians, engineers, scientists, or jobs in medical, mechanical, and aeronautical areas.

3.1.1 Sources of knowledge

When asked about the sources of their impression of STEM professionals, both types of participants mentioned social media (e.g., TV shows, news, the internet) and vicarious experiences (the job of family members). For instance, a Chinese participant formed his perspective on STEM careers as demanding and tiring through conversations with his cousin, who works in STEM fields. Hearing about the experience of his cousin firsthand reinforced his perception, making him believe that working in a STEM career is exhausting. Another Chinese participant explained, *In my daily life, such as in the reading materials, it's mentioned that these researchers work diligently, but the specifics of their research are distant and unknown*. This sense of detachment contributed to his perception that STEM is somewhat distant from daily life.

Both Chinese and Scottish students identified digital media platforms, including the internet and social media (such as websites, YouTube, and TikTok), as significant sources of knowledge about STEM subjects. Additionally, traditional media sources, like TV and movies, were also highlighted as important sources. For instance, a Chinese participant shared that his impressions of STEM occupations were primarily shaped by movies, TV shows, news reports, biographies, and societal commentary on people working in STEM.

These findings align with recent research showing that students increasingly rely on diversified media sources for career guidance compared to earlier generations (Li et al., 2021). These examples underscore the significant role that external influences play in shaping values and providing career information, a point raised in the systemic literature review (Zhou & Shirazi, 2025). Media often conveys societal values and expectations, impacting how students perceive STEM careers, often in an implicit manner. Media portrayals of STEM careers, however, are often dramatized, which can create a gap between students' expectations and the reality of STEM work (Compeau, 2016; Zhang & Barnett, 2015). Such portrayals can create a disconnect between students' expectations and the realities of STEM professions, leading to potential misunderstandings or disillusionment when they encounter the actual demands of these roles.

A Scottish student mentioned using structured online resources, such as My World of Work, to explore STEM careers, courses, and job prospects. Unlike the often dramatized and sensationalised portrayals in movies and TV programs, resources like My World of Work provide systematic information and guidance. These platforms offer insights into career opportunities, the skills needed for career development, and the realities of working in STEM fields, which are essential for making informed decisions about one's career path. Another Scottish participant shared her transformative experience in an engineering program, which broadened her understanding of STEM careers and showcased the diverse pathways available within the field, reinforcing the importance of direct engagement and exposure in shaping career aspirations.

3.2 STEM stereotypes

Stereotypes are over-generalised beliefs regarding a group of people that are often negative (Matsumoto, 2009). However, while negative stereotypes often dominate discussions—given their potential to perpetuate bias and hinder opportunities—this study recognises that stereotypes can also encompass neutral or even positive characteristics. Previous studies have found that students hold negative stereotypes of scientists and engineers and their work (Capobianco et al., 2011; Garriott et al., 2017) and the stereotypes may have a negative influence on students' STEM career interest (Garriott et al., 2017; Luo et al., 2021; Van Tuijl & Van Der Molen, 2016). Surveys conducted by the OECD revealed that students tend to view science and engineering professionals as "doing boring, uninteresting work in unpleasant surroundings, cut off from other people" (OECD & Development, 2008). Similarly, Masnick et al. (2010) found that high school students perceived STEM-related occupations as less people-oriented and creative when compared to non-STEM careers. Archer et al. (2013) noted that students reject science as a career choice because they perceive people working in science are "geeks" or "boffins". Social skills deficits, obsessiveness, pure hygiene, and a dull lifestyle are some more stereotypes that people typically hold about those working in STEM (Barbercheck, 2001; Cheryan et al., 2011; Nassar-McMillan et al., 2011).

Contrary to these findings, none of the participants interviewed in this study expressed the typical negative stereotypes associated with STEM professions. Instead, they exhibited largely positive perceptions, describing STEM professionals as intelligent, meticulous, and dedicated. In the Q-sorting, two statements (Statement No.3 and 26) were used to test how strongly negative stereotypes about STEM professionals impacted STEM careers. Both Chinese and Scottish students generally disagreed with Statement No.3, which suggested that people in STEM jobs are odd and unattractive. For Statement No.26, which proposed that individuals in STEM jobs have poor social skills and few friends, responses were also predominantly negative.

In the post-sorting interview, the question *What's your overall impression of careers in science and technology?* aimed to gain insight into the participants' perspectives on STEM careers. For example, a participant stated, *I don't agree with card [Statement No.] 26, many* *people in science and engineering jobs have good social skills because some of my parents' friends are like that*. Another expressed admiration for the societal importance of STEM, stating, *I firmly believe that careers in science and technology play a pivotal role in our country.* These positive perceptions reflect a broader understanding of STEM professionals' social and intellectual capabilities, challenging the negative stereotypes commonly found in earlier literature.

Despite the absence of overt negative stereotypes, participants did express certain implicit stereotypes about STEM careers, particularly related to the working environment and personal traits required to succeed. For instance, many described STEM professionals as working in highly demanding settings necessitating intense concentration and dedication. One Chinese participant articulated, *I think if I pursue a science career, I would constantly be in a tense working environment*. Another participant commented, *I've fantasised about working in this field before, but I'm not the type of person who can immerse myself in research for a long time*. Similarly, a Scottish participant stated, *They [STEM professionals] have to be very hardworking to get there with some subjects.*

While these descriptions praised STEM professionals for their diligence and focus, they also suggest that pursuing a career in STEM is stressful and requires personal commitment. This perception could deter students who feel they do not possess these qualities, especially those who perceive themselves as unable to meet such high expectations. This aligns with evidence from previous research (Archer et al., 2013; Gladstone & Cimpian, 2021), which found that the prevalent perception of scientists and science careers as requiring exceptional intelligence can discourage many young students because they might feel that success is unattainable, especially those who do not see themselves as the “smartest” in their class.

A noticeable difference emerged between Chinese and Scottish students regarding their views on the creativity and intellectual engagement required in STEM careers. Some Chinese students view STEM jobs as lacking critical thinking and being tedious, which corroborates the findings of Masnick et al. (2010). For example, one participant said,

The binary nature of solving STEM problems, where you either succeed or fail, was frustrating. If I were to pursue a career in STEM, for example, nuclear physics, I would have to continuously delve into research for many years and not know if I would succeed.

This view is supported by the participants' experiences with STEM subjects, which show that school courses such as mathematics or physics frequently rely on specific stages and methods rather than fostering creative thinking or unique solutions. Furthermore, the emphasis of the educational system on acquiring accurate answers tends to overshadow the significance of the problem-solving process. As a result, some students view STEM fields as tedious, despite the actual need for creativity and innovation in advancing scientific and technological fields.

In summary, no common negative stereotypes in previous literature were found among the Chinese and Scottish participants. Instead, they highlighted positive attributes such as intelligence, dedication, and social adeptness. However, certain implicit stereotypes about the intensity and demands of STEM careers were evident, which may deter students from considering these fields. Additionally, Chinese students often view STEM jobs as dull and lacking in critical thinking, making these careers less attractive.

4 Research question 2: Comparative analysis between Chinese and Scottish findings

This section synthesises the insights gathered from Chinese and Scottish students, drawing on the findings presented earlier in this chapter. It provides an in-depth comparative analysis of the similarities and differences in their reasons for not aspiring to STEM careers and their perceptions of STEM fields.

4.1 Expectancy for success

Expectancy for success emerged as a significant determinant of STEM career aspirations in both groups. Chinese participants reported that the intense academic pressures and competitive environment of the Gaokao system diminished their self-efficacy, framing STEM careers as high-cost pathways requiring significant personal sacrifice. This aligns with previous research indicating that when task difficulty is perceived as high and linked to significant costs, expectancy for success can diminish (Eccles & Wigfield, 2002). In contrast, Scottish students were more concerned with external career prospects, such as perceived limitations in the STEM job market rather than their own abilities, which shaped their expectancy. The differences reinforce the distinction between the two key components of expectancy for success: self-efficacy (or ability belief) and overall expectancy. Although previous researchers have suggested that these two constructs are nearly identical (Eccles & Wigfield, 1995; Guo et al., 2017; Wigfield et al., 2006), these findings suggest that caution is needed when treating them as interchangeable. The distinct ways in which these components manifest suggest meaningful differences that should be acknowledged in future research and application.

Prior studies have shown that Western students tend to exhibit higher self-efficacy compared to their Chinese counterparts (Eaton & Dembo, 1997; Klassen, 2004; Lau et al., 2015; Lau & Ho, 2020). This differences are often attributed to Confucian values, where modesty and the belief that effort is the primary path to success are emphasised (Chan & Rao, 2010; Lau et al., 2015). While this study did not look at the influence of modesty, some Chinese students reported low self-efficacy, which was less apparent among Scottish students. This may be explained by the practice in Chinese schools of grouping high-achieving students together, which intensifies social comparisons and may lower individual self-efficacy. In contrast, Western students often benefit from more individualistic frameworks that reinforce their self-efficacy through personal achievement.

4.2 Influence of non-STEM career appeals

Both Chinese and Scottish students highlighted non-STEM careers as appealing alternatives, though their motivations varied. The people-thing orientation was prevalent among both groups as they were more appealing to non-STEM careers due to characteristics of non-STEM careers which are frequently related to dealing with people and words rather than technical stuff (Coetzee & De Villiers, 2010; Graziano et al., 2012; Ngo & Hui, 2018). For Chinese students, non-STEM careers were frequently associated with stability and a balanced lifestyle, reflecting a pragmatic approach to career planning. In contrast, Scottish students prioritised intrinsic enjoyment and personal interests, often viewing non-STEM fields as more aligned with passions and values.

The difference in focus—stability for Chinese students and personal enjoyment for Scottish students—highlights the influence of societal and cultural narratives. In China, the emphasis on security and utility reflects the competitive job market and societal expectations, where practical benefits are highly valued. In contrast, the Scottish emphasis on personal fulfilment mirrors a more individualistic cultural ethos, consistent with Shechter et al.'s (2011) findings that East Asian students are more motivated by the utility value of learning specific subjects, while Western students derive motivation from intrinsic enjoyment and personal interest.

Understanding these differences is essential for developing culturally sensitive career counselling practices.

4.3 Perceptions of STEM and cost

Both groups viewed STEM careers as prestigious and intellectually demanding, but these perceptions often acted as a double-edged sword. While STEM professionals were admired, the high standards associated with them deterred students who felt unable to meet these expectations. The sources of information about STEM careers also differed. Chinese students relied heavily on media portrayals, which sometimes reinforced negative stereotypes and emphasised challenges. Scottish students, although also rely on the portrayal on media, accessed more structured and diverse information sources, including career counselling services and school programs, providing a broader perspective on STEM opportunities.

The perceived costs of pursuing STEM careers emerged as a critical point of divergence. For Chinese students, cost was deeply tied to the intense effort required to excel academically and meet societal expectations. The pressure to achieve high scores in the Gaokao exam contributed significantly to the psychological and emotional toll, framing STEM careers as unreasonably demanding. In contrast, Scottish students viewed cost primarily in terms of external uncertainties, such as limited job opportunities and the fear of underemployment in STEM fields. These differences highlight the need for tailored strategies: reducing the perceived academic burden in China and addressing job market misconceptions in Scotland.

4.4 Parental and teacher influence

The role of parental influence on students' career decisions, particularly regarding STEM fields, has been consistently highlighted as a key determinant in prior research (Archer et al., 2013; Medved et al., 2006; Schmidt et al., 2012). This study, however, reveals differing patterns of influence among Chinese and Scottish students. Scottish participants reported significant parental involvement in shaping their career aspirations, while direct parental influence was notably absent among Chinese students. Although East Asian cultures often emphasise obedience to parents over individual autonomy, as rooted in Confucian traditions (Reischauer & Jansen, 1995; Tu, 1985), this study suggests a diminishing presence of such expectations. Over the past century, China has experienced transformative societal changes, encompassing political, economic, and cultural domains (Yang, 1996). These shifts have significantly reshaped family dynamics, leading many parents to adopt more supportive attitudes toward their children's career choices. With new and diverse career opportunities emerging, many parents now recognise that their children possess a greater awareness of the evolving job market and are therefore more supportive of their children's choices.

In contrast, the influence of Scottish parents may be amplified by their active engagement in their children's education, providing guidance and support for their children's career aspirations and choices. These findings indicate that while traditional cultural values are important for examining parental influence across different countries, it is essential also to consider cultural shifts and evolving societal norms. Future research should investigate whether similar patterns are observed among students in other parts of the UK, such as England or Wales, and examine the broader impact of globalised career opportunities and changing cultural values on parental influence in career decision-making.

In the interviews, a few Chinese participants mentioned the negative influence of their teachers, particularly due to the low expectations that led to feelings of incompetence. For instance, one student shared an experience where his teacher advised him to switch to social sciences in 11th grade after performing poorly on a test. This suggestion significantly undermined his confidence, even though he ultimately decided to continue with STEM subjects. Moreover, emotional stress brought by teachers was mentioned. For instance, a Chinese participant stated, *I get nervous about studying STEM, especially during math classes and this was caused by our maths teacher.* Despite these experiences, the Q-sorting results did not indicate teachers as direct influences on students' STEM career aspirations. While participants attributed emotional stress and diminished confidence to teacher influence, these were not explicitly acknowledged as factors shaping their career decisions or aspirations. Previous research, however, suggests that teachers exert an indirect influence on students' career aspirations by influencing their interests, attainment, and motivations through teaching and interactions with students (Cerini et al., 2003; Eccles, 2009; Regan & DeWitt, 2014). Although participants emphasised that their career goals were self-driven, their accounts underscore the significant role of teacher expectations in shaping self-efficacy. Low expectations from teachers were reported to reduce confidence, which indirectly affected students' motivation to pursue STEM fields. Thus, while not directly career-focused, teacher expectations remain influential in shaping student confidence and, by extension, their academic trajectories.

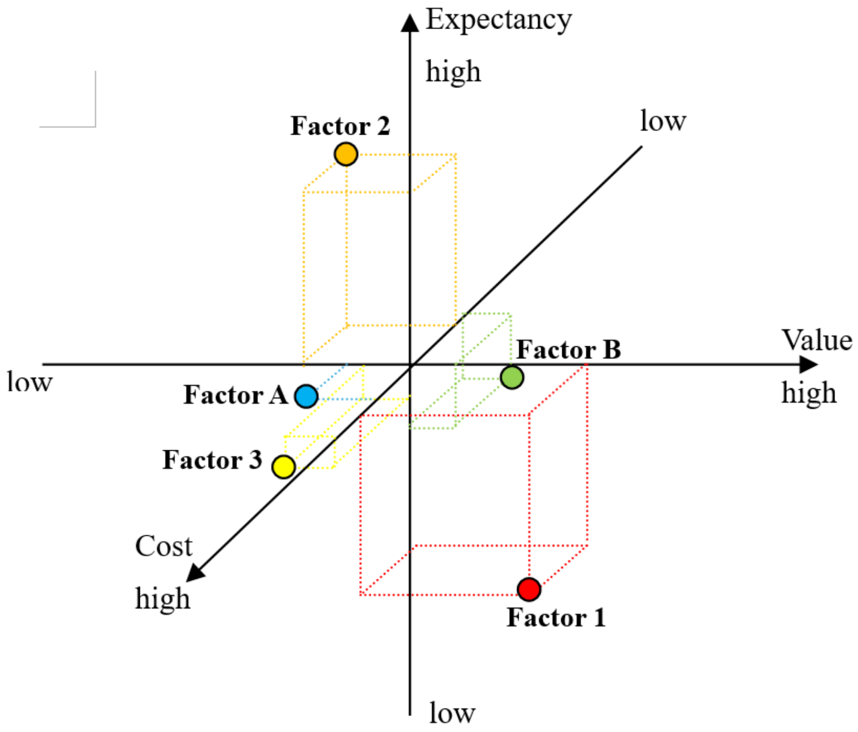
5 Summary

In summary, this chapter analysed the factors influencing students not aspiring to STEM-related careers based on Q-sorting and complemented by the interview data. Three factors emerged from the Chinese participants and two from the Scottish participants. **Factor 1: *I Lack Competitiveness*** – Students in this group feel they lack the competence to succeed in STEM fields, doubting their ability to excel academically and professionally. While they recognise the prosperity of STEM careers, they lack confidence in their potential. **Factor 2: *I Prefer a Non-STEM Career*** – These students are drawn to careers involving interpersonal interactions and work-oriented tasks. They have a limited understanding of STEM careers, viewing them as disconnected from their daily lives. **Factor 3:** ***STEM Careers Come at a High Cost*** – Students in this group view STEM careers as demanding, with high personal and academic investment required. They feel these careers offer less enjoyment compared to other fields.

Factor A: ***I Don't Belong to STEM Fields*** – This group feels disconnected from STEM careers, primarily due to a lack of interest in STEM subjects. They prioritise personal fulfilment and a sense of belonging over the practical benefits STEM fields may offer. **Factor B:** ***STEM Is Not My Dream Job*** – Students in this factor do not see STEM careers aligning with their aspirations, favouring non-STEM fields. Social influences, such as parental and teacher expectations, play a significant role in steering them away from STEM paths.

The instruments used in this study were intentionally designed within the EVC framework to ensure a comprehensive capture of students' perspectives. The model's three-dimensional structure—comprising expectancy, value, and cost—provides a robust analytical lens for situating and interpreting students' experiences and motivations. Figure 4-1 presents an approximate representation of this three-dimensional space, illustrating where the factors are located in the same coordinate.

Figure 4-1 A three-dimensional representation of the EVC model highlighting the factors revealed in this study



Both cohorts cited "expectancy for success" as a crucial determinant. However, Chinese students linked it to low self-efficacy, while Scottish students attributed it to perceived difficulties in STEM job markets. Non-STEM careers appealed to both groups because they were associated with working with words and people. However, Chinese students emphasise the stability and security of non-STEM careers, while Scottish students focus on interest and enjoyment. However, cultural distinctions emerged: Chinese students emphasised the stability and security of non-STEM careers, while Scottish students prioritised interest and enjoyment in their chosen paths.

The analysis also highlighted systemic influences. High-achieving Chinese students face significant psychological and emotional costs associated with the competitive Gaokao system, which perpetuates intense academic pressure and constant comparisons among peers. For Scottish students, parental involvement in career decisions was direct and explicit, contrasting with the expected Confucian emphasis on parental authority in Chinese culture. Surprisingly, Chinese students displayed less deference to parental expectations, reflecting evolving societal attitudes driven by rapid modernisation. Meanwhile, teachers played a subtle but pivotal role in impacting Chinese students' self-confidence and stress levels, which in turn influenced their perceptions of their abilities in STEM.

Both groups exhibited admiration for STEM professions but shared perceptions that STEM careers require exceptional intelligence and the ability to thrive under high-pressure environments. While these views admire the qualities of STEM professionals, they also contributed to a sense of intimidation, discouraging students who felt that they could not meet these high expectations. Furthermore, Chinese students' reliance on media for career information contrasted with Scottish students' access to systematic and institutionalised career guidance, highlighting the disparities in exposure and resources between the two contexts.

This chapter offers a detailed process of transforming the data into results, and a comprehensive explanation of each factor, situating them within the broader literature and frameworks. The results reveal both commonalities and divergences in the factors shaping Chinese and Scottish students' STEM career aspirations. The concluding chapter will explore the broader implications of these results, highlighting their significance and potential impact.

Chapter 5: Conclusion, Implications, and Limitations

0 Introduction

This study commenced with a description of its purpose and research questions, which provided the foundation for the investigation. Specifically, the study sought to gain a deeper understanding of why high-achieving students choose not to pursue STEM-related careers. To examine potential differences in these perspectives across cultural contexts, the study focused on students from two nations—China and Scotland—introducing the socio-cultural and educational backgrounds of these nations as contexts for comparison. This study addressed three research questions: What reasons do high-achieving Chinese and Scottish students provide for not aspiring to STEM-related careers? How do the reasons for not aspiring to STEM-related careers differ or align between high-achieving Chinese and Scottish students? What perceptions do high-achieving Chinese and Scottish students hold towards STEM careers?

To address these questions, relevant literature was reviewed to contextualise the issue of STEM career aspirations. The EVC model served as the primary theoretical framework, and studies employing the EVT and EVC model were examined. Additionally, literature exploring factors and sub-factors within the EVC framework was analysed to deepen the theoretical grounding. Specific attention was given to students' perceptions of STEM careers and the influence of social persuasion on career aspirations. When applicable, comparisons were drawn to illustrate how the EVC model and related factors have been applied across diverse cultural contexts. The literature review also highlighted key gaps in the field. First, the application of the EVC model to students with no STEM career aspirations or those with active avoidance intentions remains underexplored. Second, there is a lack of research focusing on the unique characteristics of high-achieving students, who may exhibit distinct traits compared to their peers. Lastly, the role of cultural backgrounds in shaping students' attitudes and perceptions toward STEM careers warrants further investigation, particularly in terms of how these attitudes are influenced by cross-cultural differences.

The methodology used for this study was Q-methodology. The research philosophy underpinning this study was articulated and the researcher's positionality was stated. Q-methodology, as a merged methodology, was introduced in detail and the reasons for choosing it and how it echoes the researcher's philosophy were explained. The specific research design of how Q-methodology was tailored to answer the research questions was described. Specifically, there are three phases: Phase 1 of the study involved the design of the Q-set and the creation of the research instrument with the systematic literature review and a questionnaire were two ways to develop the Q-set; Phase 2 consisted of data collection from the participants through Q-sorting and interviews; Phase 3 was the analysis stage during which Q-sorting data was analysed using varimax rotation using PQMethod 2.35 and the interview data was thematically analysed using NVivo 14.

The data analysis processes, along with the decision-making steps, were thoroughly detailed to provide transparency in the technical procedures and the derivation of findings. These processes encompassed both quantitative and qualitative methods. For the quantitative data, factor extraction and rotation techniques were employed to identify underlying factors, while qualitative data were analysed through thematic analysis to uncover nuanced insights. Each identified factor was subsequently presented and interpreted, with discussions aligning the findings with those of previous studies. This parallel presentation facilitated a comprehensive understanding of how the results fit within the broader research landscape. Beyond the factors, the study also explored students' perceptions of STEM careers, offering insights into how these perceptions influence their career aspirations.

This chapter consolidates key findings and discussions to draw conclusions on crucial aspects, highlighting emerging implications aimed at enhancing STEM education and career guidance for educators, policymakers, and the broader community. The chapter concludes with a comprehensive synthesis of the study's limitations, offering insights to inform future research and practice.

1 Conclusion of the study

STEM career aspirations have become a critical yet often overlooked topic among educators, teachers, and parents. By examining students' aspirations toward STEM careers, the obstacles preventing them from pursuing such paths can be identified and better understood. This understanding enables the implementation of measures to reduce these barriers, ultimately encouraging more students to consider STEM careers. Furthermore, exploring students' perceptions and understanding of STEM allows for actionable insights into how their awareness and knowledge of STEM-related opportunities can be enhanced. By ensuring that students receive accurate and comprehensive information about STEM fields, they are better equipped to make informed career decisions. Building on an analysis of the results, key conclusions were drawn based on a holistic interpretation of the findings contextualised within the relevant literature.

1.1 The value of the EVC framework

The choice of the EVC model as the overarching framework for this study stems from its theoretical foundation in the well-established EVT model. The EVT model has been widely employed to predict and describe students' motivation and attitudes toward various academic and career pursuits. Building on EVT, the EVC framework (Barron & Hulleman,

2014) introduces a critical advancement by emphasising the cost component as a first-order factor. This inclusion highlights the negative aspects of motivation, making the EVC model particularly relevant for exploring research questions related to why students might avoid STEM careers or express intentions to leave STEM fields.

While prior studies employing the EVC framework have explored various applications—such as examining reciprocal relationships between its factors (Flake et al., 2015), and using cost to predict course performance and avoidance intentions (Jiang et al., 2018; Jiang & Rosenzweig, 2021) —this study adopts a distinct focus. Here, the EVC model serves as a lens for understanding the unique motivational dynamics of students, particularly within the context of distinct cultural and educational settings. Although the EVC model was not the only framework employed to measure students' perspectives, it proved to be the most representative for synthesising key themes that emerged during the analysis. Each factor of the EVC model—expectancy, value, and cost—was mirrored in the themes and sub-themes identified in the study. Of particular importance was the cost factor, which emerged as a critical theme when investigating students' intentions to avoid or leave STEM careers.

Moreover, the findings suggest that cultural nuances, such as those embedded in the experiences of Chinese students, amplify the relevance of the cost factor and highlight the need to integrate it as a central consideration in studies of motivational dynamics. Interestingly, while the Chinese data strongly reflected the EVC structure—with the most agreed-upon reasons mapping neatly onto expectancy, value, and cost—this pattern was less evident among Scottish students, suggesting that cultural context mediates the model's applicability. These cross-cultural differences highlight the importance of contextualising motivational frameworks when studying STEM career aspirations.

1.2 Limited STEM career knowledge

A significant finding of this study was the participants' limited knowledge about STEM careers, stemming from inadequate career guidance. This lack of systematic or professional information results in scattered, overly simplistic, or even idealised perceptions of STEM careers, especially among Chinese participants. While school curricula focus on subject-specific knowledge, STEM careers often require interdisciplinary skills and the integration of multiple fields. Students are typically familiar with traditional STEM roles such as scientists, chemists, engineers, or mathematicians but are less aware of careers like car designers, computer system developers, or electrical engineers, which also fall under the STEM umbrella. Moreover, students lacked clarity about the qualifications required for STEM careers or the responsibilities involved. This knowledge gap contributes to an incomplete and sometimes unrealistic understanding of STEM professions, further hindering their ability to make informed career choices.

Students from both cohorts reflected media as a primary source of career knowledge, reflecting its growing influence in shaping young people's perceptions of STEM opportunities. The rapid popularisation of digital and social media platforms among younger generations underscores their role as key channels for disseminating career information. However, differences emerged between the two groups, with Scottish participants benefiting from more structured and diverse information sources, including formal career services, industry outreach, and extracurricular programs. These varied sources provided Scottish students with a broader and more accurate perspective on the range of opportunities within STEM, in contrast to the relatively limited and informal channels relied upon by their Chinese counterparts. This disparity further highlights the need for comprehensive and equitable career guidance across educational contexts.

1.3 Paradoxical stereotypes

Researchers have extensively examined the stereotypes associated with STEM careers and how these perceptions might deter students from pursuing them. This hesitancy often arises due to a misalignment between students' self-image and the stereotypical image of STEM professionals. Much of the existing literature highlights negative stereotypes, such as the portrayal of STEM professionals as socially awkward geniuses (Capobianco et al., 2011; DeWitt et al., 2013; Lachapelle et al., 2012) or individuals with poor hygiene and dull lifestyles (Barbercheck, 2001; Cheryan et al., 2011). Such characterisations may discourage students from aspiring to STEM careers, as they see these roles as incompatible with their personal values or identity. Consequently, these negative stereotypes were included in the Q-set for this study.

Interestingly, while participants in this study expressed a general lack of interest in STEM careers, they did not align STEM professionals with the commonly reported negative stereotypes. Popular media, such as the TV series *The Big Bang Theory*, which often reinforces these stereotypes, appeared not to shape participants' perceptions significantly (Weitekamp, 2017). Students did not generalise these characteristics to all scientists or engineers, suggesting a disconnect between media-driven stereotypes and personal beliefs.

Conversely, positive stereotypes about STEM professionals also play a role in shaping students' perceptions. Positive views, such as portraying STEM professionals as highly intelligent or successful, can have unintended consequences. While these perceptions may initially appear beneficial, they can inadvertently create a sense of unattainability. Students may perceive STEM careers as overly demanding or reserved for an elite group of individuals, thus discouraging their aspirations (Chan et al., 2019; Chen et al., 2024; Morgenroth et al., 2015). This was evident in the findings of this study. During interviews, students often used positive descriptors for STEM professionals, such as “talented,” “dedicated,” “smart,” and “rigorous”, focusing on their work ethic and intellectual capacity. However, they avoided discussing STEM professionals’ personal traits, social skills, or hobbies, suggesting a lack of connection between STEM professionals’ humanity and their professional image. When asked whether their traits aligned with their perceptions of STEM professionals, many students expressed doubt or disagreement. This misalignment underscores a gap between how students view themselves and how they perceive STEM professionals, potentially discouraging them from envisioning themselves in such roles.

Another pervasive stereotype in STEM is its association with masculine traits, such as analytical thinking and assertiveness, often framing it as a male-dominated field (Hand et al., 2017; Moss-Racusin et al., 2012). Despite this, female participants, who comprised half of the sample, did not cite their gender as a primary reason for avoiding STEM careers. A few female students, however, acknowledged concerns about potential discrimination in a male-dominated job market. While they expressed confidence in their ability to excel in STEM, as demonstrated by their strong performance in science and math subjects, they were apprehensive about the challenges women face in achieving equitable treatment and opportunities in STEM workplaces.

1.4 The roles of social persuasions

In the SCCT model, social persuasion is a critical factor influencing students’ learning experiences, attitudes, and ultimately, career aspirations (see Figure 1-1). Social persuasion typically comes from individuals with whom students frequently interact, including parents, peers, and teachers. Parents and peers play a significant role through daily communication and interaction (Jacobs et al., 2006; Schmidt et al., 2012; Vedder-Weiss & Fortus, 2013), while teachers influence students primarily through classroom teaching, encouragement, and guidance (Maltese & Tai, 2010; Regan & DeWitt, 2014; Tytler & Osborne, 2012). Consequently, social persuasion is widely recognised as a key factor shaping students' STEM career aspirations.

However, in this study, prominent influences of social persuasion on STEM career aspirations were only found among Scottish participants (Factor B). This finding may partly be attributed to the methodological approach employed. Q-methodology emphasises self-expression and prioritises direct, conscious reasons for students' career choices, thereby highlighting explicit forms of social persuasion while potentially overlooking subtler, implicit influences. For Factor B participants, social persuasion appeared to stem from students' internalisation and acknowledgement of values and perspectives shared through direct communication or observations with parents. Rather than feeling obligated to meet parental expectations or accommodate their wishes, these students demonstrated a more proactive stance, using parental influence as a reflective tool. Furthermore, parents also served as a lens through which students gained a deeper understanding of STEM careers. Through conversations or observations, parents helped these students critically assess their fit for STEM careers by discussing the nature of STEM work, its requirements, and its alignment with their skills and interests. This dynamic suggests that parental influence was not simply prescriptive but functioned as a mechanism for fostering self-reflection and informed decision-making.

While East-Asian cultures traditionally emphasise obedience to parents (Leung et al., 2011; Wan & Lee, 2017), Chinese students increasingly demonstrate independence in career decision-making, reflecting evolving cultural values. This reflects a broader shift from traditional values prioritising conformity to greater individual autonomy. Shaped by changing family dynamics and global cultural influences, this evolution suggests that while traditional values remain significant, students are navigating decisions with more self-direction. Such changes highlight the influence of global trends on family roles in career guidance—a pattern likely mirrored in other rapidly modernising societies. Consequently, researchers must exercise caution when attributing career choices solely to conventional cultural frameworks, as globalisation and labour market changes may have significantly reconfigured familial roles in career guidance.

Teachers' influences were not ranked as critical reasons among any of the factors in this study. This may be partly attributed to the participants' high-achieving status, as their teachers are likely to have high expectations of them. In such cases, the negative impact of low teacher expectations, which has been shown in some studies to discourage students from pursuing STEM careers, is less relevant. However, even in the absence of low expectations, some Chinese participants noted the influence of teachers on their perceptions of self-efficacy, perceived costs, or interest in STEM. For instance, participants mentioned how the structure of STEM classes, characterised by monotonous content or demanding workloads, contributed to a sense of disinterest or aversion toward STEM-related fields. Despite these experiences, students did not cite teachers' expectations as a determining factor in their career decision-making process. While teachers play a role in shaping students' classroom experiences, their influence on students' career aspirations appears more indirect.

1.5 Other reflections on this study

Q-methodology was employed as the overarching method to investigate students' perspectives on their STEM career aspirations, a novel application that sets this study apart from previous research. Traditionally, studies on STEM career aspirations have relied on quantitative surveys or qualitative interviews to explore students' motivations and barriers. While these methods provide valuable insights, they may not fully capture the nuanced and subjective nature of individual perspectives. By contrast, Q-methodology bridges the gap between qualitative and quantitative approaches, allowing for a systematic exploration of students' viewpoints while preserving the depth of their unique experiences.

The use of Q-methodology in this study proved highly effective in capturing the diversity of students' perspectives on STEM careers. This methodology allowed for a nuanced exploration of individual viewpoints, facilitating a deeper understanding of the varied ways students perceive and engage with STEM fields. During interviews, participants were invited to suggest additional statements that could be included in the Q-set to better articulate their perspectives. Almost universally, participants affirmed that the Q-set was comprehensive enough to fully convey their views, underscoring its robustness and relevance.

A key strength of Q-methodology lies in its inherent flexibility, which enables researchers to tailor the development of the Q-set to suit the specific topic under investigation. This adaptability extends to the accessibility and relevance of information, allowing researchers to incorporate contextual considerations seamlessly into the study design. Unlike more rigid methodologies, Q-studies do not prescribe a fixed structure, offering freedom in determining both the number of statements in the Q-set and the size of the participant pool. These parameters can be adjusted to align with the study's scope, objectives, and available resources, ensuring the methodology remains practical and effective.

2 Implications

To address the identified challenges and capitalise on emerging opportunities, this section offers implications to enrich the educational experience and better equip students for future endeavours. Practical implications highlight the need for collaboration among educators, policymakers, and the community. Additionally, the findings point to further avenues for research that could build on this study's insights and analysis.

2.1 Implications for practice

2.1.1 Implications for educators

Chinese students expressed concerns about their ability to compete in STEM fields, which is indicative of low self-efficacy despite their high academic performance. Recognising this disconnect allows educators to implement targeted strategies that build confidence and nurture a growth mindset. Teachers should adopt flexible grouping strategies, allowing students to transition between different levels based on their evolving interests and skills. This approach ensures that students experience growth and development without the added pressure of rigid placements. Regular reassessments of progress, coupled with constructive feedback, will further ensure that such transitions are supportive and promote growth rather than stress. Additionally, fostering a collaborative rather than competitive classroom environment could help mitigate feelings of inadequacy among students who might struggle in highly competitive settings.

For Scottish students, interest in STEM subjects was a primary factor in shaping their STEM identity, while some Chinese students were deterred by less engaging teaching methods and uninspiring classroom environments, which led them to favour non-STEM careers. To address these issues, educators should redesign STEM curricula to make subjects more engaging and applicable to real-world contexts. This includes incorporating project-based learning, where students tackle real-world challenges like climate change, renewable energy, or health technology. Emphasising the interdisciplinary nature of STEM, such as how engineering relates to art, can appeal to students who might not see themselves as "traditional" STEM learners. This broader approach demonstrates the accessibility and creativity inherent in STEM fields.

Chinese students often face high emotional and effort-related costs when engaging with STEM subjects, with many reflecting that these pressures contribute to anxiety, stress, and even depression. These challenges are exacerbated by a competitive academic culture that emphasises grades and performance over holistic development. To reduce stress and prevent burnout among Chinese students, educators should cultivate a supportive learning environment that prioritises personal growth over comparisons with peers, emphasising the recognition of effort and individual improvement. Additionally, accessible mental health resources, such as counselling services and stress management programs, should be prioritised by schools to support students' emotional well-being. Incorporating wellness practices, such as mindfulness exercises, time management training, and relaxation techniques, into the school routine can further help students manage their stress.

Finally, many pupils in both contexts lack sufficient knowledge about STEM careers, which limits their aspirations and opportunities. Educators should collaborate with career advisers to design clear, engaging pathways that connect pupils' interests to potential STEM careers. For example, teachers could demonstrate how biology intersects with environmental conservation or how mathematics underpins applications in artificial intelligence. Career guidance could be incorporated directly into STEM lessons through structured programmes, including guest lectures, mentorship opportunities, and partnerships with industry professionals. Beyond embedding career education into STEM classes, schools should implement tailored and specialised programmes. The Gatsby Benchmarks (The Gatsby Charitable Foundation, 2024) recommend that every year, every pupil should have opportunities to understand how subject knowledge and skills translate to real-world careers. Additionally, every school or college should establish a stable and structured career programme that is accessible to students, parents, teachers, governors, employers, and other stakeholders. These initiatives provide pupils with direct exposure to STEM fields, ensuring they are well-informed and empowered when making decisions about their academic and career paths.

2.1.2 Implications for policymakers

The portrayal of STEM professionals in the media has often been criticised for being exaggerated or unrealistic, creating a disconnect that deters students who might not identify with these stereotypes. To address this issue, education departments should leverage media and technology to present accurate and relatable depictions of STEM careers. This effort could include developing online platforms and mobile applications that offer comprehensive, up-to-date information on STEM degrees, career pathways, and industry trends. Additionally, investing in engaging educational resources—such as interactive modules, videos, and career guides—can expand students' understanding of STEM fields. These resources should focus on making STEM careers accessible and relatable to a diverse student population, helping to break down stereotypes and foster inclusivity.

Another critical area is reducing the academic pressures associated with secondary education, particularly in China, where the Gaokao (see Section 5.2, Chapter 1 for details) creates significant stress for students. Although the Double Reduction Policy (see Section 5.2, Chapter 1 for details) has alleviated pressures for younger students, high school students remain excluded from its scope. Policymakers should introduce regulations that extend the principles of the Double Reduction Policy to high schools, focusing on systemic changes to reduce excessive academic workloads. This could involve limiting the frequency of high-stakes exams and assignments, enabling students to focus on critical thinking, creativity, and comprehensive learning. Additionally, reforms to the Gaokao system could introduce flexible assessment methods that evaluate practical problem-solving and analytical skills, moving beyond rote memorisation and fostering a more balanced and innovative education system.

Policymakers must also foster collaboration between educational institutions, STEM industries, and the broader community. By facilitating partnerships, governments can create opportunities for students to gain real-world insights and hands-on experiences. National initiatives to organise events such as science fairs, career expos, and mentorship programmes could expose students to the breadth of opportunities in STEM fields. These efforts would not only bridge the gap between academic knowledge and professional application but also inspire students by showcasing diverse role models and success stories in STEM careers.

Lastly, policymakers should prioritise investment in the development and dissemination of practical, skill-based learning resources. Funding should support the creation of interdisciplinary projects that integrate STEM with other fields, such as art (STEAM) or environmental science, to showcase the real-world applicability of STEM education. National policies could also include measurable goals to improve diversity and inclusion in STEM pathways, ensuring that students from underrepresented backgrounds are given equitable opportunities to access and succeed in these fields.

2.1.3 Implications for the community

Parents are critical influencers in students' career decisions. Communities should prioritise initiatives that empower parents to actively participate in their children's STEM education. For instance, organising STEM family nights, workshops, or webinars can help parents understand the value of STEM careers and provide them with tools to encourage their children. Communities can also develop resources that explain emerging STEM fields, career opportunities, and the benefits of pursuing these paths, helping parents support their children in making informed decisions. As highlighted by Scotland's *STEM in a Nutshell* (the National Parent Forum of Scotland, 2020), parents can inspire their children by linking STEM subjects to real-world applications, discussing them positively, exploring career pathways, and demonstrating how STEM skills are relevant in everyday life.

Mentorship programs connecting students with STEM professionals from the local community can provide invaluable guidance and inspiration. Communities can collaborate with schools and industries to establish mentorship schemes, enabling students to interact with role models who share their backgrounds or interests. Highlighting diverse success stories through local events or media campaigns can further challenge stereotypes and demonstrate the accessibility and variety of STEM careers. Local industries can collaborate with community organisations to offer internships, apprenticeships, and sponsorships for STEM-related programs. These partnerships can provide students with practical experience, introduce them to potential career paths, and help industries connect with future talent. Such collaborations can also include funding for STEM initiatives in schools and community centres, ensuring that students have access to cutting-edge resources and opportunities.

Ensuring equitable access to STEM resources is crucial for nurturing talent within the community. Libraries, community centres, and non-profit organisations should offer free or low-cost STEM programs, such as coding workshops, robotics clubs, and maker spaces, especially in underserved areas. Mobile STEM labs or pop-up science fairs can bring STEM experiences to rural or marginalised communities, providing hands-on opportunities for students who might otherwise lack access to such resources.

2.2 Recommendations for future research

Further research is needed to explore the concept of cost as emphasised in the EVC framework. Specifically, researchers should investigate how students evaluate the psychological, effort-related, and time costs associated with pursuing STEM careers, particularly in competitive and high-pressure academic contexts. These insights could shed light on how perceived costs influence decision-making and career aspirations, especially for high-achieving students balancing multiple academic and personal demands.

Expanding the application of the EVC framework to broader populations offers significant potential. For instance, studying students with weaker academic performance or those in diverse national contexts could provide comparative insights into how cost factors vary across different educational systems, cultural settings, and academic abilities. Such research would help determine whether the framework's applicability is universal or context-specific. Additionally, involving students at different stages of their educational journey could enhance the understanding of how cost perceptions evolve over time. For example, investigating undergraduate students, who possess a more advanced understanding of their chosen fields and career paths, might reveal unique insights into the long-term influences of the EVC framework. Similarly, research focusing on younger students could identify the early formation of cost-related attitudes, offering opportunities for earlier intervention.

This study employed Q-methodology as the overarching approach to explore high-achieving students' STEM career aspirations, demonstrating its value as an educational research tool, particularly in investigating attitudes toward STEM and career aspirations. The methodology's strength lies in its ability to capture multi-dimensional perspectives, providing a depth of analysis that traditional survey research often cannot achieve. By incorporating a narrative framework, Q-methodology reveals holistic viewpoints, combining multiple themes into cohesive perspectives. An additional advantage of this approach is its capacity to uncover intercorrelations among perspectives. Participants not only express their individual views but also elucidate how various themes are interconnected, offering a richer understanding of their attitudes and motivations. This allows researchers to move beyond simply identifying what the perspectives are, to understanding how these perspectives are constructed and interrelated.

Future research should consider employing Q-methodology to investigate other educational domains, such as students' attitudes, teacher perceptions, or policy evaluations. This approach is particularly suited to uncovering the nuanced dimensions of individual subjectivity, enabling researchers to delve deeper into complex, multi-faceted issues in education. By leveraging Q-methodology, researchers can advance knowledge in areas where traditional methodologies might fail to capture the complexity of human perspectives.

3 Limitations

This study identified two primary limitations that may have influenced the findings. Firstly, the researcher's personal ties to both China and the UK introduced a potential for unintentional bias in framing research questions and interpreting results. While reflexivity and triangulation were employed to mitigate this, future studies could benefit from collaboration among researchers with diverse backgrounds to enhance objectivity and broaden perspectives. Additionally, while the research effectively highlights differences and similarities between Chinese and Scottish students, the cultural, educational, and societal factors shaping STEM career aspirations are inherently complex and multifaceted. These factors, deeply rooted in historical, social, and economic contexts, are not entirely comparable across the two nations. Despite efforts to address these disparities, some nuanced influences may have been oversimplified or overlooked.

The second limitation lies in the subject-specific focus within STEM. The research treated STEM as a collective field rather than examining specific disciplines such as science, technology, engineering, or mathematics. This approach may have obscured discipline-specific factors that influence career aspirations. Future investigations could explore whether different motivational factors or perceptions are associated with specific STEM fields.

Appendices

Appendix A: Ethical approval granted by the University of Glasgow Ethics Committee

University of Glasgow

College of Social Sciences

08 March 2023

Dear Yingying,

College of Social Sciences Research Ethics Committee

Project Title: Why do some high-achieving high school students not want to pursue STEM-related careers? —A comparative study of young people in China and the UK

Application Number: 400220122

The College Research Ethics Committee has reviewed your application and has agreed that there is no objection on ethical grounds to the proposed study. It is happy therefore to approve the project, subject to the following conditions:

- Start date of ethical approval: 08/03/2023
- Project end date: 30/09/2024

- Any outstanding permissions needed from third parties in order to recruit research participants or to access facilities or venues for research purposes must be obtained in writing and submitted to the CoSS Research Ethics Administrator before research commences: socsci-ethics@glasgow.ac.uk
- The research should be carried out only on the sites, and/or with the groups and using the methods defined in the application.
  - The data should be held securely for a period of ten years after the completion of the research project, or for longer if specified by the research funder or sponsor, in accordance with the University's Code of Good Practice in Research: (https://www.gla.ac.uk/media/media_490311_en.pdf)
- Any proposed changes in the protocol should be submitted for reassessment as an amendment to the original application. The **Request for Amendments to an Approved Application** form should be used: https://www.gla.ac.uk/colleges/socialsciences/students/ethics/forms/staffandpostgraduateresearchstudents/

Provided on behalf of: College of Social Sciences Research Ethics Committee

The University of Glasgow

socsci-ethics-lead@glasgow.ac.uk

Appendix B: Statements Derived from the Systematic Literature Review with References

Factor	Descriptor from literature	References
Self-efficacy	I am good at problem-solving in STEM	(Razali, 2021; Ok & Kaya, 2021)
	I am good at collaboration and communication in STEM	
	I am confident in my ability to learn STEM	(Yang et al., 2017)
	I have good science reasoning skills	(DiBenedetto et al., 2015)
	Math is hard for me	(Bittinger et al., 2021; Sheldrake, 2020a)
	I can handle most subjects well but I cannot do a good job with math	
	Math has been my worst subject	
	I am confident in overcoming obstacles and solving problems in STEM	(İzzet Kurbanoğlu & Arslan, 2015)
	I can perform tasks efficiently in STEM	
Self-concept	I think I have the cognitive skills to learn STEM	(Punzalan, 2022)
	I am the type of student to do well in math and science	(Bittinger et al., 2021; Sheldrake, 2020b)
	Learning advanced school science topics would be easy for me	(Taskinen et al., 2013)
Self-identity	I see myself as a STEM person	(Mangu et al., 2015)
	Others see me as a STEM person	
	I have a sense of belonging to STEM professional community	(Estrada et al., 2019)
Social identity	I have a sense of contribution to nation	(Chiu & So, 2022b)
	I have a sense of contribution to the local society	
Interest	I enjoy working on STEM problems	(Chung & Kim, 2022)
	I find STEM enjoyable	
Utility	STEM will be useful for me later in life	

	Making an effort in STEM is worth it because this will help me in the work I want to do later on	(Cairns & Dickson, 2021)
	Studying STEM is worthwhile for me because what I learn will improve my career prospects	
	I desire to help people through engagement in STEM	(Bennett et al., 2021)
	I believe STEM is an important part of my life	(Hava & Koyunlu Ünlü, 2021)
	I hope to create or invent something useful to give back to my school, community, family, or general humanity	(Shoffner et al., 2015)
	Working in STEM will lead to a prospective future	(Gokuladas, 2010)
Perception of STEM professionals	STEM professionals are associated with social responsibilities	(Petrescu et al., 2017)
	Working in STEM requires full devotion to professional line of work	
	STEM professionals do vanguard scientific experiments/studies	
	scientists have the opportunities to solve various problems the actual world faces	
	Working in STEM requires considerable physical effort/demanding intellectual work	
	STEM professionals tend to have low remuneration	
	STEM professionals are respected by other	
	STEM professionals have exciting jobs	
	STEM professionals are associated with scientific responsibilities	
Expectations	Doing a job involves STEM will make use of my talents/abilities	(Medina et al., 2021)
	STEM fields offer a lot of job opportunities	(Ogunde et al., 2017)
	STEM leads to better job	
	Working in STEM will lead to a prospective future	(Gokuladas, 2010)

	Working in STEM will guarantee a secured employment	(Maksimović et al., 2020)
	My decision is based on the information that a degree in social science and humanities will most likely secure employment	
	I have no choice but to choose to study STEM	(Ogunde et al., 2017)
Growth mindset	Your intelligence is something about you that you cannot change very much	(Huang et al., 2019)
Prior experience	I visited science centre, science museum or planetarium	(Rende et al., 2023)
	I had internships or working with a STEM professor	(Sahin et al., 2015)
	I conducted experiments or science projects in the laboratory or in the school environment	(Ferguson & Hull, 2019)
Career knowledge/ information	I know there are STEM-related careers available in the job market	(Serhan & Almeqdadi, 2021)
	I know how and where to find STEM-related careers	
	Employers generally appreciate strong scientific knowledge and skills among their employees	
	I heard the success stories of my family or acquaintance as a STEM professional	(Siringoringo et al., 2010)
	I was advised by my parents or relatives to take a STEM career	
Orientation	I prefer to work an innovative job	(Punzalan, 2022)
	I orient toward people more than things	(Yang & Barth, 2015)
	I want to invent new things	(Kang et al., 2019)
Cost	Doing STEM makes me nervous or upset	(Ahmed, 2018)
	Doing well in STEM requires more effort than I want to put into it	(Chung & Kim, 2022)
	It requires too much effort for me to get a good grade in STEM	

	Studying STEM scares me	
	Studying STEM makes me feel stress	
Stereotypes	When I think about people who work in STEM jobs, I think of people who are weird	(Garriott et al., 2017)
	When I think about people who work in STEM jobs, I think of people who are not attractive	
	When I think about people who work in STEM jobs, I think of people who have poor social skills	
	When I think about people who work in STEM jobs, I think of people who do not have many friends	
	When I think about people who work in STEM jobs, I think of people who do not have poor social skills	
	When I think about people who work in STEM jobs, I think of people who are not good athletes	
	People of my gender are important contributors to advancing knowledge	(Estrada et al., 2019)
Role model	I had a really good teacher	(Smith, 2022)
Parental influence	My family sees me as a STEM person	(Mahadeo et al., 2020)
	My parents expect me to do well in STEM and find a well-paid job in the future	(Chen et al., 2022; Mohtar et al., 2019; Sahin et al., 2018)
	It's important for my parents that I try my best in STEM subjects in school	
	My decision depends on the financial status of my family	(Guo, 2022)
	My decision is determined by the advice obtained from 122family and friends	(Maksimović et al., 2020)
	If I choose a STEM-related job, my parents will be glad	(Donmez & Idin, 2020)
Peers influence	My friends/classmates see me as a STEM person	(Mahadeo et al., 2020)

	Being a member of my friend group has a positive influence on my motivation and confidence to achieve in STEM	(Robnett & Leaper, 2013)
	Most of my friends want to engage in STEM careers	(Mohtar et al., 2019)
Teacher influence	My teachers/instructors see me as a STEM person	(Mahadeo et al., 2020)
	My teacher is interested in me and in my progress in the subject	(Aeschlimann et al., 2016)
	My teacher helps me when I am struggling	
	My teacher designs interesting and exciting lessons	
	My teacher can explain well	
	When a new concept is introduced, relevant real-life examples are discussed	(Aeschlimann et al., 2016; Kang & Keinonen, 2017)
	Experiments are usually connected with everyday objects and phenomena	
	The teacher clearly explains the relevance of STEM concepts to our lives	
	Students are given opportunities to explain their ideas	(Kang & Keinonen, 2017)
Classroom environment	Some students in this class make fun of kids who answer STEM questions wrong or make mistakes	(Lazarides et al., 2020)
Goal	Engaging in STEM is one of my future plans	(Donmez & Idin, 2020)

Appendix C: Questionnaire for Q-set construction

1. I am

□ Under 18 years old

□ 18 years old or over

2. I am

□ A student

□ Employed in work

□ None of the above

3. My gender is

□ Male

□ Female

□ Other

□ Prefer not to say

4. I am

□ A secondary school student

□ An undergraduate student

□ A postgraduate student

□ None of the above

5a. Which of the following occupations do you belong to?

5b. What is the job or occupation that you expect or plan to have **at age 30**?

STEM (Science, technology, engineering, and mathematics) occupations

□ Architects, engineers, and related professionals

□ Physicists, chemists, and related professionals

□ Mathematician, statisticians, and systems analysts

□ Computer system designers, analysts, and programmers

□ Biologists, botanists, zoologists, and related professionals

□ Medical, dental, veterinary, and related professionals

□ Nursing and midwifery professionals

□ Teaching professionals related to STEM

□ Other STEM occupations, What is your (aspired) STEM occupation:________

Non-STEM occupations

□ Accountants, personnels, and related business professionals

□ Teaching professionals unrelated to STEM

□ Lawyers, judges, and related legal professionals

□ Librarians, archivists, and related information professionals

□ Economists, sociologists, psychologists, philosophers, and related social science professionals

□ Writers, journalists, and creative or performing artists

□ Craft and related trader workers

□ Other non-STEM occupations, what is your (aspired) non-STEM occupation: _______

□ I am not sure

6a. Write down **3 reasons** for (NOT/unsure) aspiring to a STEM (science, technology, engineering, and mathematics) career (e.g., I am (not) good at learning STEM subjects):

6b. Write down **3 reasons** why you (didn't) chose a STEM (science, technology, engineering, and mathematics) occupation (e.g., I was (not) good at learning STEM subjects when I was in school):

Reason1: __________

Reason2: __________

Reason3: __________

This is the final question!

7a. These are some of the reasons that other people have chosen to work in a STEM (science, technology, engineering, and mathematics) field. Please choose **ONE OR MORE** of the following reasons that contributed to your choice/aspirations as well:

If the reasons overlap with your written reasons, please select the reasons again

Value

□ A job in STEM helps me a lot in succeeding in life

□ I enjoyed learning STEM when I was in school

□ I was interested in course that involve STEM when I was in school

□ STEM is important for society

□ STEM is important so that we understand the natural world

Identity

□ Working in STEM is connected with who I am

□ I have a strong sense of belonging to the community of STEM professionals

□ I am proud of my country's scientific achievement

□ STEM contributes to the prosperity of my country

Attitudes

□ It is important for me to do better than others in STEM careers

□ It is important for me to master the content of STEM

□ I was good at learning STEM subjects when I was in school

□ I was good as problem-solving in STEM subjects when I was in school

□ I believe I would do well working as a STEM professional when I made my career choice

□ There are many job opportunities in STEM

□ I have role models or heroes in STEM careers

□ People who work in STEM have exciting jobs

□ People who work in STEM make a lot of money

□ I thought the effort required for STEM subjects will ultimately be worthwhile

7b. These are some of the reasons that other people have chosen for **NOT** aspiring to work in a STEM (science, technology, engineering, and mathematics) field. Please choose **ONE OR MORE** of the following reasons for your **NOT** aspiring to a STEM career:

If the reasons overlap with your written reasons, please select the reasons again

STEM is not very important in getting a good job

Value

- □ STEM is not very important in getting a good job
- □ STEM will not help me much in succeeding in life
- □ I don't enjoy learning STEM
- □ I am bored by courses that involve STEM
- □ I don't find STEM important in helping us understand the natural world
- □ I don't think STEM is important for society

Identity

- □ Studying STEM is not connected with who I am
- □ I don't have a strong sense of belonging to the community of STEM professionals
- □ I don't care much about my country's scientific achievement
- □ STEM contributes little to the prosperity of my country

Attitudes

- □ I just want to avoid doing poorly in STEM classes
- □ I just want to avoid the work in STEM classes
- □ I am not good at learning STEM
- □ I am not good at problem-solving in STEM subjects
- □ I don't believe I would do well as a professional in STEM fields
- □ Studying STEM subjects provides few job opportunities for the future
- □ People who work in STEM make little money
- □ People who work in STEM have boring jobs

□ I don’t have role models or heroes in STEM careers

Cost

□ I’m not sure the effort required for STEM subjects will be ultimately worthwhile

□ Learning STEM subjects costs too much time or effort

Appendix D: Statements Derived from the Questionnaires

Factor	Descriptor from Chinese questionnaire		Descriptor from English questionnaire	
	Positive descriptor	Negative descriptor	Positive descriptor	Negative descriptor
Self-efficacy	I am better at STEM subjects than other subjects	I'm not good at learning STEM majors		I'm stupid
	I am good at STEM subjects	Learning STEM is too difficult to me		
		I'm not good at learning math		
		I didn't find the right way to learn STEM		STEM subjects are very difficult subjects
	I have a scientific spirit	I am not that good at STEM subjects		
		I don't have the right mindset to learn STEM		
		I have a scientific spirit		
	I have the right mindset to learn STEM subjects			I'm not logical to learn STEM well
Attainment value	I have a sense of achievement			

	in learning STEM			
Self-identity			I have a sense of belonging to STEM fields	I didn't see myself as a STEM person
Interest	I like learning STEM subjects	I am interested in jobs out of STEM		I am not interested in STEM subjects
	I'm interested in engineering	Learning STEM subjects is boring		
	I have passion for STEM subjects			
	I like it when I am taking STEM courses			
Utility	I think there is a lot of money to be earned in STEM professions		STEM majors typically offer high salary	STEM lacks in direct influence on human's life
			STEM subjects are more practical	
			STEM subjects are useful for understanding the world	
Expectations	STEM will lead to more opportunities in future career		I can do real research in STEM	There is very high competition in STEM
	STEM majors are in line with		There are currently many	STEM job market requires

	current employment trends		occupations available	very high qualification and it's difficult to get a good job without a PhD which I don't want to pursue
	It's easy to find a job in STEM fields			I'm not competitive enough in STEM careers
Prior experience	I am familiar with STEM subjects			
	I learnt STEM by myself when I was in school			
Orientation	I prefer jobs that require focus and less talking with people		I'd rather work on technical tasks than deal with words	I don't like to think too much
	STEM subjects are more logical and match my way of thinking		STEM is more straightforward since it has a relatively clear and definite answer or conclusion	STEM lacks critical thinking and is very black and white, for a world that isn't
				I prefer artistic and social studies

		Working in STEM can be very busy		Working in STEM leads to too much stress
Cost		Working in a STEM career will lead to little personal time		The content of STEM is too demanding
Parental influence	My parents expect me to take a STEM career			
Peers influence			Lost of my friends also enjoyed STEM subjects	
Personal plan	STEM major is my dream major			It's something I've never been drawn to career wise

Appendix E: Q-set encompassing 31 statements

Statement No.	Statement
1	Taking STEM courses is boring
2	I'd rather deal with words and people than work on technical tasks
3	When I think about people who work in STEM jobs, I think of people who are weird and not attractive
4	My teachers didn't see me as a STEM person
5	I seldom visited science centre or science museum out of school or conducted experiments or science projects in the school laboratory
6	I am not familiar with STEM subjects
7	Working in STEM offers low salaries
8	I'm interested in a job out of STEM
9	People of my gender are not important contributors to advancing STEM
10	My parents didn't expect me to take a STEM career
11	I didn't have a sense of achievement in learning STEM subjects
12	Working in STEM requires too much time and effort than I want to put into
13	I don't find STEM subjects enjoyable
14	Working in STEM leads to too much stress
15	I didn't have a sense of belonging to STEM fields
16	I expected that I will not be competitive enough to find a good job in STEM fields
17	I'm not good at STEM subjects
18	I lack confidence in my ability to excel in STEM subjects
19	Most of my friends want to engage in non-STEM careers
20	Working in STEM is not important in leading to a prospective future
21	A degree in social science and humanities, rather than STEM, will most likely guarantee secure employment
22	Studying STEM makes me nervous or upset
23	STEM careers are something I've never been drawn to career-wise
24	STEM majors are not my dream major
25	I didn't see myself as a STEM person

26	When I think about people who work in STEM jobs, I think of people who have poor social skills and do not have many friends
27	I prefer artistic and social studies than STEM
28	I seldom/never had conversations or worked with a STEM professional
29	I orient towards people more than things
30	STEM lacks direct influence on human life
31	The content of STEM is too demanding

Appendix F: Participant Consent Form

University of Glasgow
College of Social Sciences

Participant Consent Form

Title of Project: STEM career aspirations: A comparative study of young people in China and the UK

Name of Researcher: Yingying Zhou

Please tick as appropriate

(Kindly note: Our study follows specific participant screening criteria, so not all students who agree to participate will participate in the study!)

Yes ☐ No ☐ I understand that my participation is **voluntary** and that I can withdraw at any time, without giving any reason.

Yes ☐ No ☐ I consent to participate in the **card-sorting activity**

Yes ☐ No ☐ I consent to take part in the **interview**.

Yes ☐ No ☐ I have received a **Privacy Notice** for this research project.

Yes ☐ No ☐ In the future, I aspire to pursue a **career** in a field associated with **STEM** (Science, Technology, Engineering, and Mathematics).

(e.g., Mechanical Engineer, Environmental Engineer, Architect, Scientist, mathematician, Network Engineer, Programmer, Doctor, Geologist, Biologist, Agriculturist, STEM teacher etc.)

☐ I **AGREE** to my taking part in this study

☐ I **DO NOT AGREE** to my taking part in this study

Name of Participant …………………………

Signature ……………………………………

Date ……………………………………………

You have a choice to complete the card-sorting **online** or **in person**.

If you want to complete it online, check this box ☐

and leave your **email address**………………………………

Name of Researcher: Yingying Zhou Signature:

Date: 08-09-2023

Appendix G: Participant Information Sheet

University of Glasgow

College of Social Sciences

This sheet is for you to keep.

Participant Information Sheet for Students

Title of Research Project: STEM career aspirations: A comparative study of young people in China and the UK.

Hello,

You are invited to take part in a research study. Before you decide if you want to take part, it is important for you to understand why the research is being done and what it will involve. Please read the following information carefully and discuss it with others if you wish. Ask the researcher if there is anything that is not clear or if you would like more information. Take some time to decide whether or not you wish to take part.

Thank you for reading this.

What is this project about?

This project examines **STEM (science, technology, engineering, and mathematics)** career aspirations in high school students, who are taking Science and/or Mathematics. in China and Scotland. It investigates their perspectives and motivations, aiming to understand factors influencing students' STEM aspirations.

What would I need to do if I took part?

You are invited to a **15-minute** ***card-sorting activity*** with peers (up to 3 people) to rank reasons for (or not) pursuing a STEM career. Next, you will be invited for a post-activity ***interview***, lasting for approximately **10 minutes**.

You are free to decide to leave the project or the interview at any time before the data analysis process, and you will not be asked why you decided to leave.

What happens to the information I tell you about?

I will be analysing and writing up about your perspectives and motivations towards STEM career aspirations (or not). This will be a thesis and potentially published in journal articles, a book, or conferences in the future. Your real name will not be used, because when I listen back, I will assign you a number, and give you a pseudonym – a pretend name, which is what I will use when I write anything.

The personal information you tell me (your name) will be kept in a secure cabinet and destroyed in consultation with a data specialist. The research information you tell me (the discussions that we have in the interview) will be stored securely. The research project supervisors named below will have access to the information, and it might be used by other researchers in the future, but only through a personal request to me. Both of these types will be destroyed 10 years after the thesis is submitted. Your confidentiality will be maintained as far as possible; there is a chance that your classmates may be able to work out who is who, and if I hear something in the focus group that makes me worry you or someone else might be in danger of harm; I may have to speak to your teacher. This is why your confidentiality cannot be totally guaranteed.

Please note that assurances on confidentiality will be strictly adhered to unless evidence of wrongdoing or potential harm is uncovered. In such cases, the University may be obliged to contact relevant statutory bodies/agencies.

Which occupations are STEM occupations?

STEM stands for Science, Technology, Engineering, and Mathematics. STEM occupations are those that are primarily related to these fields. Here are some of the examples:

Subject	Occupations
Biology	Biologist, Microbiologist, Geneticist, Ecologist, Botanist, Zoologist, Environmental Scientist, Biotechnologist, etc.
Medicine	Physician (Doctor), Surgeon, Nurse, Pharmacist, Dentist, Medical Researcher, Radiologist, Physical Therapist, etc.
Chemistry	Chemist, Chemical Engineer, Analytical Chemist, Materials Scientist, Pharmaceutical Chemist , Environmental Chemist, etc.
Physics	Physicist, Astrophysicist, Theoretical Physicist, Nuclear Physicist, Meteorologist, Geophysicist, Quantum Physicist, etc.
Technology and Computer Science	Data Scientist, Cybersecurity Analyst, Network Engineer, User Experience (UX) Designer,

	Information Technology (IT) Specialist, Software Developer, Artificial Intelligence (AI) Engineer, Web Developer, Game Developer, etc.
Engineering	Mechanical Engineer, Civil Engineer, Electrical Engineer, Aerospace Engineer, Biomedical Engineer, Environmental Engineer, Computer Hardware Engineer, etc
Mathematics	Mathematician, Actuary, Data Analyst, Statistician, Operations Research Analyst, Cryptographer, Financial Analyst, etc
Other	Technician or apprenticeships in any of the above and below. Rural engineering, dairy technology, food technology. Any other occupations related to science, technology, engineering and mathematics.

Who is carrying out this project, and why?

This research project is being conducted by a **PhD candidate** of the **College of Social Sciences, University of Glasgow**.

As a requirement of the PhD, a thesis will be written about the study, and the main aim of the project is to provide insights for educators and relevant stakeholders.

Where can I find out about the results of the project when it is finished?

There are lots of different ways you can find out about the results of the project once I finish. I am happy to give you a written summary, or copy of published work if requested, and I can also arrange to come and visit your school to give you a presentation about the project. You can also get in touch with me if you think there will be a better way for you to find out about the results.

Useful information

This project has been considered and approved by the College Research Ethics Committee, if you have any questions about this research generally, please get in touch with **Yingying Zhou** by email: xxxxxxxx@student.gla.ac.uk

To pursue any complaint about the conduct of the research: contact the College of Social Sciences Ethics Officer, Dr Muir Houston, email: Muir.Houston@glasgow.ac.uk

Or Project supervisor: Dr Shaista Shirazi, email: Shaista.Shirazi@glasgow.ac.uk

____________________End of Participant Information Sheet____________________

Appendix H: Privacy Notice

Privacy Notice

Research Project: Why do some high-achieving high school students not want to pursue STEM-related careers? —A comparative study of young people in China and Scotland

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Your Personal Data

The University of Glasgow will be what's known as the 'Data Controller' of your personal data processed in relation to your participation in the research project: Why do some high-achieving high school students not want to pursue STEM-related careers? —A comparative study of young people in China and Scotland. This privacy notice will explain how The University of Glasgow will process your personal data.

Why we need it

We are collecting basic personal data such as your name and contact details in order to conduct our research. We need your name and contact details to arrange the Q-sorting process and follow-up interviews.

We only collect data that we need for the research project, your name and school name will be de-identified from the research data through pseudonymisation.

Please note that your confidentiality may be impossible to guarantee for example due to the size of the participant group, location etc. Please see the accompanying **Participant Information Sheet**.

Legal basis for processing your data

We must have a legal basis for processing all personal data. As this processing is for Academic Research, we will be relying upon **Task in the Public Interest** in order to process the basic personal data that you provide. For any special categories of data collected, we will be processing this on the basis that it is **necessary for archiving purposes, scientific or historical research purposes or statistical purposes**

Alongside this, in order to fulfil our ethical obligations, we will ask for your **consent** to take part in the study Please see the accompanying **Consent Form**.

What we do with it and who we share it with

All the personal data you submit is processed by the principal researcher (**Yingying Zhou**). In addition, security measures are in place to ensure that your personal data remains safe: pseudonymisation, secure storage, and encryption of files and devices. Please consult the **Consent form** and **Participant Information Sheet** which accompanies this notice.

Possible further use of data suggested clause: Due to the nature of this research, it is very likely that other researchers may find the data collected to be useful in answering future research questions. We will ask for your explicit consent for your data to be shared in this way.

We will provide you with a copy of the study findings and details of any subsequent publications or outputs on request.

What are your rights?*

GDPR provides that individuals have certain rights including: to request access to, copies of and rectification or erasure of personal data and to object to processing. In addition, data subjects may also have the right to restrict the processing of the personal data and to data portability. You can request access to the information we process about you at any time.

If at any point you believe that the information we process relating to you is incorrect, you can request to see this information and may in some instances request to have it restricted, corrected, or erased. You may also have the right to object to the processing of data and the right to data portability.

Please note that as we are processing your personal data for research purposes, the ability to exercise these rights may vary as there are potentially applicable research exemptions under the GDPR and the Data Protection Act 2018. For more information on these exemptions, please see UofG Research with personal and special categories of data.

If you wish to exercise any of these rights, please submit your request via the webform or contact dp@gla.ac.uk

Complaints

If you wish to raise a complaint on how we have handled your personal data, you can contact the University Data Protection Officer who will investigate the matter.

Our Data Protection Officer can be contacted at dataprotectionofficer@glasgow.ac.uk

If you are not satisfied with our response or believe we are not processing your personal data in accordance with the law, you can complain to the Information Commissioner's Office (ICO) https://ico.org.uk/

Who has ethically reviewed the project?

This project has been ethically approved by the College of Social Sciences Research Ethics Committee.

How long do we keep it for?

Your **personal** data will be retained by the University only for as long as is necessary for processing and no longer than the period of ethical approval (30 Sep 2024). After this time, personal data will be securely deleted.

Your **research** data will be retained for a period of ten years in line with the University of Glasgow Guidelines. Specific details in relation to research data storage are provided on the Participant Information Sheet and Consent Form which accompany this notice.

____________________End of Privacy Notice ______________________________

Appendix I: Participants Demographic Information Sheet

Participant Demographic Information Sheet

Your Name ………………………………

Your Gender …………………………….

Your Age …………………………………

Your Grade Level ………………………

1. The **grades** you **received** for the STEM subjects in your most recent National 5/Highers exams:

1st STEM subject (write down the name here) ……………………………

□ National 5 □ Highers

□ A □ B □ C □ D

2nd STEM subject (If applicable) ………………………………

□ National 5 □ Highers

□ A □ B □ C □ D

3rd STEM subject (If applicable) ………………………………

□ National 5 □ Highers

□ A □ B □ C □ D

4th STEM subject (If applicable) ………………………………

□ National 5 □ Highers

□ A □ B □ C □ D

2. What is the occupation of your **father** ………………………………

3. What is the education level of your **father**?

□ Secondary school or lower □ Bachelor's Degree

□ Master's Degree □ Doctorated or Professional Degree

4. What is the occupation of your **mother** ………………………………

5. What is the education level of your **mother**?

□ Secondary school or lower □ Bachelor's Degree

□ Master's Degree □ Doctorated or Professional Degree

Appendix J: Parental Consent Form

University of Glasgow
College of Social Sciences

Parental Consent Form

Title of Project: STEM career aspirations: A comparative study of young people in China and the UK

Name of Researcher: Yingying Zhou

Supervisors: Dr Shaista Shirazi, Dr Saima Salehjee, and Dr Jeremy Law

Please tick as appropriate

Yes ☐ No ☐ I understand that my child's participation is **voluntary** and that he/she is free to withdraw at any time, without giving any reason.

Yes ☐ No ☐ I consent to my child's participation in the **card-ranking activity**

Yes ☐ No ☐ I consent to my child taking part in the **interview** and having his/her **audio recorded**.

Yes ☐ No ☐ I acknowledge the provision of a **Privacy Notice** in relation to this research project.

☐ I **AGREE** to my child taking part in this study

☐ I **DO NOT AGREE** to my child taking part in this study

Name of Participant ……………………………

Parent's Signature ……………………………

Date ……………………………………

Name of Researcher: Yingying Zhou **Signature**:

Date: 08-09-2023

Appendix K: Parental Information Sheet

University of Glasgow

College of Social Sciences

This sheet is for you to keep.

Parental Information Sheet

Title of Research Project: STEM career aspirations: A comparative study of young people in China and the UK.

Hello,

Your child is invited to take part in a research study. Before you decide if you want your child to take part, it is important for you to understand why the research is being done and what it will involve. Please read the following information carefully and discuss it with others if you wish. Ask the researcher if there is anything unclear or if you would like more information.

What is this project about?

This project examines STEM (science, technology, engineering, and mathematics) career aspirations in high school students, who are taking Science and/or Mathematics. in China and Scotland. It investigates their perspectives and motivations, aiming to understand factors influencing students' STEM aspirations.

What would my child need to do if my child took part?

Your child is invited to a **15-minute *card-ranking activity*** with peers (up to 3 people) to rank reasons for (or not) pursuing a STEM career. Next, your child will be invited for a post-activity ***interview***, lasting for approximately **10 minutes**.

Your child can withdraw from this project at any time before the data analysis process.

Why and how is my child recruited to participate?

Your child is contacted by the researcher with permission from the school and the schoolteacher. Your child is allowed to participate in this research because he/she is eligible to be a participant in this project and he/she is free to choose whether to participate.

How will my child's information be used?

Please note that any personal details collected will be destroyed before the end of this project (30 September 2024). The researcher is responsible for maintaining confidentiality of the data and will anonymise it where needed. Confidentiality will be respected subject to legal constraints and professional guidelines.

Data collected will be used in the production of journal articles, and conference papers. After the research period, anonymised data will be stored in the University of Glasgow data archives for a period of ten years to be available for further analysis by other researchers.

Who will see the information of my child?

Only the researcher will have access to the information provided. For student data that you have provided permission for, the Q-sorting results and interview data will be de-identified as far as possible. Where individual comments are used, they will be anonymised to prevent tracking of the resources.

All paper responses will be kept safe in a locked cabinet at the University by the researcher. No names will be associated with student responses. All electronic responses will be stored in an encrypted folder on the University of Glasgow server. The researcher alone will have access to the folder.

Who is carrying out this project, and why?

This research project is being conducted by a **PhD candidate** of the **College of Social Sciences, University of Glasgow**.

As a requirement of the PhD, a thesis will be written about the study, and the main aim of the project is to provide insights for educators and relevant stakeholders.

Where can I find out about the results of the project when it is finished?

There are lots of different ways you can find out about the results of the project once I finish. I am happy to give you a written summary, or copy of published work if requested, and I can also arrange to come and visit your school to give you a presentation about the project. You can also get in touch with me if you think there will be a better way for you to find out about the results.

Useful information

This project has been considered and approved by the College Research Ethics Committee, if you have any questions about this research generally, please get in touch with Yingying Zhou by email: xxxxxxxx@student.gla.ac.uk

Or,

Project supervisor: Dr Shaista Shirazi, by phone: 01387 702037 or email: Shaista.Shirazi@glasgow.ac.uk

To pursue any complaint about the conduct of the research: contact the College of Social Sciences Ethics Officer, Dr Benjamin Franks, email: socsci-ethics-lead@glasgow.ac.uk

____________________End of Parental Information Sheet_____________________

www.gla.ac.uk

Appendix L: Participants' Demographic Information

Country	Q-sort No.	School Name	Student Name (anonymised)	Gender	Age	Grade	Parents' occupation	Parents' education level
Scotland	1	S-School M	Ava	Female	16	S5	N/A Carer	N/A Bachelor's
	2	S-School M	Leo	Male	17	S6	Lorry driver Baker	Secondary school Secondary school
	3	S-School M	Finn	Male	17	S6	Farmer Accountant	Secondary school Secondary school
	4	S-School L	Mia	Female	17	S5	Children's social worker unemployed	Secondary school Secondary school
	5	S-School L	Zoe	Female	16	S5	Famer Famer	Master's Bachelor's
	6	S-School C	Lily	Female	16	S5	N/A N/A	N/A N/A
	7	S-School C	Nora	Female	16	S5	Engineer Chemistry teacher	Bachelor's Master's
	8	S-School J	Max	Male	17	S6	N/A	N/A

							N/A	N/A
	9	S-School J	Ella	Female	17	S6	N/A N/A	N/A N/A
	10	S-School J	Ethan	Male	16	S5	N/A N/A	N/A N/A
China	1	C-School N	Elena	Female	17	11th	Farmer Farmer	Junior high school Junior high school
	2	C-School N	Liam	Male	17	11th	Civil servant Farmer	Junior high school Junior high school
	3	C-School N	Silas	Male	17	11th	Chemical workers Unemployed	High school Junior high school
	4	C-School N	Owen	Male	17	11th	Driver Farmer	Junior high school Junior high school
	5	C-School N	Mira	Female	17	11th	Self-employed Self-employed	Junior High School High school
	6	C-School N	Clara	Female	16	11th	Farmer Farmer	High School Junior high school
	7	C-School Q	Nadia	Female	17	11th	Worker Worker	High School High school

	8	C-School Q	Felix	Male	17	11th	Self-employed Self-employed	Bachelor's Bachelor's
	9	C-School Q	Jude	Male	17	11th	N/A N/A	N/A N/A
	10	C-School Q	Leah	Female	17	11th	Self-employed Self-employed	High school High school
	11	C-School Q	Sienna	Female	17	11th	Self-employed Self-employed	Junior high school Junior high school
	12	C-School Q	Rhys	Male	17	11th	Architecture Self-employed	High school Junior high school
	13	C-School N	Kai	Male	17	11th	Military Nurse	Bachelor's Bachelor's
	14	C-School N	Ivy	Female	17	11th	Physical teacher History teacher	N/A N/A
	15	C-School N	Zara	Female	16	11th	Physics teacher Bank employee	Bachelor's Bachelor's

Appendix M: Permission for Research in Secondary Schools

OFFICIAL

Your Ref:

Our Ref: I:\Schools Services\Directorate\Education and Learning Filing System\Current\Research and Surveys\2023

26 October 2023

Dr Shaista Shirazi
University of Glasgow
College of Social Sciences

Shaista.shirazi@glasgow.ac.uk

Education and Learning
Militia House
English Street
Dumfries
DG1 2HR

Any enquiries please contact
Gillian Brydson
DirectorSkillsEducationandLearning@dumgal.gov.uk

Appendix N: Factor Arrays of Chinese Participants

Statement No.	Statement	Factor Arrays		
1	Taking STEM courses is boring	-1	1	3
2	I'd rather deal with words and people than work on technical tasks	1	3	-4
3	When I think about people who work in STEM jobs, I think of people who are weird and not attractive	-3	-3	-3
4	My teachers didn't see me as a STEM person	-2	-1	-1
5	I seldom visited science centre or science museum out of school or conducted experiments or science projects in the school laboratory	0	2	-2
6	I am not familiar with STEM subjects	0	2	-2
7	Working in STEM offers low salaries	-4	-3	0
8	I'm interested in a job out of STEM	1	4	3
9	People of my gender are not important contributors to advancing STEM	-1	-4	2
10	My parents didn't expect me to take a STEM career	-3	-2	-2
11	I didn't have a sense of achievement in learning STEM subjects	2	-2	-3
12	Working in STEM requires too much time and effort than I want to put into	1	1	4
13	I don't find STEM subjects enjoyable	0	0	2
14	Working in STEM leads to too much stress	2	0	3
15	I didn't have a sense of belonging to STEM fields	2	-1	1
16	I expected that I will not be competitive enough to find a good job in STEM fields	4	1	-2
17	I'm not good at STEM subjects	2	-2	-1
18	I lack confidence in my ability to excel in STEM subjects	3	-1	1
19	Most of my friends want to engage in non-STEM careers	-2	0	0
20	Working in STEM is not important in leading to a prospective future	-2	2	0
21	A degree in social science and humanities, rather than STEM, will most likely guarantee secure employment	-1	2	1
22	Studying STEM makes me nervous or upset	4	-3	2

23	STEM careers are something I've never been drawn to career-wise	-2	0	0
24	STEM majors are not my dream major	-1	3	4
25	I didn't see myself as a STEM person	3	-4	-1
26	When I think about people who work in STEM jobs, I think of people who have poor social skills and do not have many friends	-3	-2	1
27	I prefer artistic and social studies than STEM	1	4	-1
28	I seldom/never had conversations or worked with a STEM professional	0	1	0
29	I orient towards people more than things	0	3	2
30	STEM lacks direct influence on human life	-4	0	-4
31	The content of STEM is too demanding	3	-1	-3

Appendix O: Factor Arrays of Scottish Participants

Statement No.	Statement	Factor Arrays	
1	Taking STEM courses is boring	-1	-3
2	I'd rather deal with words and people than work on technical tasks	1	1
3	When I think about people who work in STEM jobs, I think of people who are weird and not attractive	-1	-4
4	My teachers didn't see me as a STEM person	-2	2
5	I seldom visited science centre or science museum out of school or conducted experiments or science projects in the school laboratory	-1	-2
6	I am not familiar with STEM subjects	-2	-1
7	Working in STEM offers low salaries	-4	-1
8	I'm interested in a job out of STEM	2	2
9	People of my gender are not important contributors to advancing STEM	-3	-2
10	My parents didn't expect me to take a STEM career	-1	2
11	I didn't have a sense of achievement in learning STEM subjects	0	-1
12	Working in STEM requires too much time and effort than I want to put into	0	0
13	I don't find STEM subjects enjoyable	3	-4
14	Working in STEM leads to too much stress	1	0
15	I didn't have a sense of belonging to STEM fields	4	1
16	I expected that I will not be competitive enough to find a good job in STEM fields	1	3
17	I'm not good at STEM subjects	0	-3
18	I lack confidence in my ability to excel in STEM subjects	0	2
19	Most of my friends want to engage in non-STEM careers	-3	1
20	Working in STEM is not important in leading to a prospective future	-2	-2

21	A degree in social science and humanities, rather than STEM, will most likely guarantee secure employment	-3	3
22	Studying STEM makes me nervous or upset	3	-3
23	STEM careers are something I've never been drawn to career-wise	4	0
24	STEM majors are not my dream major	2	4
25	I didn't see myself as a STEM person	1	4
26	When I think about people who work in STEM jobs, I think of people who have poor social skills and do not have many friends	-2	-1
27	I prefer artistic and social studies than STEM	3	1
28	I seldom/never had conversations or worked with a STEM professional	0	3
29	I orient towards people more than things	2	0
30	STEM lacks direct influence on human life	-4	-2
31	The content of STEM is too demanding	2	0

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