

Original Research

Received 01 June 2026

Revised 23 July 2026

Accepted 07 Aug 2026

Natural Resources for Human Health 2026, Vol. 6 (15s): 479–497

KEYWORDS:

Career exploration; STEM education-to-career pathways; STEM career development; Social Cognitive Career Theory; educational transitions; systematic review.

Career exploration across STEM education-to-career pathways: A systematic review and evidence-informed conceptual framework

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ABSTRACT: Career exploration is increasingly recognised as an important process in shaping how students understand, evaluate, and navigate STEM education and career pathways. However, existing evidence remains fragmented across educational stages, learning contexts, psychological mechanisms, and equity-related conditions, limiting an integrated understanding of how career exploration operates across STEM education-to-career pathways. This systematic review synthesised recent empirical evidence and developed an evidence-informed conceptual framework. Following PRISMA 2020 guidelines, journal articles published between 2022 and 2026 were identified through Scopus and Web of Science. After database filtering, duplicate removal, screening, and full-text eligibility assessment, 28 empirical studies were included and analysed using a hybrid inductive-deductive thematic synthesis. Five interrelated themes emerged: career exploration as a structured developmental process; experiential, informal, and out-of-school STEM learning as career exploration contexts; social-cognitive and psychological mechanisms linking STEM experiences to career outcomes; career exploration across educational transitions and STEM career pathways; and equity, gender, and access in STEM career exploration. The synthesis indicates that career exploration functions as a recurrent and context-sensitive developmental process that supports career awareness, clarification, refinement, persistence, redirection, and transition across STEM pathways. Its operation is shaped by learning experiences, self-efficacy, outcome expectations, identity, social support, and access to meaningful career-development opportunities. The resulting framework integrates these processes and positions career exploration as an important developmental link between STEM learning experiences and educational and occupational pathway decisions.

1. INTRODUCTION

The transition from STEM education to STEM employment is increasingly understood as involving multiple and potentially changing pathways rather than a single linear progression. Although the pipeline metaphor has historically been used to describe movement toward STEM degrees and careers, it inadequately captures trajectories in which individuals may enter, leave, redirect, or re-enter STEM pathways over time (Cannady et al., 2014). Recent research similarly highlights the dynamic nature of STEM educational and career trajectories, particularly during adolescence and early adulthood, when individuals evaluate educational opportunities, occupational possibilities, and alternative career directions (Zhou and Shirazi, 2025).

Within these pathways, career exploration represents an active developmental process through which individuals seek, evaluate, and interpret information about themselves and the career environment to support career-related understanding and decision-making (Stumpf et al., 1983). In the STEM context, educational experiences alone do not necessarily translate into clear occupational directions. Students must also identify available career options, evaluate their interests and capabilities, and interpret how STEM learning may connect with possible future roles. Contemporary evidence indicates that STEM career aspirations and choices are influenced by interacting personal and contextual factors, including self-efficacy, positive STEM experiences, social persuasion, and access to career-related opportunities (Zhou and Shirazi, 2025).

Social Cognitive Career Theory (SCCT) provides a useful theoretical lens for understanding these processes because it explains how learning experiences, self-efficacy beliefs, outcome expectations, interests, goals, and contextual influences interact in shaping academic and career-related development (Lent et al., 1994). From this perspective, learning experiences influence career development partly through individuals' beliefs about their capabilities and anticipated outcomes, while contextual supports and barriers may facilitate or constrain subsequent career-related choices and actions. Career exploration can therefore be understood as an active process through which individuals examine self- and career-related information while interpreting possible educational and occupational pathways within their personal and contextual circumstances. In this review, SCCT serves as an interpretive lens rather than a predetermined coding framework, enabling the synthesis to consider how social-cognitive processes and contextual conditions shape STEM career development.

Taken together, these perspectives suggest that STEM career development cannot be understood solely in terms of whether students ultimately choose a STEM career. It is also necessary to examine how individuals repeatedly explore, interpret, and reassess possible STEM directions as they encounter new learning experiences, transition points, and contextual opportunities or constraints.

Career exploration is conceptually distinct from related constructs such as career awareness, interest, aspiration, intention, and choice. Whereas these constructs refer broadly to occupational knowledge, attraction toward particular careers, future-oriented preferences, intended directions, or more concrete decisions, career exploration concerns the active examination and interpretation of self- and career-related information (Stumpf et al., 1983). In this review, career pathways refer more broadly to the educational and occupational routes through which individuals may enter, remain within, redirect, or re-enter STEM.

Despite growing attention to STEM career aspirations, career choice, learning experiences, and career-development activities, the role of career exploration across the broader education-to-career continuum remains insufficiently integrated. Existing research is distributed across educational stages, learning contexts, psychological mechanisms, and transition points, making it difficult to understand how career exploration operates across STEM education-to-career pathways as a recurring developmental process. Recent synthesis has identified a broad range of personal, experiential, and contextual influences on STEM career aspirations and choices, but career exploration itself has not been comprehensively synthesised across successive educational and career transitions (Zhou and Shirazi, 2025). A focused systematic synthesis is therefore needed to clarify how career exploration is conceptualised, how its role changes across developmental and educational stages, and how psychological and contextual conditions influence its operation within STEM pathways.

Accordingly, this systematic review examines career exploration across STEM education-to-career pathways and develops an evidence-informed conceptual framework. The review addresses the following research questions:

RQ1: How is career exploration conceptualised and enacted as a developmental process across different stages of STEM education-to-career pathways?

RQ2: How do experiential learning contexts and social-cognitive or psychological mechanisms shape the relationship between career exploration and STEM career-related outcomes?

RQ3: How do educational transitions, gender, equity, and access to career-development opportunities influence career exploration and progression within STEM pathways?

2. MATERIALS AND METHODS

2.1 Review protocol and methodological approach

This systematic review was reported in accordance with the PRISMA 2020 guidelines to support transparent reporting of study identification, screening, eligibility assessment, and inclusion (Page et al., 2021). The review was guided by the PICO framework, comprising Population, Interest, and Context, to define the review scope and inform the search strategy (Stern et al., 2014). The population included adolescents and students across educational stages relevant to STEM pathway development, particularly secondary/high-school and postsecondary populations. The phenomenon of interest was career exploration and closely related exploratory processes, while the context concerned STEM education-to-career pathways, including career awareness, educational transitions, career preparation, and movement toward STEM employment.

The review focused on empirical journal articles published between 2022 and 2026 to capture recent research on STEM career exploration and pathway development. Scopus and Web of Science were selected as the principal databases because of their broad multidisciplinary coverage across education, psychology, career development, and STEM-related fields. Searches were limited to English-language peer-reviewed journal articles. Studies were eligible when career exploration, career-related learning, or closely related exploratory processes formed a substantive part of the relationship between STEM experiences and educational or career-related outcomes.

2.2 Identification and search strategy

The database search was conducted on 16 February 2026. The search strategy was organised around four conceptual blocks: (1) career exploration and related career-development processes, (2) STEM-related educational and occupational contexts, (3) career-related outcomes, and (4) populations representing different stages of the education-to-career pathway. Career-exploration terms included career exploration, career exploration behaviour/behavior, vocational exploration, occupational exploration, career planning, career development, career decision making, and career information seeking. These were combined with STEM-related terms; career outcomes including career interest, aspiration, intention, choice, and pathway; and population terms covering secondary/high-school and postsecondary students, adolescents, youth, young adults, and emerging adults.

Database-specific syntax was applied using TITTLE-ABS-KEY in Scopus and Topic Search (TS) in Web of Science. Boolean operators were used to combine the conceptual blocks using database-specific syntax based on the same conceptual structure. The initial search identified 229 records, comprising 120 records from Scopus and 109 records from Web of Science. Predefined filters were then applied for publication years 2022-2026, English-language publications, journal articles, and eligible publication status. Records published before 2022, non-English publications, conference papers, books, review articles, and articles in press were excluded at this stage. Following filtering, 84 records remained, consisting of 54 records from Scopus and 30 records from Web of Science.

Table 1. Search strategy and applied filters

Database	Search string	Applied filters	Date of access
Scopus	TITTLE-ABS-KEY("career exploration" OR "career exploration behavior" OR "career exploration behaviour" OR "vocational exploration" OR "occupational exploration" OR "career planning" OR "career development" OR "career decision making" OR "career decision-making" OR "career information seeking") AND TITTLE-ABS-KEY("STEM" OR "science technology engineering mathematics" OR "STEM education" OR "science education" OR "engineering education" OR "technology education" OR "mathematics education" OR "STEM career*" OR "science career*" OR "engineering career*" OR "technology career*" OR "mathematics career*") AND TITTLE-ABS-KEY(	Publication years: 2022-2026 Document type: Article Language: English	16 February 2026

Web of Science (WoS)	"career interest" OR "STEM interest" OR "career aspiration*" OR "STEM aspiration*" OR "career intention*" OR "STEM intention*" OR "career choice*" OR "career pathway*" OR "STEM pathway*") AND TITLE-ABS-KEY("secondary school" OR "high school" OR "middle school" OR "college student*" OR "university student*" OR undergraduate* OR "postsecondary student*" OR adolescen* OR youth OR "young adult*" OR "emerging adult*") TS=(("career exploration" OR "career exploration behavior" OR "career exploration behaviour" OR "vocational exploration" OR "occupational exploration" OR "career planning" OR "career development" OR "career decision making" OR "career information seeking") AND ("STEM" OR "science technology engineering mathematics" OR "STEM education" OR "science education" OR "engineering education" OR "technology education" OR "mathematics education" OR "STEM career*" OR "science career*" OR "engineering career*" OR "technology career*" OR "mathematics career*")) AND ("career interest" OR "STEM interest" OR "career aspiration*" OR "STEM aspiration*" OR "career intention*" OR "STEM intention*" OR "career choice*" OR "career pathway*" OR "STEM pathway*") AND ("secondary school" OR "high school" OR "college student*" OR "university student*" OR undergraduate* OR "postsecondary student*" OR adolescen* OR youth OR "young adult*" OR "emerging adult*"))	Publication years: 2022-2026 16 February 2026 Document type: Article Language: English
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2.3 Eligibility criteria

Eligibility criteria were defined before screening to maintain consistency between the review questions, search strategy, and study-selection process. The eligibility criteria were applied consistently during the assessment process and confirmed through full-text examination of all potentially eligible records. Duplicate records were managed separately to prevent double counting. The inclusion and exclusion criteria are presented in Table 2.

Table 2. Inclusion and exclusion criteria with rationales

Criterion	Inclusion	Exclusion	Rationale
Population	Adolescents and students across relevant stages of the STEM education-to-career pathway, including middle/secondary/high-school, postsecondary, college, and undergraduate populations. Mixed-age samples were included when findings were relevant to the review focus.	Primary-school-only populations, adult workforce-only samples, or studies without a relevant student/youth population.	Captures career exploration across educational transition points rather than restricting the review to a single educational stage.
Core phenomenon	Career exploration or closely related exploratory processes, including career	Career-related studies with no meaningful exploration,	Maintains career exploration as the

	planning, career information seeking, vocational/occupational exploration, and career decision-making where these contributed to STEM career development.	planning, information-seeking, or decision-development component.	central phenomenon of the review.
Career outcome	STEM career interest, aspiration, intention, choice, pathway, major-related direction, persistence, career preparation, or transition toward STEM employment.	Studies examining only academic achievement, general attitudes, or subject performance without a STEM career-development outcome.	Allows examination of career exploration across different stages and outcomes of STEM education-to-career pathways.
STEM context	STEM education, science, technology, engineering, mathematics, or related STEM career-development contexts.	Non-STEM occupational or educational domains.	Maintains consistency with the substantive focus of the review.
Study design	Primary empirical quantitative, qualitative, mixed-methods, experimental, quasi-experimental, or longitudinal studies.	Reviews, meta-analyses, conceptual/theoretical papers, editorials, commentaries, and protocols.	Ensures that the synthesis is based on primary empirical evidence.
Publication type	Peer-reviewed journal articles.	Conference papers, books/book chapters, theses/dissertations, grey literature, and non-final publications.	Provides a consistent evidence base for quality appraisal.
Publication period	2022-2026.	Studies published before 2022 or outside the predefined period.	Focuses the review on recent developments in STEM career exploration.
Language	English.	Non-English publications.	Supports consistent screening, interpretation, and data extraction.

2.4 Screening, eligibility, and inclusion

Following database filtering, 84 records remained for further assessment, comprising 54 records from Scopus and 30 from Web of Science. After two duplicate records were removed, 82 unique records remained. Full texts were retrieved for all 82 records and assessed against the predefined eligibility criteria. Of the 82 full-text articles assessed for eligibility, 54 were excluded because they did not satisfy the predefined eligibility criteria or were outside the scope of the review. The remaining 28 studies were included in the quality appraisal and thematic synthesis. The complete study-selection process is summarised in the PRISMA 2020 flow diagram presented in Figure 1.

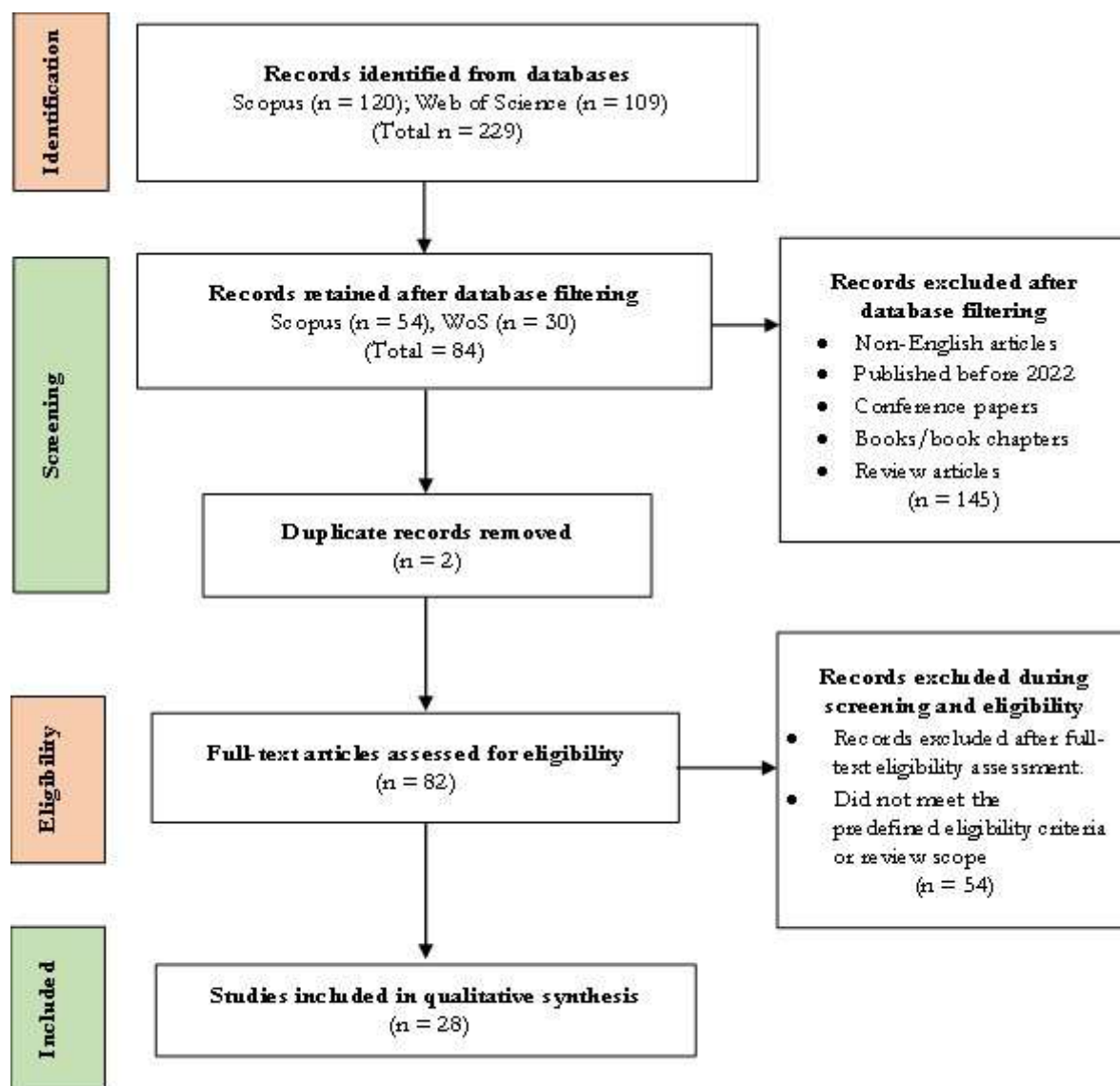


FIGURE 1. PRISMA 2020 flow diagram of the study selection process.

2.5 Data extraction and thematic synthesis

Data from the 28 included studies were extracted using a structured study-level evidence matrix designed to capture both methodological characteristics and findings relevant to career exploration across STEM education-to-career pathways. Extracted information included author and publication year, country or study context, participant group and educational stage, research design, STEM learning or career context, theoretical framework, forms of career exploration or related career-development activity, career-related outcomes, key findings, and reported implications. Particular attention was given to how career exploration was conceptualised and how informational, experiential, psychological, transitional, and access-related processes were represented across the studies.

The thematic synthesis followed a hybrid inductive-deductive approach. The deductive component was informed by the developmental logic of STEM career formation and by recurrent social-cognitive constructs, including learning experiences, self-efficacy, outcome expectations, identity, career awareness, contextual supports, and barriers. These constructs functioned as sensitising concepts rather than predetermined coding categories, allowing theoretically relevant relationships to be examined while preserving openness to patterns emerging from the empirical evidence.

Inductively, recurring patterns were identified through comparison of study findings across educational stages and contexts. Initial codes captured repeated ideas such as structured career-learning activities, informal and out-of-school STEM experiences, professional exposure, mentoring, identity development, self-efficacy, career awareness, pathway transitions, workforce preparation, gender, and differential access to career-development opportunities. Related codes were progressively clustered, compared, and refined into broader analytical themes.

Theme development proceeded iteratively through coding, clustering, cross-study comparison, and refinement against the study-level evidence matrix. A theme was retained when it demonstrated recurrence across multiple studies, internal conceptual coherence, sufficient distinction from other themes, and clear relevance to the review questions. Studies were permitted to contribute to more than one theme when their findings addressed overlapping processes. This iterative process resulted in five final themes: Career Exploration as a Structured Developmental Process; Experiential, Informal, and Out-of-School STEM Learning as Career Exploration Contexts; Social-Cognitive and Psychological Mechanisms Linking STEM Experiences to Career Outcomes; Career Exploration Across Educational Transitions and STEM Career Pathways; and Equity, Gender, and Access in STEM Career Exploration.

2.6 Quality appraisal

The methodological quality of the 28 included studies was evaluated using a quality-appraisal framework adapted from Kitchenham and Charters (2007) and Abouzahra et al. (2020). The appraisal comprised six criteria: clarity of the study purpose, relevance and contribution of the study, appropriateness of the methodological approach, clarity of key concepts and research procedures, engagement with relevant literature, and acknowledgement of study limitations.

Each criterion was scored as 1 when fully satisfied, 0.5 when partially satisfied, and 0 when not adequately addressed, yielding a maximum possible score of 6. The same predefined criteria were applied to all studies to support consistency in appraisal. A total score above 3.0, representing satisfaction of more than half of the appraisal criteria, was used as the minimum threshold for methodological adequacy and retention in the synthesis.

The six quality-appraisal criteria were defined as follows:

1. Clarity of study purpose: the extent to which the research aim or objective was explicitly stated and clearly defined.
2. Relevance and contribution: the extent to which the study demonstrated its significance, practical relevance, or contribution to the field.
3. Appropriateness of methodology: the suitability of the research design, data-collection procedures, and analytical methods for addressing the stated research aim.
4. Clarity of key concepts and procedures: the extent to which the main concepts, methodological procedures, and research processes were described in sufficient detail.
5. Engagement with related literature: the extent to which the study was positioned within relevant existing research and theoretical perspectives.
6. Acknowledgement of limitations: the extent to which the authors explicitly identified and discussed the limitations of their study.

Appraisal decisions were recorded at the criterion level for each study to maintain a transparent audit trail between individual quality judgements and the final study-level scores.

3. RESULTS AND DISCUSSION

3.1 Quality Appraisal Results

Table 3 presents the methodological quality assessment of the 28 studies included in the systematic review. All studies achieved scores above the predefined minimum quality threshold of 3.0. Consequently, no study was excluded on the basis of methodological quality, and all 28 studies were retained for thematic synthesis.

Table 3. Quality appraisal results for selected primary studies

	Author	QA1	QA2	QA3	QA4	QA5	QA6	Total Mark	Percentage (%)
1.	Amanova et al. (2025)	Y	Y	Y	Y	P	Y	5.5	91.7
2.	Bahr et al. (2025)	Y	Y	Y	Y	Y	Y	6.0	100.0
3.	Blanchard et al. (2023)	Y	Y	Y	Y	Y	Y	6.0	100.0
4.	Burnett et al. (2025)	Y	Y	Y	Y	Y	Y	6.0	100.0
5.	Chen et al. (2023)	Y	Y	Y	Y	Y	Y	6.0	100.0
6.	Chen et al. (2022)	Y	Y	Y	Y	Y	Y	6.0	100.0
7.	Chen et al. (2024)	Y	Y	Y	Y	Y	Y	6.0	100.0
8.	Choudhary et al. (2025)	Y	Y	Y	Y	Y	Y	6.0	100.0
9.	Ferguson et al. (2023)	Y	Y	Y	Y	Y	Y	6.0	100.0
10.	Ford et al. (2024)	Y	Y	P	Y	P	Y	5.0	83.3
11.	Foster et al. (2025)	Y	Y	Y	Y	P	P	5.0	83.3
12.	Gossen (2024)	Y	Y	Y	Y	Y	Y	6.0	100.0
13.	Gossen and Ivey (2023)	Y	Y	Y	Y	Y	Y	6.0	100.0
14.	Guo et al. (2026)	Y	Y	Y	Y	Y	Y	6.0	100.0
15.	Hiçde and Aktamış (2022)	Y	Y	Y	Y	Y	N	5.0	83.3
16.	Huang et al. (2022)	Y	Y	Y	Y	Y	Y	6.0	100.0
17.	Jiang et al. (2024)	Y	Y	Y	Y	Y	Y	6.0	100.0
18.	Kitchen et al. (2022)	Y	Y	Y	Y	Y	Y	6.0	100.0
19.	Kitchen et al. (2024)	Y	Y	Y	Y	Y	Y	6.0	100.0
20.	Lincoln et al. (2025)	Y	Y	Y	Y	Y	Y	6.0	100.0
21.	Liu et al. (2024)	Y	Y	Y	Y	Y	Y	6.0	100.0
22.	McCartney et al. (2022)	Y	Y	Y	Y	Y	P	5.5	91.7
23.	Price et al. (2025)	Y	Y	Y	Y	Y	Y	6.0	100.0
24.	Rende et al. (2022)	Y	Y	Y	Y	Y	Y	6.0	100.0
25.	Sonnert et al. (2025)	Y	Y	Y	Y	Y	Y	6.0	100.0
26.	Thibodeaux et al. (2025)	Y	Y	Y	Y	Y	Y	6.0	100.0
27.	Webber et al. (2025)	Y	Y	Y	Y	Y	Y	6.0	100.0
28.	Zhou et al. (2025)	Y	Y	Y	Y	Y	Y	6.0	100.0

Note. Y = fully satisfied (1.0); P = partially satisfied (0.5); N = not adequately addressed (0).

3.2 Summary of Quality Assessment

Overall, the included studies demonstrated generally strong methodological adequacy according to the predefined appraisal criteria. Of the 28 studies, 23 achieved the maximum score of 6.0 (100%), while two scored 5.5 (91.7%) and three scored 5.0 (83.3%). The lower-scoring studies showed only limited shortcomings in selected criteria and remained above the predefined quality threshold. Accordingly, all 28 studies were retained for thematic synthesis and development of the evidence-informed conceptual framework.

3.3 Characteristics of the Included Studies

The 28 studies represented a geographically concentrated but methodologically diverse body of evidence. Most were conducted in the United States ($n = 19$), followed by China ($n = 3$) and Hong Kong SAR ($n = 3$), with single studies conducted in Australia, Türkiye, and across Germany/Austria. This geographical distribution is illustrated in Figure 2 and indicates that, although career exploration within STEM pathways has attracted attention across different educational systems, the current evidence base remains strongly dominated by the U.S. context.

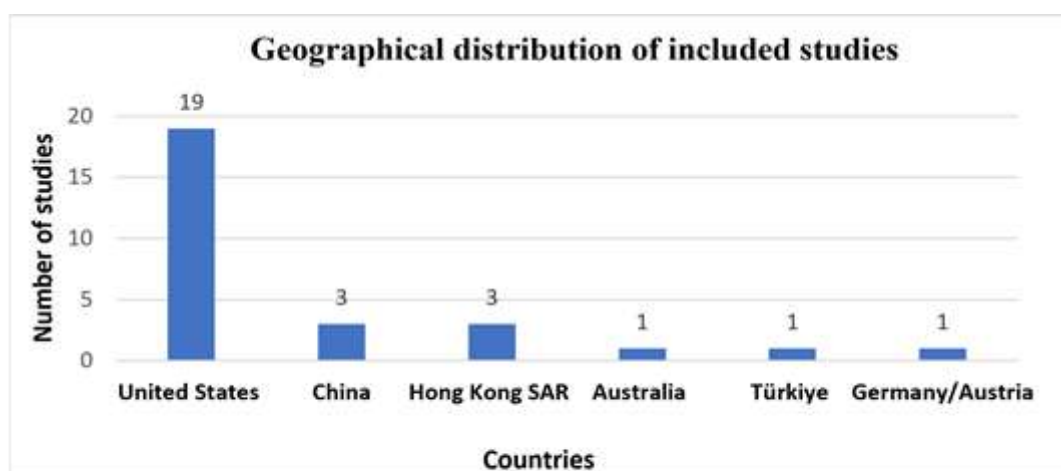


Figure 2. Geographical distribution of the included studies.

Methodologically, the evidence base was relatively balanced between mixed-methods ($n = 13$) and quantitative studies ($n = 12$), whereas only three studies adopted primarily qualitative designs. As shown in Figure 3, this distribution supports examination of both measurable career-related outcomes and students' interpretations of educational and occupational experiences. However, the limited number of longitudinal studies constrains understanding of how career exploration changes across extended educational and career transitions.

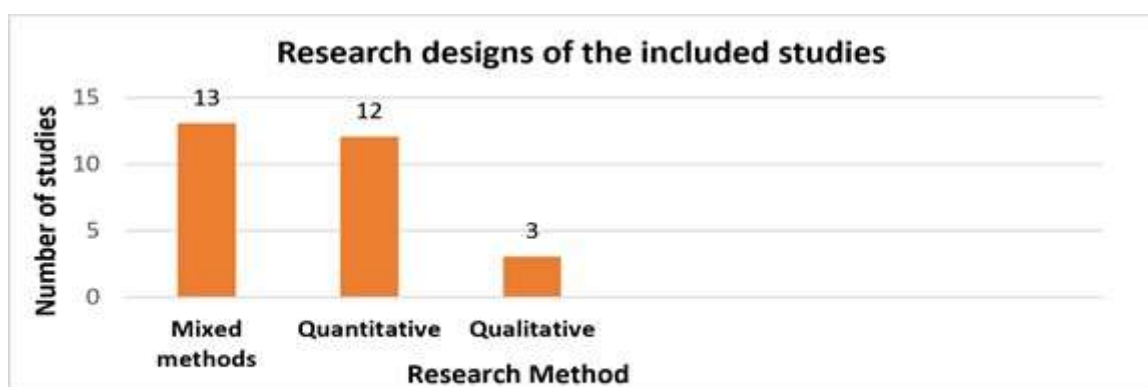


Figure 3. Distribution of the included studies by research design.

The distribution across STEM education-to-career pathways was uneven, as shown in Figure 4. Fifteen studies focused on secondary or high-school populations, seven examined transitions between pre-college experiences and postsecondary career intentions, four focused primarily on undergraduate career exploration and preparation, and only two traced participants across educational stages toward later career outcomes. This distribution reveals a clear concentration of evidence on the formation of STEM career interest and aspirations, with substantially less evidence on how career exploration operates during later transitions into employment or across longer-term career trajectories.

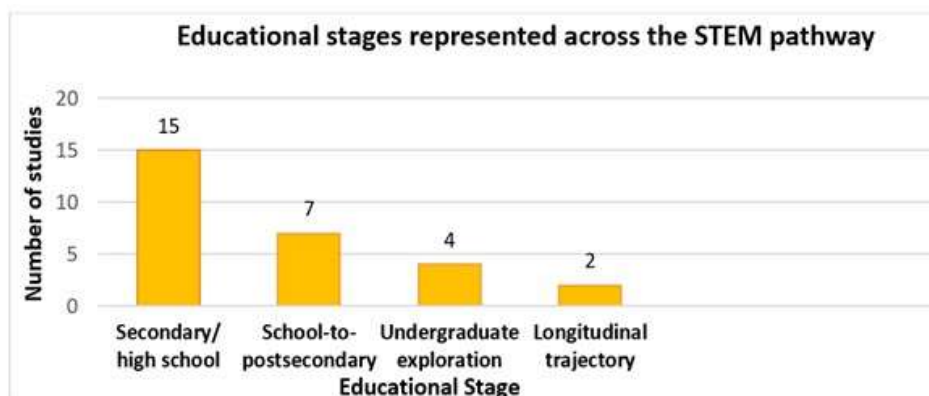


Figure 4. Distribution of the included studies across the STEM education-to-career pathway.

3.4 Thematic Synthesis of the Selected Studies

The thematic synthesis identified five interrelated themes that explain the role of career exploration across STEM education-to-career pathways. These themes represent complementary rather than mutually exclusive processes through which students encounter, interpret, and act on STEM-related career opportunities across different developmental and educational stages. Theme 1, Career Exploration as a Structured Developmental Process, captures deliberate activities through which students develop career awareness, investigate occupational options, plan possible pathways, and refine career decisions. Theme 2, Experiential, Informal, and Out-of-School STEM Learning as Career Exploration Contexts, reflects learning environments that expose students to authentic STEM practices, professionals, and occupational possibilities. Theme 3, Social-Cognitive and Psychological Mechanisms Linking STEM Experiences to Career Outcomes, focuses on processes such as self-efficacy, outcome expectations, identity, self-concept, and career awareness through which STEM experiences are translated into career interest, intention, and choice. Theme 4, Career Exploration Across Educational Transitions and STEM Career Pathways, addresses how exploration operates across transitions from secondary education to postsecondary study, undergraduate preparation, and movement toward employment. Theme 5, Equity, Gender, and Access in STEM Career Exploration, captures the social and structural conditions that shape access to meaningful career-development opportunities, including mentoring, role-model exposure, family support, socioeconomic resources, and participation in enrichment programmes. Collectively, the five themes indicate that career exploration operates as a recurring and context-sensitive developmental process through which STEM experiences are interpreted, career possibilities are evaluated, and educational or occupational directions may be formed, confirmed, refined, or redirected.

Table 4. Distribution of included studies across the identified themes

Studies	Theme 1 (n=7): Career exploration as a structured developmental process	Theme 2 (n=11): Experiential, informal, and out-of-school STEM learning as career exploration contexts	Theme 3 (n=8): Social-cognitive and psychological mechanisms linking STEM experiences to career outcomes	Theme 4 (n=9): Career exploration across educational transitions and STEM career pathways	Theme 5 (n=7): Equity, gender, and access in STEM career exploration
Amanova et al. (2025)		✓			
Bahr et al. (2025)		✓			✓
Blanchard et al. (2023)		✓			
Burnett et al. (2025)					✓

Chen et al. (2022)			✓		
Chen et al. (2023)			✓		
Chen et al. (2024)			✓		
Choudhary et al. (2025)		✓			✓
Ferguson et al. (2023)	✓				
Ford et al. (2024)	✓			✓	✓
Foster et al. (2025)	✓				
Gossen (2024)			✓		
Gossen and Ivey (2023)			✓		
Guo et al. (2026)			✓		
Higde and Aktamış (2022)		✓			
Huang et al. (2022)		✓			
Jiang et al. (2024)			✓		
Kitchen et al. (2022)		✓		✓	
Kitchen et al. (2024)	✓			✓	
Lincoln et al. (2025)		✓			✓
Liu et al. (2024)	✓			✓	
McCartney et al. (2022)	✓			✓	
Price et al. (2025)		✓		✓	✓
Rende et al. (2022)		✓		✓	
Sonnert et al. (2025)			✓		
Thibodeaux et al. (2025)	✓			✓	
Webber et al. (2025)				✓	
Zhou et al. (2025)		✓			✓

As shown in Table 4, several studies contributed to more than one theme, underscoring the interdependence of experiential, psychological, transitional, and contextual dimensions of career exploration. Across the evidence base, structured career-learning activities and authentic STEM experiences were interpreted through social-cognitive processes such as self-efficacy, outcome expectations, identity, self-concept, and career awareness, while access to these opportunities varied across student groups. This pattern supports a developmental interpretation of career exploration as a recurring process that is revisited across educational and occupational transitions rather than confined to a single career-decision point.

3.4.1 Theme 1: Career Exploration as a Structured Developmental Process

The studies within this theme portray career exploration as a deliberate developmental process rather than passive exposure to STEM occupations. At the secondary-school stage, structured career information and guided exploration were particularly important in helping students develop awareness of available STEM pathways. Ferguson et al. (2023), for example, found that students remained unfamiliar with many technician and technologist careers despite reporting the use of several career-exploration resources during high school. Kitchen et al. (2024) reported that participation in college-run STEM career days was associated with 1.3 times greater odds of expressing STEM career aspirations, while Ford et al. (2024) showed that career discovery, industry engagement, mentorship, and practical experiences enabled female high-school students to examine STEM careers in more concrete ways.

Evidence from undergraduate settings shows that structured career exploration extends beyond occupational awareness to reflection, planning, confidence building, and evaluation of alternative career pathways. Foster et al. (2025) reported that

integrating purpose-driven career exploration into an introductory biology course encouraged a more reflective approach to career planning while strengthening career-related self-efficacy and understanding of outcome expectations. Liu et al. (2024) similarly found that a structured life-sciences career exploration course increased students' satisfaction with their career choices, confidence in remaining in their major, confidence in securing employment or pursuing graduate study, and career self-efficacy. McCartney et al. (2022) further showed that career-development modules encouraged biology students to consider broader applications of their scientific knowledge and strengthened science- and biology-related identities.

Structured exploration also appeared to be more meaningful when informational activities were combined with authentic or career-relevant experiences. Thibodeaux et al. (2025) reported significant pre-post improvements in students' knowledge of STEM careers, college applications, college-readiness resources, and educational routes linked to specific career pathways following an industry-focused STEM camp. Ford et al. (2024) similarly highlighted the value of interaction with STEM professionals, mentoring, industry-linked projects, and leadership activities, while Kitchen et al. (2024) demonstrated that even relatively brief career-day experiences could contribute to STEM career aspirations when occupational information was presented in a structured setting. Ferguson et al. (2023), however, showed that the use of multiple career-exploration resources did not necessarily ensure adequate awareness of less visible technical STEM occupations.

Overall, Theme 1 indicates that structured career exploration supports progression from broad occupational awareness toward more deliberate consideration, planning, and evaluation of STEM pathways. Across educational stages, information provision alone appeared insufficient; its value was greater when career information was specific, connected to authentic experiences, and accompanied by opportunities for reflection and evaluation of personal fit.

3.4.2 Theme 2: Experiential, Informal, and Out-of-School STEM Learning as Career Exploration Contexts

The studies grouped under this theme show that career exploration frequently develops through experiential and informal settings that allow students to encounter STEM beyond conventional classroom instruction. Summer camps, after-school clubs, university-linked programmes, enrichment activities, and community-based STEM experiences created opportunities for students to connect disciplinary knowledge with possible educational and occupational futures. Amanova et al. (2025) reported significant increases in STEM career interest following participation in a summer STEM camp, particularly in engineering, alongside greater understanding of the practical applications of STEM and available career opportunities. Hıgde and Aktamış (2022) similarly found that STEM activities improved students' career interests, motivation, and science-process skills relative to a control group. Blanchard et al. (2023) further found that 77% of participants in culturally relevant after-school STEM clubs expressed interest in at least one STEM career, with stronger career interest among students with higher levels of club attendance.

A recurring pattern across the studies was the importance of authentic participation and contact with real-world STEM practices. Choudhary et al. (2025) found that a short enrichment programme combining female role models, hands-on workshops, and industry immersion increased Grade 9 girls' confidence and interest in STEM careers, with particularly positive responses to engineering and sustainability activities. Huang et al. (2022) reported similar benefits in a community-service STEM programme in which students applied STEM knowledge to authentic community problems, with improvements in STEM career interest as well as creativity, collaboration, and perseverance. Lincoln et al. (2025) likewise showed that participation in an experiential after-school programme was associated with stronger self-efficacy experiences, greater willingness to explore careers, and deeper prosocial motivation among adolescents.

Across Theme 2, the career-related value of experiential and informal STEM settings appeared to depend less on whether learning occurred outside formal classrooms and more on the presence of authentic participation, professional or role-model exposure, and explicit connections between STEM activities and possible futures. These features distinguish career-relevant exploration from extracurricular participation that provides exposure without meaningful interpretation of occupational possibilities.

3.4.3 Theme 3: Social-Cognitive and Psychological Mechanisms Linking STEM Experiences to Career Outcomes

The studies within this theme indicate that STEM experiences do not shape career outcomes through exposure alone. Instead, their influence is frequently mediated or conditioned by social-cognitive and psychological mechanisms, particularly self-efficacy, outcome expectations, identity, self-concept, career awareness, and perceptions of STEM professionals. Jiang et al. (2024) found that STEM career awareness strengthened career interest through self-efficacy and outcome expectations, with

the effect on analytical STEM career interest fully mediated by these two constructs. Chen et al. (2023) similarly reported that pre-college STEM media exposure was associated with later STEM career interest primarily through STEM identity and, to a lesser extent, personal career outcome expectations. Chen et al. (2024) further showed that school STEM opportunities were not directly associated with career aspirations but became relevant when students developed more positive perceptions of STEM professionals.

Self-beliefs emerged as a particularly consistent mechanism across the reviewed studies. Gossen and Ivey (2023) found that students in STEM majors were more likely to report early STEM experiences, family involvement, strong performance in STEM coursework, extracurricular participation, and career-specific learning experiences. Their findings suggested that what students perceived as innate STEM interest may partly reflect accumulated prior experiences. Gossen (2024) likewise showed that experiences related to career futures, interest and ability, direct instruction, and discipline-specific activities predicted STEM beliefs and career intentions differently across STEM fields. Chen et al. (2022) also found that perceived parental expectations, out-of-school STEM experiences, and media consumption were associated with adolescents' aspirations partly through mathematics and science self-efficacy.

Identity and self-concept were also important in explaining whether positive STEM experiences translated into career-related outcomes. Chen et al. (2024) found that positive perceptions of STEM professionals were associated with career aspirations among students with average or high STEM self-concept, but not among those with low self-concept. Sonnert et al. (2025) showed that both in-school and out-of-school experiences contributed to STEM identity and career interest, although the two forms of learning appeared to operate differently. In-school preparation showed a relatively stronger relationship with career interest, whereas out-of-school experiences were more strongly associated with identity. Chen et al. (2023) also identified STEM identity as an important mechanism linking several forms of media exposure with career interest.

Guo et al. (2026) provided particularly direct evidence of the role of career exploration within this social-cognitive process. In their model, career exploration was the strongest direct predictor of science-related career choice and functioned as an important bridge between learning experiences and later career decisions. Science identity did not consistently translate directly into career choice; instead, its influence operated through career exploration. These findings align with Jiang et al. (2024), Chen et al. (2024), and Sonnert et al. (2025), which collectively show that the relationship between STEM experiences and career outcomes is shaped by students' beliefs, interpretations, identities, and perceptions of possible career pathways.

Overall, Theme 3 positions career exploration within a broader social-cognitive process in which STEM experiences are interpreted through beliefs about capability, anticipated outcomes, identity, career awareness, and perceived attainability. Across the reviewed studies, these constructs help explain why similar STEM experiences may be associated with different career-related outcomes across individuals and contexts.

3.4.4 Theme 4: Career Exploration Across Educational Transitions and STEM Career Pathways

The fourth theme shows that career exploration extends across successive educational transitions rather than occurring at a single decision point. At the secondary-school level, exploration often supported movement from general STEM interest toward decisions about postsecondary study and future career directions. Ford et al. (2024) showed that female high-school students benefited from career discovery, industry engagement, mentorship, and practical experience that supported preparation for postsecondary STEM education and later career opportunities. Kitchen et al. (2022) found that students who participated in college-run STEM clubs and programmes during high school had 1.49 times the odds of expressing STEM career aspirations at the beginning of college, while Kitchen et al. (2024) reported a comparable positive association for participation in college-run STEM career days. Thibodeaux et al. (2025) further found that an industry-focused STEM camp increased students' familiarity with college applications, college-readiness resources, educational requirements, and specific STEM career pathways.

At the undergraduate stage, career exploration became more closely associated with evaluating career fit, refining occupational preferences, and preparing for post-degree transitions. Liu et al. (2024) found that a structured life-sciences career exploration course increased students' satisfaction with their chosen career paths, confidence in remaining in their majors, and confidence in obtaining employment or pursuing graduate study. The course also encouraged students to consider career fit in relation to interests, values, personality, and skills. McCartney et al. (2022) similarly used career-development modules to connect scientific skills with employer expectations, professional societies, resumes, personal statements, and future career options. Webber et al.

(2025) extended this pattern toward workforce preparation by showing that work-related experiential activities before graduation contributed to the development of career competencies, particularly professionalism and communication.

Several studies also demonstrated that STEM career pathways are not always linear. Rende et al. (2022) found that participation in a multi-year science-museum volunteer programme was associated with sustained science career interest and accelerated academic and career development. Price et al. (2025) provided longitudinal evidence that some participants moved out of STEM majors and later returned to STEM-related pathways, indicating that movement away from STEM at one stage did not necessarily represent permanent exit. Liu et al. (2024) likewise showed that career exploration could reduce confidence in an initially selected pathway while increasing clarity about more suitable alternatives. McCartney et al. (2022) similarly recognised that graduates may need to reconsider career goals after degree completion.

Overall, Theme 4 indicates that the function of career exploration changes across transition points. During secondary education, exploration primarily supports awareness and preparation for postsecondary choices; during undergraduate education, it increasingly concerns career fit, employability, and workforce preparation; and across longer trajectories, it can support confirmation, redirection, and re-entry. This pattern reinforces a non-linear rather than pipeline-based interpretation of STEM career development.

3.4.5 Theme 5: Equity, Gender, and Access in STEM Career Exploration

The studies within this theme show that opportunities for STEM career exploration are not distributed equally across student groups. Access to mentoring, professional role models, enrichment programmes, extracurricular activities, family support, and other career-related resources can shape the extent to which students are able to explore and sustain interest in STEM pathways. Choudhary et al. (2025) found that a short enrichment programme designed for Grade 9 girls, incorporating female role models, hands-on activities, and industry exposure, increased participants' confidence and interest in STEM careers. Ford et al. (2024) similarly demonstrated that mentorship, career discovery, leadership development, and engagement with STEM professionals helped female high-school students explore technical STEM careers more concretely.

Several studies also highlighted the importance of social and contextual resources beyond formal schooling. Zhou et al. (2025) showed that access to supportive learning environments and career-related opportunities influenced how students developed and sustained STEM aspirations. Lincoln et al. (2025) likewise found that participation in an experiential after-school programme provided adolescents with opportunities to strengthen self-efficacy, explore possible careers, and connect STEM learning with broader personal and social goals. Bahr et al. (2025) and Price et al. (2025) further indicated that differences in access to enrichment experiences, institutional support, and educational resources may shape how students navigate STEM pathways over time.

Gender also emerged as a recurring dimension of career exploration. Burnett et al. (2025), Choudhary et al. (2025), and Ford et al. (2024) drew attention to the value of targeted programmes, female role models, mentoring, and inclusive STEM experiences in helping girls and young women consider STEM careers. These studies suggest that career exploration may be particularly important for students who have had limited prior exposure to STEM professionals or who encounter social expectations that can restrict perceptions of available career options.

Overall, Theme 5 indicates that career exploration is shaped not only by individual interests and beliefs but also by unequal access to social, educational, and institutional resources. Differential access to mentors, role models, enrichment programmes, authentic STEM activities, and supportive networks may influence both the breadth of career possibilities students can consider and their capacity to sustain or revise STEM-related directions across transitions.

Taken together, the five themes provide the empirical and conceptual basis for the evidence-informed framework presented in Figure 5, which integrates the recurring relationships among STEM learning experiences, social-cognitive interpretation, career exploration, pathway decisions, and contextual conditions.

Evidence-Informed Conceptual Framework of Career Exploration Across STEM Education-to-Career Pathways

Career exploration is conceptualised as a recurrent developmental process rather than a single pre-choice event.

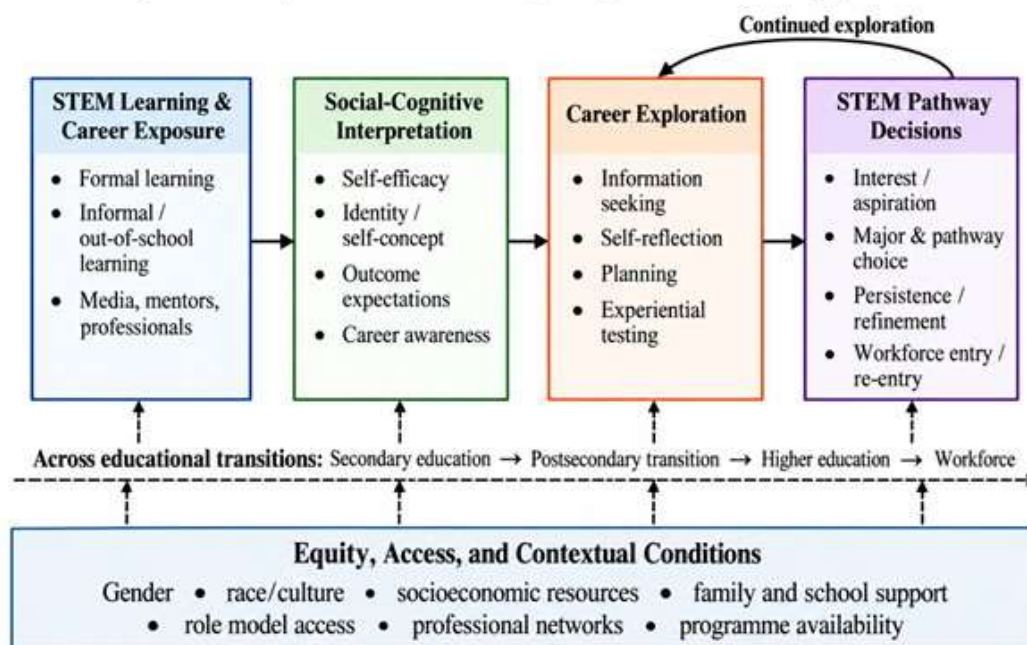


Figure 5. Evidence-informed conceptual framework of career exploration across STEM education-to-career pathways.

3.5 Empirical Support for the Evidence-Informed Career Exploration Framework

The five themes collectively support an evidence-informed framework that positions career exploration as a recurrent developmental process connecting STEM learning experiences with educational and occupational pathways. The framework represents a recurring interpretive sequence in which learning and career exposure interact with social-cognitive processes before individuals engage in more active exploration and pathway evaluation. Structured career information, authentic STEM experiences, and opportunities for reflection may therefore support movement from broad awareness toward more specific consideration of possible careers (Ferguson et al., 2023; Liu et al., 2024).

The social-cognitive component reflects evidence that self-efficacy, outcome expectations, identity, self-concept, and career awareness influence how students interpret STEM experiences. Career exploration may then provide the process through which these interpretations are examined in relation to personal interests, capabilities, and possible occupational routes. Jiang et al. (2024) demonstrated the roles of self-efficacy and outcome expectations in linking career awareness with STEM career interest, while Guo et al. (2026) identified career exploration as an important pathway connecting learning experiences and science identity with science-related career choice.

The framework also represents STEM career development as non-linear. Career exploration may recur as individuals move from secondary education through postsecondary and higher education into the workforce, allowing earlier directions to be confirmed, refined, redirected, or re-entered. Longitudinal evidence of movement out of and back into STEM pathways supports this interpretation (Price et al., 2025). Equity, access, and contextual conditions are positioned across the framework because opportunities to engage with mentors, role models, professional networks, and high-quality STEM experiences are not distributed uniformly across students (Burnett et al., 2025; Ford et al., 2024; Zhou et al., 2025).

Accordingly, Figure 5 should be interpreted as an evidence-informed conceptual synthesis rather than an empirically validated causal model. It integrates recurring relationships identified across the reviewed studies and proposes career exploration as a

dynamic, revisitable process operating within changing educational, psychological, and contextual conditions. The framework therefore offers a basis for future empirical testing rather than evidence of a fixed causal sequence.

4. IMPLICATIONS AND CONTRIBUTIONS

The review contributes theoretically by positioning career exploration as a recurrent and adaptive process across STEM education-to-career pathways rather than as an activity confined to an initial career-choice stage. Across transitions, exploration may support the confirmation, refinement, redirection, or re-entry of STEM-related directions as new experiences and contextual conditions emerge. This interpretation extends social-cognitive accounts of STEM career development by highlighting how self-efficacy, outcome expectations, identity, and career awareness are revisited through exploration over time (Guo et al., 2026; Jiang et al., 2024; Liu et al., 2024).

Methodologically, the review integrates evidence across educational stages, research designs, and learning contexts through a hybrid inductive-deductive thematic synthesis. Permitting individual studies to contribute to multiple themes enabled the analysis to preserve the overlap among experiential, psychological, transitional, and contextual dimensions of career exploration rather than treating them as discrete processes.

Practically, the findings support embedding structured career exploration across secondary and higher education rather than relying on isolated career-information activities. Career-development provision may be strengthened through authentic STEM experiences, professional exposure, mentoring, reflection on career fit, and work-related learning. Particular attention is warranted to equitable access because opportunities for meaningful exploration may vary with school resources, family support, socioeconomic conditions, role-model exposure, and professional networks (Burnett et al., 2025; Ford et al., 2024; Zhou et al., 2025).

5. LIMITATIONS AND FUTURE RESEARCH

This review has several limitations. First, it was restricted to English-language peer-reviewed journal articles published between 2022 and 2026 and indexed in Scopus and Web of Science; relevant evidence from other databases, languages, and grey literature may therefore have been omitted. Second, the 28 included studies varied in educational stage, national context, research design, and the operationalisation of career exploration and related constructs, limiting direct comparability and the extent to which findings can be generalised across settings. Third, both quality appraisal and thematic synthesis involved interpretive judgement; accordingly, the resulting themes should be understood as analytical categories developed from the evidence rather than as mutually exclusive empirical constructs.

Future research should prioritise longitudinal and multi-stage designs that follow individuals across key educational and occupational transitions, particularly beyond secondary education and into workforce entry. Greater attention is also needed to how self-efficacy, outcome expectations, identity, career awareness, and perceived fit interact with career exploration over time. Expanding research beyond predominantly U.S.-based samples would also clarify how gender, socioeconomic background, cultural context, geographic location, and differential access to mentors, professional networks, and high-quality STEM opportunities shape pathway development.

6. CONCLUSION

This systematic review synthesised 28 empirical studies examining career exploration across STEM education-to-career pathways. Across the evidence base, career exploration emerged as a recurring developmental process associated with how students interpret STEM learning experiences, develop career awareness and self-beliefs, evaluate pathway options, and prepare for future participation in STEM.

The review further indicates that STEM career development is not necessarily linear: career directions may be confirmed, refined, redirected, or revisited as individuals move across educational and occupational transitions. Meaningful career exploration therefore depends not only on individual interests and beliefs but also on access to authentic experiences, mentoring, professional exposure, and supportive learning environments. The proposed evidence-informed framework integrates these interconnected processes and provides a theoretically grounded basis for future empirical testing, career-development practice, and STEM education research.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the Faculty of Education, Universiti Kebangsaan Malaysia (UKM), and the Ministry of Education Malaysia (MOE) for their support throughout the study.

FUNDING

This study was conducted with funding support from the Faculty of Education, Universiti Kebangsaan Malaysia, Malaysia.

AUTHOR CONTRIBUTIONS

Kamarnisa Abd Rahim: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Writing.

Izwan Mahmud: Supervision, Review, Final Approval.

Ku Suhaila Ku Ali @ Ku Johari: Supervision, Review, Final Approval.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ETHICS STATEMENT

Ethical approval was not required for this study because it involved a systematic review and synthesis of previously published studies and did not involve direct participation of humans or animals.

DATA AVAILABILITY STATEMENT

The data supporting the findings of this systematic review were derived from published studies included in the review. The study-level evidence matrix and related extracted data are available from the corresponding author upon reasonable request.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES

During the preparation of this manuscript, the authors used ChatGPT (OpenAI, GPT-5.6) for language refinement, structural editing, and assistance in preparing the conceptual framework. All AI-assisted content was critically reviewed, verified, and approved by the authors, who take full responsibility for the accuracy, integrity, and final content of the manuscript.

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