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Learning Motivation, Self-Efficacy, and Learning Outcomes in Chemistry Education: A Systematic Literature Review

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ABSTRACT

Chemistry education faces persistent challenges in engaging students and fostering meaningful learning. Learning motivation and self-efficacy are recognized as critical psychological factors that influence student learning outcomes, yet their roles in chemistry education have not been systematically synthesized. This systematic literature review examines how learning motivation and self-efficacy have been investigated in chemistry education, and what relationships between these variables and learning outcomes have been reported. A systematic search was conducted across electronic databases using predefined search terms combining learning motivation, self-efficacy, learning outcomes, and chemistry education contexts. From 300 initially identified records, 222 underwent screening and 18 studies met the final inclusion criteria. All included studies were assessed for quality using eight quality assessment questions, and data were extracted using a structured framework. The 18 included studies employed diverse research designs, operationalized motivation and self-efficacy in varied ways, and reported predominantly positive relationships between motivation and learning outcomes, and between self-efficacy and learning outcomes. Fewer studies examined the relationship between motivation and self-efficacy within chemistry education specifically. Instructional contexts including problem-based learning, virtual laboratories, and gamification were frequently associated with improvements in motivation, self-efficacy, and achievement. While empirical evidence supports the importance of motivation and self-efficacy in chemistry learning, the literature exhibits gaps in simultaneous examination of both constructs, longitudinal designs, and chemistry-specific measurement instruments. Future research should employ rigorous designs to clarify mediating mechanisms and examine contextual factors that shape these relationships.

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Introduction

Chemistry education represents a critical component of science curricula worldwide, yet students consistently report difficulties engaging with chemistry content and struggle to achieve desired learning outcomes (Huda & Rohaeti, 2023; Salta & Koulougliotis, 2022). These challenges occur at both secondary and tertiary levels, where chemistry is frequently perceived as abstract, difficult, and disconnected from students' everyday experiences. Understanding the psychological factors that influence chemistry learning outcomes has therefore become increasingly important for educators and researchers seeking evidence-based approaches to improve students' learning experiences and achievement. Persistent difficulties in chemistry achievement and students' engagement with chemistry suggest that cognitive factors alone may not fully explain learning in this discipline. Increasing attention has consequently been directed toward affective and motivational dimensions, particularly students' motivation to learn and their beliefs about their capability to succeed in chemistry. These psychological variables do not operate independently but interact with instructional design, educational context, and individual student characteristics to shape students' engagement and learning outcomes.

Learning motivation encompasses students' willingness to engage with academic content, the reasons underlying their pursuit of learning goals, and the persistence they demonstrate when encountering challenging learning tasks (Fitriyana et al., 2021; Lin & Wu, 2021). Within chemistry education, motivation has been conceptualized in various ways, including intrinsic motivation arising from interest and curiosity about chemical phenomena, extrinsic motivation associated with grades or external incentives, and motivation derived from the perceived relevance of chemistry to everyday life, future careers, and practical applications (Lutfi et al., 2023; Magwilang, 2022). Motivation is particularly important in chemistry because students frequently encounter abstract concepts, complex representations, mathematical reasoning, and demanding laboratory activities. Evidence from chemistry education research indicates that students with stronger motivation tend to demonstrate greater persistence, effort, and engagement, which may contribute to improved academic achievement (Ahmad et al., 2021; Vogelzang et al., 2019). Motivation also appears to be influenced by instructional approaches, with approaches such as context-based instruction, problem-based learning, and gamification being associated with increased student engagement and motivation toward chemistry learning (Vogelzang et al., 2021). Nevertheless, the ways in which motivation contributes to learning outcomes, particularly in interaction with other psychological factors such as self-efficacy, remain insufficiently synthesized.

Self-efficacy represents students' beliefs regarding their capability to successfully perform particular tasks and achieve desired outcomes. In chemistry education, self-efficacy is particularly relevant because chemistry learning requires students to engage with complex conceptual, procedural, mathematical, problem-solving, and laboratory-based tasks (Fitriyana et al., 2020; Rusmansyah et al., 2019). Unlike general academic self-concept, self-efficacy is typically understood as more closely related to students' perceived capability within particular domains or tasks. Students who possess stronger chemistry-related self-efficacy may be more willing to undertake challenging tasks, persist when difficulties arise, and invest greater effort in learning activities. Empirical studies have also indicated that instructional environments can influence students' self-efficacy. Virtual laboratory environments, scaffolded learning, collaborative activities, and technology-supported instruction, for example, have been associated with changes in students' confidence in performing chemistry-related tasks (Ali et al., 2023; Astiningsih & Partana, 2020). However, despite growing attention to self-efficacy in chemistry education, the relationship between self-efficacy, learning motivation, and learning outcomes has not yet been comprehensively synthesized.

Learning outcomes in chemistry education have been operationalized through diverse indicators, including academic achievement, conceptual understanding, test performance, laboratory performance, problem-solving ability, and retention of chemical knowledge (Redhana & Suardana, 2021; Johnson et al., 2022). This diversity reflects the multidimensional nature of chemistry learning, which extends beyond the acquisition of factual knowledge to include conceptual reasoning, higher-order thinking, problem solving, and the integration of different representations of chemical phenomena. Such variation in outcome measures is important when examining the relationships between motivation, self-efficacy, and learning outcomes because different forms of achievement may respond differently to psychological factors. Motivation, for instance, may be particularly relevant to students' persistence and engagement during demanding learning activities, whereas self-efficacy may be more closely associated with students' confidence in solving complex chemistry problems or completing laboratory tasks. Consequently, synthesizing the different ways learning outcomes have been conceptualized and measured is necessary for understanding the broader relationship between psychological factors and achievement in chemistry education.

Although learning motivation and self-efficacy have each been examined in chemistry education research, the existing literature remains fragmented across different educational levels, chemistry topics, instructional contexts, and methodological approaches. Individual studies have reported associations between motivation and achievement, self-efficacy and achievement, or motivation and self-efficacy, but these findings have not been sufficiently integrated to establish broader patterns across chemistry education research. This fragmentation makes it difficult to determine whether the relationships among these constructs are consistent across contexts or whether they vary according to educational level, chemistry topic, instructional approach, and measurement strategy. In addition, differences in the instruments and research designs used to investigate

Southeast Asian Journal of technology and Science
Vol. 6, No. 1, 2025, pp. 142-159

motivation, self-efficacy, and learning outcomes raise questions about the comparability and methodological strength of the available evidence. A systematic synthesis is therefore needed to examine how these constructs have been investigated and to identify the nature and consistency of their reported relationships.

This systematic literature review synthesizes empirical research examining learning motivation, self-efficacy, and learning outcomes within chemistry education. The review seeks to clarify how these psychological constructs have been conceptualized and investigated, the contexts and methodological approaches in which they have been examined, and the relationships reported among motivation, self-efficacy, and students' learning outcomes. Particular attention is given to the characteristics of the research contexts, measurement approaches, instructional settings, and methodological quality of the available evidence. By integrating findings across empirical studies, this review aims to provide a clearer understanding of the role of motivation and self-efficacy in chemistry learning and to identify important directions for future research. This systematic literature review addresses two research questions. RQ1. How have learning motivation and self-efficacy been investigated in chemistry education, particularly in relation to students' learning outcomes? RQ2. What relationships between learning motivation, self-efficacy, and students' learning outcomes have been reported in chemistry education research? These research questions provide the analytical direction for the review by focusing on how learning motivation and self-efficacy have been investigated and how the relationships among motivation, self-efficacy, and learning outcomes have been reported within the specific context of chemistry education.

Method

Review Design

This systematic literature review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The review employed a structured and transparent methodology to identify, evaluate, and synthesize empirical research examining learning motivation, self-efficacy, and learning outcomes in chemistry education. The review protocol was established prior to the screening process and followed a predetermined procedure for study identification, selection, quality assessment, data extraction, and synthesis.

Search Strategy

Systematic searches were conducted across electronic databases relevant to education, psychology, and science education, including ERIC (Education Resources Information Center), PsycINFO, PubMed, and Google Scholar as a supplementary source. The searches were designed to identify empirical studies addressing learning motivation, self-efficacy, and learning outcomes within chemistry education. No language restrictions were applied during the initial search stage; however, only English-language publications that met the predefined eligibility criteria were retained during the screening process.

Information Sources

The primary information sources consisted of peer-reviewed journal articles indexed in educational, psychological, and science education databases. To enhance the identification of potentially relevant studies, citation tracking of included articles and examination of reference lists from relevant literature were also considered. Gray literature, conference proceedings, dissertations, theses, book chapters, and non-peer-reviewed publications were excluded from the final evidence base in accordance with the predefined eligibility criteria.

Search Terms

The search strategy combined four conceptual domains using Boolean operators. The first domain represented learning motivation and included "learning motivation," "student motivation," "academic motivation," "motivation to learn," "intrinsic motivation," "extrinsic motivation," and "motivational beliefs." The second domain represented self-efficacy and included "self-efficacy," "chemistry self-efficacy," "academic self-efficacy," and "chemistry learning self-efficacy." The third domain represented learning outcomes and included "learning outcomes," "academic achievement," "chemistry achievement," "learning achievement," and "chemistry learning outcomes." The fourth domain represented the chemistry education context and included "chemistry education," "chemistry learning," "chemistry teaching," and "chemistry classroom." The complete search strategy combined these four domains using the AND operator, such that studies were retrieved when their records contained terms representing motivation, self-efficacy, learning outcomes, and chemistry education.

Eligibility Criteria

Studies were included when they met all predefined eligibility criteria. Eligible studies were conducted within chemistry education or chemistry learning contexts at the secondary or tertiary level and involved students as participants in chemistry learning. The studies were required to explicitly examine learning motivation, student motivation, or a related motivational construct, as well as self-efficacy or chemistry-specific self-efficacy related to learning. In addition, studies were required to report learning outcomes, academic achievement, or related measures of chemistry learning achievement and to provide empirical evidence concerning relationships, influences, differences, or connections involving motivation, self-efficacy, and/or learning outcomes. Only empirical studies presenting primary data, with full-text availability, published in English, and appearing in peer-reviewed journals were considered eligible. Studies were excluded when they were not focused on chemistry education or chemistry learning, did not include students as primary data sources, did not examine learning motivation or self-efficacy, or did not measure relevant chemistry learning outcomes or academic achievement. Studies in which motivation or self-efficacy was mentioned only superficially without substantive analysis were also excluded. In addition, publications without empirical data, including editorials, commentaries, opinion papers, theoretical papers, conference proceedings, book chapters, theses, dissertations, and other non-journal publications, were excluded. Studies without accessible full texts, studies not written in English, and studies that did not provide substantive evidence relevant to at least one of the research questions were also excluded.

Study Selection

The study selection process consisted of four sequential stages. In the first stage, database searches using the predefined search strategy yielded 300 records, which were subsequently exported for reference management and deduplication. In the second stage, titles and abstracts were screened to assess their apparent relevance to the four core concepts of the review, namely motivation, self-efficacy, learning outcomes, and chemistry education.

Table 1. <Inclusion and Exclusion Criteria>

Criterion	Inclusion	Exclusion
Discipline Context	Studies explicitly in chemistry education or chemistry learning (secondary or tertiary)	Studies in general science education, technology education, or disciplines other than chemistry
Study Population	Students (grades 9-12 or undergraduate/graduate) as primary participants in chemistry learning	Studies without student participants; studies using only teacher/administrator samples
Motivation	Studies examining learning motivation, student motivation, intrinsic/extrinsic motivation, or related constructs (motivation to learn, motivational beliefs)	Studies not examining motivation; studies mentioning motivation only in passing without substantive analysis
Self-Efficacy	Studies examining self-efficacy, chemistry self-efficacy, or chemistry-specific self-efficacy related to learning and achievement	Studies not examining self-efficacy or capability beliefs in chemistry contexts
Learning Outcomes	Studies measuring learning outcomes, academic achievement, conceptual understanding, chemistry achievement, or learning-related performance	Studies not measuring learning outcomes or achievement; focus on factors unrelated to achievement
Empirical Data	Studies presenting primary empirical data from original research with quantitative, qualitative, or mixed-methods designs	Literature reviews, theoretical papers, editorials, commentaries, opinion pieces without empirical data collection
Variable Relationships	Studies providing information about relationships, influences, differences, or connections among motivation, self-efficacy, and/or learning outcomes in chemistry contexts	Studies examining single constructs in isolation without exploring relationships or connections
Full Text Availability	Full text article publicly accessible through databases or institutional repositories	Full text not accessible; only abstract available; article not retrievable
Language	Articles written in English	Articles in languages other than English (e.g., Chinese, Spanish, French, Indonesian)
Publication Type	Peer-reviewed journal articles in academic or scientific journals	Conference proceedings, dissertations, master's theses, book chapters, technical

Criterion	Inclusion	Exclusion
		reports, unpublished manuscripts, non-peer-reviewed publications

Records that were clearly irrelevant were excluded, whereas records that potentially met the eligibility criteria were retained for further assessment, resulting in 222 records proceeding to the next stage. In the third stage, the full texts of the 222 potentially eligible studies were assessed against the predefined inclusion and exclusion criteria, resulting in 68 studies that appeared to meet the eligibility requirements. In the fourth stage, these 68 candidate studies underwent quality assessment using the predefined quality assessment framework. Studies obtaining a quality score of at least 4.5 and providing substantive evidence relevant to the research questions were considered for final inclusion. Following this process, 18 studies that satisfied the eligibility criteria and demonstrated adequate methodological quality were selected as the final included studies.

Quality Assessment

Each included study was assessed using eight quality assessment questions covering the clarity of research objectives, description of the chemistry education context and participants, operationalization of learning motivation and self-efficacy, appropriateness of measurement procedures, assessment of learning outcomes, research design and data collection, appropriateness of data analysis, and alignment between findings and conclusions.

Table 2. <Quality Assessment Framework: Questions and Scoring Procedures>

Code	Quality Assessment Question	Scoring Criteria	Purpose
QA1	Does the study clearly describe its research objectives or research questions related to learning motivation, self-efficacy, and/or learning outcomes in chemistry education?	Yes (1): Clear, specific RQ/objectives related to all three constructs in chemistry context. Partially (0.5): Objectives clear but limited connection to all three constructs. No (0): Vague, unclear, or no mention of objectives related to constructs	Assesses clarity of research direction and alignment with review focus
QA2	Is the chemistry education context and participant population clearly described (educational level, sample size, demographics, institutional setting, chemistry topic)?	Yes (1): All key contextual elements clearly reported. Partially (0.5): Most elements reported but some gaps. No (0): Minimal or no description of context/population	Evaluates transparency and reproducibility; enables assessment of generalizability
QA3	Are learning motivation and self-efficacy clearly defined and operationalized (theoretical framework, specific constructs measured, dimensions)?	Yes (1): Both constructs clearly defined; operationalization explicit. Partially (0.5): One construct clear, other vague; partial operationalization. No (0): Constructs poorly defined or not operationalized	Assesses conceptual clarity and precision; directly relevant to core review constructs
QA4	Are valid and appropriate instruments or procedures used to measure learning motivation and self-efficacy (established instruments, reported psychometric properties, appropriate adaptation)?	Yes (1): Validated instruments used with reported psychometrics (Cronbach's $\alpha \geq 0.70$). Partially (0.5): Established instruments used but incomplete psychometric reporting; adapted instruments without full validation evidence. No (0): Unclear instrument quality; self-created measures without validation; problematic measurement procedures	Evaluates measurement validity and reliability; critical for construct operationalization (QA3, QA4, QA5 are key quality dimensions)
QA5	Are learning outcomes or academic achievement measured using clearly described and appropriate indicators (achievement tests, conceptual	Yes (1): Learning outcomes measured with clearly described, appropriate instruments; well-established indicators. Partially (0.5): Outcomes measured but description incomplete; indicator appropriateness questionable. No (0):	Assesses quality of outcome measurement; critical for answering RQ2; directly relevant to review focus

Code	Quality Assessment Question	Scoring Criteria	Purpose
	understanding measures, performance ratings, grades)?	Poorly described outcomes; inappropriate measurement; unclear outcome indicators	
QA6	Is the research design and data collection procedure adequately described and appropriate for the stated objectives (design type, participant assignment, data collection timeline, procedures clearly explained)?	Yes (1): Design type explicitly stated; procedures clearly described; design appropriate for objectives. Partially (0.5): Design type clear but procedures partially described; design somewhat appropriate. No (0): Design unclear or inappropriate for objectives; procedures inadequately described	Evaluates methodological transparency and appropriateness; affects internal validity assessment
QA7	Are the data analysis methods appropriate for examining the relationships between learning motivation, self-efficacy, and learning outcomes (statistical methods match design; analysis addresses relationships among variables)?	Yes (1): Analysis methods clearly described and appropriate for examining variable relationships (correlation, regression, SEM, t-tests, ANOVA appropriate to data/design). Partially (0.5): Methods described but partially appropriate; some analyses missing. No (0): Methods not described; inappropriate for examining relationships; incomplete analysis	Assesses analytical rigor; critical for answering RQ2 regarding variable relationships
QA8	Are the findings and conclusions clearly supported by the data presented in the study (findings match reported statistics; conclusions justified by evidence; limitations acknowledged)?	Yes (1): Findings clearly supported by data; conclusions justified; limitations acknowledged. Partially (0.5): Most findings supported; some overgeneralization; limited limitation discussion. No (0): Findings/conclusions not well supported; overgeneralization without evidence; no acknowledgment of limitations	Evaluates evidence-conclusion alignment and interpretive integrity; affects confidence in reported relationships
	Maximum Possible Score		8.0 points
	High-Quality Studies		6.5–8.0
	Moderate-Quality Studies		4.5–6.0
	Low-Quality Studies		0–4.0

Each criterion was evaluated using a three-point scoring system in which Yes (Y) received 1 point, Partially (P) received 0.5 points, and No (N) received 0 points, producing a maximum possible score of 8.0. Studies scoring between 6.5 and 8.0 were categorized as high quality, those scoring between 4.5 and 6.0 as moderate quality, and those scoring between 0 and 4.0 as low quality. Studies scoring below 4.5 were excluded from the final synthesis, whereas moderate-quality studies were retained with their methodological limitations considered during interpretation. The complete quality assessment framework and its criteria are presented in Table 2.

Data Extraction

Data were extracted from each included study using a structured extraction framework comprising eleven dimensions presented in Table 3.

Table 3. <Data Extraction Framework: Items And Purposes>

Data Item	Description	Purpose/Research Question
1. Author & Year	Complete author names; publication year; publication venue (journal)	Study identification and tracking; enables citation-reference verification
2. Country & Educational Level	Geographic location of research; educational stage (secondary/upper secondary or tertiary/undergraduate); specific grade levels when available	RQ1: Examining geographic patterns and educational level distribution of research; assessing generalizability across

Data Item	Description	Purpose/Research Question
		contexts
3. Sample & Research Design	Sample size (N); participant demographics when reported (age, gender, prior achievement level, socioeconomic factors); research methodology classification (quantitative, qualitative, mixed-methods); specific design type (correlational, quasi-experimental, etc.)	RQ1: Characterizing research approaches and designs employed; methodological quality assessment; sample representativeness
4. Learning Motivation	Which motivational constructs examined (intrinsic motivation, extrinsic motivation, chemistry-specific motivation, interest, attitudes, achievement motivation, motivational beliefs, engagement); motivation dimensions/types measured	RQ1: How motivation operationalized and investigated in chemistry contexts; identifying construct variations across studies
5. Self-Efficacy	Which self-efficacy constructs examined (general academic self-efficacy, chemistry self-efficacy, chemistry-domain efficacy, task-specific self-efficacy for lab work/problem-solving); specificity level of measurement	RQ1: How self-efficacy operationalized and investigated; assessing measurement specificity and appropriateness
6. Learning Outcomes	How learning outcomes measured and defined (standardized achievement test scores, course grades, conceptual understanding assessment scores, laboratory performance ratings, problem-solving scores, retention measures, transfer measures); outcome construct clarity	RQ1: Characterizing learning outcomes assessed; RQ2: Understanding which outcomes are examined in relation to motivation/self-efficacy
7. Measurement Instruments	Specific names of scales/instruments used for motivation (e.g., Intrinsic Motivation Inventory), self-efficacy (e.g., Chemistry Self-Efficacy Scale), and outcomes; instrument authors when available; reported psychometric properties (Cronbach's α, validity evidence)	RQ1: Characterizing measurement approaches and instrument quality; assessing measurement validity and reliability; identifying gaps in measurement practices
8. Instructional Context/Approach	Pedagogical methods employed (traditional lecture, problem-based learning, project-based learning, virtual laboratory, gamification, inquiry-based learning, blended learning, cooperative learning, case-based learning); duration and intensity of intervention when applicable	RQ1: Characterizing instructional contexts; RQ2: Examining potential moderating effects of instruction on relationships among variables
9. Relationship among Variables	Specific relationships examined and direction if clear (motivation ↔ self-efficacy; motivation → outcomes; self-efficacy → outcomes; motivation + self-efficacy → outcomes combined effects; mediation effects; moderation effects); nature of relationships (positive, negative, non-significant)	RQ2: Primary focus; identifies directly reported relationships among core constructs; enables categorization of findings
10. Main Findings	Key empirical results including effect sizes when available (correlation coefficients r, standardized regression coefficients β, t-values, F-values, means/standard deviations, Cohen's d); directional findings (positive/negative/non-significant); confidence intervals when reported	RQ2: Synthesizing quantitative evidence about variable relationships; comparing effect sizes across studies
11. Study Limitations	Acknowledged limitations noted by authors (sample size, generalizability constraints, measurement limitations, temporal constraints, contextual limitations, methodological constraints)	Quality assessment; synthesis of evidence strength; informing interpretation of findings; identifying research gaps

The extracted information included author and year, country and educational level, sample and research design, learning motivation, self-efficacy, learning outcomes, measurement instruments, instructional context or approach, relationships among the core variables, main findings, and study limitations. Data extraction was conducted systematically to preserve the meaning and findings reported in the original studies. Where statistical information such as correlation coefficients, regression coefficients, significance levels, or other relevant statistical indicators was reported, these values were recorded as presented in the respective source.

Data Synthesis

The findings were synthesized through narrative synthesis and organized according to the two research questions. For RQ1, the synthesis focused on identifying and comparing how learning motivation and self-efficacy have been investigated in chemistry education, including differences in educational level, research design, participant characteristics, chemistry learning context, constructs, measurement instruments, instructional approaches, and learning outcomes. For RQ2, the synthesis focused on the reported relationships among learning motivation, self-efficacy, and students' learning outcomes. Findings were organized according to the relationships between motivation and self-efficacy, motivation and learning outcomes, self-efficacy and learning outcomes, and, where evidence was available, the combined relationship among the three constructs. Reported relationships were characterized as positive, negative, or non-significant, while differences across educational contexts, instructional approaches, measurement strategies, and methodological characteristics were considered when interpreting variations in findings.

Results and Discussions

Study Selection

The study selection process followed a sequential screening procedure designed to identify empirical studies relevant to learning motivation, self-efficacy, and learning outcomes in chemistry education. The initial database search identified 300 records. Following the removal of duplicates and preliminary relevance filtering, 222 records remained for further screening. Title and abstract screening was then conducted to assess the relevance of each record to the core concepts of the review. Studies that were clearly unrelated to chemistry education, learning motivation, self-efficacy, or learning outcomes were excluded at this stage. Full-text assessment was subsequently conducted on the potentially eligible studies, resulting in 68 studies that met the basic eligibility requirements. These studies were then subjected to the predefined quality assessment process. Following the application of the methodological quality criteria, 18 studies satisfied the eligibility requirements and demonstrated moderate-to-high methodological quality and were therefore retained as the final evidence base for synthesis.

Characteristics of the Included Studies

The 18 included studies represented a range of geographical and educational contexts, although the evidence base was concentrated in several regions. Eleven studies originated from Asian contexts, particularly Indonesia, the Philippines, and Malaysia, while four studies were conducted in Europe and one in Africa. In terms of educational level, secondary education accounted for 10 studies (56%), whereas 8 studies (44%) focused on tertiary or undergraduate chemistry education. Sample sizes varied substantially, ranging from 32 to 427 students, reflecting considerable variation in study scope and research context. Quantitative approaches were dominant, comprising 11 studies (61%), followed by mixed-methods research with 5 studies (28%) and qualitative research with 2 studies (11%). The included studies covered a range of chemistry contexts, including organic chemistry, electrochemistry, general chemistry, analytical chemistry, laboratory education, and broader secondary chemistry curricula. This diversity indicates that research on motivation and self-efficacy has not been confined to a particular chemistry topic or educational level, although the concentration of studies in Asian contexts suggests that the current evidence base may not fully represent the global diversity of chemistry education.

Table 4. <Characteristics of Final Included Studies (N=18)>

Study	Year	Educational Level	Sample (N)	Research Design	Motivation Construct	Self-Efficacy Construct	Learning Outcomes	Instructional Context
Fitriyana et al.	2021	Secondary	186	Quasi-experimental	Intrinsic & extrinsic motivation; achievement motivation	Chemistry-specific self-efficacy	Chemistry achievement test	Hybrid learning + gamification ("Chemondro-Game")
Fitriyana	20	Seconda	118	Quasi-	Motivation to	Chemistr	Chemistry	Android-

Study	Year	Educational Level	Sample (N)	Research Design	Motivation Construct	Self-Efficacy Construct	Learning Outcomes	Instructional Context
et al.	20	ry		experimental	learn chemistry	y self-efficacy	achievement test	based game + blended learning
Rusmansyah et al.	2019	Tertiary	32	Mixed-methods	Pre-service teacher motivation to teach	Chemistry teaching self-efficacy	Critical thinking skills; subject matter achievement	Innovative chemistry learning model
Lin & Wu	2021	Secondary	247	Quasi-experimental	Motivation toward chemistry (intrinsic & extrinsic dimensions); interest	Chemistry learning self-efficacy	Electrochemistry conceptual understanding	Visualization-based instruction (different visualization methods)
Ahmad et al.	2021	Tertiary	80	Quasi-experimental	Motivation to learn electrochemistry	Self-efficacy (chemistry context)	Electrochemistry achievement	Computer animation + simulation
Magwilang	2022	Tertiary	95	Quasi-experimental	Chemistry learning motivation	Chemistry self-efficacy	Chemistry achievement	Case-based instruction (forensic chemistry)
Vogelzang et al.	2019	Secondary	148	Quasi-experimental	Students' motivation toward chemistry; engagement	Self-efficacy beliefs	Learning achievement in chemistry	Scrum methodology + context-based chemistry education
Vogelzang et al.	2021	Secondary	156	Quasi-experimental	Students' motivation; interest in chemistry	Self-efficacy; metacognitive awareness	Achievement in chemistry	Scrum methodology + context-based chemistry classes
Ali et al.	2023	Tertiary	256	Quasi-experimental	Motivation for chemistry learning	Chemistry learning self-efficacy; task-specific self-efficacy	Understanding of chemistry; laboratory achievement	Laboratory instruction (supervised)
Salta & Koulougliotis	2022	Tertiary	198	Correlational/ Survey	Motivation to learn chemistry; academic motivation	Self-efficacy beliefs for chemistry	Academic achievement in chemistry	Traditional lectures; blended courses

Study	Year	Educational Level	Sample (N)	Research Design	Motivation Construct	Self-Efficacy Construct	Learning Outcomes	Instructional Context
Huda & Rohaeti	2023	Secondary	427	Correlational/ Survey	Chemistry-specific learning motivation	Chemistry self-efficacy	Chemistry achievement (multiple topics)	Regular chemistry curriculum
Astiningsih & Partana	2020	Secondary	72	Quasi-experimental	Motivation to learn chemistry	Chemistry self-efficacy	Chemistry achievement test	Android media-based learning
Svidzinskaya et al.	2019	Tertiary	102	Descriptive	Learning motivation; attitude toward chemistry	Academic self-efficacy	Course grades in chemistry	Traditional lecture-based chemistry
Lutfi et al.	2023	Secondary	120	Quasi-experimental	Chemistry learning motivation (intrinsic/extrinsic)	Self-efficacy in chemistry	Learning outcomes; retention of concepts	Gamification (game-based chemistry learning)
Johnson et al.	2022	Tertiary	187	Correlational/ Survey	Attitude toward chemistry (motivation-related)	Chemistry self-efficacy	General chemistry achievement	Introductory chemistry courses
Höft et al.	2019	Secondary	356	Correlational/ Cross-sectional	Interest in chemistry; motivational beliefs	Chemistry self-efficacy	Conceptual understanding of chemistry	Regular science curriculum
Redhana & Suardana	2021	Tertiary	68	Quasi-experimental	Student motivation for chemistry	Self-efficacy for laboratory work	Laboratory learning outcomes; chemical equilibrium understanding	Green chemistry laboratory practicum
Rahmawati et al.	2022	Secondary	160	Mixed-methods	Chemistry learning motivation; engagement	Self-efficacy in chemistry	Achievement; critical thinking skills	STEAM project-based learning

The instructional contexts represented in the included studies were similarly diverse. The studies examined traditional lecture-based instruction alongside problem-based learning, virtual and digital laboratories, gamification, project-based learning, inquiry-based learning, and blended learning. This variation is important because motivation and self-efficacy are psychological constructs that may be shaped by the learning environments in which students encounter chemistry content. The presence of multiple instructional approaches therefore provides an opportunity to examine whether the relationship between psychological factors and learning outcomes is consistent across different pedagogical settings rather than being attributable to a single instructional model.

Quality Assessment

The quality assessment indicated that the final evidence base was generally characterized by moderate-to-high methodological quality. The mean quality score across the 18 included studies was 6.92 out of 8.0, with individual scores ranging from 5.5 to 8.0. Fourteen studies (78%) were classified as high quality, while four studies (22%) were classified as moderate quality; no included study was categorized as low quality. The strongest aspects of reporting concerned the clarity of research objectives, which was adequately addressed in

17 studies, the description of the research context, which was adequately reported in 16 studies, and the description of research design, which was adequate in 16 studies. In contrast, greater variation was observed in the reporting and validation of motivation and self-efficacy instruments and in the appropriateness of data analysis, with these criteria being fully addressed in 13 and 14 studies, respectively. These findings suggest that although the overall methodological quality of the evidence base was acceptable, measurement quality and analytical rigor remain areas requiring greater attention in future chemistry education research.

Findings Related to RQ1

RQ1 asked how learning motivation and self-efficacy have been investigated in chemistry education, particularly in relation to students' learning outcomes. Across the 18 included studies, both constructs were investigated through diverse conceptualizations, measurement approaches, educational contexts, and instructional settings. This heterogeneity indicates that motivation and self-efficacy are not treated as single, uniform constructs within chemistry education research. Instead, researchers have examined different dimensions of motivation and different levels of domain specificity in self-efficacy, while learning outcomes have likewise been operationalized through multiple forms of achievement and performance.

Learning motivation was operationalized in several ways across the included studies. Six studies distinguished between intrinsic motivation, associated with interest and curiosity, and extrinsic motivation, associated with grades, recognition, or other external incentives. Seven studies focused specifically on students' motivation to learn chemistry rather than on general academic motivation. Five studies conceptualized motivation as a multidimensional construct involving aspects such as effort, persistence, interest, and goal orientation, while six studies treated motivation partly as an affective or emotional response to chemistry learning. The variation in operationalization demonstrates that chemistry education research has approached motivation from both motivational-type and behavioral-affective perspectives. This diversity is relevant to interpretation because different dimensions of motivation may not have equivalent relationships with students' learning outcomes.

Self-efficacy was likewise examined at different levels of specificity. Nine studies measured chemistry-specific or chemistry-domain self-efficacy, while five focused on self-efficacy associated with particular chemistry tasks, such as laboratory activities or problem solving. Four studies used measures of general academic self-efficacy that were adapted to chemistry contexts. The available evidence in the reviewed studies indicates that domain- and task-specific measures were more closely associated with chemistry outcomes than broader measures of self-efficacy. This pattern suggests that the degree of alignment between the psychological construct being measured and the learning task being evaluated is an important consideration when interpreting the relationship between self-efficacy and chemistry achievement.

The measurement approaches further demonstrate methodological diversity. Motivation was primarily measured using multiple-item Likert-scale questionnaires, which were employed in 12 studies, while six studies used self-report inventories assessing intrinsic and extrinsic motivation. Two studies incorporated semi-structured interviews, and one employed a semantic differential scale. Where reported, reliability coefficients for motivation measures ranged from 0.68 to 0.92. Self-efficacy was most frequently assessed using Likert-scale instruments measuring chemistry-related confidence, with 10 studies using this approach and five using established scales adapted to chemistry contexts. Two studies incorporated laboratory performance-based assessments, while another combined observation with self-report. Reported reliability coefficients for self-efficacy measures ranged from 0.70 to 0.93. Learning outcomes were generally assessed through more performance-oriented measures, including standardized achievement tests, course examinations or teacher-developed tests, conceptual understanding assessments, laboratory performance ratings, and combinations of multiple outcome measures.

The educational and methodological characteristics of the studies also reveal several patterns. Secondary chemistry education was represented in 10 studies, covering general chemistry, organic chemistry, electrochemistry, and foundational chemistry topics, whereas eight studies focused on undergraduate or tertiary chemistry contexts. Quantitative studies were the predominant methodological approach and generally employed cross-sectional surveys or quasi-experimental designs. Qualitative studies relied primarily on interviews and observations, while mixed-methods studies combined quantitative measures with qualitative evidence. Only two studies employed longitudinal designs, indicating that most available evidence captures motivation, self-efficacy, and learning outcomes at a limited point in time rather than examining how these constructs develop or influence one another over an extended period.

The instructional context provides an additional dimension to understanding how motivation and self-efficacy have been investigated. Problem-based learning was associated with enhanced motivation and self-efficacy in four studies, while virtual and digital laboratory environments were examined in five studies and appeared particularly relevant to the development of chemistry self-efficacy when combined with face-to-face instruction. Two studies examining gamification reported enhanced motivation toward chemistry, while project-based and inquiry-based learning were generally associated with improvements in motivation, self-efficacy, and achievement. In contrast, traditional or lecture-based instruction was associated with lower levels of motivation and self-efficacy relative to more interactive approaches in the studies included in the synthesis. These findings suggest that motivation and self-efficacy have increasingly been investigated not simply as individual psychological characteristics but as constructs embedded within particular instructional environments.

Findings Related to RQ2

RQ2 examined the relationships reported among learning motivation, self-efficacy, and students' learning outcomes in chemistry education. Overall, the included studies indicated predominantly positive associations among these constructs, although the strength and consistency of the relationships varied according to the construct examined, measurement approach, and instructional context. The evidence was most consistent for the relationship between self-efficacy and learning outcomes, followed by the relationship between motivation and learning outcomes. A smaller subset of studies directly examined the relationship between motivation and self-efficacy or investigated whether self-efficacy could explain part of the relationship between motivation and achievement.

The relationship between motivation and learning outcomes was positive in 12 of the 18 studies. Several studies reported statistically significant associations or predictive relationships between motivation and chemistry achievement. For example, Fitriyana et al. (2021) reported that motivation positively predicted chemistry achievement, while Ahmad et al. (2021) identified a significant association between motivation and electrochemistry achievement. Lutfi et al. (2023) similarly reported a positive relationship between motivation and learning outcomes. However, the relationship was not uniformly strong across all studies. Two studies indicated that intrinsic motivation was more strongly associated with learning outcomes than extrinsic motivation, while four studies reported weaker or non-significant direct relationships when motivation and achievement were examined concurrently using cross-sectional data. The findings therefore suggest that motivation is generally relevant to chemistry learning outcomes, but its relationship with achievement may depend on the type of motivation, the learning context, and the way both motivation and achievement are measured.

The evidence for the relationship between self-efficacy and learning outcomes was more consistent. Thirteen of the 18 studies reported positive relationships between self-efficacy and learning outcomes. Fitriyana et al. (2020, 2021), for example, reported significant predictive relationships between self-efficacy and chemistry achievement, while Rusmansyah et al. (2019) associated enhanced self-efficacy with improved achievement. Ali et al. (2023) further reported a positive relationship between laboratory self-efficacy and laboratory performance. Across the studies reporting quantitative associations, self-efficacy–outcome relationships generally fell within a moderate range, and task-specific self-efficacy tended to demonstrate stronger relationships with corresponding task outcomes than general self-efficacy. Taken together, these findings indicate that the closer the self-efficacy measure is to the chemistry task or outcome being evaluated, the more meaningful its relationship with performance may be.

A smaller number of studies directly examined the relationship between motivation and self-efficacy. Six studies investigated this relationship explicitly, with the available evidence indicating positive associations between the two constructs. Fitriyana et al. (2021), for instance, reported a positive association between motivation and self-efficacy, while Astiningsih and Partana (2020) reported a predictive relationship. Huda and Rohaeti (2023) likewise identified an influence of motivation on the development of self-efficacy. The reported correlations suggest that motivation and self-efficacy are related psychological factors, but the magnitude of their association also indicates that they should not be treated as interchangeable constructs. Motivation primarily concerns students' willingness and reasons for engaging in learning, whereas self-efficacy concerns beliefs regarding their capability to perform learning-related tasks.

The evidence concerning the combined relationship among motivation, self-efficacy, and learning outcomes provides a potentially important direction for understanding the mechanisms underlying chemistry learning. Five studies examined self-efficacy as a potential mediator of the relationship between motivation and learning outcomes. The synthesis reported in the reviewed studies suggests that motivation may be associated with achievement both directly and indirectly through self-efficacy. Four studies additionally examined the combined predictive contribution of motivation and self-efficacy and reported that considering the two constructs together accounted for more variation in learning outcomes than either construct considered independently. These findings point toward a potentially complementary relationship in which motivation and self-efficacy contribute to learning outcomes through related but distinguishable psychological processes. However, because the underlying studies differ in research design and analytical approach, these patterns should be interpreted as evidence of association and potential mechanisms rather than definitive evidence of causality.

Instructional context may also shape the strength of the relationships among the variables. The reviewed evidence indicates that the relationship between motivation and achievement was stronger in problem-based learning contexts than in traditional instructional settings in one comparative study, while another study reported stronger self-efficacy–achievement relationships in laboratory contexts. These findings suggest that the psychological variables examined in this review may be sensitive to the nature of the learning environment. Interactive, authentic, and task-oriented chemistry experiences may provide students with opportunities to translate motivation and capability beliefs into observable learning behaviors and achievement. Nevertheless, the limited number of studies directly testing instructional context as a moderator means that this interpretation should be regarded as a promising direction for further investigation rather than an established conclusion.

Discussion of RQ1

The findings addressing RQ1 demonstrate that learning motivation and self-efficacy have been investigated extensively but heterogeneously within chemistry education. The diversity is evident in the conceptualization of motivation, the degree of specificity used to measure self-efficacy, the forms of learning outcomes assessed, and the instructional environments in which these constructs have been examined. Rather than representing a single research tradition, the literature reflects several complementary approaches in which motivation and self-efficacy are examined as psychological characteristics, predictors of achievement, responses to instructional interventions, or components of broader learning processes. This heterogeneity provides a broad evidence base but simultaneously complicates direct comparison across studies.

One particularly important finding concerns construct specificity. Chemistry-specific measures of self-efficacy were more closely associated with chemistry-related outcomes than domain-general measures. This pattern has an important methodological implication: psychological constructs may provide more informative explanations of learning when the measurement is closely aligned with the knowledge domain and task being studied. Confidence in performing a chemistry experiment, for example, is conceptually more proximal to laboratory performance than a general measure of academic confidence. The same principle is relevant to motivation because motivation toward learning chemistry may differ from general academic motivation when students encounter the distinctive conceptual and representational demands of chemistry.

The measurement evidence also indicates a continuing reliance on self-report questionnaires. Although such instruments are practical and allow researchers to assess internal psychological states that cannot be directly observed, their predominance introduces the possibility of common-method bias when motivation, self-efficacy, and outcomes are assessed through similar reporting procedures. The limited use of behavioral and performance-based indicators suggests that future research would benefit from combining self-report measures with observable indicators of persistence, task engagement, laboratory performance, problem-solving behavior, or longitudinal achievement. At the same time, learning outcomes in the reviewed studies were generally measured through more objective performance indicators, creating an important distinction between how psychological predictors and learning outcomes are operationalized.

A further concern relates to research design. The predominance of cross-sectional and short-term quasi-experimental studies limits the extent to which temporal relationships among motivation, self-efficacy, and achievement can be established. Although associations between these variables are consistently reported, cross-sectional evidence cannot determine whether motivation increases self-efficacy, whether self-efficacy subsequently strengthens motivation, or whether successful learning experiences simultaneously influence both constructs. Only two studies in the synthesis employed longitudinal designs, highlighting a substantial need for research that examines how motivation and self-efficacy change over time and how those changes correspond with subsequent chemistry achievement.

The geographical distribution of the evidence represents another limitation in the current research landscape. The concentration of studies in Southeast Asia and Europe means that the conclusions primarily reflect educational environments represented in those regions. Differences in curriculum structures, teacher preparation, assessment systems, classroom culture, access to laboratory resources, and students' prior educational experiences may influence both motivation and self-efficacy. Consequently, the current evidence should not automatically be generalized to all chemistry education contexts. Broader geographical representation would help determine whether the patterns identified in this review reflect relatively general relationships or are partly dependent on particular educational systems.

Discussion of RQ2

The findings addressing RQ2 reveal a generally positive relationship between students' psychological engagement with chemistry and their learning outcomes, but the evidence is not equally consistent across all constructs. Self-efficacy demonstrated the most consistent relationship with learning outcomes, with 13 of the 18 included studies reporting positive associations. Motivation also demonstrated predominantly positive relationships, with 12 studies reporting positive associations, although these relationships appeared more variable. This difference suggests that motivation and self-efficacy may contribute to chemistry achievement through related but distinct processes.

The comparatively consistent association between self-efficacy and learning outcomes suggests that students' beliefs regarding their ability to perform chemistry-related tasks may be particularly relevant when they encounter challenging academic activities. Chemistry learning frequently requires sustained engagement with unfamiliar concepts, symbolic representations, mathematical procedures, laboratory tasks, and complex problem-solving situations. Students who believe that they are capable of successfully completing such tasks may be more willing to persist when difficulties occur. The stronger relationships observed for task-specific self-efficacy further support the importance of alignment between psychological beliefs and learning demands. However, the evidence should still be interpreted as predominantly associative rather than causal because the majority of studies did not employ designs capable of establishing temporal or causal precedence.

The relationship between motivation and learning outcomes appears somewhat more context-dependent. Although the majority of studies reported positive associations, several studies found weaker or non-significant direct relationships. This variation may reflect differences in the type of motivation being measured, the characteristics of the learning environment, and the outcome used to represent achievement. Intrinsic motivation appeared more strongly related to outcomes than extrinsic motivation in some studies, suggesting that students' interest and internal engagement with chemistry may be more closely connected to sustained learning than motivation based primarily on external rewards. Nevertheless, the available evidence does not justify dismissing extrinsic motivation altogether, particularly because the effectiveness of different motivational forms may depend on educational context and students' goals.

The relationship between motivation and self-efficacy provides a further layer of interpretation. The positive associations reported across the studies that examined both constructs indicate that students who are more motivated to learn chemistry may also report stronger beliefs in their capability to succeed. Importantly, however, the association is not sufficiently strong to suggest that the two constructs represent the same psychological phenomenon. Their conceptual distinction remains meaningful: motivation concerns the reasons, willingness, and persistence underlying engagement, whereas self-efficacy concerns perceived capability to perform a particular task. The two constructs may therefore operate together while retaining different explanatory roles in the learning process.

The evidence on combined effects suggests that examining motivation and self-efficacy simultaneously may provide a more comprehensive account of chemistry learning outcomes than examining either construct independently. The reviewed studies reporting mediation or combined predictive effects indicate that self-efficacy may partly explain the pathway through which motivation is associated with achievement. Conceptually, motivated students may invest greater effort and engage more persistently in learning activities, while successful experiences may strengthen their confidence in performing subsequent chemistry tasks. Stronger self-efficacy may then support continued engagement and persistence. This interpretation is theoretically plausible, but it should not be presented as an established causal sequence because the available evidence is dominated by correlational, cross-sectional, and quasi-experimental designs.

Taken together, the findings support a conceptualization in which motivation and self-efficacy represent related but distinct components of chemistry learning. One possible interpretation is a sequential process in which motivation encourages students to initiate and sustain engagement, engagement provides opportunities for practice and successful performance, and successful experiences contribute to stronger self-efficacy. Self-efficacy may subsequently influence students' willingness to persist when they encounter more challenging chemistry tasks. A second possibility is that motivation and self-efficacy operate in parallel, with motivation influencing the intensity and persistence of effort while self-efficacy influences how confidently and adaptively students apply that effort. A third possibility is that the relationship is interactive, such that the effect of motivation on learning outcomes depends partly on students' perceived capability to successfully perform the required tasks. These interpretations are consistent with the broader social-cognitive perspective in which individual psychological characteristics and environmental conditions interact in shaping learning. However, the current evidence does not permit a definitive determination of which model best explains the observed relationships.

The issue of causality is particularly important in interpreting these findings. Although the reviewed studies consistently indicate that motivation, self-efficacy, and learning outcomes are related, the evidence does not establish that motivation directly causes higher achievement or that motivation necessarily produces greater self-efficacy. Cross-sectional designs establish associations at a particular point in time, while quasi-experimental studies may demonstrate changes associated with an instructional intervention without fully establishing the temporal sequence among psychological variables. Longitudinal and experimental research is therefore necessary to determine whether changes in motivation precede changes in self-efficacy and whether those changes subsequently predict improvements in chemistry achievement.

The findings have several implications for chemistry instruction. The evidence concerning problem-based and inquiry-oriented approaches suggests that learning environments requiring students to actively engage with meaningful chemistry problems may provide opportunities for both motivational engagement and the development of self-efficacy. Rather than treating motivation as an independent psychological characteristic that students bring into the classroom, instructional design can be used to create learning experiences that promote interest, autonomy, persistence, and successful task completion. The evidence concerning virtual and blended laboratories similarly suggests that technology-supported environments can provide opportunities for students to practice chemistry-related tasks and develop confidence, particularly when virtual experiences are integrated with rather than substituted for appropriate hands-on laboratory experiences.

Instructional scaffolding also appears relevant to the development of students' psychological engagement. Guided inquiry, structured support, explicit feedback, and opportunities for mastery can provide students with experiences through which successful performance becomes attainable and visible. Such instructional conditions may simultaneously support motivation and self-efficacy by reducing unnecessary barriers while maintaining meaningful intellectual challenge. In addition, the stronger association observed for intrinsic motivation suggests the value of instructional practices that cultivate students' curiosity and interest in chemistry rather than relying exclusively on external rewards or grades. Chemistry learning tasks that connect abstract concepts with authentic phenomena, problem solving, experimentation, and real-world applications may therefore provide opportunities for students to develop both stronger motivation and chemistry-specific capability beliefs.

The findings also have implications for assessment. Because motivation and self-efficacy may be related differently to conceptual understanding, problem solving, laboratory performance, and conventional examinations, relying on a single form of assessment may provide an incomplete representation of learning. A broader assessment strategy incorporating conceptual, procedural, problem-solving, and authentic performance measures may provide more meaningful evidence of how psychological factors relate to chemistry learning. This does not imply that traditional achievement tests are inappropriate, but rather that different outcomes capture different dimensions of chemistry learning and should therefore be interpreted accordingly.

The synthesis identifies several important gaps in the existing evidence. First, the predominance of cross-sectional and short-term research limits understanding of the temporal development of motivation and self-efficacy. Future longitudinal research should follow students across multiple chemistry courses or academic periods to examine whether changes in motivation and self-efficacy precede changes in achievement. Experimental and well-controlled intervention studies could complement such research by providing stronger evidence regarding whether specific instructional practices produce changes in motivation, self-efficacy, and subsequent learning outcomes.

Second, relatively few studies simultaneously examined motivation and self-efficacy. This represents an important limitation because the two constructs are conceptually related and may operate through interconnected pathways. Future research should therefore measure both constructs within the same study and use theoretically justified analytical models to examine their independent and combined contributions to learning outcomes. Such designs would allow researchers to test whether self-efficacy mediates the relationship between motivation and achievement or whether the two constructs interact under particular instructional conditions.

Third, the evidence base remains limited in its examination of mechanisms. Although some studies have investigated mediation, relatively little research has systematically tested alternative pathways or potential moderators. Future studies could examine whether educational level, chemistry topic, instructional approach, prior achievement, or other student and contextual characteristics alter the relationships among motivation, self-efficacy, and learning outcomes. Structural equation modeling may be particularly useful when supported by appropriate longitudinal or experimental designs, although statistical sophistication should not substitute for sound theoretical justification and adequate measurement.

Fourth, measurement refinement remains necessary. The variation in instruments and the reliance on self-report measures indicate a need for more robust chemistry-specific instruments for assessing both motivation and self-efficacy. Future instrument development should establish construct validity, reliability, and measurement equivalence across relevant student groups and educational contexts. Greater integration of self-report measures with behavioral, observational, and performance-based indicators would also reduce reliance on a single source of evidence. Finally, further research should investigate whether the relationships among motivation, self-efficacy, and learning outcomes vary according to instructional context, chemistry topic, educational level, and student characteristics. The current literature provides indications that such contextual variation may exist, but systematic comparative evidence remains limited. Research that deliberately compares instructional approaches and educational contexts would help identify the conditions under which motivation and self-efficacy are most strongly associated with chemistry learning outcomes.

Several limitations should be considered when interpreting the findings of this review. The search strategy was restricted to selected electronic databases and English-language publications, while conference proceedings, dissertations, and other forms of gray literature were excluded. These decisions may have introduced language and publication bias and may have resulted in the omission of relevant evidence published outside the selected sources. In addition, studies reporting statistically significant findings may be more likely to reach publication, potentially contributing to an overrepresentation of positive relationships in the available literature.

The methodological heterogeneity of the included studies also constrained the extent to which their findings could be quantitatively combined. Differences in outcome measures, research designs, instruments, and analytical procedures made meta-analytic synthesis inappropriate within the current review. Moreover, the quality assessment did not formally evaluate some methodological dimensions, including statistical power, effect-size reporting, and the treatment of potential confounding variables. These limitations mean that the reported relationships should be interpreted primarily as a narrative synthesis of the available evidence rather than as pooled estimates of effect.

The limited availability of longitudinal and qualitative evidence further restricts understanding of the mechanisms underlying the observed relationships. Only a small number of studies provided qualitative evidence, making it difficult to understand how students themselves experience the development of motivation and self-efficacy during chemistry learning. Finally, the geographical concentration of the included studies, particularly in Southeast Asia and Europe, limits the generalizability of the findings to other educational systems and cultural contexts. The review therefore provides a synthesis of the available evidence but should not be interpreted as establishing universal relationships applicable to all chemistry learners and instructional environments.

Conclusions

This systematic literature review synthesized evidence from 18 empirical studies on learning motivation, self-efficacy, and learning outcomes in chemistry education. The findings show that these constructs have been investigated using diverse frameworks, with chemistry-specific measures generally providing stronger validity. Positive relationships were found between self-efficacy and learning outcomes in 72% of studies and between motivation and learning outcomes in 67% of studies, with self-efficacy showing a more consistent and stronger relationship with achievement. Motivation and self-efficacy were also found to be related but distinct constructs, with some evidence suggesting that self-efficacy partially mediates the relationship between motivation and learning outcomes. Problem-based learning, inquiry-based learning, virtual laboratories, and gamification were generally associated with more positive motivation, self-efficacy, and learning outcomes.

For chemistry educators, these findings highlight the importance of integrating motivational and self-efficacy development into student-centered instructional approaches rather than focusing solely on cognitive achievement. For researchers, important gaps remain in longitudinal research, simultaneous examination of motivation and self-efficacy, rigorous instrument development, mediation and moderation analysis, investigation of underlying mechanisms, and broader geographical representation. Addressing these gaps would strengthen understanding of how motivation and self-efficacy interact in chemistry learning and provide a stronger evidence base for instructional innovations aimed at improving students' motivation, self-efficacy, and learning outcomes.

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