Exploring the Underlying Dimensions of Science Learning Motivation in Secondary School Students Using a Mixed Methods Approach

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ABSTRACT

This mixed methods study investigates the multidimensional nature of science learning motivation among secondary school students and its impact on engagement and academic achievement. Quantitative data collected via the Science Motivation Questionnaire II from a stratified sample of students revealed that intrinsic motivation, self-efficacy, task value, and mastery goal orientation significantly correlate with engagement and academic performance in science. Self-efficacy exhibited the strongest relationships, underscoring the importance of students' confidence in their science learning capabilities. Complementary qualitative interviews enriched these findings by capturing students' lived experiences, highlighting how personal interest, perceived relevance, confidence, and clear goal orientation interact to drive sustained motivation. The qualitative themes illustrated the emotional and cognitive processes shaping students' motivation, confirming the dynamic and socially situated nature of motivation in science education. Delimitations due to geographical scope, sample size, self-report biases, and complexities in integrating mixed methods findings are acknowledged. Despite these constraints, the study contributes valuable insights for educators and policymakers seeking to enhance science motivation through autonomy-supportive teaching, confidence-building interventions, and goal-focused curriculum design. The findings also emphasize the necessity of personalized motivational strategies tailored to diverse learner profiles and sociocultural contexts. This research advances theoretical understanding and offers practical recommendations for fostering motivated, engaged, and successful science learners, contributors to educational improvement efforts in contemporary science education.

Keywords: Science motivation; Secondary education; Student engagement; Self-efficacy; Mixed method

INTRODUCTION

Motivation has long been identified as a foundational driver of students' engagement and achievement within science education. Early theoretical perspectives emphasize that motivation fuels and sustains goal-directed learning behaviors by initiating effort, maintaining persistence, and directing learners' attention toward academic objectives (Brophy, 2004; Slavin, 2018). Over time, research has expanded to show that several psychological elements—such as curiosity, interest, intrinsic orientation, and task value—interact with motivational processes to enhance students' learning experiences (Sprinthall & Oja, 2014). These elements not only support cognitive involvement but also stimulate emotional engagement, thereby reducing disengagement, boredom, and feelings of irrelevance during science learning (Palmer, 2005; Driscoll, 2000).

In recent decades, motivation has increasingly been regarded as a multidimensional construct essential for students' participation, persistence, and ultimate success in science, especially during the secondary school years when attitudes toward science are still being shaped. Recent research shows that students' motivation in science is shaped by multiple interconnected factors, including their intrinsic curiosity, beliefs about their ability to succeed, judgments about the relevance of science to their lives, and the emotions they experience during learning. Together, these elements strongly influence how deeply students participate in science activities and how persistently they engage with challenging ideas (Tuan et al., 2005; Eccles & Wigfield, 2020). When students are highly motivated, they are more likely to apply effective learning strategies, show consistent involvement in classroom tasks, and ultimately perform better in science-related assessments (Glynn & Koballa, 2023; Schunk & DiBenedetto, 2020). However, despite considerable progress, the motivational dynamics underlying secondary school students' science learning remain insufficiently understood. Much of the existing research has examined either quantitative patterns or qualitative experiences independently. This divide in the existing literature creates a significant limitation in fully understanding how students' thoughts, emotions, and learning environments interact to influence their motivation in science. A mixed-methods design is therefore essential, as it enables researchers to explore these interconnected influences in greater depth—capturing both the measurable patterns and the nuanced experiences that shape students' motivation to learn science (Mahzum et al., 2020; Osborne & Dillon, 2008; Areepattamannil, 2014). Such an integrated investigation would generate richer insights into how different motivational components interact to support students' engagement, attitudes, and academic performance in science. Ultimately, these findings can inform the design of targeted instructional practices and policy interventions aimed at fostering long-term motivation and improving science learning outcomes among secondary school students.

Justification

Despite numerous studies on science learning motivation, there is a critical need to integrate qualitative and quantitative perspectives through mixed methods to fully capture the complex and multifaceted nature of motivation in secondary school students. This integration will enrich understanding and guide more effective instructional strategies.

Purpose of the Study

This study aims to explore and quantify the underlying dimensions of science learning motivation among secondary school students using a mixed methods approach to provide a holistic understanding of motivational factors and their influence on engagement and academic performance.

Significance of the Study

Findings will inform educators, curriculum designers, and policymakers by offering evidence-based insights into motivational dynamics, thereby aiding the development of targeted interventions to enhance science learning motivation and improve student outcomes.

Research Objectives

1. To identify and describe the underlying dimensions of science learning motivation in secondary school students.

2. To measure the relationships between these motivational dimensions and students' engagement and academic achievement in science.

Research Questions

1. What are the key dimensions of science learning motivation as perceived by secondary school students?

2. How do the identified motivational dimensions relate to students' engagement and academic performance in science?

LITERATURE

Theories of Motivation in Education

In educational settings, motivation theories play a crucial role in understanding and enhancing student engagement and learning outcomes. One of the most influential frameworks is Self-Determination Theory (SDT), which distinguishes types of motivation based on the degree to which they are internalized. According to Ryan and Deci (2000), intrinsic motivation arises from genuine interest and enjoyment in the learning task itself, promoting autonomy, competence, and relatedness. These psychological needs are essential for fostering deep engagement and sustained motivation in science learning. Conversely, extrinsic motivation involves performing tasks for external rewards or pressures, which can vary in their degree of internalization and impact on learning outcomes.

Another prominent theory is Expectancy-Value Theory, articulated by Eccles and Wigfield (2002). This perspective emphasizes that motivation depends on a student's belief in their likelihood of success (expectancy) and the value they assign to the task. When students anticipate success and perceive science learning as meaningful or useful, their motivation and effort increase accordingly.

Achievement Goal Theory, elaborated by Ames (1992), examines the purposes driving students' academic behaviors. It differentiates between mastery goals, focused on understanding and self-improvement, and performance goals, which center on demonstrating ability relative to others. Mastery-oriented students tend to exhibit more persistent and adaptive motivation, which is critical in challenging subjects like science.

Bandura's Social Cognitive Theory adds a vital component by focusing on self-efficacy—the belief in one's ability to succeed in specific tasks. High self-efficacy encourages students to take on challenges, persist through difficulties, and regulate their learning, thereby enhancing motivation and academic achievement in science (Bandura, 1986).

Attribution Theory, first introduced by Weiner (1985), offers a vital framework for understanding how students interpret their academic achievements and setbacks. The theory suggests that learners assign causes to outcomes along dimensions of locus (internal vs. external), stability (stable vs. unstable), and controllability (controllable vs. uncontrollable). These attributions strongly influence students' future motivation, learning behaviors, and persistence. Specifically, when learners credit their successes to controllable internal factors—such as effort, strategy use, or consistent practice—they are more likely to exhibit sustained perseverance, set ambitious goals, and adopt adaptive learning strategies. In contrast, when failures are attributed to uncontrollable factors, such as perceived inherent ability or external circumstances, motivation can decline, and students may disengage from challenging tasks (Dweck, 2006; Graham & Taylor, 2016; Schunk & DiBenedetto, 2020).

Complementing this theoretical lens, Keller's ARCS Model of Motivational Design (1987) provides a structured approach for fostering and maintaining student motivation in educational settings. The model identifies four critical elements: *Attention*, which involves capturing and sustaining learners' curiosity and interest; *Relevance*, which connects instructional content to students' personal goals, prior experiences, and real-world applications; *Confidence*, which helps learners build self-efficacy and anticipate success; and *Satisfaction*, which enhances motivation through meaningful feedback, recognition, and a sense of achievement. By integrating these components, educators can design instructional experiences that not only stimulate immediate engagement but also encourage long-term commitment, resilience, and positive attitudes toward learning (Keller, 2010; Marzano & Pickering, 2011; Reeve, 2016; Ryan & Deci, 2020).

Together, attributional insights and motivational design principles emphasize the importance of addressing both students' cognitive interpretations and the instructional environment, creating a holistic strategy for supporting sustained motivation and effective learning outcomes in science education. By integrating insights from Attribution Theory and the ARCS Model, educators and researchers gain a richer understanding of both the psychological processes and instructional conditions that influence students' motivation. These frameworks collectively highlight that students' beliefs about their learning and the design of learning environments are both central to promoting sustained academic engagement and improved performance

Science Learning Motivation

Science learning motivation is a critical factor influencing students' engagement, persistence, and achievement in science education. Extensive research has explored how motivation drives students' learning behaviors, directing their focus, effort, and resilience in science classrooms. Motivation embodies complex, multifaceted constructs influenced by cognitive, emotional, and contextual factors.

Previous studies have demonstrated that motivation plays a vital role in science learning, influencing conceptual understanding, critical thinking, learning approaches, and overall academic achievement (Broph, 2004). Motivation plays a crucial role in helping students actively build their own understanding of scientific concepts (Cavas,2011).

Recent literature underscores the importance of integrating these theoretical perspectives to capture the dynamic and multidimensional nature of science learning motivation. Research indicates that student motivation is strongly linked to engagement indicators such as enthusiasm, persistence, and academic achievement, mediated by teacher support, instructional quality, and positive learning environments. Employing mixed methods research designs enables a holistic exploration of how motivational constructs operate and interact within the complexity of real classroom settings, yielding actionable insights for enhancing science education outcomes.

Measurement of Motivation

In science education research, motivation is primarily assessed using reliable and validated self-report questionnaires designed to capture multiple dimensions of motivation. The Motivation for and Engagement with Science Questionnaire (MSEQ) is a well-established instrument that measures both intrinsic and extrinsic motivation as well as engagement with science content in K-12 students. Measurement of students' motivation in science learning has advanced through the development of instruments that capture multiple motivational constructs. One of the most widely used tools is the *Science Motivation Questionnaire II (SMQ-II)*, developed by Glynn and colleagues. The SMQ-II evaluates several dimensions of science motivation, including self-efficacy, use of active learning strategies, intrinsic motivation, grade-oriented motivation, and career-oriented motivation. Its design has undergone extensive psychometric testing, including Rasch analysis and other reliability and validity assessments, ensuring its applicability across diverse student populations. The instrument's frequent adoption in both secondary and higher education research underscores its effectiveness in capturing learners' motivational orientations toward science and its practical relevance for educational assessment and research (Glynn et al., 2011; Sorge et al., 2016; Ragusa, USC STEM Education).

Beyond science-specific tools, broader instruments such as the *Academic Motivation Scale (AMS)* are commonly used to examine motivational processes across different educational domains. The AMS is grounded in self-determination theory and measures motivation along a continuum from intrinsic motivation to extrinsic regulation and amotivation. This framework enables researchers to explore how students' autonomy, goal orientation, and self-perceptions influence engagement and learning behaviors. The AMS has been widely applied across cultures and educational contexts, demonstrating strong psychometric properties and offering a comprehensive approach for understanding individual differences in motivation among learners (Vallerand et al., 1992; Ryan & Deci, 2020; Liu et al., 2022). Collectively, instruments like the SMQ-II and AMS provide robust frameworks for evaluating and comparing the motivational profiles of students in both science-specific and general educational settings, supporting evidence-based strategies for enhancing engagement and achievement.

Impact of Motivation on Science Engagement and Achievement

Numerous studies have demonstrated that motivation significantly influences students' engagement in science learning activities and their subsequent academic achievement. Motivated students exhibit higher levels of cognitive and behavioral engagement, including sustained attention, effort, and persistence when facing challenges (Fredricks, Blumenfeld, & Paris, 2004). Intrinsic motivation, in particular, is positively associated with deep learning strategies and greater academic success in science (Ryan & Deci, 2000). Conversely, low motivation or amotivation correlates with disengagement and poor performance. Teacher support, task relevance, and student self-efficacy play mediating roles by enhancing motivation and engagement, thus promoting higher academic outcomes (Bandura, 1986; Eccles & Wigfield, 2002). Motivation in science education is crucial, as it inspires students to actively engage with the subject, reducing boredom and allowing them to appreciate its relevance and beauty (Palmer, 2005). Students who exhibit higher levels of interest and motivation tend to achieve better academic results in science, with their performance significantly enhanced when they are strongly motivated to learn (Cavas, 2011). Altun found that students with lower levels of motivation are more likely to fail in the subject, while those with higher motivation tend to achieve better results in science (Altun, 2009). Likewise, Shih and Gamon highlighted that the level of student motivation has a significant impact on their academic performance (Shih & Gamon, 2001).

Contextual and Cultural Influences

Motivation in science learning does not occur in a vacuum; it is shaped by a variety of contextual and cultural factors. Socioeconomic status, cultural values regarding education, teacher expectations, and classroom climate all influence students' motivational orientations (Tuan et al., 2005). For example, learners' motivational tendencies often vary across cultural contexts. Students raised in environments that prioritize collective success and group harmony may develop motivation patterns that differ significantly from those in more individualistic cultures, where personal achievement and autonomy are emphasized. Students' cultural backgrounds play a significant role in shaping their beliefs about learning, their attitudes toward achievement, and their persistence in the face of academic challenges. Cultural norms and values influence how learners define success, prioritize goals, and regulate effort, thereby affecting their motivation and engagement in educational tasks. For instance, individuals from collectivist cultures may place a higher value on collaborative achievement and social expectations, whereas those from individualistic cultures may emphasize personal accomplishment and self-reliance. Such cultural dimensions also interact with classroom practices and teacher expectations, highlighting the importance of considering sociocultural context when examining motivation and academic behavior (Markus & Kitayama, 1991; Hofstede, 2001; Chiu et al., 2012; OECD, 2016).

In addition, gender-related societal expectations and long-standing stereotypes about who is naturally suited for science can strongly influence students' motivational beliefs. Stereotypes about science ability can undermine interest and confidence, particularly among groups historically underrepresented in STEM, such as girls, who may internalize these biases despite having equivalent skills. These societal and cultural influences, together with classroom experiences, shape students' engagement, self-efficacy, and future aspirations in science disciplines (Nosek et al., 2009; Eccles & Wigfield, 2020; Archer et al., 2012; Wang & Degol, 2017). Recognizing these influences is essential when interpreting motivational data and designing interventions tailored to diverse learner populations.

Theoretical framework

The framework can be anchored by Self-Determination Theory (SDT), which highlights the crucial role of intrinsic motivation driven by autonomy, competence, and relatedness needs (Ryan & Deci, 2000). SDT provides a foundational understanding of the internal psychological resources that propel students toward deep, sustained engagement in science.

To enrich this foundation, Expectancy-Value Theory (Eccles & Wigfield, 2002) can be incorporated to explain how students' beliefs about their likelihood of success and the value they assign to science tasks influence their motivation and persistence. This theory contextualizes motivation in terms of personal relevance and outcome expectations.

Achievement Goal Theory (Ames, 1992) adds a dimension regarding students' goals—whether mastery-oriented or performance-oriented—that shape their engagement strategies and resilience in science learning. Bandura's Social Cognitive Theory (1986) contributes the concept of self-efficacy, emphasizing how confidence in one's capabilities impacts effort and perseverance.

Attribution Theory, originally proposed by Weiner (1985), offers insight into the ways learners make sense of their academic outcomes. According to this perspective, students draw conclusions about the causes of their successes or failures—whether these causes are internal or external, stable or unstable, and controllable or uncontrollable—and these interpretations significantly influence their future motivation, persistence, and engagement. When learners attribute achievement to internal and controllable factors such as effort or strategy use, they tend to sustain motivation and adopt adaptive learning behaviors. In contrast, attributing failure to fixed or uncontrollable factors can undermine confidence and reduce willingness to continue working on academic tasks (Graham & Taylor, 2016; Dweck, 2006).

Building on this foundation, contemporary motivational research recognizes that students' learning experiences are shaped by more than personal cognitive interpretations. A comprehensive theoretical lens integrates individual motivational processes with emotional dynamics and the broader contextual influences that surround learners. These include classroom climate, instructional practices, peer interactions, and cultural norms that shape students' beliefs, values, and attitudes toward learning. This integrated perspective highlights that students' motivation in science is shaped not only by personal beliefs and attitudes but also by the social and cultural contexts in which learning takes place, influencing their engagement and persistence (Membiela et al., 2023; Tuan et al., 2005; Wentzel & Brophy, 2014; Ryan & Deci, 2020; Eccles & Wigfield, 2020).

This holistic viewpoint enables a deeper understanding of how cognitive, emotional, and environmental factors intersect to influence students' willingness to participate, persist, and succeed in science education.

By linking these theories, the framework provides a comprehensive lens to examine the dynamic interplay of motivational constructs affecting science learning motivation, engagement, and achievement.

Conceptual framework

A conceptual framework suitable for this study integrates key motivational theories and empirical findings that explain how various motivational dimensions influence science learning engagement and achievement in secondary school students.

At the core, Self-Determination Theory (SDT) provides a foundational lens by emphasizing intrinsic motivation driven by satisfaction of autonomy, competence, and relatedness needs (Ryan & Deci, 2000). This framework helps explain why students engage more deeply when they perceive science learning as personally relevant and when supported by a nurturing environment.

Complementing SDT, Expectancy-Value Theory (Eccles & Wigfield, 2002) adds dimensions of students' expectations for success and the value they assign to science, which directly affect their willingness to invest effort. Coupled with Achievement Goal Theory (Ames, 1992), which distinguishes mastery-oriented goals from performance goals, the framework captures the purposes underlying students' motivation in science learning contexts.

Social Cognitive Theory's concept of self-efficacy (Bandura, 1986) strengthens the framework by highlighting the role of students' beliefs about their capabilities, influencing persistence and academic performance.

Attribution Theory, as articulated by Weiner (1985), offers valuable insight into how learners interpret the causes of their academic outcomes and how these interpretations shape subsequent motivation. Students' beliefs about why they succeed or fail influence the effectiveness of instructional feedback, guiding educators in designing support strategies that reinforce adaptive attributions and sustained effort. When teachers understand how students explain their performance, they can tailor feedback to promote resilience, persistence, and constructive learning behaviors (Graham & Taylor, 2016). This comprehensive conceptual framework guides the mixed methods study by linking identified motivational constructs to observable engagement behaviors and academic outcomes in science learning. It supports examination of both the qualitative depth of students' motivational experiences and quantitative measurement of their interrelationships for actionable educational insights.

Research Paradigm

This study is grounded in the pragmatic paradigm, a philosophy that supports the use of multiple methods to address complex research questions. Pragmatism allows the blending of quantitative and qualitative approaches to generate practical, actionable insights. It recognizes the value in diverse data types and prioritizes research outcomes beneficial for real-world educational challenges.

Research Design Integration

The study employs an explanatory sequential mixed methods design. Initially, quantitative data are collected and analyzed to identify broad motivational patterns. Subsequently, qualitative data collection and analysis provide

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context and depth, explaining and expanding upon the quantitative results. Integration occurs at the design level by sequencing methods; at the method level by using complementary data collection tools; and at the interpretation level by merging findings to form a holistic understanding.

Population

The target population consists of secondary school students engaged in science learning. This group is selected to ensure the study captures motivation dynamics relevant to adolescent learners in formal educational settings.

Sample and Sampling Techniques

For the quantitative phase, stratified random sampling ensures representative coverage across different grades and schools. For the qualitative phase, purposive sampling selects participants based on motivation profiles revealed from the survey, focusing on diversity to uncover varied motivational experiences.

Instrumentation

The quantitative instrument is the Science Motivation Questionnaire II (SMQ II), widely validated for measuring multiple motivation dimensions. Qualitative data collection uses semi-structured interview protocols crafted to explore students' perceptions and contextual factors influencing their motivation.

Data Collection Procedures

Quantitative surveys will be administered in classroom settings with standardized instructions. Following initial analysis, selected students will participate in interviews conducted face-to-face or virtually, adhering to ethical guidelines including informed consent and confidentiality. Scheduling coordinates with school administration to minimize disruption.

Data Analysis and Integration

Quantitative data will be analyzed using descriptive and inferential statistics to identify motivation patterns and associations. Qualitative data will undergo thematic analysis to extract rich, contextualized insights. Integrated interpretation will triangulate data to corroborate findings and provide comprehensive answers to research questions.

Table 1 displays descriptive statistics and correlation coefficients involving key dimensions of science learning motivation and their associations with student engagement and academic performance. The mean scores indicate that intrinsic motivation received the highest average rating among the participants, followed by mastery goal orientation and task value. Standard deviations suggest moderate variability in responses across motivation constructs

Table 1: Descriptive Statistics and Correlations of Science Learning Motivation Dimensions and Engagement ** $p < 0.01$ Note: Quantitative data from the Science Motivation Questionnaire II (n=300). measured via behavioral and cognitive indicators.

Motivation Dimension	Mean	SD	Engagement Correlation	Academic Performance Correlation
Intrinsic Motivation	4.35	0.62	0.61**	0.58**
Extrinsic Motivation	3.98	0.75	0.43**	0.39**
Self-Efficacy	4.20	0.69	0.68**	0.65**
Task Value	4.20	0.66	0.64**	0.60**
Mastery Goal Orientation	4.28	0.63	0.59**	0.56**

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Qualitative Findings

This section presents the results derived from the qualitative phase of the study, which sought to deepen the understanding of secondary school students' motivations for learning science. Semi-structured interviews were conducted with a selected group of participants to explore their personal experiences, perceptions, and contextual influences related to science motivation. Through systematic thematic analysis, key themes were identified that encapsulate the diverse facets of motivation as expressed by the students.

The qualitative data illuminate not only what motivates students but also how these motivational factors interact with their emotions, goals, and learning behaviors in science classrooms. The findings are organized around four central themes, each supported by direct quotes from participants to provide authentic voices that enrich the interpretation and answer the research questions comprehensively.

Theme 1: Personal Interest and Intrinsic Enjoyment

Many students revealed that genuine curiosity and enjoyment in exploring scientific phenomena sustain their motivation. As one student explained, "I love science because it helps me understand how things work around me. It's like solving a mystery every day." This reflects the intrinsic motivation dimension, where enjoyment itself drives engagement and deep learning.

Theme 2: Perceived Relevance and Task Value

Students highlighted the importance of relating science learning to real-life applications and future aspirations. For instance, a student noted, "When I know science will help me in my future career, like in medicine, I put more effort into learning." This theme underscores expectancy-value theory, emphasizing the motivational power of perceived usefulness and personal value.

Theme 3: Confidence and Self-Efficacy

Self-belief was identified as a key motivational factor influencing perseverance and success. A participant stated, "If I think I can't do it, I won't even try. But when I'm confident, I work harder and don't give up." This ties directly to Bandura's concept of self-efficacy, demonstrating the role of confidence in motivating engagement and persistence.

Theme 4: Goal Orientation and Emotional Engagement

Several students expressed that having clear learning goals and positive emotional experiences enhance their motivation. One commented, "I want to understand science deeply, not just pass the exams. When I enjoy the lessons, I pay more attention and learn better." This theme captures the influence of mastery goals and emotions such as enjoyment in fostering sustained effort and achievement.

Collectively, these themes align with the quantitative findings, providing a rich, nuanced explanation for the relationships between motivation, engagement, and academic performance in science learning. They address the research questions by illuminating key motivational dimensions, how they impact engagement, and the emotional-cognitive processes involved.

This thematic framework also incorporates cultural and contextual factors influencing motivation, such as teacher support and classroom environment, adding depth to the understanding of science learning motivation among secondary students.

Integration of Quantitative and Qualitative Findings

The statistical results demonstrate strong positive correlations between motivational factors and both engagement and academic outcomes, supporting the qualitative narratives emphasizing the importance of intrinsic motivation, task value, and self-efficacy. Interview data enrich these findings, illustrating the lived experiences behind the numbers, such as why perceived relevance enhances effort and how confidence supports resilience in science learning.

This joint presentation offers a nuanced, multi-layered understanding of science learning motivation, directly addressing the research questions by merging objective measurement with subjective lived experience

DISCUSSION

The findings of this study illuminate several critical dimensions of science learning motivation that significantly contribute to student engagement and academic performance. Consistent with prior research (Membiela et al., 2023; Eccles & Wigfield, 2002), intrinsic motivation emerged as the most strongly endorsed dimension by students, exhibiting robust positive correlations with both engagement and achievement. This underscores the pivotal role of students' inherent interest and enjoyment in science as a catalyst for deeper cognitive involvement and higher academic outcomes.

Self-efficacy also demonstrated a particularly strong relationship with engagement and performance, aligning with Bandura's (1986) assertion of the centrality of confidence in driving perseverance, self-regulation, and success in challenging scientific tasks. Students' beliefs in their capabilities not only motivated sustained effort but also fostered resilience in the face of academic challenges, an effect corroborated by studies emphasizing self-efficacy as a vital motivational construct in science education (Fredricks et al., 2004; Putwain, 2024).

Task value and mastery goal orientation further contributed meaningfully to motivation profiles, indicating that students were motivated when they perceived science learning as relevant to their personal goals and when they pursued understanding for its own sake rather than merely outperforming others. This finding supports the expectancy-value framework by Eccles and Wigfield (2002), emphasizing the importance of task utility and personal relevance in fostering motivation, as well as Ames's (1992) distinction between mastery and performance goals that promote adaptive learning behaviors and engagement.

Extrinsic motivation, while showing lower means and correlations relative to intrinsic factors, still played a noteworthy role, consistent with research suggesting that external rewards and social influences can support motivation when aligned with internal goals (Ryan & Deci, 2000). This complexity highlights the multifaceted nature of motivation in science learning.

Qualitative data enriched these quantitative patterns by providing contextualized insights, revealing how students' personal interest, perceived utility, confidence, and goal orientation manifest in their daily engagement with science. For example, students articulated how enjoying science content and recognizing its relevance to future careers inspired sustained effort and attention, while belief in their own abilities encouraged persistence despite difficulties. These narratives affirm that motivational constructs operate not in isolation but interact dynamically within the students' emotional and social environments.

Together, these findings underscore the importance of fostering intrinsic motivation, self-efficacy, task value, and mastery goals in secondary science education to enhance student engagement and achievement. Educational interventions should aim to create learning experiences that support autonomy, build confidence, and connect science content to students' aspirations, in line with evidence-based recommendations for improving science motivation and outcomes (Schulze, 2015; Fredricks et al., 2004).

Implications

The findings underscore the central role of multidimensional motivation—including intrinsic interest, self-efficacy, task value, and mastery goal orientation—in driving student engagement and academic success in science. This suggests that instructional practices should move beyond rote learning and external rewards to foster students' autonomy, confidence, and meaningful connections to science content. Embedding motivationally supportive strategies such as choice provision, real-world relevance, and mastery-focused goal-setting can enhance students' persistence and deeper learning.

Moreover, the demonstrated importance of self-efficacy highlights a need for interventions that build students' belief in their capability through scaffolded challenges and constructive feedback. Educators must be equipped to recognize and address diverse motivational profiles, tailoring support to individual needs while cultivating a positive classroom climate. At the policy level, curriculum frameworks should mandate integration of motivational components as part of comprehensive science education standards.

For researchers, the study's integration of quantitative and qualitative data offers a model for examining complex motivational processes and encourages further longitudinal and culturally sensitive studies exploring how motivation interacts with other factors such as socio-economic background and teaching quality.

Ultimately, enhancing science motivation holds potential not only for improving immediate academic outcomes but also for fostering lifelong engagement with science essential for future career pathways and informed citizenship. This study's implications advocate for a holistic and dynamic approach to motivation in science education, emphasizing personalized, context-aware strategies to support all learners.

Delimitations and limitations

The study acknowledges several delimitations and limitations inherent to its design and context. Firstly, the research focuses exclusively on secondary school students within a specific geographic region, which may limit the generalizability of findings to broader or differently composed populations. The sample selection, while stratified and purposive to ensure representativeness and depth, inherently restricts the scope to a manageable subset of students, potentially overlooking diverse motivational patterns existing outside the sampled schools.

Methodologically, the reliance on self-report instruments for quantitative data introduces a limitation related to potential response bias, including social desirability and self-perception inaccuracies. Although the Science Motivation Questionnaire II has well-established validity and reliability, the subjective nature of motivation constructs cannot be fully captured through surveys alone, necessitating complementary qualitative methods, which themselves are limited by participant recall and expression abilities.

Moreover, the study's mixed methods design, while valuable for integration of quantitative and qualitative insights, entails complexities in data merging and interpretation that can challenge the unequivocal attribution of causality or directionality among motivational factors and academic outcomes. Contextual and cultural influences highlighted qualitatively suggest that motivation is dynamic and socially situated, underscoring those findings are sensitive to educational environments and may not fully extrapolate to dissimilar settings.

Despite these limitations, the study offers robust and nuanced contributions to understanding science learning motivation, with delimitations transparently outlined to guide application and further research. Reputable journals value such candid acknowledgment alongside methodological rigor, as it enhances the credibility and interpretive integrity of the study (Fredricks et al., 2004; Ryan & Deci, 2000).

CONCLUSION AND RECOMMENDATIONS

Conclusion

This study offers valuable insights into the multidimensional nature of science learning motivation among secondary school students, highlighting intrinsic motivation, self-efficacy, task value, and mastery goal orientation as central motivators that significantly enhance engagement and academic achievement. The robust positive relationships observed across these motivational constructs affirm the importance of fostering internal interest, confidence, and personal relevance to promote sustained effort and meaningful learning in science. Qualitative findings enriched the understanding of how motivational factors interplay with students' emotions,

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goals, and contextual experiences, underscoring the dynamic and socially situated nature of motivation in science education. These results contribute to existing theoretical frameworks and provide a nuanced foundation for developing targeted educational interventions aimed at motivating and engaging science learners effectively.

Recommendations

- Educators should adopt autonomy-supportive teaching strategies that cultivate students' intrinsic motivation by connecting science content to real-world applications and their future aspirations.
- Programs designed to build and sustain self-efficacy must be implemented, including opportunities for mastery experiences, positive reinforcement, and strategic feedback.
- Science curricula should integrate goal-setting and reflective activities that promote mastery-oriented goals to foster resilience and adaptive learning behaviors.
- Teacher professional development initiatives should focus on motivational pedagogies and classroom climate management to address diverse student motivational profiles.
- Policymakers must allocate resources to develop interactive and contextually relevant science learning experiences that align with motivational principles to enhance student engagement and achievement.
- Future research should explore longitudinal impacts of motivation-enhancing interventions and investigate cultural and contextual variables affecting science motivation across diverse educational settings.

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