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Designing A STEM Module Through EDP: A Conceptual Framework for Enhancing Science Achievement and Motivation

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ABSTRACT: Science education in Malaysia continues to face pressing challenges, particularly in students' conceptual understanding of topics such as Force and Motion. International assessments, including TIMSS and PISA, consistently report low achievement among Malaysian students. At the same time, motivation to learn science remains a significant concern, with many perceiving it as abstract and disconnected from real life. This conceptual paper proposes a framework for a STEM learning module grounded in the Engineering Design Process (EDP). The framework is anchored in constructivist learning theory and structured through the ADDIE instructional design model to organise the five EDP phases namely Ask, Imagine, Plan, Create and Improve. To strengthen the affective dimension of learning, Self Determination Theory (SDT) is incorporated by aligning each design phase with the psychological needs of autonomy, competence and relatedness. The proposed framework is expected to foster students' science achievement through hands-on experiences while also enhancing motivation by supporting their psychological needs. Although no empirical data are reported, this paper is positioned as a conceptual contribution. Accordingly, a pre-experimental design involving pre-test, post-test, and delayed post-test is proposed for future research as a pathway for future empirical validation to evaluate effectiveness and retention. By presenting a theoretically informed instructional design, this study contributes to the advancement of science education through an innovative approach that addresses both cognitive and motivational outcomes, while supporting Sustainable Development Goal (SDG) 4 on quality education.

INTRODUCTION

In recent decades, emphasis on science, technology, engineering and mathematics (STEM) education has intensified worldwide, driven by the need to prepare future generations for a rapidly changing global landscape. The Fourth Industrial Revolution (IR 4.0), marked by automation, artificial intelligence and digital transformation, has increased demand not only for STEM knowledge but also for higher order competencies such as critical thinking, creativity, collaboration and communication (World Economic Forum, 2020). STEM education is therefore viewed both as a pathway for skilled workforce development and as a means of nurturing STEM literacy for all citizens (Kelley & Knowles, 2016).

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At its core, STEM education emphasizes integration that reflects the interconnectedness of real-world problems. It links abstract concepts with applications, bridging the gap between knowledge and practice. Unlike traditional subject based teaching, STEM encourages students to draw upon multiple disciplines to solve authentic challenges that foster innovation (Roehrig et al., 2021). Scholars increasingly identify engineering design as an effective anchor for integration. Engineering tasks require students to apply scientific principles, mathematical reasoning and technological tools to address authentic, ill-structured problems (Moore et al., 2013). In this way, engineering serves as a connector across disciplines, ensuring knowledge is applied meaningfully rather than learned in isolation (Dasgupta et al., 2019; English & King, 2019).

The urgency to strengthen STEM education is evident in Asia, where countries are investing strategically to compete in innovation driven economies (Cheng, 2022). In Malaysia, this push is reinforced by the Malaysia Education Blueprint 2013-2025, which identifies STEM as a national priority to raise participation and achievement (MOE, 2013). However, international assessments such as TIMSS indicates that Malaysian students continue to struggle with fundamental concepts and demonstrate lower motivation towards science learning compared to their peers in high performing countries (MOE, 2024; von Davier et al., 2024).

Motivation is a particular challenge. It sustains engagement and influences perseverance when difficulties arise (Bayanova et al., 2023). Without it, achievement gains remain unlikely despite reforms. Research indicates that many Malaysian students report low interest and confidence in science, often viewing it as difficult and disconnected from real life experiences (Wong et al., 2021; Rashidin Idris et al., 2023). These findings highlight the need for innovative instructional designs that can improve achievement while sustaining interest and motivation.

Problem Statement

Students' achievement in science, particularly in the topic of Force and Motion, remains a challenge both globally and in Malaysia. Students frequently struggle with the abstract and mathematically demanding nature of these concepts, leading to persistent misconceptions and low performance (Kaniawati et al., 2019; Wangchuk et al., 2022; Shariza Shahari & Fatin Aliah Phang, 2023; Izni Aqilah Rosli et al., 2022). Beyond these cognitive difficulties, motivation to learn science is also limited, with Malaysian students reporting only moderate levels of interest and engagement (Chan & Norlizah Che Hassan, 2017) and often perceiving science as abstract and disconnected from real life (Wong et al., 2021). At the same time, the engineering dimension of STEM is underrepresented in classroom practice, where design-based approaches are rarely applied at the lower secondary level (Edy Hafizan Mohd Shahali et al., 2017) and are further constrained by rigid curricula and exam-oriented teaching (Siti Hamizah Aspin et al., 2022).

In sum, these challenges highlight the need for a theoretically grounded framework that integrates engineering design into science instruction to address both cognitive and motivational outcomes. In response, this conceptual paper aims to:

1. Propose a framework for a STEM-EDP learning module for Form Two science focusing on Force and Motion.
2. Highlight its theoretical grounding and potential contributions to student achievement and motivation, while suggesting directions for future empirical validation.

LITERATURE REVIEW

STEM Education in the 21st-Century

STEM education is increasingly recognized as a key driver of 21st-century learning because it develops students' ability to think critically, solve problems and apply knowledge in authentic contexts. Globally, the integration of science, technology, engineering and mathematics is designed to mirror the interdisciplinary nature of real-world challenges and to promote hands-on application of knowledge (Kelley & Knowles, 2016; Roehrig et al., 2021). In science classrooms, STEM integration is particularly significant as scientific concepts provide a foundation for inquiry, while engineering design tasks create opportunities for students to apply theory in practice. Reviews of integrated STEM approaches report

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consistent benefits, including improvement in achievement, gains in conceptual understanding, increased motivation and the development of collaboration and problem-solving skills, particularly when students engage in project based and design-based activities (Kozan et al., 2023; Sungur Gül et al., 2023).

At the same time, previous studies have also highlighted enduring challenges. Integration within STEM can be realized in multiple forms. It may occur by emphasizing one discipline as the focal point while the others serve as supporting contexts, or by giving equal weight to all four disciplines in a balanced through interdisciplinary or transdisciplinary tasks (National Academy of Sciences, 2014). Scholars continue to debate the level of integration that is realistic in STEM education. Partial integration, where one subject is the main focus and the others provide support, is often viewed as more practical. In contrast, full integration across all subjects is seen as more authentic but also places greater demands on teachers (Barclay & Bentley, 2021). Furthermore, systematic reviews point out that teachers often struggle to design interdisciplinary STEM tasks within limited time and rigid curriculum. Additional challenges such as technical demands, lack of resources, teacher reluctance and an emphasis on products rather than the learning process have further hindered effective implementation (Sungur Gül et al., 2023).

In Malaysia, STEM education has been prioritized in policy documents and embedded within the science curriculum as part of national education reform. However, research shows that implementation in schools is uneven and marked by several challenges. A qualitative study with science teachers revealed limited exposure to STEM pedagogy, inadequate facilities and heavy workload as barriers to meaningful practice (Mohamad Hisyam Ismail et al., 2019). Teachers often reported being instructed to conduct STEM activities without sufficient training or resources, leading to stress and reduced motivation. These findings echo broader concerns about declining student enrolment in science streams and persistent perceptions of science as abstract and difficult. A study with Malaysian science and mathematics teachers found that knowledge of STEM integration and pedagogy was the strongest predictor of effective teaching practices, while perceived difficulties such as lack of time, resources and curriculum constraints hindered implementation (Karpudewan et al., 2023).

Taken together, previous literature underscores that while science classrooms offer fertile ground for STEM integration, success depends heavily on strengthening teachers' pedagogical knowledge and confidence, along with providing structural support to reduce resource and time barriers. Without addressing these factors, efforts to use STEM in science education to enhance achievement and motivation may remain limited in impact.

Engineering Design Process (EDP) in Science Learning

The EDP is increasingly recognized as a central pedagogical approach for operationalizing STEM integration in K12 education. Defined as an iterative, problem solving framework, the EDP typically involves identifying real world problems, generating possible solutions, creating prototypes, testing and refining outcomes (Cunningham et al., 2020). When integrated into science instruction, EDP allows students to engage with scientific content through authentic, hands-on experiences that mirror the practices of professional engineers.

Evidence from multiple studies affirms the pedagogical value of EDP in enhancing students' science learning. For example, Edy Hafizan Mohd Shahali et al. (2017) demonstrated that middle school students engaged in EDP-based STEM projects developed stronger interest and engagement in science, particularly when activities were contextualized to real world problems. These findings are supported by systematic reviews conducted by Winarno et al. (2020) as well as Nur Rosliana Mohd Hafiz and Shahrul Kadri Ayop (2019), which highlight consistent improvements in scientific literacy, conceptual understanding and student motivation across various EDP implementations in science education. Extending these insights, Astano (2025) conducted a systematic review of 31 peer reviewed studies and confirmed that the integration of EDP in science classrooms significantly enhances students' conceptual understanding, critical thinking and collaborative skills, thereby fostering deeper engagement and supporting interdisciplinary learning.

Despite these promising outcomes, challenges persist in implementing EDP effectively in science classrooms. Hammack and Ivey (2019) identified common barriers such as insufficient teacher training, limited planning time and uncertainties regarding how to assess student performance in design-based

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tasks. These challenges often lead to underdeveloped EDP activities that fail to maximize student inquiry and problem-solving potential.

Moreover, deeper pedagogical concerns have been raised. Ali and Tse (2023) argue that many teachers struggle to meaningfully connect science content with engineering design activities, resulting in fragmented instruction and superficial integration. Limited understanding of how students cognitively engage with the stages of EDP may also contribute to inconsistencies in classroom practice. These issues underscore the need for coherent instructional models that embed EDP within clearly defined science learning objectives.

In light of these findings, several scholars advocate for structured instructional frameworks to support educators in integrating EDP more effectively. Cunningham et al. (2020) emphasize that curriculum designs rooted in real world contexts and iterative learning can enhance both student outcomes and teacher confidence. Therefore, to fully realize the benefits of EDP in science education, future initiatives should focus on the development of instructional modules that offer practical guidance and support for teachers, while maintaining alignment with science standards and pedagogical goals.

Motivation in Science Education

Motivation is widely recognised as a central determinant of students' engagement and achievement in science learning. Students who are intrinsically motivated are more likely to engage deeply with content, persist in the face of difficulties and achieve higher outcomes (Ryan & Deci, 2020). Unfortunately, research consistently shows that students' interest in science tends to decline as they progress through schooling, particularly during secondary years. Steidtmann (2022) demonstrated that lower secondary students experience a marked decrease in interest, often due to traditional, content heavy teaching approaches that emphasize memorisation rather than inquiry. Similarly, Bayanova et al. (2023) highlighted that motivation not only sustains engagement but also determines students' perseverance in the face of difficulties. Without adequate intrinsic motivation, students are less likely to persist with science learning, even when curricular reforms are introduced. Adding to this, Johansen et al. (2023) found that increasing the relevance of content significantly enhances motivation, vitality and positive affect, suggesting that students are more engaged when science is connected to real world contexts that matter to them.

In Malaysia, evidence mirrors these global trends. Chan and Norlizah Che Hassan (2017) reported that students demonstrate only moderate levels of motivation towards science learning. Their study also confirmed a strong correlation between motivation and science achievement, underscoring that low motivation directly constraints performance. Wong et al. (2021) further observed that students frequently perceive science as abstract, exam oriented and disconnected from real life, which undermines both confidence and curiosity. Similarly, Rashidin Idris et al. (2023) pointed to systemic challenges such as rigid curricula, exam driven practices and insufficient opportunities for inquiry-based learning can contribute to declining interest.

At the same time, motivation in Malaysia is also strongly tied to students' future aspirations. Fazilah Razali et al. (2020) found that motivation towards science is a powerful predictor of interest in STEM careers, explaining more than half the variance in career orientation. However, the steady decline in enrolment in the science stream at the upper secondary level suggests that many students do not see science as relevant to their future pathways. On a more encouraging note, Edy Hafizan Mohd Shahali et al. (2017) demonstrated that interventions grounded in engineering design and integrated STEM activities significantly increase students' interest in science and related careers. Their findings highlight the potential of authentic, hands-on approaches to counter motivational decline and make science more engaging.

In summary, the literature indicates that while low achievement remains a concern, the deeper issue lies in sustaining students' motivation to learn science. Both international and Malaysian studies confirm that when science is presented as abstract, exam oriented and disconnected from students' lives, motivation declines rapidly. Conversely, learning environments that emphasise relevance, collaboration and authentic problem solving are more likely to foster intrinsic motivation and long-term engagement. These insights point to the urgent need for innovative instructional designs that not only strengthen achievement but also make science meaningful, relevant and motivating for students.

https://doi.org/10.37134/ejoss.vol12.sp.5.2026

Conceptual Understanding and Achievement in Force and Motion

One of the recurring challenges in science education is that students often perceive scientific concepts as abstract and disconnected from daily life. This is particularly evident in topics such as Force and Motion, where research consistently shows the persistence of misconceptions that hinder accurate Newtonian understanding. Common alternative ideas include the belief that motion requires a continuous force or that acceleration always follows the direction of motion (Liu & Fang, 2016). Misconceptions about Newton's Laws remain highly prevalent, with diagnostic assessments revealing persistently high error rates (Kaniawati et al., 2019). More recently, Bahtaji (2023) reported that even STEM undergraduates struggled with basic concepts, confirming that misconceptions are widespread and persist across educational levels.

Research further indicates that such misconceptions are shaped less by lack of knowledge than by intuitive reasoning derived from everyday experience. Students often construct alternative frameworks that feel logical but conflict with scientific principles. For example, daily life schemas strongly influence interpretations of Force and Motion, making intuitive reasoning a common barrier to formal understanding (Bahtaji, 2023; Resbiantoro et al., 2022). As a result, many students display fragmented and disconnected knowledge that prevents them from linking concepts with accurate representations (Mufit et al., 2023).

In Malaysia, these challenges are especially pronounced. Studies highlight Force and Motion as one of the most difficult science topics, with students showing persistently low levels of understanding despite early exposure in the curriculum (Putri Sathirah Saaban & Nur Jahan Ahmad, 2024). Shariza Shahari and Fatin Aliah Phang (2023) found that alternative conceptions of force continued to shape students' reasoning, limiting their grasp of Newtonian mechanics. Similarly, Izni Aqilah Rosli et al. (2022) reported critically low achievement in linear motion, pointing to deep conceptual weaknesses.

Instructional practices contribute to the persistence of these difficulties. Teaching in many classrooms remains dominated by teacher centred and examination driven approaches. Traditional methods that emphasise rote memorisation and procedural problem solving provide little space for inquiry or application, leaving misconceptions uncorrected and reinforcing negative perceptions of science concepts as abstract and overly difficult (Siti Nursaila Alias & Faridah Ibrahim, 2017; Wangchuk et al., 2022).

Addressing these challenges requires more than minor adjustments to existing methods. What is needed are comprehensive frameworks that confront misconceptions directly, strengthen conceptual understanding and engage students in meaningful learning experiences. The EDP offers such potential by involving students in iterative problem solving that mirrors authentic engineering practice. In science classrooms, EDP not only supports conceptual learning but also fosters autonomy, collaboration and competence, thereby enhancing motivation. Integrating EDP into STEM education thus provides a promising pathway to connect cognitive gains with affective outcomes such as interest and sustained engagement.

METHODOLOGY

This article is positioned as a conceptual contribution that does not involve empirical data collection or statistical analysis. Instead, the methodology outlined herein presents a proposed pathway for examining the effectiveness of the STEM-EDP module in future research. The module is proposed to be structured using the ADDIE instructional design model, which provides a systematic framework comprising five phases namely Analysis, Design, Development, Implementation and Evaluation (Branch, 2009). This process is intended to align the module's theoretical foundations, namely Social Constructivist Theory (SCT) and Self Determination Theory (SDT), and its pedagogical aim of embedding the EDP into science instruction.

For future empirical application, a pre-experimental design involving one group of Form Two students learning the topic of Force and Motion could be employed. Data could be collected at three stages (pre-test, post-test, and delayed post-test) to capture both immediate and retained learning outcomes. While the proposed design entails inherent methodological limitations, such as maturation and testing effects, it remains appropriate as an initial exploratory pathway.

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In terms of measurement and analysis, science achievement could be assessed using a validated test of Force and Motion concepts, while science motivation could be measured with the Students' Motivation Toward Science Learning (SMTSL) questionnaire (Tuan et al., 2005), which has been shown to be reliable in Malaysian contexts. Repeated Measures ANOVA could be employed as the analytic approach to examine changes across measurement points (pre-test, post-test, and delayed post-test), providing insights into both cognitive and motivational effects.

Overall, by presenting this methodological pathway, this article positions the STEM-EDP module as a theory driven framework with practical potential, while underscoring the importance of future empirical studies to examine its classroom application and effectiveness. Any future empirical implementation will adhere to relevant ethical approval and informed consent requirements.

THEORETICAL FOUNDATION

The development of the proposed STEM-EDP module is anchored in two major theoretical perspectives that together provide both epistemological and pedagogical justification: Social Constructivism and Self Determination Theory. SCT, as advanced by Vygotsky, emphasises that learning is an active process that occurs through social interaction, collaboration and the use of scaffolding (Vygotsky, 1978). Knowledge is not transmitted directly from teacher to student but is co-constructed through engagement with peers, tools and meaningful tasks. Within the context of science education, the EDP offers a fertile ground for constructivist learning, as students are required to work collaboratively to solve problems, design solutions, test prototypes and refine their ideas. This iterative and interactive process creates opportunities for students to internalise scientific concepts through active engagement and collaboration.

Complementing this epistemological foundation, SDT provides the motivational underpinning of the framework. According to SDT, motivation is sustained when students' psychological needs for autonomy, competence and relatedness are met (Deci & Ryan, 1985). Autonomy refers to the experience of choice and self direction, competence relates to the perception of mastery and effectiveness in learning tasks, while relatedness emphasises meaningful connections with peers and teachers. Environments that support these needs foster intrinsic motivation and promote deeper engagement.

A meta analysis by Su and Reeve (2011) confirmed that interventions designed to support autonomy significantly improved students' motivation and learning outcomes across multiple domains. When applied to science classrooms, SDT highlights the importance of designing instructional approaches that not only convey knowledge but also foster ownership, mastery and collaboration. The EDP naturally aligns with these constructs, where open-ended challenges support autonomy, iterative problem solving strengthens competence, and teamwork fosters relatedness. By explicitly designing learning tasks that attend to these needs, the proposed module is expected to enhance students' motivation to learn science and sustain their engagement over time.

In combination, these dual perspectives form a comprehensive theoretical foundation for the proposed STEM-EDP module. SCT ensures that learning is student centred, collaborative and grounded in authentic problem solving, while SDT ensures that such learning experiences are accompanied by sustained motivation through the fulfilment of psychological needs.

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CONCEPTUAL FRAMEWORK

The proposed conceptual framework is designed to guide the development of a STEM module grounded in the EDP with the aim of enhancing students' science achievement and motivation. The framework integrates principles of STEM education and engineering design-based learning to illustrate how structured engineering design experiences can support both cognitive and affective learning outcomes in science classrooms.

The framework positions STEM integration as a contextual layer that enriches the implementation of the EDP. STEM integration enables students to perceive science learning as relevant, applied and connected to real-world contexts. By situating engineering design tasks within interdisciplinary STEM contexts, students are exposed to the practical application of scientific knowledge alongside technological tools, mathematical reasoning and engineering thinking, thereby strengthening their conceptual understanding.

At the core of the framework is the EDP, which functions as the central pedagogical mechanism through which STEM learning experiences are organized. For the purpose of this study, the EDP framework developed by Cunningham (2009) is adopted, as it is considered developmentally appropriate for younger students while retaining the essential features of authentic engineering practice. The framework employs five iterative phases namely Ask, Imagine, Plan, Create and Improve, which serve as the structural basis for guiding student learning (see Figure 1). Across these phases, the integration of STEM content knowledge is embedded systematically, ensuring meaningful application throughout the design, construction and testing of solutions.

Furthermore, the iterative nature of the EDP encourages continuous engagement with scientific ideas rather than one-time exposure. As students revisit and improve their designs, they are prompted to reflect on prior decisions, revise misconceptions and refine their understanding of underlying scientific principles. This process aligns with constructivist views of learning, in which knowledge is actively constructed through meaningful interaction with tasks and contexts.

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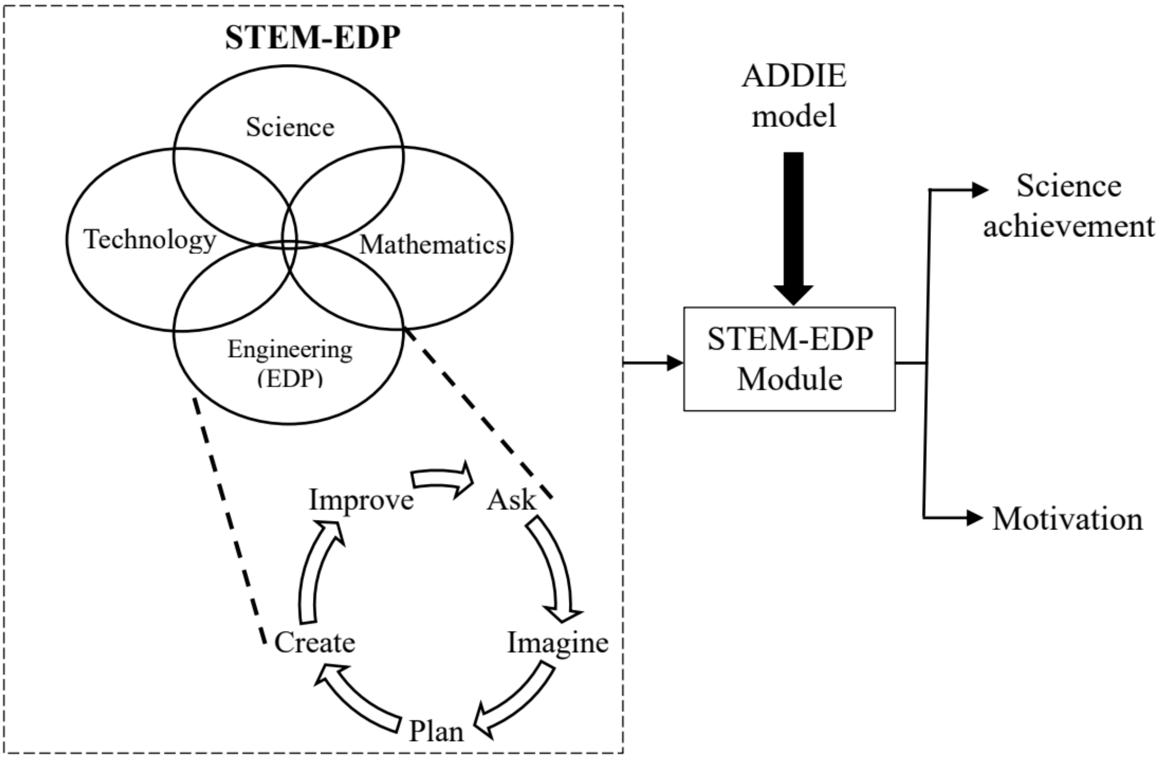

Figure 1. Conceptual framework of STEM-EDP module

In this framework, achievement is not viewed solely as the acquisition of factual knowledge but as the ability to apply scientific understanding to solve problems and make informed decisions. Science achievement is conceptualized in the framework as an outcome of sustained cognitive engagement with scientific concepts through STEM-EDP activities. The structured design tasks encourage students to test ideas, analyze evidence and make reasoned decisions. Through repeated cycles of designing, testing and improving, students develop a more robust understanding of scientific concepts, particularly within the topic of Force and Motion.

In addition to cognitive outcomes, the framework emphasizes student motivation as a key affective outcome influenced by STEM-EDP learning experiences. Engineering design tasks are inherently student centered and problem oriented, providing opportunities for autonomy, active participation and collaborative learning. More specifically, each phase of the EDP is conceptually aligned with the basic psychological needs outlined in SDT. During the ‘Ask’ and ‘Imagine’ phases, students are encouraged to identify problems and generate multiple design ideas, supporting autonomy through choice and open-ended inquiry. The ‘Plan’ and ‘Create’ phases emphasise the application of Force and Motion concepts, which are intended to strengthen students’ sense of competence through hands-on problem solving across the design challenges. Similarly, the ‘Improve’ phase promotes reflection, redesign and group discussion, thereby fostering relatedness through collaboration and shared meaning making. These features are expected to foster positive motivational responses by increasing students’ interest, engagement and persistence in science learning.

Taken together, the proposed conceptual framework illustrates a coherent relationship between STEM-EDP learning experiences and educational outcomes. Through this integration, the framework is expected to simultaneously improve cognitive outcomes by enhancing achievement in Force and Motion, while also strengthening affective outcomes related to students’ motivation to learn science. This dual focus addresses both the immediate challenge of declining performance and the need to foster sustained motivation in science learning.

https://doi.org/10.37134/ejoss.vol12.sp.5.2026

DISCUSSION

The proposed conceptual framework seeks to address two persistent challenges in Malaysian science education: low student achievement in the topic of Force and Motion and declining motivation to learn science. By grounding in the EDP, students are positioned as active problem solvers who apply scientific knowledge in authentic contexts, moving beyond teacher centred practices that rely heavily on memorisation. Through design challenges, students engage in inquiry that connects theory with practice, thereby deepening conceptual understanding and reducing common misconceptions.

The framework is further informed by SCT, which conceptualises learning as a process of meaning making through interaction with peers, teachers and the environment. Collaborative teamwork, discussion and reflection embedded in the module create opportunities for students to co-construct knowledge rather than passively receive information. This theoretical grounding complements the use of SDT, which guides the design of learning activities that nurture autonomy, competence and relatedness. Prior research has consistently shown that fulfillment of these psychological needs is associated with enhanced intrinsic motivation and sustained engagement. Integrating EDP, SDT and SCT therefore provides a coherent foundation for addressing both cognitive and motivational dimensions of science learning.

In addition, the proposed use of a pre-experimental design with repeated measures offers a practical means for future study to evaluate the dual outcomes of achievement and motivation. This design makes it possible to capture both immediate learning gains and retention over time, thereby providing evidence of sustainability. Such evidence is critical in demonstrating the long-term potential of the module, as short-term improvements alone are insufficient to justify large scale adoption.

From a classroom implementation perspective, the STEM-EDP framework offers practical guidance for teachers seeking to integrate engineering design into the Force and Motion topic. Teachers may facilitate learning through structured design challenges implemented over several lessons, allowing students to apply scientific concepts through iterative planning, testing and improvement. The framework supports teachers in shifting from teacher centred instruction to a facilitative role, where questioning, feedback and reflection are used to scaffold students' thinking rather than providing direct solutions. Such an approach aligns with the expectations of the Malaysian science curriculum, while remaining feasible within typical classroom constraints.

Finally, the incorporation of the ADDIE instructional design model ensures that the module is developed in a systematic and rigorous manner. This structured approach addresses a key challenge in innovative pedagogy, namely the limited availability of validated instructional resources to support STEM and engineering design-based learning. By offering a ready to use and adaptable resource, the framework bridges theoretical principles with classroom practice and provides teachers with practical guidance for implementation.

Expected Contributions

This conceptual paper contributes to science education by advancing a framework for integrating the EDP into STEM instruction at several interrelated levels, namely theoretical, pedagogical and policy related contributions. At the theoretical level, the proposed STEM-EDP framework advanced existing STEM literature by offering an explicit integration of the EDP with both SCT and SDT. While previous STEM or EDP-based studies often emphasise cognitive outcomes or design practices in isolation, this framework uniquely articulates how engineering design activities can be intentionally structured to support students' psychological needs for autonomy, competence and relatedness. By mapping these motivational constructs across the EDP phases, the framework provides a theoretically coherent model for addressing achievement and motivation simultaneously in science learning, particularly within the challenging topic of Force and Motion.

At the pedagogical level, the framework offers practical guidance for teachers to integrate engineering design into science lessons by supporting students in learning scientific concepts through iterative processes of planning, testing and design improvement. Furthermore, the proposed framework is not limited to the topic of Force and Motion, but can be adapted to other science topics and extended to interdisciplinary STEM learning contexts. This contribution is particularly relevant for Malaysian lower

https://doi.org/10.37134/ejoss.vol12.sp.5.2026

secondary classrooms, where engineering design is often underrepresented and teachers report limited pedagogical support for STEM integration.

At the policy and curriculum level, the proposed framework aligns closely with the aspirations of the Malaysian Education Blueprint and the Standard Curriculum for Secondary Schools (KSSM), which emphasise STEM integration, higher-order thinking skills and student-centred learning. By anchoring STEM instruction in engineering design while supporting motivation and conceptual understanding, the framework also contributes to the broader agenda of Sustainable Development Goal 4 (SDG 4) on quality education. As such, it offers insights that may inform curriculum development, teacher professional development programmes and future STEM education initiatives at both national and international levels.

In sum, this study contributes to a theoretically grounded and contextually relevant STEM-EDP framework that highlights the importance of integrating cognitive and motivational dimensions in science education. While conceptual in nature, the framework provides a foundation for future empirical research and practical application aimed at advancing STEM pedagogy and improving students' learning experiences in Force and Motion.

CONCLUSION

This conceptual paper emphasizes the potential of the STEM-EDP framework to strengthen both achievement and motivation in science learning through the integration of EDP and STEM learning contexts. As a conceptual contribution, it highlights how integrating cognitive and motivational perspectives can inform the design of science instruction. Although the framework has not yet been empirically tested, it offers a clear theoretical foundation for future studies examining cognitive and affective learning outcomes. Such studies will be essential to refine its classroom application and determine effectiveness. If validated, the framework may not only transform science education in Malaysia, but also contribute to the advancement of global discourse on STEM pedagogy and instructional innovation.

STATEMENT ON THE USE OF GENERATIVE ARTIFICIAL INTELLIGENCE

During the preparation of this work, the author used OpenAI's ChatGPT to enhance the clarity of the writing. After using OpenAI's ChatGPT, the author reviewed and edited the content as needed and takes full responsibility for the content of the publication.

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