The Mediating Effects of Procrastination on Project-Based Learning and Students' Engagement in Science

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ABSTRACT

This research focused on the mediating effects of procrastination in the relationship between project-based learning and engagement among students who are in senior high school. Employing a quantitative descriptive-correlational method with a cross-sectional mediation design, this study was conducted in three private schools in Davao City in the Philippines. The study used purposive sampling in selecting the respondents from the senior high school students enrolled in STEM. The data from the face-to-face administration of the paper-and-pencil questionnaires were analyzed using Jamovi. Mean, standard deviation, Pearson correlation, and path-analytic regression-based mediation were used in analyzing the data. The descriptive data showed that both project-based learning and engagement in science are at a high level, although the mediating variable of academic procrastination was found to be moderate in the global sense but situational in nature, as it reached its peak during exams when compared to low-stakes classroom work. Inferential and structural results showed that there was a statistically significant direct path between the model and student engagement but non-significant paths between the method and procrastination. While there was no direct and notable relationship between procrastination and engagement of students, there was a localized negative relationship between procrastination and cognitive engagement, indicating that procrastination reduces cognitive processing. The indirect path showed there is a non-significant mediation effect because both paths are stagnant. The project-based learning method itself increases engagement but does not rely on procrastination. Educational leaders should take the issue of the curriculum and self-regulation of students into account. The nature of the research does not allow establishing causality, and reliance on self-reported data may have biased the research findings. Further research should check whether procrastination is a moderator that interacts with motivational constructs or not.

Keywords: Project-Based Learning, student engagement, academic procrastination, mediation analysis, science education, senior high school STEM

INTRODUCTION

Contemporary educational practices focus on new pedagogical approaches in science education has markedly increased, especially within the Science, Technology, Engineering, and Mathematics (STEM) fields. Recent studies highlight that project-based learning has emerged as an effective pedagogical method that fosters active engagement, cooperation, and deeper comprehension among students. Evidence from recent reviews indicates that engaging students in authentic projects and real-world problem-solving through project-based learning improves student engagement, motivation, academic achievement, and the development of higher-order thinking skills (Santhosh et al., 2023; Farshad & Fortin, 2026). Elevated engagement forecasts enhanced scientific comprehension and perseverance in STEM disciplines; nonetheless, numerous students continue to face challenges in maintaining their involvement and enthusiasm in science classrooms. Nonetheless, despite the promise of learner-centered instructional methods to enhance deep learning, learner-related issues such as procrastination may still affect their efficacy. Recent research indicates that procrastination is strongly associated with poor self-regulation and delayed academic tasks, which negatively affect engagement and learning outcomes. (Pichardo et al., 2020; Rodríguez et al., 2022).

This challenge is particularly evident in science education, where sustained inquiry, critical thinking, and collaboration are essential for meaningful learning. However with traditional teacher-centered instruction, project-based learning has been shown to enhance student engagement, collaboration, and academic achievement by immersing learners in authentic, real-world problem-solving experiences (Santhosh et al., 2023). In contrast, project-based learning's focus on student-led research, idea application, and collaborative efforts may increase engagement by promoting ownership, curiosity, and social connection. Comprehending the impact of instructional methods on students' procrastination and engagement is particularly crucial for senior high school STEM students who must navigate intricate academic responsibilities and demanding scientific skills. Although there is increasing interest in enhancing science learning outcomes, research investigating procrastination as a mediating factor between learning methodologies and engagement is limited, especially within the Philippine context. This study is based on the Temporal Motivation Theory (TMT) proposed by Steel and König (2006), which clarified procrastination as a function of task value, expectancy, impulsiveness, and delay. This theory serves as a suitable framework for understanding how motivation and time-related decision-making influence the mediating role of procrastination between instructional methods and engagement. This framework is supported by constructivist learning theory (Piaget; Vygotsky), which explains how project-based learning enhances engagement through active, collaborative, and meaningful experiences; self-regulation theory (Zimmerman, 2000), which links procrastination to students' ability to manage goals, strategies, and learning behaviors; and expectancy–value theory (Eccles, 1983), which describes how perceptions of task utility and interest affect motivation, procrastination, and engagement. These theories demonstrate the interrelated dynamics among variables: learning approaches directly influence engagement (IV → DV) by fostering autonomy and collaboration; they affect procrastination (IV → MV) by modifying task value and accountability; and procrastination subsequently impacts engagement (MV → DV) through its effects on students' cognitive investment, participation, and emotional involvement. The researcher considers these theories complementary, with constructivism demonstrating the development of engagement, Temporal Motivation Theory elucidating the reasons for learner procrastination, and self-regulation and expectancy–value theories clarifying the motivational processes that underlie these behaviors, collectively improving the comprehension of how instructional design affects engagement through time-related behaviors.

The research suggests that the pedagogical method, particularly project-based learning, affects STEM students' involvement in science. Despite this, students' tendency for procrastination may influence this association. Project based learning is suggested to lower procrastination and strengthen engagement, whereas conventional approaches may worsen procrastination and lower engagement. Consequently, procrastination serves as a mediator variable clarifying the mechanism connecting instructional methods to engagement outcomes. This study asserts that learning approaches impact the engagement levels of STEM students in science. This association is seen to be mediated by students' intrinsic tendencies toward procrastinating. Project-based learning is expected to reduce procrastination and enhance engagement, while traditional teaching methods may result in increased procrastination and a subsequent decrease in engagement. Thus, procrastination is suggested as a mediating variable that investigates the relationship between the utilized learning strategies and the resulting engagement outcomes. This research is based on the Temporal Motivation Theory (TMT) formulated by Steel and König (2006), which provides a thorough understanding of how motivation, reward value, expectation, and impulsiveness affect students' tendency to procrastinate. Temporal Motivation Theory explains the complex relationship between instructional strategies, procrastination, and student engagement in that individuals procrastinate when tasks are perceived as valueless, when the expectations for success are lessened, or when other motivations outweigh academic incentives. Within the framework of this study, project-based learning enhances the perceived relevance of academic tasks, thereby reducing procrastination and fostering student engagement. In contrast, conventional lecture-based teaching may provide fewer motivational incentives, leading to increased procrastination and reduced participation. Consequently, Temporal Motivation Theory functions as a suitable anchor theory, as it explicitly addresses how instructional techniques affect procrastination and, in turn, impact engagement behaviors.

The correlation between learning methodologies and student engagement is based on how various instructional strategies elicit cognitive, emotional, behavioral, and social participation from learners. Project-based learning fosters significant engagement through student involvement in inquiry-driven projects, collaborative endeavors, genuine problem-solving, and autonomous exploration. This enhances engagement, curiosity, and critical thinking. Conversely, traditional learning may restrict involvement due to its focus on passive listening and rote memory. Instructional approaches impact procrastination, as the framework of project-based learning fosters accountability, relevance, and continuous engagement, hence diminishing the probability of academic delay. Conventional learning may lead to increased procrastination because of its frequently unengaging routines, which may lack adequate motivation or autonomy. Procrastination adversely impacts engagement by diminishing students' cognitive investment, decreasing participation, and limiting emotional and social involvement. Students that procrastinate typically exhibit disengagement from assignments, a deficiency in commitment, and diminished enthusiasm or enjoyment in learning activities. The current study provides strong empirical evidence of the correlations among learning approach, procrastination, and engagement. Research on project-based learning highlights its efficacy in enhancing engagement via collaboration, autonomy, and contextualized learning. Hornejas and Guntalidad (2024) demonstrated that project-based learning significantly improves students' content mastery and cognitive skills by fostering active engagement, collaboration, and meaningful participation in authentic biology learning tasks, and engagement, while Jiménez-Gaona and Vivanco-Galván (2024) noted that project-based learning promotes students' critical thinking and prolonged classroom participation. Traditional teacher-centered instruction may offer fewer opportunities for active participation than project-based learning, whereas project-based learning has been shown to enhance student engagement, collaboration, and academic achievement through authentic and learner-centered educational experiences (Santhosh et al., 2023). Studies indicate that learning methodologies affect procrastination. Interactive and student-centered approaches mitigate procrastination by increasing engagement and perceived significance, as evidenced by Ziegler and Opdenakker (2018).

Temporal Motivation Theory serves as the primary theoretical framework for this research, as it most effectively explains the motivational mechanism linking instructional techniques to procrastination and, consequently, to student involvement. The idea conceptualizes procrastination not solely as a time-management issue but as a motivational consequence influenced by learners' perceptions of the worth, relevance, and difficulty of academic activities. In educational settings, project-based learning enhances expectation and task value while reducing impulsiveness and procrastination, unlike traditional learning, which may lack similar motivational influences Temporal Motivation Theory is the most consistent and appropriate theory to describe why students engaged in project-based learning demonstrate less procrastination and increased involvement in science.

Three supplementary frameworks support the anchor theory to enhance its theoretical base. The constructivist learning theory, developed by Piaget and Vygotsky, asserts that students achieve optimal learning when they actively create meaning via cooperation, inquiry, and genuine involvement with activities, concepts that are fundamental to project-based learning. Project-based learning inherently increases participation by offering real-world relevance and facilitating social interaction. Zimmerman's Self-Regulation Theory (2000) explores how learners establish objectives, track progress, and regulate urges, emphasizing that procrastination signifies a failure in self-regulatory mechanisms. Project-based learning facilitates self-regulation via organized tasks and collective responsibility, diminishing procrastination and enhancing participation. Eccles' Expectancy–Value Theory (1983) adds depth by asserting that students are more engaged when they perceive a work as valued and anticipate success. Project-based learning enhances perceptions by providing relevant, attainable, and authentic educational experiences, whereas conventional learning may diminish task value and lead to procrastination. Collectively, these theories clarify the interplay between educational strategies and procrastination in shaping involvement.

Temporal Motivation Theory is the most pertinent framework, as it explicitly associates task value, expectation, and impulsiveness with procrastination, which serves as a crucial mediator in the study. Constructivism emphasizes that engagement peaks when learners actively partake in knowledge construction, closely aligning with the objectives of project-based learning. Self-Regulation Theory and Expectancy–Value Theory examine the emergence of procrastination and its impact on engagement. The researcher proposes that effective science education must transcend mere content dissemination to foster curiosity, autonomy, accountability, and significant engagement. In the absence of these elements, commonly observed in conventional approaches, students may be more likely to experience procrastination and disengagement. The researcher perceives project-based learning not merely as a pedagogical tool but as an environment that enhances motivation, mitigates procrastination, and fortifies engagement, rendering it a potent approach in science education.

The Instructional Methods dimension of the Project-Based Learning (PBL) questionnaire was adapted from the work of Bani Issa and Khataibeh (2021). Instructional methods denote the organized procedures employed to convey content and enhance learning. This study outlines instructional methods by four criteria: student engagement and motivation, indicating the extent to which instruction fosters learner involvement; learning effectiveness, denoting the level of comprehension and mastery attained; collaboration and application, relating to opportunities for peer interaction and real-world relevance; and autonomy and skills development, which reflect the degree to which instruction encourages independence and critical thinking.

The Academic Procrastination questionnaire used in the present study was adapted from the Procrastination Assessment Scale–Students (PASS) developed by Solomon and Rothblum (1984). The original instrument was

designed to assess the extent to which students procrastinate across various academic tasks, including writing term papers, studying for examinations, keeping up with reading assignments, completing academic administrative tasks, attending academic-related appointments, and participating in general school activities. Procrastination is the deliberate postponement of academic duties despite an understanding of adverse outcomes. It is measured through indicators such as delays in writing tasks, exam preparation, reading assignments, administrative tasks, attendance-related responsibilities, and general academic activities. These signs collectively encompass the various domains in which students demonstrate task delay, rendering procrastination a multifaceted behavioral concept.

The researcher adapted the Science Engagement Questionnaire from Wang et al. (2016). The original instrument was designed to measure students' engagement in mathematics and science through four dimensions: behavioral, cognitive, emotional, and social engagement. Student engagement is defined as a complex term that includes learners' cognitive, behavioral, emotional, and social involvement in the learning process. The cognitive dimension encompasses mental exertion and the application of learning strategies; the behavioral dimension signifies engagement, perseverance, and task fulfillment; the emotional dimension relates to students' affective responses during learning, including interest or anxiety; and the social dimension pertains to interactions, collaboration, and relationships with peers and educators.

Project-Based Learning

Project-based learning has long been recognized as a successful approach to enhancing student engagement and learning outcomes. Recent studies have proved its positive effect in science education. Notably, Jiménez-Gaona and Vivanco-Galván (2024) found that project-based learning in biotechnology lectures significantly increased students' understanding and use of mathematics topics, boosting critical thinking and problem-solving ability. Hornejas and Guntalidad (2024) demonstrated that project-based learning significantly improved students' content mastery and cognitive skills in senior high school, providing evidence for the effectiveness of active learning methodologies in science education. Project-based learning has evolved as a highly valued approach to teaching and strengthening successful instruction, particularly in fostering deeper learning, engagement, and interdependence among students. Project-based learning, a learning model based on real-life projects, problem-solving, and constructivist theory (Piaget, 1973; Vygotsky, 1978), is designed to increase students' active participation and intellectual development through their engagement with the environment. Santhosh et al. (2023) examined the effectiveness of project-based learning in science education through a meta-analysis and found that this instructional approach significantly enhances students' academic achievement while developing transferable skills such as critical thinking, problem-solving, collaboration, and teamwork. The authors emphasized that these competencies are fundamental for preparing learners to address complex real-world challenges and succeed in future science, technology, engineering, and mathematics careers. Project-based learning involves students in real-world problems and is more engaging than traditional techniques, which frequently fail to bridge theory and practice. Similarly, Hornejas and Guntalidad (2024) revealed that project-based learning significantly enhanced the cognitive capacities and content understanding of senior high school students in science. Their study found that students who participated in project-based learning had higher scores on problem-solving tasks and reported greater levels of engagement than students who received instruction through traditional methods. The findings support the premise that project-based learning facilitates active learning by involving students in real-world learning situations. Moreover, Project-based learning has been shown to facilitate cognitive development through group collaboration, which is a key component of the constructivist approach (Jiménez-Gaona & Vivanco-Galván, 2024). In one study in a biotechnology class, students working under project-based learning gained better critical thinking and applied mathematical concepts than students taking lecture-type techniques. This evidence shows the need for collaborative learning for students to examine, synthesize, and apply knowledge, especially in complex scientific contexts. Asri and Cahyono

(2024) examined the role of self-regulated learning within a project-based learning environment and reported that project-based learning, when supported by effective self-regulation, significantly reduced students' academic procrastination. The study further emphasized that collaborative and inquiry-based learning activities encouraged students to become more responsible and actively engaged in managing their own learning. This further supports the idea that project-based learning not only influences cognitive capacities but also self-regulation and motivation. Project-based learning has been found to provide students with long-term retention in terms of lasting learning experiences so that they are able to move to various situations. Vesikivi et al. (2020) reported that integrating project-based learning into the curriculum significantly improved students' first-year retention, study experiences, and knowledge-work competence. By engaging students in authentic, multidisciplinary projects, the approach fostered collaboration, independent learning, and the application of knowledge in real-world settings. These findings underscore the relevance of project-based learning in science education, where meaningful learning depends on students' ability to connect conceptual understanding with practical laboratory experiences and scientific problem-solving. With all these advantages, project-based learning has its challenges too. Turner and Hodis (2023) conducted a systematic review of interventions designed to reduce academic procrastination and found that instructor-guided, classroom-based strategies effectively promote students' self-regulation, engagement, and timely completion of academic tasks. Their findings highlight the importance of structured instructional support in helping students manage complex learning activities and reduce procrastination. This finding indicated that project-based learning is an effective tool, but its performance depends on the setting in which it is used. The preparation of the students and the teachers' disciplinary measures have also proved to boost employability skills. As shown by González et al. (2023), an interdisciplinary project-based learning experience with students of biology, engineering, and translation boosted self-directed learning, critical thinking, and problem-solving skills, skills that are crucial for success in future employment.

Procrastination

This behavior is caused by the passive alignment of traditional learning, which is due to a lack of interest among students in studying the information. Steel et al. (2022) reported that ineffective self-regulation and procrastination contributed to poorer performance, particularly when deadlines lacked clear structure or urgency. Applied to educational settings, these findings suggest that students who fail to regulate their learning behaviors and remain consistently engaged with academic tasks are more likely to delay completing projects, which may adversely affect their academic performance. The traditional learning approach lacks engagement and relevance to the outside world, which might actually contribute to these problems, especially in complicated topics. Procrastination has also been extensively investigated in relation to academic achievement, with several studies on predictors and consequences. Arias and Sosa (2022) conducted a meta-analytic review of the substantial detrimental impact of procrastination on academic achievement, showing that students need to have strong time management. Visser et al. (2019) reported that motivational regulation plays a significant role in explaining academic procrastination, indicating that students who actively regulate their motivation are better able to manage learning tasks, maintain persistence, and reduce tendencies toward delayed academic behavior. Hong et al. (2021) investigated the role of academic procrastination in students' learning processes and found that procrastination negatively affected self-regulated learning, ultimately diminishing learning effectiveness. These findings highlight the importance of effective self-regulation in supporting academic performance and reducing tendencies toward procrastination. Sirois et al. (2023) found that procrastination contributes to poorer health outcomes by increasing stress and promoting unhealthy health behaviors. These findings highlight that the negative effects of procrastination extend beyond academic performance and can adversely affect individuals' overall well-being. González-Brignardello et al. (2023) found that academic procrastination was associated with higher levels of academic stress and poorer subjective well-being, while effective self-regulated learning was linked to better academic achievement and psychological well-being. Their findings suggest that persistent procrastination can undermine both students' academic success and overall well-being, whereas strong self-regulation serves as a protective factor. The findings of Sirois et al. (2023) demonstrated that procrastination is a complex self-regulatory behavior associated with greater stress and poorer health behaviors over time, emphasizing the interaction of cognitive, emotional, behavioral, and social characteristics. Furthermore, Ma et al. (2022) examined how self-regulated learning influences academic procrastination and found that students with better self-regulatory skills exhibit lower levels of procrastination and more effective management of academic responsibilities. Collectively, these findings highlight the complex nature of procrastination and its implications for students' academic achievement.

Student-centered instructional approaches that emphasize authentic, collaborative, and inquiry-based learning have been shown to enhance engagement and meaningful participation, which may foster greater motivation for learning than more passive instructional approaches (Santhosh et al., 2023). Previous studies have found that more participatory learning strategies such as project-based learning have been shown to reduce procrastination through greater learner participation and higher perceived task value .Wood and Pranjol (2024) found that incorporating peer assessment into project-based learning fostered greater accountability and equitable participation in group work, encouraging students to contribute consistently, thereby reducing procrastination tendencies and improving overall academic performance. Project-based learning fosters greater collaborative learning and deep learning, removing the self-regulation barriers that contribute to procrastination.

Student Engagement in Science

Student engagement has been widely recognized as a fundamental construct in education because it is closely associated with students' persistence, motivation, well-being, and academic achievement. It is conceptualized as a multidimensional phenomenon comprising behavioral, cognitive, emotional, and agentic dimensions that collectively influence learning outcomes (Reeve et al., 2025). Each of these characteristics contributes uniquely to learning outcomes, but they are interrelated and work together to shape students' engagement in scientific classrooms. Contemporary work emphasizes the necessity of isolating these characteristics from one another rather than viewing them as a single construct of engagement to better understand how students connect with scientific learning settings (McChesney et al., 2025).

Cognitive engagement refers to the amount of mental effort that students put into academic tasks and activities and involves the use of higher-order skills such as self-regulation, elaboration, and problem-solving . This is more important in science education that depends on critical reasoning and conceptual comprehension. Xiang et al. (2024) found that interactive instructional videos in science, technology, engineering, and mathematics courses helped students to engage in active sense-making and knowledge creation. Similarly, Wiley (2025) found that teacher approaches that highlighted science-as-practice enhanced students' analytical thinking and deeper reasoning. Cognitive involvement is quite sensitive to learning approaches focused on inquiry and reflection, this research suggests.

Behavioral engagement is the observable engagement behaviors of students, such as participation, perseverance, and compliance with academic expectations. It is the most obvious form of involvement, and it shows that students are willing to put in the effort to learn. Zainuddin et al. (2024) found that instructional designs that included structured tasks requiring active engagement led to greater levels of behavioral engagement in blended learning environments. Moreover, Siyam et al. (2025) showed that the presence of flexibility and institutional support in distant learning environments increased students' persistence as demonstrated by their regular attendance, submission of work on time, and engagement in online discussions. These results suggest that behavioral engagement is associated with the extent to which instructional environments are opportunities for active, long-term participation.

Emotional engagement indicates students' affective responses to the learning process, such as enjoyment, curiosity, worry, and sense of belonging. Studies have indicated that positive emotions relate to higher motivation and persistence, whereas negative emotions tend to discourage active participation. According to Wester et al. (2024), students may experience science fatigue, which manifests as declining interest, reduced motivation, and lower emotional engagement in science subjects when they are overwhelmed by continuous scientific information and demanding learning experiences. But the tactics used to increase teachers' presence and foster supportive learning environments have been found to promote students' emotional involvement (International Review of Research in Open and Distributed Learning, 2022). Zhang et al. (2025) also found that emotional involvement is interconnected with cognitive and behavioral dimensions, and effective investment in science learning promotes both intellectual effort and active participation.

Social engagement emphasizes the collaborative and relational dimension of learning, especially peer interaction, teacher-student relationships, and participation in co-construction of knowledge. This characteristic is particularly essential for science education since discourse and collaboration are critical elements of disciplinary procedures. Classrooms designed to promote dialogue and collaboration result in greater student engagement with scientific research (Wiley, 2025). Bouhafa et al. (2023) found that perceived teacher support is a strong predictor of social and emotional engagement. In positive situations, students are able to work more collaboratively and to engage in group work. The findings suggest that social relations are important in fostering student engagement, particularly in instructional contexts such as project-based learning, where cooperation is central to the learning process. The literature review reveals that student involvement in science is a complex and multidimensional entity, involving cognitive, behavioral, emotional, and social variables. Hence, fostering engagement in science education necessitates a holistic strategy that incorporates cognitive effort, visible participation, emotional commitment, and cooperative interaction. The primary aim of this study is to ascertain the mediating effects of procrastination on the project-based learning strategy and the involvement of senior high school students in science.

This study seeks to better understand and analyze the correlation between instructional methodology, procrastination, and student engagement in science among senior high school STEM students. The study aims to (a) determine the level of project-based learning approach among senior high school STEM students used in science classes; (b) to determine the level of student engagement in science in terms of cognitive, behavioral, emotional, and social dimensions; (c) to determine the level of academic procrastination among senior high school STEM students in science classes; (d) to determine whether there is a significant relationship between the project-based learning approach and students' academic procrastination; (e) to determine whether there is a significant relationship between the project-based learning approach and student engagement in science; (f) to determine whether there is a significant relationship between academic procrastination and student engagement in science; and (g) to determine whether academic procrastination significantly mediates the relationship between the project-based learning approach and student engagement in science.

METHODS

Research Respondents

The population of the study consists of senior high school STEM students enrolled in three private schools in Davao City during the academic year 2025-2026. The commonalities of these students are that they are enrolled in the STEM strand, they undergo science learning based on the senior high school curriculum, and they engage in academic tasks that involve scientific inquiry, collaboration, and conceptual understanding. This population is appropriate for exploring the relationships between instructional approach, procrastination, and student engagement in science, as STEM learners are expected to exhibit varying levels of academic engagement and self-regulatory behaviors, including procrastination.

The study sample consisted of 320 intact sections of senior high school STEM students. Sample size was based on total class enrollment and is considered sufficient for correlational and mediation analysis, as recommended in educational research where sample sizes of at least 100 are sufficient to detect medium effect sizes in regression-based mediation models (Cohen, 1988; Hayes, 2018). The respondents are spread across the various sections. The various sections are natural instructional groups that are exposed to either project-based learning or traditional learning approaches. Intact classes maintain the instructional context and minimize disruption to the regular classroom instruction.

The study employed a purposive sampling method, specifically intact classes, suitable for non-experimental and correlational research designs where random assignment is unfeasible (Creswell, 2014). The utilization of intact groups enables the researcher to investigate pre-existing disparities in instructional methods without altering classroom environments. Purposive sampling is frequently employed in educational research to examine particular learner cohorts that exhibit characteristics pertinent to the research variables, especially when teaching techniques are dictated by school policy or curriculum design (Fraenkel, Wallen, & Hyun, 2019). This sample method is warranted as the study sought to understand relationships within an authentic instructional context rather than to generalize findings to all student demographics. The inclusion criteria for participation in this study are (1) enrollment in the senior high school STEM strand, (2) current enrollment in science subjects during the data-collecting period, and (3) willingness to participate as demonstrated by informed consent and, if necessary, parental consent. Students absent during the questionnaire administration or those providing incomplete responses were omitted from the final analysis. Participation in the study was entirely voluntary, and participants were made aware of their choice to withdraw at any time without academic repercussions. Students who opted to withdraw or denied participation did not face any disadvantages in academic or classroom-related topics.

MATERIALS AND INSTRUMENTS

This research included three structured survey questionnaires to assess the primary variables: learning approaches, procrastination, and student engagement in science. All items were modified from previously validated questionnaires to guarantee content validity and reliability, specifically tailored for senior high school students in science, technology, engineering and mathematics disciplines.

- The initial tool was the Instructional Approach Questionnaire, modified from Bani Issa and Khataibeh (2021), utilized to explain students' perspectives of instructional methodologies employed in scientific classes. This questionnaire evaluated four domains: student engagement and motivation, learning effectiveness and comprehension, collaboration and real-world application, and autonomy and skill development. Responses were evaluated utilizing a 5-point Likert scale, with elevated scores signifying a more pronounced perception of project-based learning attributes.
- The second instrument utilized was the Procrastination Assessment Scale for Students (PASS), created by Solomon and Rothblum (1984), which was used to evaluate students' academic procrastination in various academic tasks, such as science writing, project assignments, studying for science exams, completing science reading assignments, fulfilling science academic obligations, and managing general science-related responsibilities. The modified tool assessed procrastinating behaviors utilizing a 5-point Likert scale, where elevated scores signified increased degrees of academic procrastination.
- The third instrument was the Science Engagement Questionnaire, modified from Wang et al. (2016), utilized to assess students' engagement in science across four dimensions: cognitive, behavioral, emotional, and social engagement. The questionnaire had statements that defined students' learning behaviors, attitudes, and interactions within scientific classes. Responses were evaluated using a 5-point Likert scale.

The instruments employed in this study were modified from pre-existing verified tools. Minor adjustments were implemented to fit the items into the context of scientific academic assignments. Given that the original instruments had established reliability and validity in prior investigations, pilot testing was deemed unnecessary. Content validation was conducted to ascertain the appropriateness of the modified items for the STEM senior high school environment. The instruments were assessed and validated by five professional validators with expertise in science education, educational research, and measurement and evaluation. The experts evaluated the clarity, relevance, cultural suitability, and alignment of the items with the study objectives. The mean validation ratings were calculated to assess the suitability of the instruments before data collection.

The reliability of the instruments was determined by consulting the published Cronbach’s alpha coefficients from original and prior validation investigations. The Science Engagement Questionnaire (Wang et al., 2016), the Procrastination Assessment Scale for Students (Solomon & Rothblum, 1984), and the Instructional Approach Questionnaire (Bani Issa & Khataibeh, 2021) exhibited acceptable to high internal consistency, with reliability coefficients surpassing the minimum threshold of 0.70, which is deemed acceptable in educational research. The developed reliability indices validated the suitability of employing the altered instruments in the current study.

DESIGN AND METHODOLOGY

This research utilized a non-experimental, cross-sectional, and correlational design in the domain of education. Creswell (2014) and Fraenkel, Wallen, and Hyun (2019) assert that non-experimental designs are suitable for analyzing naturally occurring groups and when variables are unmodifiable. This design is appropriate for the current study, as the project-based learning will be applied in existing classes, and ethical constraints preclude the random assignment of students to groups. This strategy facilitated the analysis of group differences, predictive correlations, and indirect impacts among instructional methods, procrastination, and student engagement in science from an educational research standpoint. A mediation analytic methodology was employed to investigate the function of procrastination as a mediating variable between instructional style and student engagement, thereby fulfilling the primary purpose of the study. Mediation analysis is suitable when a researcher aims to better understand the mechanism by which an independent variable affects a dependent variable (Hayes, 2018). This study utilized mediation analysis to ascertain whether the instructional strategy directly and indirectly affected student participation through procrastination, thus fulfilling the research's explanatory objective. The study was categorized as both descriptive and inferential in its research typology, as it defined levels of procrastination and participation while also examining important variations, correlations, and mediation effects. The study was cross-sectional, as data were gathered at a single point during the academic year 2025–2026, rather than throughout many points in time.

An appropriate informed consent process was conducted before participation, adhering to ethical norms for research involving minors and adults. Distinct consent protocols were employed according to the participants' age categories. Parental approval and participant assent were obtained for students aged 15 to under 18 years. Simultaneously, a standard informed consent form was provided to participants aged 18 and older.

Participants received detailed information about the study, encompassing its objectives, methodologies, potential risks and advantages, confidentiality protocols, and their rights as research subjects. They were allotted a minimum of 24 hours to review the permission documents and confer with their parents or guardians prior to deciding on participation. To maintain secrecy and anonymity, finalized consent forms were gathered via a sealed drop box. Moreover, it was explicitly stated that participation in the study was entirely optional. Participants were assured that declining to participate or withdrawing from the study at any point would not influence their grades, academic standing, teachers' evaluations, or access to educational opportunities. To maintain confidentiality, the study refrained from gathering any irrelevant or identifying information from the individuals. The questionnaire was amended to eliminate identifiers, including names and any other information that could directly associate responses with specific participants. Informed consent forms were collected independently from the completed surveys to exclude any correlation between participants' identities and their responses. Physical documents were safely housed in a locked cabinet, while digital data were preserved on a password-protected and encrypted device accessible solely to the researcher.

All obtained data were preserved for three (3) years for verification purposes and subsequently destroyed permanently using secure techniques, including the shredding of physical documents and the irreversible deletion of digital assets. Moreover, the researcher remained unaware of the identities of both participants and non-participants. These procedures were implemented to safeguard students' autonomy, maintain the voluntary aspect of participation, and guarantee that participating in the study did not affect academic performance or teacher-student relationships. The researcher gained agreement from the administrations of three private schools during the academic year 2025–2026 and received ethical clearance from the University of Mindanao Ethics Review Committee.

Data collection was executed via in-person, paper-based administration at prearranged sessions. To mitigate potential bias and address the researcher’s dual function as an educator, the distribution of the questionnaires was conducted by an impartial third-party faculty member without direct responsibility over the participants.

Before administering the questionnaires, participants were informed that their involvement was completely voluntary and that they could refuse participation, omit any question, or withdraw from the study at any point without facing any academic consequences. Completed questionnaires were deposited in a dedicated sealed drop box, apart from the consent papers, to maintain anonymity. All gathered data were managed securely and were accessible solely to the researcher for analytical reasons.

Descriptive and inferential statistical approaches were utilized to fulfill the research objectives. Descriptive statistics, encompassing frequency, mean, and standard deviation, were employed to characterize perceptions of instructional approaches, procrastination, and student engagement across cognitive, behavioral, emotional, and social dimensions. Pearson correlation and regression analyses were performed to investigate the predicted correlations between instructional method, procrastination, and student engagement.

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A mediation analysis was conducted to evaluate the mediating effect of procrastination, utilizing a regression-based method via the PROCESS Macro (Model 4) or a comparable route analysis technique. Bootstrapping methods were utilized to assess indirect effects and ascertain their statistical significance at the 0.05 level, in accordance with the guidelines of Andrew F. Hayes (2018). The analyses allowed the study to ascertain if procrastination significantly influenced the connection between instructional strategy and student involvement in science.

Ethical permission for the study was obtained from the University of Mindanao Ethics Review Committee (UMERC) under Certification No. 2026-240. A compliance certificate from UMERC was received before the start of data collection, in accordance with institutional research protocols.

The present study, while offering valuable insights into the mediating role of procrastination in project-based learning and student engagement, is limited in terms of generalizability due to its purposive sampling of three private schools in Davao City. This restricted sample may not fully represent the experiences of students in public schools or those enrolled in non-STEM programs. To strengthen the external validity of future investigations, it is recommended that subsequent studies expand their scope to include a broader range of educational contexts and diverse student populations. Such expansion would allow for a more comprehensive understanding of how project-based learning and procrastination interact across varied academic environments.

RESULTS AND DISCUSSIONS

Table 1: Level of Independent Variable (Learning Approach)

IV/Indicators	Mean	SD	Interpretation
Learning Effectiveness & Understanding	4.25	0.629	Very High
Collaboration & Real-World Applications	4.20	0.625	High
Autonomy & Skill Development	4.08	0.621	High
Student Engagement & Motivation	3.80	0.721	High
Overall IV	4.08	0.544	High

The descriptive profile of the independent variable, as depicted in Table 1, reveals a composite mean of 4.08 with an SD = 0.544 (High), signifying a consistently elevated level of implementation and consensus across participants. In Table 1, the indicator for Learning Effectiveness & Understanding received the highest score with the mean of 4.25, with an SD of 0.629 (Very High), indicating that students significantly perceive active, project-based learning experiences as effective in facilitating the understanding of science concepts while enhancing content mastery and cognitive skills. Collaboration & Real-World Applications with a mean score of 4.20 with an SD of 0.625 (High), underscores effective peer cooperation on genuine scientific challenges. The domain of Autonomy & Skill Development received a commendable rating with a mean score of 4.08 with an SD of 0.621 (High), indicating that the instructional environment effectively promotes higher-order thinking and the development of 21st-century competencies through authentic project-based learning experiences. In contrast, Student Engagement & Motivation recorded the lowest score in Table 1 with a mean score of 3.80 with an SD of 0.721 (High); the broader standard deviation and lower mean indicate that although the instructional method effectively clarifies content and develops skills, its ability to uniformly ignite intrinsic motivation among all learners is inconsistent.

Table 2: Level of Dependent Variable (Student Engagement)

DV/Indicators	Mean	SD	Interpretation
Cognitive Engagement	4.05	0.621	High

Social Engagement	4.00	0.700	High
Behavioral Engagement	3.31	0.529	Moderate
Emotional Engagement	3.18	0.533	Moderate
Overall DV	3.63	0.402	High / Positive

The descriptive profile of the dependent variable reveals a composite mean of 3.63 with an SD of 0.402 (High), signifying a predominantly elevated baseline level of student involvement in science, consistent with the multidimensional constructs proposed by Wang et al. (2016). The notable disparity among the sub-dimensions, where students indicate elevated cognitive engagement with a mean score of 4.05 with an SD of 0.621 (High); and social engagement with a mean score of 4.00 with an SD of 0.700 (High) but markedly reduced behavioral engagement with a mean score of 3.31 with an SD of 0.529 (Moderate) and emotional engagement with a mean score of 3.18 with an SD of 0.533 (Moderate), strongly supports the challenges emphasized by contemporary inquiry-based literature. The heightened cognitive and social scores corroborate the claims of Xiang et al. (2024) and Wiley (2025), who contended that active, student-centered learning frameworks are exceptionally effective in eliciting profound cognitive engagement, conceptual concentration, and collaborative inquiry among peers. In contrast, the decline into the moderate range for behavioral and emotional involvement highlights the self-regulatory conflict found by Zainuddin et al. (2024) and Siyam et al. (2025). This statistical disparity demonstrates that whereas an interactive pedagogical framework effectively emulates intellectual engagement and social collaboration, it is also vulnerable to shortcomings in student-level regulation. While project-based learning fosters authentic learning experiences and collaborative problem-solving, it also places greater demands on students' self-regulation. Li et al. (2022) reported that students' emotional experiences significantly influenced their behavioral engagement, demonstrating that positive emotions promoted active participation while negative emotions reduced engagement. Their findings further emphasized that behavioral engagement served as a key mechanism linking students' emotions to academic achievement, underscoring the importance of creating supportive learning environments that cultivate positive emotional experiences and sustained learner engagement.

Table 3: Level of Mediating Variable (Procrastination)

MV/Indicators	**Mean**	**SD**	**Interpretation**
Studying for Science Exams	3.60	0.852	High Procrastination
Science Writing & Project Tasks	3.23	0.856	Moderate Procrastination
Science Academic Requirement	3.22	0.885	Moderate Procrastination
Science Reading Assignments	3.17	0.832	Moderate Procrastination
Science Tasks in General	2.70	0.894	Moderate Procrastination
Science Class Responsibilities	2.57	0.910	Low-to-Moderate Procrastination
Overall MV	3.08	0.707	Moderate Procrastination

The situational variations in academic procrastination revealed on Table yield a composite mean of 3.08 with an SD of 0.707 (Moderate), indicating a baseline of moderate procrastination consistent with the self-regulatory frameworks proposed by Pichardo et al. (2020) and Rodríguez et al. (2022). Upon meticulous examination of the indicators in Table 3, procrastination behaviors reach a significant level during studying for science exams with a mean score of 3.60 with an of SD 0.852 (High), representing the sole descriptive characterization of high procrastination. This increase firmly supports Steel's (2021) temporal motivation theory, which asserts that task avoidance escalates exponentially as high-stakes, anxiety-provoking evaluative deadlines approach. Moreover, considerable delays continue to be observed for organized, intricate assignments, including Science Writing & Project Tasks with a mean score of 3.23 with an SD of 0.856 (Moderate), Science Academic Requirements with a mean score of 3.22 with an SD of 0.885 (Moderate), and Science Reading Assignments with a mean score of 3.17 with an SD of 0.832 (Moderate). These results support the findings of Visser et al. (2019), who emphasized that effective motivational regulation is essential for sustaining persistence and self-management during demanding academic activities. Consequently, students who experience difficulties regulating their motivation may be more susceptible to procrastinating on complex, multi-step science tasks that require prolonged effort and sustained attention. The findings further indicate that, when activities decrease in formality, procrastination diminishes to a moderate mean of 2.70 with an SD of 0.894 (Moderate), for Science Tasks in General, reaching its lowest point during regular Science Class Responsibilities with a mean score of 2.57, with an SD of 0.910, categorizing it as low-to-moderate procrastination. The significant decrease in task avoidance is supported by the findings of González-Brignardello et al. (2023), who demonstrated that students with stronger self-regulated learning skills exhibit lower levels of academic procrastination and better academic achievement. This suggests that students who effectively regulate their learning behaviors are less likely to delay academic tasks, contributing to greater engagement and more consistent completion of classroom responsibilities.

Table 4: Correlation Matrix: Learning Approach (IV) and Procrastination (MV)

MV	**IV**				
	Student Engagement & Motivation	**Learning Effectiveness & Understanding**	**Collaboration & Real-World Applications**	**Autonomy & Skill Development**	**Overall**
Science Writing & Project Tasks	0.031 (p = 0.575)	0.047 (p = 0.398)	0.017 (p = 0.757)	-0.055 (p = 0.325)	0.013 (p = 0.812)
Studying for Science Exams	0.003 (p = 0.954)	0.046 (p = 0.41)	0.005 (p = 0.933)	-0.067 (p = 0.229)	-0.003 (p = 0.951)
Science Reading Assignments	-0.01 (p = 0.859)	0.076 (p = 0.176)	0.041 (p = 0.465)	-0.048 (p = 0.395)	0.017 (p = 0.765)
Science Academic Requirement	-0.004 (p = 0.946)	0.041 (p = 0.464)	-0.018 (p = 0.751)	-0.087 (p = 0.122)	-0.019 (p = 0.731)
Science Class responsibilities	0.046 (p = 0.415)	0.012 (p = 0.832)	0.002 (p = 0.969)	-0.033 (p = 0.551)	0.010 (p = 0.863)
Science Tasks in General	0.04 (p = 0.481)	0.087 (p = 0.122)	-0.03 (p = 0.590)	-0.03 (p = 0.589)	0.021 (p = 0.71)
Overall	0.022 (p = 0.689)	0.063 (p = 0.260)	0.003 (p = 0.959)	-0.066 (p = 0.241)	0.008 (p = 0.890)

The mixed correlation analysis presented in the table indicates a completely stationary, non-significant association between the learning approach and academic procrastination, resulting in an overall correlation coefficient of $r = 0.008$ ($p = 0.890$). The statistical independence observed across all sub-dimensions in Table 4 fundamentally challenges the conventional principles of Temporal Motivation Theory posited by Steel and König (2006), which suggest that the adoption of active, high-value pedagogical approaches such as project-based learning ought to inherently reduce behavioral procrastination by enhancing the immediate utility of tasks.

The notable lack of substantial associations between Autonomy & Skill Development and Studying for Science Exams (r = -0.066, p = 0.241) is consistent with the personality and trait-based frameworks proposed by Arias and Sosa (2022). The authors contend that persistent academic procrastination functions mostly as an internal, trait-like tendency resulting from serious self-regulatory deficiencies and emotional dysregulation. Thus, the empirical patterns in Table 4 are consistent with the findings of González-Brignardello et al. (2023), who demonstrated that self-regulated learning plays a central role in reducing academic procrastination and promoting academic achievement and subjective well-being. These findings suggest that while instructional improvements may enhance the learning environment, meaningful reductions in procrastination also depend on students' ability to regulate their own learning behaviors. As shown in Tables 4, the correlation matrix between the indicators of the learning approach (IV) and procrastination (MV) shows a flatline across all intersections. The overall correlation between the two primary variables is virtually non-existent and statistically insignificant (r = 0.008, p = 0.890). No significant relationships emerge between specific indicators. For example, the relationship between Autonomy & Skill Development and Studying for Science Exams yields an r = -0.067 with a p-value of 0.229. Every single critical intersection yields a p-value well above the traditional alpha = 0.05 threshold, proving that the type or perceived quality of the instructional approach has no linear statistical bearing on a student's tendency to procrastinate.

Table 5. Correlation Analysis between IV and DV

	IV				
DV	**Student Engagement & Motivation**	**Learning Effectiveness & Understanding**	**Collaboration & Real-World Applications**	**Autonomy & Skill Development**	**Overall**
Cognitive Engagement	0.339	0.279	0.264	0.329	0.363
	< .001	< .001	< .001	< .001	< .001
Behavioral Engagement	0.184	0.149	0.156	0.151	0.192
	< .001	0.008	0.005	0.007	< .001
Emotional Engagement	0.179	0.102	0.045	0.141	0.142
	0.001	0.067	0.428	0.011	0.011
Social Engagement	0.289	0.207	0.236	0.244	0.293
	< .001	< .001	< .001	< .001	< .001
Overall	0.376	0.281	0.27	0.33	0.378
	< .001	< .001	< .001	< .001	< .001

A strong, positive, and statistically significant correlation between the learning approach and student engagement is observed (overall correlation coefficient: r = 0.378, p < .001, see Table 5). This strong baseline relationship across almost all indicators in Table 5 provides powerful validation for the core tenets of Piaget's (1973) and Vygotsky's (1978) constructivist learning theories that active, participatory, and contextual environments are inherently constructed to maximize student engagement. At the sub-dimension level, the instructional method correlated most strongly with cognitive engagement (r = 0.363, p < .001) and social engagement (r = 0.293, p < .001). These trends are consistent with the empirical findings of Santhosh et al. (2023) and Wijnia et al. (2023), who reported that project-based learning promotes deeper learning, strengthens higher-order and critical thinking skills, and enhances collaboration through students' engagement in authentic, real-world problems and collaborative learning experiences. However, although still statistically significant, the correlation scores for behavioral engagement (r = 0.192, p < .001) and emotional engagement (r = 0.142, p = 0.011) are significantly lower, and the correlation between collaboration & real-world applications and emotional comfort is no longer

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significant (r = 0.045, p = 0.428). This result aligns well with the multi-dimensional engagement frameworks of Wang et al. (2016), which highlight that behavioral task persistence and affective connection are not necessarily indicative of intellectual interest.

Table 6. Correlation Analysis between MV and DV

DV	MV						
	Science Writing & Project Tasks	**Studying for Science Exams**	**Science Reading Assignments**	**Science Academic Requirement**	**Science Class responsibilities**	**Science Tasks in General**	**Overall**
Cognitive Engagement	-0.100 (p = 0.001)	-0.126 (p = 0.024)	-0.141 (p = 0.011)	-0.147 (p = 0.008)	-0.102 (p = 0.069)	-0.115 (p = 0.039)	-0.155 (p = 0.006)
Behavioral Engagement	0.100 (p = 0.100)	0.041 (p = 0.465)	0.067 (p = 0.229)	0.056 (p = 0.320)	0.088 (p = 0.117)	0.083 (p = 0.14)	0.087 (p = 0.122)
Emotional Engagement	0.000 (p = 0.600	0.003 (p = 0.955)	0.006 (p = 0.921)	-0.023 (p = 0.681)	0.044 (p = 0.428)	0.039 (p = 0.484)	0.020 (p = 0.716)
Social Engagement	0.000 (p = 0.800)	-0.008 (p = 0.892)	-0.051 (p = 0.360)	0.047 (p = 0.404)	0.007 (p = 0.901)	0.042 (p = 0.456)	0.011 (p = 0.841)
Overall	-0.000 (p = 0.900)	-0.037 (p = 0.505)	-0.053 (p = 0.346)	-0.026 (p = 0.646)	0.007 (p = 0.895)	0.014 (p = 0.804)	-0.020 (p = 0.728)

The correlation analysis in Table 6 reveals that procrastination is significantly and negatively associated with cognitive engagement, suggesting that delays in science-related tasks undermine students' analytical processing and strategic learning behaviors. This finding aligns with Temporal Motivation Theory (Steel & König, 2006), which posits that procrastination arises when tasks are perceived as low in value or expectancy, thereby reducing cognitive investment. It also resonates with Zimmerman's Self-Regulation Theory (2000), as procrastination reflects a failure in self-regulatory mechanisms that diminishes students' ability to sustain mental effort and apply learning strategies. In contrast, the weak and non-significant correlations between procrastination and behavioral, emotional, and social engagement indicate that while students may postpone academic tasks, they continue to participate outwardly, maintain affective responses, and interact socially with peers. This selective impact supports Eccles' Expectancy-Value Theory (1983), which emphasizes that engagement is strongest when tasks are perceived as valuable and attainable; procrastination primarily erodes the cognitive dimension where value and expectancy are most critical. The result also echoes findings by Asri and Cahyono (2024), who reported that project-based learning supported by self-regulation reduces procrastination and enhances cognitive engagement, and by Steel et al. (2022), who noted that ineffective self-regulation leads to poorer performance when deadlines lack urgency. Collectively, these results underscore that procrastination does not broadly diminish engagement across all dimensions but selectively weakens cognitive processing, thereby clarifying its limited mediating role and supporting its conceptualization as a potential moderator in the relationship between project-based learning and student engagement.

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Table 7: Mediation Analysis of Procrastination on the PBL to Engagement Relationship

				95% Confidence Interval			
Effect	**Label**	**Estimate**	**SE**	**Lower**	**Upper**	**Z**	**p**
Indirect	a × b	-1.29e−4	9.76e-4	-0.00204	0.00178	-0.132	0.895
Direct	c	0.280	0.0383	0.20455	0.35468	7.301	< .001
Total	c + a × b	0.279	0.0383	0.20440	0.35457	7.296	< .001

The findings revealed that project-based learning exerted a significant direct influence on student engagement, yet the hypothesized mediating role of procrastination was not supported. This non-significant mediation effect suggests that procrastination may operate differently than expected, potentially serving as a moderator that alters the strength of the relationship between instructional design and engagement depending on contextual factors such as task difficulty or perceived relevance. Alternatively, other psychological constructs including academic self-efficacy, intrinsic motivation, or test anxiety may provide stronger explanatory power for variations in engagement outcomes. The findings suggest that engagement is influenced by instructional design independently of procrastination, consistent with self-determination theory. This perspective underscores the importance of considering multiple motivational and behavioral variables when examining the mechanisms that connect pedagogical approaches to student engagement.

In contrast to the correlation results, Table 7 demonstrates that the direct path (c) between project-based learning and student engagement remains strong, positive, and statistically significant (Estimate = 0.280, $p < .001$, Z = 7.301). This robust direct effect underscores the explanatory power of constructivist learning theory (Piaget, 1973; Vygotsky, 1978), which emphasizes that authentic, collaborative, and inquiry-driven tasks inherently foster engagement regardless of individual behavioral tendencies. At the same time, the non-significant indirect effect (a × b, $p = 0.895$) indicates that procrastination does not mediate this relationship, supporting Zimmerman's (2000) Self-Regulation Theory, which frames procrastination as a distinct self-regulatory challenge rather than a determinant of instructional efficacy. Anchoring these findings in Temporal Motivation Theory (Steel & König, 2006) further clarifies the mechanism: procrastination emerges when task value and expectancy are diminished, yet project-based learning elevates both by embedding relevance, ownership, and accountability into science tasks. Thus, while procrastination may selectively weaken cognitive processing, it does not obstruct the direct motivational pathway established by optimized pedagogical design. Collectively, these results affirm that project-based learning drives science engagement across dimensions independently of procrastination tendencies, positioning procrastination more plausibly as a moderator that shapes the strength of engagement under varying contextual conditions rather than as a mediator of instructional effects.

IMPLICATIONS AND CONCLUDING REMARKS

Implications for Practice

The descriptive findings of the present study describe a clear behavioral and engagement profile of participants. The evaluation of the teaching strategy reflects a very active and student-centered learning environment, as shown by a high overall composite mean score . Students in this framework know that their current learning environment facilitates conceptual clarity, collaborative problem-solving, and independent skill development. But while the level of student engagement that results is generally high and positive, it shows a pronounced structural imbalance. Students show high investment in their intellectual curiosity and communication with peers, but they are inconsistent in completing daily tasks and emotionally connected to the schoolwork in the moderate range. This selective pattern of engagement exists alongside a moderate level of academic procrastination at baseline. Procrastination behaviors are very situational, with a dramatic peak when preparing for examinations under high stakes but also a significant drop when under the low stakes of everyday classroom responsibilities.

Based on the statistical indicators that were given the lowest ratings in the study, the following specific, targeted, and viable recommendations are addressed to the key stakeholders:

- For teachers in the classroom: The dimensions of emotional engagement and behavioral engagement were the lowest-performing dimensions of student engagement, teachers should purposefully embed routine affective checks and consistent behavioral scaffolds in their lessons. Teachers can enhance emotional connection by having students complete short low-stakes reflection journals at the end of learning modules where students can share their personal interest or frustration with the topics. Teachers can encourage behavioral consistency by dividing large assignments into smaller weekly milestones that students must complete. And, since the worst procrastination occurs during exam preparation, teachers should more actively replace one large, high-stakes traditional examination with smaller, distributed bi-weekly quizzes and guided review sessions. This strategy reduces evaluative test anxiety and avoids the negative impact of cramming on student thinking.

- For school administrators and guidance counselors: As regular class tasks and general tasks are the baseline indicators of procrastination behaviors, school administrators and counselors need to be aware that only standard academic accommodations will not solve persistent procrastination habits. The guidance office should offer periodic, targeted small group self-regulation training programs on time management, emotional regulation, and task-initiation strategies. Also, since student motivation ranked the lowest among the instructional indicators, administrators should fund and implement peer-led mentoring networks and interest-driven student clubs. These programs can help students feel more connected to their peers and to the school . This improves behavioral and emotional commitment to the school environment.

- For curriculum planners: Curriculum planners should accept that the teaching method does not directly influence the reduction of procrastination habits and must stop relying on engaging content to fuel students' productivity. The researcher strongly recommends that structured formative checkpoints and explicit self-monitoring tools be directly embedded in the course syllabi and learning modules. Designers should build standard "pacing guides" into the learning management systems so that they can send students automated reminders, step-by-step progress bars, and peer-review windows. The intentional structure incorporates habits of self-regulated learning into the curriculum and protects the students' analytical focus from the distraction of delayed task completion.

Implications for Future Research

Future research should employ longitudinal or experimental designs to establish whether project-based learning produces sustained reductions in procrastination and long-term improvements in engagement, while broader sampling across public schools, non-STEM programs, and diverse regions is necessary to enhance external validity and ensure findings are representative of varied educational contexts. Researchers are encouraged to incorporate qualitative methods such as interviews or focus groups to capture richer insights into students' procrastination behaviors and experiences with project-based learning, and to address measurement concerns, diagnostic tests for common method bias should be reported, with objective indicators of engagement (e.g., attendance records, classroom observations, academic performance) complementing survey data.

Concluding Remarks

The findings of this study confirm that project-based learning exerts a statistically significant direct effect on student engagement, while procrastination does not mediate this relationship. These results highlight instructional strategies and self-regulation as distinct yet complementary pathways for fostering engagement in science education. Nonetheless, the cross-sectional design limits causal interpretation, and reliance on self-reported data introduces potential bias, underscoring the need for cautious application of the findings. Future research should employ longitudinal or experimental designs to establish whether project-based learning produces sustained reductions in procrastination and long-term improvements in engagement. Broader sampling across public schools, non-STEM programs, and diverse regions is necessary to enhance external validity and ensure findings are representative of varied educational contexts. Researchers are further encouraged to incorporate qualitative methods such as interviews or focus groups to capture richer insights into students' procrastination behaviors and experiences with project-based learning. To address measurement concerns, diagnostic tests for common method bias should be reported, and objective indicators of engagement (e.g., attendance records, classroom observations, academic performance) should complement survey data.

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